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Craig HARNESS B.Sc., RMT
[redacted]

A complex exploration into the osteopathic philosophy as introduced by Andrew Taylor Still, MD, DO (Self-proclaimed) exemplified by commentary on the embryology, anatomy, and treatment of the peritoneal viscera

Membres du jury :

Président : Guy VOYER Pht, MD, DO
Juges : Daniel MICHEL MD, DO
Carla DELANGE Pht, DO
Serge TURMEL DO
Véronique DURAND DO
Andy BURKE MSc Sport Medicine, DO
Carl DUFRESNE DO
Karyne MARIN DO

Memoir advisor

Chantale Bertrand DO

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Abstract

Complexity thinking offers new frontiers in the world of clinical practice of manual osteopathy. It offers an appreciation for 'real time' experience of change, whether it be instant or delayed, between the patient and osteopath alike; that is to say their shared experience, an interaction as it were. As interaction is a key concept within the field of complexity science it seems at least superficially that manual osteopathy must then be complex. After entering into the roots of both manual osteopathy and complexity science *it will be shown undeniably that to practice manual osteopathy according to the laws of osteopathy as laid down by Dr. Still, MD, DO (Self proclaimed), a complex way of thinking must be utilized which respects that health is a process with its deepest roots in Nature.*

Within the matrix of complexity thinking aspects of the embryology and anatomy of the peritoneal viscera are explored as testimony for the complex nature of both human structure and function. In doing so a potential 'space of emergence' is created for a theoretical approach to treatment for the peritoneal viscera with manual osteopathy. It is an open space. Please don't expect "cookie-cutter" if someone presents with A, do this; with B, do that, etc.. That is simply not in the spirit of either complexity thinking or that of Dr. Still.

If nothing more this work is intended to give the practicing osteopath a different view of the embryology and anatomy of the human peritoneal viscera. These pieces of knowledge are of crucial importance if one is to unfold the etiology of mechanical disease.

Please enjoy.

Object of this Research

A complex exploration into the osteopathic philosophy as introduced by Andrew Taylor Still, MD, DO (Self-proclaimed) exemplified by commentary on the embryology, anatomy, and treatment of the peritoneal viscera

Résumé

La pensée complexe offre de nouvelles frontières au monde de la pratique clinique de l'ostéopathie manuelle. Elle permet d'apprécier en temps réel l'expérience du changement, qu'il soit immédiat ou tardif, tant pour le patient que pour l'ostéopathe; autrement dit leur expérience partagée, voire même leur interaction. Et comme l'interaction est un concept clé dans le domaine de la science du complexe, il semble, du moins en surface, que l'ostéopathie manuelle soit donc elle aussi complexe. Après avoir touché aux racines de l'ostéopathie manuelle et de la science du complexe *il sera démontré incontestablement que pour exercer l'ostéopathie manuelle selon les lois de l'ostéopathie telles que décrites par le Dr Still, MD, DO (Autoproclamé), on doit utiliser une forme de pensée complexe respectant que la santé est un processus ayant ses racines les plus profondes dans la Nature.*

Dans la matrice de la pensée complexe différents aspects de l'embryologie et de l'anatomie des viscères péritonéaux sont étudiés à titre de témoignage pour la nature complexe de la structure et de la fonction du corps humain. De cette façon, un « espace d'émergence » potentiel est créé pour une approche théorique du traitement des viscères péritonéaux grâce à l'ostéopathie manuelle. Il s'agit d'un espace libre. Et surtout ne vous attendez pas à des recettes du genre : si quelqu'un se présente avec A, faites ceci; avec B, faites cela; etc. Ce n'est tout simplement pas dans l'esprit de, ni la pensée complexe, ni celle de Dr Still.

À tout le moins, ce travail vise à donner à l'ostéopathe praticien une vision différente de l'embryologie et de l'anatomie des viscères péritonéaux de l'être humain. Ces connaissances sont d'une importance cruciale si l'on désire dévoiler l'étiologie des troubles mécaniques.

En vous souhaitant bonne lecture.

Objet de cette Recherche

Une étude complexe de la philosophie ostéopathique telle qu'introduite par Andrew Taylor Still, MD, DO (Autoproclamé) illustrée de commentaires sur l'embryologie, l'anatomie, et le traitement des viscères péritonéaux.

Chapter 1: Introduction and Methodology

1.1 Overview of the Memoir Process

This work is qualitative in nature. Its primary role is to fulfill the requirements for a diploma of osteopathy (DO). With a topic such as the peritoneal viscera all signs seem to point in the direction of a closely controlled clinical study with much statistical analysis followed by a need for further study. The author believes that the generation of such a study cannot truly occur within the paradigm of complexity. With that; the opposite end of the spectrum has been utilized, a philosophical model with no patients, but ideas founded in scientifically 'acceptable' data. When the process of this memoir began it was truly emergent in nature: the author had another topic in mind that had previously been approved for commencement, but with an *ad hoc* discussion lasting perhaps 20 seconds with Mr. Voyer the inception of this work was initiated. Its conception closely followed and has now been evolving as an ongoing process.

Concurrently with this memoir, the author has been attending Queen's University in Kingston, Ontario, Canada where he is now a Master's of Science in Anatomical Sciences Candidate, scheduled for thesis defense in the fall of 2012. The aim of this program is to teach people to teach anatomy at the university level. The main attraction for the author to this program was the opportunity for human dissection and a further knowledge of anatomy to apply in his treatments. The author's experience at Queen's University has changed greatly the course of this memoir. Additional studies in embryology, histology, neuroanatomy, gross anatomy as well as both teaching and learning have been instrumental in allowing the author to apply the complexity model to the embryology, gross anatomy and histology of the abdominal cavity during the course of lecturing and laboratory tutorials. The author's time in Kingston over the last eleven months has continued to validate his faith in complexity thinking as a tool for teaching and learning anatomy which has carried over into the treatment of his patients as well as their homecare education which must be an essential aspect of any osteopathic treatment.

These studies have also hindered this work in that it represented a time constraint. A normal problem of higher education arose: more knowledge led to the realization that the new knowledge gained is exponentially smaller than the collective knowledge of even one scientific community. It is a difficult edge of chaos to delaminate. The author has attempted to coral the knowledge required for this memoir by limiting the topics of discussion to the peritoneal viscera as much as possible. While as painful as this is, to break with the desire for totality, the author has created this boundary, but stresses it is fuzzy. The recognition of this limitation has shaped this work such that it does not include intricacies of pathology, biomechanics, physiology etc. that can arguably be regarded as necessary. The decision for their exclusion was made by the author so that the present memoir would not constitute an attempt at a closed system of treatment for the peritoneal viscera with manipulative means, but would represent a true philosophical foundation based on the embryology, anatomy, and palpation of the peritoneal viscera.

The author believes this foundation is in the spirit of the discoverer of osteopathy, Andrew Taylor Still, MD, DO (self-proclaimed) [AT Still from here forward]. A note: the rationale for stating that AT Still's DO designation was self-proclaimed is this: it indicates that he was the discoverer of the philosophy and therefore deserves both the greatest admiration and respect for any philosophical discussion pertaining to osteopathy. Since the opening of the first osteopathic school in 1892 no other person could proclaim that they were an osteopath without first studying at the American School of Osteopathy or one of its subsequent schools.

Osberg & Biesta[1] have argued that students must be offered a 'space of emergence' that is not bound by limiting constraints such that their learning will emerge. This form of emergent learning is amongst the deepest possible in that it can be looked at as a type of enculturation. The information to follow in this memoir strives to create such a 'space of emergence' for the student of osteopathy as well as the practicing osteopath in creating their own treatment protocol in correlation with their physical diagnosis. The foundation of knowledge includes complexity science and thinking, embryology, gross anatomy, and palpation. The model developed is by necessity not a model at all. It is an attempt to open such a space of emergence for both the author and reader to utilize in their treatment.

1.2 Methodology

The methodology followed by the author in this memoir is that of complexity thinking. As "complexity" seemingly defies being defined, chapter 2 of this memoir will examine it in great depth for the purposes of evolving the idea of complexity into how the author utilized it. With this methodology some aspects may not satisfy the most stringent of scientific standards

[1] Osberg, D. & Biesta, G. (2007). Rethinking schooling through the 'logic' of emergence: some thoughts on planned enculturation and educational responsibility. In: Bogg, J. & Geyer, R. (Eds.). (2007). *Complexity science & society*. Radcliffe: UK.

regarding a qualitative research study. To minimize the potential detriment of this lack of conformity certain much more familiar research methods are included here, but it is stressed that they do not in themselves constitute complexity thinking and that the true methodological framework of this memoir is to be found in chapter 2.

1.2.1 Phenomenology

"Phenomenology is an approach to thinking about what life experiences of people are like and what they mean."[2] This approach is very much within the paradigm of complexity as it does not attempt to bound down and objectify. Life experiences are naturally subjective in nature, but with proper and adequate collection can represent manipulative data revealing much about the topic under study. The data collection regarding the life of AT Still was obtained primarily from this autobiography. Secondary resources included the writings of many of his students and close friends, for example the writings of Hildreth[3] and Booth.[4]

1.2.2 Ethnography

"Ethnography…provides a framework for studying the meanings, patterns, and experiences of a defined cultural group in a holistic fashion."[5] The cultural group defined by the author is the osteopathic profession. A limitation of this segregation is that it does just that, segregates a population from the whole thus ignoring a part of that whole. It is accepted here however in a qualified manner: the acknowledgment of the potential insights offered to the osteopathic profession from sources other than intrinsic ones. An example of this situation being the research work of a physiologist, Irvin Korr Ph.D., and his contribution of the theory of the facilitated segment that is prominent within the current osteopathic community. The defining factor of determining if someone is an osteopath is their ability to physically manipulate the body to achieve a desired outcome. That does not preclude people from understanding the complex philosophy of osteopathy and applying it in a different manner such as in a laboratory setting. To overcome this limit in ethnographic research a fuzzy boundary was applied to the segregation

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[2]Loiselle, C. G., Profetto-McGrath, J., Polit, D. F. & Beck, C. T. (2007). *Canadian essentials of nursing research (2nd Ed.).* Lippincott Williams & Wilkins: USA, p.55
[3]Hildreth, A. G. (1938). *The lengthening shadow of Andrew Taylor Still.* The Journal Printing Company: Kirksville.
[4]Booth, E. R. (1905). *History of osteopathy and twentieth-century medical practice.* Jennings and Graham: Cincinnati. Downloaded from www.archive.org.
[5] Loiselle, Profetto-McGrath, Polit & Beck, 2007, p.211

of the osteopathic community. The community was bound in the relative sense to both osteopathic practitioners as well as any scholar whose thinking is in accord with the osteopathic philosophy as defined in chapter 2.

1.2.3 Grounded Theory

The closest association of this memoir with a classical model of qualitative research is with grounded theory. Within the realm of grounded theory "both the research problem and the process used to resolve it are discovered during the study. A fundamental feature of grounded theory research is that data collection, data analysis, and sampling of participants occurs simultaneously."[6] This emergent nature is intrinsic to the paradigm of complexity and for that reason will not be elaborated further under this heading.

1.2.4 Data Collection and Potential Biases

With the growth of technology, so too grew the potential for information exchange and collection. Some of the greatest, and most accurately detailed, works of anatomy are available on the internet for free as they have become out of copyright. With an institutional relationship, modern works are also readily available free to the user. The pitfall of modern technology and information collection is the lack of time to read all of what is obtained.

The data collected in this memoir came from books and articles published by the scientific community in general which has a variety of intentions: anatomic, embryologic, etc. When these intentions are purely informational in nature, they become very easily applied to the osteopathic philosophy. Saturation of the collected data can arguably never be accomplished as the fields of study never stop evolving. For the purposes of this memoir an acceptable level of saturation was achieved utilizing science libraries, online access to peer-reviewed scientific journals, and the internet. With respect to data collection the point of satisfaction was when a redundancy of information started to emerge in the collection process.

[6] Loiselle, Profetto-McGrath, Polit & Beck, 2007, p.219

The author attempted to exclude biases in information gathering by not limiting himself to any scientific community for;

> there is only one way of seeing one's own spectacles clearly: that is, to take them off. It is impossible to focus both on them and through them at the same time. A similar difficulty attaches to the fundamental concepts of science. We see the world through them to such an extent that we forget what it would look like without them: our very commitment to them tends to blind us to other possibilities. Yet a proper sense of the growth and development of our ideas will come only if we are prepared to unthink them.[7]

It is easy to become complacent with the level of knowledge acquired if one is content with the results of their treatments. If the stimulus of having the inability to utilize the osteopathic philosophy in cases as vast as those treated by AT Still is not enough to take one's glasses off and re-evaluate their level of knowledge and skill, perhaps another profession should be sought.

As will be shown later in this memoir, complexity thinking enables the researcher to realize biases within both themselves and their collected data and take it into account during the interpretation of that data. All boundaries become fuzzy. One obvious bias was the limitation of information gathering regarding the osteopathic philosophy passed the early twentieth century literature. The reason for this bias was just that; a bias. The author wanted to learn the philosophy "from the discoverer" so to speak. The four texts of AT Still are the foundation of the interpretation of the osteopathic philosophy in this memoir. The subsequent fuzzy boundary between AT Still and his disciples was created arbitrarily around the end of the first decade of the twentieth century as there was a growing concern within the professional literature at that time that many osteopaths were not practicing what AT Still had discovered and attempted to propagate.[8,9,10,11] The author respects any legitimate interpretation of the osteopathic philosophy of AT Still provided there is merit to the argument. The paradigm of complexity would have it no other way as will become apparent in chapter 2.

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[7] Toulmin, S. (1961). *Foresight and understanding an enquiry into the aims of science.* Greenwood Press: Connecticut, p.101

[8] Bass, J. T. (1905). Are the osteopaths to be swallowed up? *The Journal of the American Osteopathic Association, 5, p.111-113.*

[9] Ellis, S. A. (1907). Is the practice of eclectic osteopathy a menace to the osteopathic school. *Journal of the American Osteopathic Association, 7, p.1-6.*

[10] Evans, A. L. (1906b). Unity in diversity. *The Journal of the American Osteopathic Association, 5, p.318-322.*

[11] Hazzard, C. (1906b). Are we progressing? And whither? *The Journal of the American Osteopathic Association, 6, p.497-498.*

Chapter 2: Philosophical Framework

2.1.0 Was Osteopathy Original?

To efficiently discuss any complex scientific or philosophical argument, the context of that argument must be combined with an acceptable level of knowledge on the part of both/all parties involved in the discussion. This; however, cannot possibly be the case when the subject at hand is new or unknown to one of the participants. "Often, one cannot judge the truth of some claimed observation without going to the trouble of learning a lot of things that most people do not automatically know."[12] The situation of 'lack of knowledge' on behalf of one of the parties was exactly what AT Still faced when he first decided to propagate the discovery of his philosophy of osteopathy.

A question from any person without knowledge of what osteopathy's founding pillars are becomes: is this "new idea" really original? Being a rather logical method of inquiry, this question was explored and subsequently answered "yes"; osteopathy was a new philosophy for the treatment of human ailments.[13] Littlejohn was not the only early osteopath to inquire into the origins of osteopathy. The admission that osteopathy was a new philosophy of medical treatment is prevalent throughout the earliest professional writings of the osteopathic community.[14,15,16,17,18,19,20,21,22,23] "At the time it was started, Osteopathy…was an idea in the mind of only one man, Dr. A. T. Still; and its practical applications were unknown to all but him, his sons, and a few friends."[24]

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[12] Goldstein, M., & Goldstein, I. (1984). *The experience of science an interdisciplinary approach*. Plenum Press: New York, p.18
[13] Littlejohn, J. M. (1901). Osteopathy an independent system co-extensive with the science and art of healing. *The Journal of the American Osteopathic Association, 1, p.22-34.*
[14] Hulett, C. M. T. (1901). Historical sketch of the a. a. a. o.. *The Journal of the American Osteopathic Association, 1, p.1-6.*
[15] Littlejohn, 1901
[16] Lyne, S. (1904). Osteopathic philosophy of the cause of disease. *The Journal of the American Osteopathic Association, 3, p.395-403.*
[17] Pressly, A. B. (1904). Osteopathy as an educational movement, past, present and prospective. *The Journal of the American Osteopathic Association, 3, p.175-185.*
[18] Evans, A. L. (1906a). The future of osteopathy. *The Journal of the American Osteopathic Association, 6, p.1-11.*
[19] Taplin, G. C. (1906). Are we progressing? *The Journal of the American Osteopathic Association, 6, p.459-461.*
[20] Hazzard, C. (1906a). Safeguard the future. *The Journal of the American Osteopathic Association, 5, p.244-251.*
[21] Atzen, C. B. (1908). Osteopathy a new school of therapeutics. *The Journal of the American Osteopathic Association, 7, p.370-375.*
[22] Burns, L. (1908). On mixing treatments. *The Journal of the American Osteopathic Association, 7, p.267.*
[23] Littlejohn, J. M. (1908). The principle of osteopathy. *The Journal of the American Osteopathic Association, 7, p.237-246.*
[24] Booth, 1905, p.71

2.1.1 Incubation Period of Osteopathic Thought

Further examination into the development of osteopathy in working towards what its philosophy involves, demands that one becomes cognoscente of the time period in which it was developed. AT Still was born in the year 1828[25] and studied medicine from 1856-1860.[26] In this era AT Still was not privy to the many scientific developments to which we are now accustom. During his upbringing there were "no schools, churches, nor any of the comforts of older-settled States."[27] The lack of these basic necessities for learning; however, did not hinder AT Still in his education and the lifelong development of his philosophy. He describes in his autobiography why this era was so important to the discovery of his philosophy of osteopathy:

> my frontier experience was valuable to me in more ways than I can ever tell. It was invaluable in my scientific researches. Before I had ever studied anatomy from books I had almost perfected the knowledge from the great book of nature.[28]

He described skinning squirrels and other animals which exposed him to the various muscles, nerves, vessels and bones of these animals which he, in turn, related to an understanding of the intricacies of Nature.[29] It was this understanding of the intricacies of Nature that led him to reason that there was a more appropriate way of thinking when applied to medicine. "With no teacher but the facts of nature, and no classmate save the badger, cayote, and my mule, I sat down to my desk on the prairie to study over what I had learned at medical schools."[30]

This contemplation did not lead AT Still to drop all medical practice, but to start incorporating a mechanical philosophy into his medical practice. Trained as a medical doctor AT Still used antidotes in the treatment of snake bites[31] which; even after he divorced himself from the medical brotherhood, he continued to use, not because they were allopathic or osteopathic, but because the use of an antidote for snake venom is appropriate as per one of the key features of the osteopathic philosophy – removing the cause of the ailment. During the winter of 1878-1879, four years after AT Still had raised the banner of osteopathy he "treated

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[25] Hildreth, 1938
[26] Still, A. T. (1897). *Autobiography of Andrew T. Still with a history of the discovery and development of the science of osteopathy.* Published by the Author: Kirksville. Downloaded from www.archive.org.
[27] Still, 1897, p.55
[28] Still, 1897, p.45
[29] Still, 1897
[30] Still, 1897, p.96-97
[31] Still, 1897

partly by drugs, as in other days, but also gave Osteopathic treatments."[32] Many of the early writings of AT Still are filled with his vehement rejection of the use of drugs in the treatment of the sick, but nonetheless it was not the drugs that he was rejecting, but the *way of thinking* in which they were administered. It was this shift in thinking that separated his osteopathic philosophy from that of the medical doctors. Influencing others to venture into the unknown territory of osteopathy and away from the traditional methods of medical doctors needed such a harsh thrust from AT Still. This was the only way to break the cycle of the traditional methods and treatments of the old school medical doctors. Only after that disengagement from the traditional system could potential osteopaths understand his way of thinking based in letting *Nature* make well the patient, assisted by the mechanical treatment of the osteopath, not *causing* the patient to become well based on external forces such as drugs or manipulation.

2.1.2 Could Osteopathy be Taught?

If osteopathy was to be successfully propagated, AT Still needed to teach it to others. With this, the reasonable question of whether or not osteopathy could be taught emerges. It was "not until he felt that he had fully established Osteopathy upon a scientific basis and demonstrated its efficacy in the treatment of almost all kinds of diseases, would Dr. Still consent to the organization of a school."[33] This very organization was the first attempt that AT Still made in teaching osteopathy outside of his family.

It is a well known story that at the age of ten AT Still stopped his headache by hanging a plow-line between two trees and resting his head on it. He described this as the first osteopathic treatment[34] and from that time "worked for more than fifty years, to obtain a more thorough knowledge of the workings of the machinery of life, to produce ease and health."[35] The knowledge gained by AT Still in his work resulted in the rapid growth of his practice between 1885 and 1892[36], so much so that it demanded he start to teach his discovery if he was to secure the survival of osteopathy as an independent system. This was the true test of whether or not the philosophy of osteopathy could be taught.

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[32] Still, 1897, p.114
[33] Booth, 1905, p.71-2
[34] Still, 1897
[35] Still, 1897, p.32-33
[36] Hildreth, 1938

As AT Still was not an educator by trade there were many inherent difficulties in the first school of osteopathy. "In fact, his radical ideas, his originality, his short cut methods of doing things, all tended to repel, at first, the man or woman educated in the conventional methods of the schools."[37] Arthur Hildreth was included in the first promotion of students of the American School of Osteopathy as founded by AT Still.[38] Apprehensive at first, Hildreth "felt that it would be impossible for him [AT Still] to teach others"[39] as many were convinced that AT Still had supernatural powers in diagnosis and treatment, or that he was possessed by the devil.[40] When Hildreth voiced his apprehensive concerns to AT Still, "his reply was, "I can teach you all I know.""[41] AT Still firmly stated that osteopathy was "a science which any man of average intelligence, who will studiously apply himself, can learn."[42] His confidence in his ability to propagate the philosophy of osteopathy was a driving force behind the exponential growth of osteopathic colleges. "In 1896 there were sixty-six of its [American School of Osteopathy] graduates in the field. During the session of 1896-7 there was an enrollment of 280 students – prospective Osteopaths."[43] Table 1 represents a summary of the various osteopathic schools that opened after the original 'American School of Osteopathy' at Kirksville dating up until May 1900 as elaborated by Booth.[44]

[37] Booth, 1905, p.71
[38] Hildreth, 1938
[39] Hildreth, 1938, p.27
[40] Still, 1897
[41] Hildreth, 1938, p.27
[42] Still, 1897, p.306
[43] Hulett, 1901, p.1
[44] Booth, 1905

Table 1: Early Osteopathic Schools

School	Established	Comments
American School of Osteopathy	June 1892	
National School of Osteopathy	June 1895	Not accepted into the Associated Colleges of Osteopathy and subsequently closed in 1900
Pacific College of Osteopathy	May 1896	
Northern Institute of Osteopathy	June 1896	Subsequently consolidated with the S.S. Still College of Osteopathy in June 1902
Colorado College of Osteopathy	Sept 1897	
Southern School of Osteopathy	March 1898	
California College of Osteopathy	March 1898	
Milwaukee College of Osteopathy	May 1898	
S.S. Still College of Osteopathy	June 1898	
Massachusetts College of Osteopathy	Oct 1898	Originally called the Boston Institute of Osteopathy
Atlantic School of Osteopathy	Feb 1899	
Philadelphia College and Infirmary of Osteopathy	Early 1899	
American College of Osteopathic Medicine and Surgery	May 1900	

The exponential growth in the number of colleges of osteopathy and its continued growth to the present condition, demonstrates clearly that both the philosophy and technique of osteopathy could be taught. It now remains to be clarified exactly what osteopathy is, or what its philosophy contains.

2.2.0 Definition of Osteopathy

It is difficult to define osteopathy for various reasons. AT Still wrote of osteopathy not as an object created, but a philosophy discovered.[45] He did offer various definitions of osteopathy as seen in Table 2; however, they fail to offer the clean cut objective definition that is sought by many.

Table 2: A Summation of AT Still's Definition of Osteopathy

Technical: Osteopathy is that science which consists of such exact, exhaustive, and verifiable knowledge of the structure and functions of the human mechanism, anatomical, physiological, and psychological, including the chemistry and physics of its known elements, as had made discoverable certain organic laws and remedial resources, within the body itself, by which nature under the scientific treatment peculiar to osteopathic practice, apart from all ordinary methods of extraneous, artificial, or medicinal stimulation, and in harmonious accord with its own mechanical principles, molecular activities, and metabolic processes, may recover from displacements, disorganizations, derangements, and consequent disease, and regain its normal equilibrium of form and function in health and strength.[46]
You wonder what osteopathy is; you look in the medical dictionary and find as its definition "bone disease." That is a grave mistake. It is compounded of two words, *osteon*, meaning bone, *pathos*, meaning to suffer. Greek lexographers say it is a proper name for a science founded on a knowledge of bones. So instead of "bone disease" it really means "usage"[47]
What is osteopathy? It is a scientific knowledge of anatomy and physiology in the hands of a person of intelligence and skill, who can apply that knowledge to the use of man when sick or wounded by strains, shocks, falls, or mechanical derangement or injury of any kind to the body[48]
Osteopathy is knowledge or it is nothing[49]

In writing about osteopathy AT Still desired not a linear definition that could be simply memorized by those who desired to learn it, but to change their way of thinking. He stated: "my object is to make the osteopath a philosopher, and place him on the rock of reason. Then I will

[45] Still, 1897
[46] Still, 1897, p.3
[47] Still, 1897, p.221
[48] Still, A. T. (1902). *The philosophy and mechanical principles of osteopathy.* Hudson-Kimberley Publishing Co.: Kansas City. Downloaded from www.archive.org, p.18
[49] Still, 1902, p.152

not have the worry of writing details of how to treat any organ of the human body....”[50] The propagation of a philosophy based on the exhaustive knowledge of the human form is problematic if before learning that philosophy, one is not very well versed in the anatomy of the human body. AT Still wrote about osteopathic studies: “…you begin with anatomy, and you end with anatomy, a knowledge of anatomy is all you want or need, as it is all you can use or ever will use in your practice, although you may live one hundred years.”[51] The author cannot stress enough the relationship between this thought and chapter 5 of this memoir.

2.2.1 Development of a Definition of the Osteopathic Philosophy

The exponential growth of osteopathy with the opening of the American School of Osteopathy in 1892 made certain that there would be a deviation from AT Still’s original concepts and theories. AT Still himself was a proponent of growing osteopathy, not according to what he or anyone else wrote or said, but according to the laws of osteopathy which are firmly based in Nature.[52] Early in the twentieth century osteopathy was growing at such a rate that it was also inevitable that the organization of an osteopathic community would emerge. This was a necessity if an accepted definition amongst the osteopathic community was to be created. “A more or less clearly defined sense of this was beginning to be felt by all thinking osteopathists, and in the autumn of 1896 a move was started among the students at Kirksville to effect an organization.”[53] It was March 13, 1897 that the proposal for the creation of the ‘American Association for the Advancement of Osteopathy’ (AAAO) was approved and by April 19 of that same year the organization was permanently created.[54] The AAAO was subsequently modified to the current ‘American Osteopathic Association’ (AOA) in 1901.[55]

With the osteopathic profession being in its infancy and finally receiving its first acceptance into any legislature, that of Vermont in 1896,[56,57] a greater need for a more concrete

Still, A. T. (1910). *Osteopathy research and practice.* Published by the Author: Kirksville. Downloaded from www.archive.org, p.38
[51]Still, A. T. (1899). *Philosophy of osteopathy.* Published by the Author: Kirksville. Downloaded from www.archive.org, p.16
[52] Still, 1899
[53] Hulett, 1901, p.2
[54] Hulett, 1901
[55] Peterson, B. E. (2003). Major events in osteopathic history. In: Ward, R. C. (Ed.). (2003). *Foundations for osteopathic medicine (2nd Ed.)* Lippincott Williams & Wilkins: Philadelphia.
[56] Hulett, 1901
[57] Hildreth, 1938

definition was necessary. This sentiment being prevalent throughout the osteopathic community, several osteopaths sent their version of a definition of osteopathy to the newly formed 'Journal of the American Osteopathic Association'. A collection of these definitions is shown in Appendix A – First Definitions of Osteopathy.

Reading these definitions brings support to the notion that osteopathy is not a 'thing', but a philosophy and as such can be interpreted in many ways. One very common theme amongst these definitions is the notion of a 'science' or a 'scientific system'. AT Still referred to osteopathy as a science throughout his writings,[58,59,60,61] but many of his claims would fail to fulfill the current definition of science. Before moving forward a working definition of science in relation to the osteopathic philosophy needs to be established.

2.2.2 Is the Definition Scientific?

Before passing judgment as to if osteopathy can be considered a true science, science itself needs to be defined within some boundaries. As with osteopathy, this too is difficult. The scientific community, however, has managed to define their topic of interest in much more concrete terms than the osteopathic community. That is not to say there are not disagreements amongst scientists within the scientific community, but for the purpose of this work a generalized and widely accepted definition is necessary. Goldstein and Goldstein[62] define science as having three key features as displayed in Box 1.

<u>Box 1: Three key features of Science as defined by Goldstein and Goldstein</u>[63]

1. It is a search for understanding.
2. The understanding is achieved by means of statements of general laws or principles – laws applicable to the widest possible variety of phenomena.
3. The laws or principles can be tested experimentally.

[58] Still, 1897
[59] Still, 1899
[60] Still, 1902
[61] Still, 1910
[62] Goldstein & Goldstein, 1984
[63] Goldstein & Goldstein, 1984, p.3

Of these three features “the feature that distinguishes science from other ways of understanding and explaining the world is an ultimate reliance on the authority of the experimental test.”[64]

While it is obvious that the first two features in Box 1 can be directly applied to the osteopathic philosophy, the third is not so obvious. The osteopath searches for an understanding of both the normal human form as well as the etiology of abnormal form. General laws or principles have also been generated by the osteopathic community such as “structure governs function” or “the rule of the artery is absolute”. The real problem for the osteopathic community in arguing the science of osteopathy is with the experimental test. “For something to be a subject of scientific inquiry it must be *measurable* in one way or another. Science is, therefore, *empirical* in that it relies on observation and experience.”[65] While it is easy to see a patient recover from severe illness, it is not always possible to measure and account for all of the variables involved in their recovery, nor is it easy to observe a recovery from a less severe ailment that may have even resolved without treatment. This is a direct violation of one of the key features of science therefore osteopathy is not a science, right? Not quite.

Lee[66] reminds us that non-scientific components are found in many of the sciences. The nature of the evolution of the osteopathic philosophy and treatment modalities provides an excellent example of this, in both positive and negative ways. The original students of AT Still and their successors found great success in treating a vast amount of ailments, but also realized that in some cases a strict adherence to AT Still’s original principles was not possible if they were to be successful in treating a variety of other ailments. This interaction of applying osteopathic techniques to ailments outside the scope of manual therapeutics set the stage for the emergence of other schools of thought within the osteopathic community such as reverting to some degree back to internal medicine. As internal medicine can be used “osteopathically” with great potential it cannot simply be discarded as unosteopathic because it does not have a mechanical basis. Nevertheless, it is very important to note that the content of this memoir is limited to the original mechanical or manual form of osteopathy with the understanding that an open relationship must be maintained with our allopathic cousins.

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[64] Goldstein & Goldstein, 1984, p.293
[65] Lee, J. A. (2000). *The scientific endeavor a primer on scientific principles and practice.* Addison Wesley Longman: San Francisco, p.2
[66] Lee, 2000

In a move towards a complex way of thinking for the osteopathic community, perhaps it is more appropriate to inquire “not whether the theories are scientific, but rather: Are those who believe in them scientists, in the sense that they are capable of recognizing the relevance of cogent refuting evidence when it is presented to them?”[67] This movement requires that the realm of ‘pure science’ be left and a new realm entered. The author will argue that the realm of complexity is the only realm capable of propagating the philosophy of osteopathy as developed by AT Still.

2.3.0 What is Complexity Science?

What is complexity science? Naturally this question cannot be answered in a linear way. “The “field” of complexity science is a popular stream of thought that brings together a diverse range of apparently disparate disciplines within contemporary science.”[68] Naturally, the science of complexity has, and will continue, to evolve and emerge. Alhadeff-Jones[69] describes three generations of complexity theory: 1) those emerging during the second world war, 2) the evolution of those theories and 3) a duel path: an English-speaking path concerned with complex adaptive order systems as well as a theory prevalent in Latin speaking countries “characterised by a reflexive dimension that aims to explore new ways of representing multiple complexities and that promotes an epistemology driven by the will of scientists to determine, conceive and construct the rules of their own action, including ethical ones.”[70]

2.3.1 Origins of the Theory of Complexity

The first generation of complexity theory was developed largely from handling large amounts of information and communication during the course of the Second World War. According to Alhadeff-Jones,[71] the interaction of these components grew from a mathematical theory of communication through automata theories and neural networks to cybernetics and operations analysis as well as operational research. Essentially, new math needed to be developed to handle such large amounts of information that was constantly interacting. Once

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[67] Goldstein & Goldstein, 1984, p.302
[68] Richardson, K. & Cilliers, P. (2001). Special editors’ introduction: what is complexity science? A view from different directions. *Emergence, 3, p.5-23.*
[69] Alhadeff-Jones, M. (2008). Three generations of complexity theories: nuances and ambiguities. In: Mason, M. (Ed.). (2008). *Complexity theory and the philosophy of education*. Wiley-Blackwell: United Kingdom.
[70] Alhadeff-Jones, 2008, p.70
[71] Alhadeff-Jones, 2008

this new math had been developed, automata theories emerged with theories of cybernetics closely following. Operations analysis and operational research was concurrently being developed. Powering this development were the British and their mixed teams approach to tactics and strategy.[72] "Challenges raised by the Second World War thus accelerated the emergence and institutionalisation of the first body of research informing the concept of complexity.[73] The stage was officially set for the interaction and emergence of the next generation of complexity theory.

Following the turmoil of the Second World War and the subsequent development of large corporation, new technologies as well as pressure from the cold war, all set the stage for the development of new theories involving complexity;[74] not just mathematical ones, but social and philosophical as well. Key features of the second generation of complexity include computer and engineering sciences, management sciences and artificial intelligence, systems sciences, self-organization, non-linear dynamics and evolutionary biology.[75] While it is not appropriate here to enter into the finer details of each of these components, it is necessary to point out the far reaching potentials of complexity theory. As will be demonstrated subsequently, the paradigm of complexity can be adapted to incorporate each of these separate features, provided enough information is obtained. It is along this line of thought that the author will demonstrate that the philosophy of osteopathy belongs in none other than the paradigm of complexity.

The third generation of complexity theory is divided into a primarily English speaking school, and a school prevalent throughout Latin countries.[76] The former can be considered more of a practical form of complexity theory while the latter can be considered more of a philosophical form of complexity theory. The key component of the English speaking school is complex adaptive systems while the in Latin counties it is 'intelligence de la complexité'.[77] The view of complex adaptive systems led to the development of the Santa Fe Institute[78] whose chief work is in the complexity research of science. The complexity school of the Latin countries has

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[72] Alhadeff-Jones, 2008
[73] Alhadeff-Jones, 2008, p.66
[74] Alhadeff-Jones, 2008
[75] Alhadeff-Jones, 2008
[76] Alhadeff-Jones, 2008
[77] Alhadeff-Jones, 2008
[78] Alhadeff-Jones, 2008

Edgar Morin as a core contributor[79] and is very philosophic. "Morin advocated a conception of complexity that dispensed with the antagonist, contradictory and complementary tensions which shape its own understanding."[80] With the philosophical views of Morin it is possible to eliminate boundaries between disciplines and incorporate all relevant information into productive theories and a way of thinking. This is a desired state when first learning, refining and eventually perfecting one's skill in the osteopathic field.

2.3.2 Refinement of Complexity Science towards Complexity Thinking

The brief outline of the first few generations of complexity theory does little to offer a definition of complexity theory. What this outline does offer is an overview of how vast the paradigm of complexity is. An excellent comparison between the paradigm of simplicity and the paradigm of complexity by Horn[81] exemplifies the concept that complexity theory is really a way of thinking. This comparison is displayed in Table 3.

[79] Alhadeff-Jones, 2008
[80] Alhadeff-Jones, 2008, p.71
[81] Horn, J. (2008). Human research and complexity theory. In: Mason, M. (Ed.). (2008). *Complexity theory and the philosophy of education*. Wiley-Blackwell: UK.

Table 3: Comparison of Paradigms of Simplicity and Complexity

Paradigm of Simplicity	Paradigm of Complexity
Adheres to the principle of universality and treats all individual and local phenomena as residual and contingent	Without denying universality, also adopts the complementary principle that the individual and the local are intelligible in themselves
Rejects temporal irreversibility and, in general, the historical	Seeks to bring irreversibly into physics, biology and systems theory so as to give events in these fields a temporal direction
Seeks to reduce wholes to their simple constituents	Integrates elements into their ensembles or complexes
Seeks principles in order within complexes	Looks for self-organization among elements of complexity
Employs linear causality	Searches for principles and causal interrelations
Assumes total determinism and thus excludes chance	Allows for chance in its 'dialogic' of the process order-disorder-interaction-organization
Isolates the object from its environment or context	Places the object back into interaction with its environment or context
Separates subject from object, observer from observed	Puts the observer back into the experimental situation and relocates human subjects into their normal environments
Ultimately eliminates the subject from objective scientific knowledge	Provides for a scientific theory of the subject
Eliminates being and existence through formalization	Pursues a view of self-organization and self-production which enables being and existence to be acknowledged scientifically
Does not recognize autonomy	Considers autonomy in terms of self-organization and self-production
Treats contradiction as error and logic as absolute	Sees logic as limited, and regards contradictions and paradoxes … as indices of a deeper reality
Thinks mono-logically	Thinks dialogically and so relates contrary concepts in a complementary manner

[82]

[82] Horn, 2008, p.132

In the midst of many differing opinions of what complexity is, three schools of complex thought have developed in recent years: reductionistic complexity science, soft complexity science and complexity thinking.[83]

2.3.3 Three Schools of Complex Thought

Much like reductionistic science, the reductionistic model of complexity science tends towards a search for a neatly compiled set of theories that in essence becomes linear. This theory of complexity is likened to the "quest for a theory of everything (TOE) in physics."[84] The demands for this theory are so stringent that very little advancement is possible due to the required set of information that needs to be manipulated in order to advance. While perhaps this stance works well in theory, in a practical philosophy such as osteopathy it does not lend itself to the process of growth that AT Still had started. The perfect knowledge of anatomy and physiology that AT Still demanded from the students of his philosophy of osteopathy when combined with appropriate manual manipulation of the body would theoretically fit into the reductionistic science model, but currently there is not sufficient information and understanding of the anatomy and physiology of the human body to make the philosophy of osteopathy fit into the reductionistic model of complexity science.

The soft complexity science model differs from the reductionistic complexity science model in that it does not search for a 'theory of everything', but using "complexity thought, with its associated language, provides a powerful lens through which to "see" organizations. Concepts such as connectivity, edge of chaos, far from equilibrium, dissipative structures, emergence, epi-static coupling, co-evolving landscapes etc."[85] are all utilized to understand systems and manage the complexity of the situation being studied. Often within this model of complexity science metaphors are used in an attempt to gain an understanding of the situation at hand, but this method reduces the scientific validity because while many of these metaphors fit, they have not necessarily been rigorously validated.[86] Davis & Sumara[87] describe the soft complexity science model "as an interpretive system rather than a route to or representation of

[83] Richardson & Cilliers, 2001
[84] Richardson & Cilliers, 2001, p.5
[85] Richardson & Cilliers, 2001, p.6
[86] Richardson & Cilliers, 2001
[87] Davis, B. & Sumara, D. (2006). *Complexity and education inquiries into learning, teaching, and research.* Routledge: New York.

reality."[88] While osteopathy partially fits into this model of complexity science, especially due to the many metaphors linking both the normal human form and the abnormal found throughout the writings of AT Still,[89,90,91,92] the rigorous validation of these metaphors cannot all be justified. In the following example AT Still uses the metaphor of the steam engine with its mechanic and engineer. When thought of in terms of the human form with its associated mechanical ailments, it seems absolutely perfect. The problem lies in the fact that it is not "scientific".

He is called into this room for the purpose of comparing engines that have been strained from being thrown off the track, or run against other bodies with such force as to bend journals, pipes, break or loosen bolts; or otherwise deranged, so as to render it useless until repaired. To repair signifies to readjust from the abnormal condition in which the machinist finds it, to the condition of the normal engines which stand in the shop of repairs. His inspection would commence by first lining up the wheels with straight journals; then he would naturally be conducted to the boiler, steam chest, shafts, and every part that belongs to a complete engine. To know that they are straight and in place as shown upon the plan and described by the specification, he has done all that is required of a master mechanic. Then it goes into the hands of the engineer, who waters, fires and conducts this artificial being on its journey. You as Osteopathic machinists can go no farther than to adjust the abnormal condition, in which you find the afflicted. Nature will do the rest.[93]

The complexity thinking model "considers the limits of our knowledge in the light of complexity, limits that are often trivialized by contemporary scientific thinking."[94] A realization of the limits of our own knowledge of anatomy, physiology, osteopathic philosophy and manual technique will allow the osteopathic profession to continue to "Dig On" as AT Still would say and approach those limits. David & Sumara[95] stress that complexity thinking "is a new attitude toward studying particular sorts of phenomena that is able to acknowledge the insights of other traditions without trapping itself in absolutes or universals."[96] This ability to offer the insights of other traditions without being trapped is exactly what AT Still did when developing his philosophy of osteopathy. AT Still took the insights he learned in medical school not as an absolute, but an option in his armamentarium of treatment options that he developed under the

[88] Davis & Sumara, 2006, p.18
[89] Still, 1897
[90] Still, 1899
[91] Still 1902
[92] Still, 1910
[93] Still, 1899, p.20-21
[94] Richardson & Cilliers, 2001, p.7
[95] Davis & Sumara, 2006
[96] Davis & Sumara, 2006, p.4

autopsies of his philosophy of osteopathy. He realized and considered the limits of his knowledge of medicine and made a conscious decision to reform that knowledge according to the laws of nature as he saw them. The connection between complexity thinking and the philosophy of osteopathy will be exposed throughout the course of this memoir.

2.3.4 Definition of Complexity

Within the three schools of complexity science, there is naturally a difference of opinion as to the definition of complexity science. Despite the inherent problems in defining complexity theory, various definitions do exist. Morrison[97] defines complexity as "a theory of change, evolution, adaptation and development for survival."[98] Mason[99] describes complexity theory as being "developed principally in the fields of physics, biology, chemistry, and economics…[and]…in some senses out of chaos theory in that it shares chaos theory's focus on the sensitivity of phenomena to initial conditions that may result in unexpected and apparently random subsequent properties and behaviours".[100] Horn[101] writes "the sciences of complexity are concerned with understanding emergent behaviours and behavioural pattern formations that result from interactions of system agents."[102] Morin[103] states that, "at first glance it is a quantitative phenomenon, the extreme quantity of interactions and of interference between a very large number of units."[104] Burton[105] offers not a definition of complexity, but a set of key features that are essential to complex systems. These features are displayed in Box 2.

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[97] Morrison, K. (2008). Educational philosophy and the challenge of complexity theory. In: Mason, M. (Ed.). (2008). *Complexity theory and the philosophy of education*. Wiley-Blackwell: UK.
[98] Morrison, 2008, p.16
[99]Mason, M. (2008). What is complexity theory and what are its implications for educational change? In: Mason, M. (Ed.). (2008). *Complexity theory and the philosophy of education*. Wiley-Blackwell: UK.
[100] Mason, 2008, p.32
[101] Horn, 2008
[102] Horn, 2008, p.126
[103] Morin, E. (2008). *On complexity.* (Postel, R. Transl.). Hampton Press: New Jersey.
[104] Morin, 2008, p.20
[105] Burton, C. (2002). *Introduction to complexity.* In: Sweeney, K. & Griffiths, F. (Eds.). (2002). *Complexity and healthcare an introduction.* Radcliffe Medical Press: Cornwall.

Box 2: Burton's Key Features of Complex Systems

- Complex systems consist of multiple components. Such systems are understood by observing the rich interaction of these components, not simply understanding the system's structure.
- The interaction between components can produce unpredictable behavior.
- Complex systems have a history and are sensitive to initial conditions.
- Complex systems interact with and are influenced by their environment.
- The interactions between elements of the system are non-linear, that is to say that the result of any action depends on the state of the elements at the time as well as the size of the input. Small inputs have large effects and vise versa.
- The interactions generate new properties, called 'emergent behaviours' of the system, which cannot be explained through studying the elements of the system however much detail is known.
- In complex systems such emergent behavior cannot be predicted.
- Complex systems are open systems: when observed, the observer becomes part of the system.

[106]

This table can easily be related to the human form especially for the practicing osteopath.

This list of definitions of complexity is not all-encompassing, but nonetheless identifies certain aspects such as interaction, systems, emergence and discipline boundaries that are indistinct or fuzzy. "The transdisciplinary character of complexity…makes it difficult to provide any sort of hard-and-fast definition of the movement."[107] In working towards a solution to this problem Davis & Sumara[108] suggest that the 'complexity science' be replaced with 'complexity thinking'. As was described above, complexity thinking is consistent with the flowing, often lengthy definitions of osteopathy supplied by the early osteopaths in the profession. This presents solid evidence for why the osteopathic philosophy must be interpreted with a complex way of thinking.

[106] Burton, 2002, p.2
[107] Davis & Sumara, 2006, p.4
[108] Davis & Sumara, 2006

2.4 Why the Osteopathic Philosophy is Complex

It has been shown that there have been many attempts to define osteopathy conclusively. This simply is not possible because to do so would require the system under study (the human body along with its associated mechanical disease states) to be closed. Such a closed system would allow for accounting for all variables; that is to say, there would be a finite number of such. To close this system incorporating all the variables necessary would be to incorporate the entire ecosphere in the least, if not the universe. It must be accepted that osteopathy is not a definitive entity and needs to be considered in terms of a process, or, more accurately, the interaction of many complex processes operating on different hierarchical levels. The starting point of the mechanical disease process is not always known and must be sought by the osteopath, even when dealing with organic causes of disease. In these cases the mechanical component may not be the primary cause of the ailment, but nonetheless mechanical manipulation is not futile; it must be used to adjust the framework to allow for the most efficient work of the body now existing in a diseased state. Only then can there be a free flow of fluids, especially the blood and extracellular matrix of the connective tissues, which will assist in the migration of the all important cells of the immune system.

Also due to the complex nature of the philosophy of osteopathy, there have been developed many different interpretations since its inception. These interpretations have caused "a trend for many current authors to not even attempt to define it, as to encompass all of the potential aspects would make a lengthy and somewhat complicated essay; rather, there is a tendency to state the key principles."[109] Like the attempts to create an objective definition for the osteopathic philosophy, the key principles have evolved and have been subject to various interpretations by the osteopathic community. As compiled by Dowling & Martinke[110] the original four osteopathic precepts developed in Kirksville in 1953 by the osteopathic community representing their collective interpretation of AT Still's original philosophy of osteopathy were:

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[109] Parsons, J. & Marcer, N. (2006). *Osteopathy models for diagnosis, treatment and practice.* Elsevier Churchill Livingstone: China, p.5

[110] Dowling, D. J. & Martinke, D. J. (2005). The philosophy of osteopathic medicine. In: DiGiovanna, E. L., Schiowitz, S. & Dowling, D. J. (2005). *An osteopathic approach to diagnosis and treatment (3rd Ed.)* Lippincott Williams & Wilkins: USA.

- The body is a unit
- Structure and function are interrelated
- The body possesses self-regulatory mechanisms
- The body has the inherent capacity to defend and repair itself

with an addition of the following in 1981 as elaborated by Sprafka, Ward and Neff and reported by Dowling & Martinke[111] :

- When normal adaptability is disrupted, or when environmental changes overcome the body's capacity for self-maintenance, disease may ensue
- Rational treatment is based on the previous principles

As with the evolution of any process other precepts of the osteopathic philosophy have emerged throughout the years. Dowling & Martinke[112] also add:

- Movements of body fluids is essential to the maintenance of health
- The nervous system plays a crucial part in controlling the body
- There are somatic components to disease that not only are manifestations of disease but also are factors that contribute to maintenance of the diseased state

It is arbitrary to pick any of these precepts as they are not by themselves osteopathy, but guiding ideas that have each been adapted with a complex way of thinking, consciously or unconsciously. The first four precepts are the most widely known throughout the osteopathic community and their familiarity offers a good place to start when introducing the various aspects of the osteopathic philosophy. Perhaps this is due simply to their length on the page. It becomes more tedious to attempt to memorize each of these increasingly lengthy precepts. What must be cautioned is that the list of osteopathic precepts can be extended to great lengths with the rewards reaped from each succession becoming less and less each time as they start to become redundant or even confusing. The principle of *Occam's razor* applies to the osteopathic philosophy just as equally as does any osteopathic diagnostic test or manipulation.

[111] Dowling & Martinke, 2005
[112] Dowling & Martinke, 2005

As each of these precepts are not closed, this memoir will use a modified version of the original 1953 precepts:

- The body is a dynamic open physical system
- Structure and function are irreparably linked
- The rule of supply and demand dictates
- Let Nature make well

In lieu of a linear progression of discussion for each of these precepts followed by the pertinent details of the basic sciences regarding the peritoneal viscera, leading into a tidy model of treatment of that those viscera, a more complex direction will be taken. It is hoped that this will facilitate both the discussion of the basic sciences while setting a stage for the emergence of, not a model of treatment *per se*, but the ability to create such a model each time you place your hands on a patient. This level of treatment, based on emergence, combined with an intimate knowledge of anatomy satisfies both the requirements of respecting the philosophy of AT Still as well as those of complexity thinking.

Chapter 3: Embryology

3.1 Why the Study of Embryology is Complex

"Once we see the relationship between structure and behavior, we can begin to understand how systems work, what makes them produce poor results, and how to shift them into better behavior patterns."[113] This relationship is not easily seen in terms of the complexity of both the anatomical (biomechanical; structural) and physiological (biochemical; functional) systems of the human body when it has achieved an adult form; or for that matter, its less fully developed prenatal form. The most superficial relationships seen are that of the derivatives of the various intraembryonic –derms: ecto-, meso- and endo-. To state that the mucosa of the small intestine is of endodermal ancestry does little more than that. It does not offer any assistance in the 'how' those cells either arrived there or became mucosal tissue. A seemingly short and tidy table such as one depicting the derivatives of the various -derms does little in offering insight into the amount of scientific endeavour previously undertaken to produce such a chart. To study and comprehend the complexity of each of the interactions producing the adult form of the human body in its entirety would require much more information than currently available in the scientific literature. For this reason, the less complex aspects of the anatomical (biomechanical; structural) and physiological (biochemical; functional) interactions must be employed in an attempt to understand the ontogeny of the human form in terms of anatomy, biomechanics and physiology; namely, the tools of the osteopathic philosophy used when applying osteopathic manipulation. Fortunately a less complex example, in terms of obvious interactions, can be seen in the earlier stages of embryonic development.

3.2 Embryologic Processes Applied to the Osteopathic Philosophy

Various authors state that during osteopathic palpation of the visceral organs the intrinsic movements perceived by the osteopath are the reverberations of the ontogenetic movement of the tissues that still resides in them driving their intrinsic biomechanical movements to and fro.[114,115,116,117] As palpation is the cornerstone of the osteopathic treatment it becomes obvious that the origins of these movements should be investigated. Since all three germ layers originate

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[113] Meadows, D. H. (2008). *Thinking in systems a primer.* Wright, D (Ed.). Chelsea Green Publishing: Vermont, p.1
[114] Barral, J. & Mercier, P. (2005). *Visceral manipulation revised edition.* Eastland Press: Seattle.
[115] Stone, C. A. (2007). *Visceral and obstetric osteopathy.* Churchill Livingstone Elsevier: New York.
[116] Helsmoortel, J., Hirth, T. & Wührl, P. (2010). *Visceral osteopathy the peritoneal organs.* (MacKenzie, R. Transl.) Eastland Press: Seattle.
[117] Hebgen, E. U. (2011). *Visceral manipulation in* osteopathy. (Wilms, S., Transl.). Thieme: New York.

initially from the more primitive epiblast[118] it offers an excellent starting point to examine the complex interactions of human ontogeny. This discussion will consequently begin at Carnegie Stage 5 of development to initiate more refined details of the embryology of the peritoneal viscera in relation to osteopathic treatment. It should be noted here that the intention of this section is not to supply a full working knowledge of the embryology of the human peritoneal viscera, but to undisputedly show that the mechanisms are *complex* and require *complexity thinking* in order to utilize the knowledge to its greatest potential. The first four stages of development will for the purpose of this argument be dismissed as superfluous in the temporal relation of osteopathic treatment; superfluous, not unimportant.

Caution must be raised regarding any attempt at comprehending the complexity of the interactions necessary for even such a relatively simple task: following cell lineages throughout development from their origin to the present form. Much of the information required to describe these developmental relations is not currently understood. Regarding the motility of the digestive system Ruckebusch[119] describes the rationale for using the lamb gut in studies of human gastrointestinal development. He states that “the patterns of volume change of amniotic fluid, the morphological maturation of the intestinal tube, and the ultrastructure of the epithelium are almost identical in the two species.”[120] Unfortunately a sheep is not a human; a human, not a sheep. Obvious ethical limitations are placed when dealing with manipulating human physiology during experimentation. It will take many more years of scientific study to obtain the level of knowledge needed for the application of therapeutic agents that is desired by all.

As there are an abundance of good embryology texts available, it seems counterproductive to simply cut and paste their work *en masse*. As such, this discussion will be limited to information pertaining largely to the application of osteopathic therapeutics, or in relation to palpation and treatment of the patient. The reader is referred to the embryology texts listed in the reference list if the finer details are desired or elaboration needed.

[118] Sadler, T. W. (2006). *Langman’s medical embryology (10th Ed.).* Lippincott Williams & Wilkins: Philadelphia.
[119] Ruckebusch, Y. (1989). Motility of the gut during development. In: Lebenthal, E. (Ed.). (1989). *Human gastrointestinal development.* Raven Press: New York.
[120] Ruckebusch, 1989, p.184

3.3 Details Pertaining to Carnegie Stages 5 – 8

During Stage 5 the inner cell mass has differentiated into epiblast and hypoblast while the adnexa continue to solidify their relationship with the maternal tissues.[121] Definitive lacunae can be observed in the trophoblast[122] marking another step towards the nutrient stability of the embryo; namely, the uteroplacental circulation. During stage 6 the secondary umbilical vesicle is formed and the "entire amnio-embryonic region is attached to the chorion by a bridge of extraembryonic mesenchyme termed the connecting stalk.[123] At this time the embryonic disc has interacted both with itself and its surroundings such that the bilayer disc is stable enough for a third layer of hierarchical complexity to emerge. This third layer is represented by the appearance of migratory tissues arising from epithelial-mesenchymal transformation (EMT) and is termed the intraembryonic mesoderm (mesoblast). "The first and most important EMT in the embryo of the higher vertebrate produces the mesenchyme that condenses to form definitive mesoderm (middle layer of the embryo) and endoderm (inner layer)".[124] This type of transition also occurs in the opposite direction: the mesenchymal-epithelial transition[125] demonstrating the complexity of embryonic cell interactions. Until this point the various cell lineages can be traced from the initial one cell conceptus to the bilaminar embryonic disc and moving forward to that of the trilaminar disc.

A superficial list of the five genetic signaling pathways of EMT present in early embryonic development consists of the Wnt pathway, the TGFβ, the Hedgehog family, receptor tyrosine kinase (RTK) pathway and the Notch pathway.[126] With an understanding of each of their dynamics and an ability to manipulate them, the level of understanding of this aspect of early embryology will evolve tremendously, along with it the capabilities of allopathic medicine. It would essentially reach what is desired in the reductionistic model of complexity science. This however is not currently possible within allopathic medicine and is outside the scope of practice for osteopathic manual treatment. If however, the therapeutic measures of osteopathic palpation

[121] O'Rahilly, R. & Müller, F. (2001). *Human embryology & teratology (3rd Ed.).* Wiley-Liss: USA.
[122] O'Rahilly, R. & Müller, F. (1987). *Developmental stages in human embryos.* Carnegie Institution of Washington: USA.
[123] O'Rahilly & Müller, 2001, p.46
[124] Hay, E. D. (2005). The mesenchymal cell, its role in the embryo, and the remarkable signaling mechanisms that create it. *Developmental Dynamics, 233, p.706-720,* p.711
[125] Hay, 2005
[126] Hay, 2005

and treatment are to be based on solid embryologic grounds, another hypothesis must be utilized; not in place of the genetic, but both in lieu and concurrently with it. The work of Blechschmidt[127] lays stress on the holistic biomechanical accompaniment to the genetic pathways currently being studied and serves such a means. While he does not negate the genetic control of early tissue differentiation, he relies on observations of those developing tissues and combines those observations with concepts of metabolic fields having a significant biomechanical role in the formation of the tissues. Blechschmidt[128] relies heavily on the observations and reconstructions of a massive amount of embryonic and fetal material inferring many reasonable forces that could/would/do work in the ontogeny of the human form.

In relation to the development of the primitive streak Blechschmidt[129] points out that as the proliferating ectoderm of the expansion dome grows over the impansion pit [Henson's knot] a finger-like invagination, the axial process [notochordal process], develops. The axial process itself is a point of slow intrinsic growth rate, but is elongated by the influence of the expansion dome continuously rolling over the impansion pit.[130] Osteopathically, it is important as "the apex of the axial process provides a natural reference for interpreting all subsequent biomechanical movements and the action of biodynamic forces."[131] These forces, according to Blechschmidt,[132] act both in the formation of the intraembryonic mesoderm as well as the future notochord. With the notochord being the basis of the axial skeleton[133] and the mesoderm being the basis for much of the connective tissues of adult anatomy, it is understandable why biodynamic osteopathic treatment is successful in many cases, despite its lack of "scientific" basis.

While some osteopaths utilize a biodynamic approach to treatment, it is not exclusive amongst all working osteopaths. Gracovetsky[134] has shown that the spinal column and its ability to change lateral sidebending into a torsional propulsive movement is the basis for the biomechanics of the spine as a propulsive unit. Since it is the notochord that will develop into an

[127] Blechschmidt, E. (2004). *The ontogenetic basis of human anatomy. a biodynamic approach to development from conception to birth*. Freeman, B. (Ed. and Transl.). North Atlantic Books: California.
[128] Blechschmidt, 2004
[129] Blechschmidt, 2004
[130] Blechschmidt, 2004
[131] Blechschmidt, 2004, p.41
[132] Blechschmidt, 2004
[133] Sadler, 2006
[134] Gracovetsky, S. (2008). *The spinal engine updated version.* Published by the author: St Lambert.

integral part of the intervertebral disc, which assists in allowing these movements of the spine, a common meeting place of the biodynamic and mechanically based osteopaths arises: it is necessary to understand the biodynamic formation of the notochord, but also the biomechanical consequences seen in the postnatal form.

A purely biomechanical explanation of the ontogeny of the human form would; however, be just as false as a purely genetic one. Hay[135] describes movement of mesenchymal cells after undergoing an EMT, offering a dynamic physiologic explanation of this type of cellular movement that must be combined with the biomechanical explanations of Blechschmidt.[136]

> A probable method of locomotion is that the myosin endoplasm…slides forward along the actin-rich cortex…, which is attached by integrins to the adjacent ECM. For forward motion to be achieved… the renewing cell cortex apparently becomes fixed to ECM…because parts of it are always left behind with cytoplasm attached to ECM.[137]

Thankfully these questions can be left to the embryologists for definitive answers that will take many years to solve. Presently, the combined biomechanical and genetic hypotheses offers the practicing osteopath enough information to justify palpation and subsequent treatment of dysfunction with decision making processes based on embryologic links.

Cycling back and in summary, it can be seen that Stages 5 – 8 sees the progressive emergence of the prechordal plate, primitive streak, notochordal [axial] process and primitive pit. Once again the stage has been set for the emergence of yet another hierarchical layer of complex physical form: the somites.

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[135] Hay, 2005
[136] Blechschmidt, 2004
[137] Hay, 2005, p.708

3.4.0 Details Within Carnegie Stages 9 – 15

3.4.1 General Remarks

"After gastrulation, the cells of the embryo contribute to two fundamental types of tissues, namely epithelial and mesenchymal. Differentiation of specialized circulating blood cells and other cell types occurs in sequence."[138] Also very important at this stage is the presence of the extracellular matrix in which the migrating cells utilize to achieve their desired morphology and position. As these changes are also non-linear and dynamic, their interactions become increasingly difficult to appreciate. It is necessary to visualize multiple populations of cells and developing tissues all in relation to each of the other tissues.

These relations can be separated, in no particular order: biomechanical, physiological, chemical. Biomechanical relations deal primarily with the global movements of the embryo – caused by spatial constraints, physiologic processes and ultimately chemical changes. Physiologic relations can also be considered as linked manifestations of biomechanics and chemistry; just as chemical relations can be considered linked manifestations of the biomechanical and physiologic processes that are underway at any point of development. Essentially this concept of interaction and interdependence may have been what lead AT Still to his "structure governs function" idea in the osteopathic philosophy, which then evolved and emerged as the 'structure and function are interrelated' precept of current osteopathic literature. Perhaps AT Still's idea came, not while reading an embryology text, but through experience with Nature in its more global biological sense; nonetheless, it remains a valid point.

Despite the complexity of physical interactions operating at this point, it becomes increasingly obvious that the governance of the internal fluids must be established if all of the cells are to be nourished and continue to proliferate. This is in definite accord with the osteopathic precept 'the rule of supply and demand dictates'. The elaboration on the development of the cardiovascular system during Stages 9 – 15 will follow in section 3.4.3.

[138] Standring, S. (Ed.). (2005). *Gray's anatomy the anatomical basis of clinical practice (39th ed.).* Spain: Elsevier Churchill Livingstone, p.201

The epithelial cells at this stage of development have many of the same morphologic characteristics of differentiated cells.[139] They exist "as simple or compound cellular sheets that separate phases of differing composition."[140] These sheets of tissues assist in making possible the biomechanical, chemical and physiological interactions of embryonic tissues by governing the passage of material through the sheet. The interchange of materials across the sheets of epithelial tissues is dependent upon "their limiting membranes, which function as energy-dependent selective barriers, enhance the passage of some materials and impede the passage of others."[141] Not all epithelial sheets at this stage are the same thickness. This creates a possibility for certain sheets to offer more of a global biomechanical resistance than others. Blechschmidt[142] notes the difference between thin and thick epithelial sheets with the former acting as a true diathelium for the free permeation of fluids, and the latter largely responsible for creating a restricting force for the explosive growth of the relational mesenchyme.

"Mesenchymal populations are formed from a range of germinal epithelia and by proliferation of mesenchymal cells directly."[143] Mesenchymal cells play a key role in the development of the intraembryonic tissues. They function as a cellular support network for epithelia both locally by contributing to the basement membrane and forming the lamina propria, and globally by differentiating into connective tissues.[144] In harmony with the philosophy of osteopathy, the mesenchymal tissues and their derivatives are of utmost importance: one of their functions is to form the smooth muscle of the various tissue tubes of the body.[145] Without them, 'the rule of supply and demand dictates' would not exist as the formation of the tubes of the cardiovascular system could not arise. This link must be constantly remembered if osteopathic therapeutics are to be based on an understanding of how the fluid transmitting pathways of the body are formed. Those tissues responsible for the support and formation of these pathways may take priority in treatment.

The extracellular matrix at this stage must not be ignored as the dynamics of tissue migration and differentiation is dependent on interaction with it. This is demonstrated by the fact

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[139] Standring, 2005
[140] Standring, 2005, p.201
[141] Standring, 2005, p.201
[142] Blechschmidt, 2004
[143] Standring, 2005, p.202
[144] Standring, 2005
[145] Standring, 2005

that both the epithelial and mesenchymal tissues produce the molecules of the extracellular matrix as well as their receptors.[146] Without wandering into the more refined details of the physiology of the extracellular matrix, its importance can be summarized as follows: “epithelial and mesenchymal cell populations can structure the space around them by secretion of particular matrix molecules or growth factors, which in turn can organize the cells that contact them.”[147] This self-organization is yet another piece of evidence for the complexity of the embryonic processes.

Much work has been undertaken to untangle the mystery of which populations of cells are permissive, inductive, or both. Intraspecies heterotopic tissue recombinations have shown that “the occurrence of *de novo* synthesis of sucrase in conformity with enterocytic ultrastructural characteristics assessed either biochemically or immunohistochemically strongly suggested that intestinal mesenchyme can control the differentiation process of stomach endoderm at the genomic level.”[148] When looking at the endodermal-induced morphogenesis of mesenchyme it is interesting to see that "although the mesenchyme supports epithelial differentiation, its own differentiation requires an induction from the endoderm."[149] The complex nature of these interactions is well beyond the scope of this work. The important point to move forward osteopathically is the evidence at least in the stomach of “the importance of stromal organization in maintaining epithelial differentiation in the glandular stomach and that the glandular stomach may not be strictly determined even in adulthood.”[150] This seems to represent viable grounds for the claim that the osteopathic normalization of both the mobility and motility of the gastrointestinal system can at the very least indirectly have a positive influence on the continuous turnover of cellular material that constitutes the life cycle of the tissues. With this normalization the cellular constituents of the organ tissue may enhance their vitality and drive towards normalcy in accordance with the precept ‘let Nature make well’.

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[146] Standring, 2005
[147] Standring, 2005, p.203
[148] Haffen, K., Kedinger, M. & Simon-Assmann, P. M. (1989). Cell contact dependent regulation of enterocytic differentiation. . In: Lebenthal, E. (Ed.). (1989). *Human gastrointestinal development.* Raven Press: New York, p.21
[149] Haffen, Kedinger & Simon-Assmann, 1989, p.25
[150] Haffen, Kedinger & Simon-Assmann, 1989

3.4.2 Somites and the Associated Body Wall

Stage 9 is defined by the development of 1 – 3 pairs of somites and can now be considered the 'embryo proper', Stage 10 shows 4 – 12 pairs of somites, Stage 11 shows 13 – 20 pairs, Stage 12 is marked by 21 – 29 pairs of somites, and finally Stage 13 contains more than 30 pairs which then lose their efficiency as an external marker for development.[151] The approximate age range for Stages 9 – 15 are 25 to 56 days.[152] With the stepwise fashion of somitic development so grows the intraembryonic coelom which occurs definitively as of Stage 10. Some traces can be seen of what is to become the pericardial cavity in Stage 8, but it is a definite finding in Stage 9, although still underdeveloped.[153] By Stage 10 the walls of the body have "grown laterally and ventrally and enclosed a major portion of the pericardium and heart"[154] See figure 1.

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[151] O'Rahilly & Müller, 1987
[152] O'Rahilly & Müller, 2001
[153] O'Rahilly & Müller, 1987
[154] Severn, C. B. (1971). A morphological study of the development of the human liver. I. development of the hepatic diverticulum. *American Journal of Anatomy, 131, p.133-158*, p.136

Figure 1: Development of the Coelom

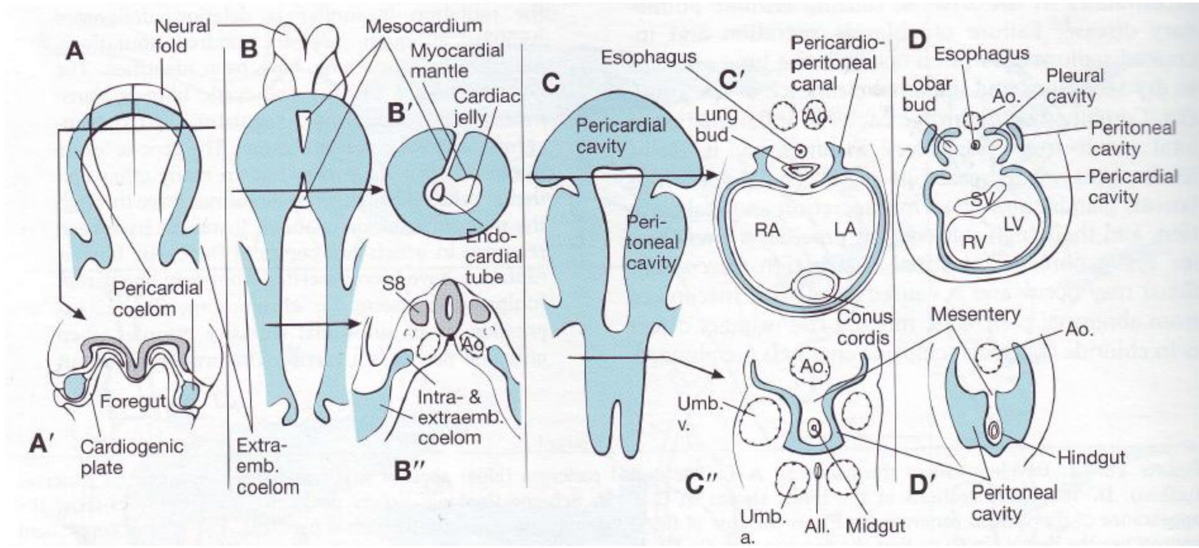


FIGURE 13-47. Development of the coelom. **A.** Dorsal view of semitransparent embryo at 3½ weeks[9], showing horseshoe-shaped pericardial coelom. **A′**. Cross section indicating the cardiogenic plate ventrally. **B.** Two days later[10], the pericardial cavity is more extensive and the dorsal mesocardium is evident. In **B′** the layers of the heart can be seen: endocardial tube, cardiac jelly, and myocardial mantel. In **B″** (through somite pair 8) the communication between the intra- and the extra-embryonic coelom is visible. **C.** At 4½ weeks[13], showing further enlargement of the coelom. **C′** is a section through the pericardioperitoneal canals. **C″** shows the midgut and its mesentery projecting into the peritoneal cavity. **D.** At 5 weeks[16], showing the three components of the coelom: pericardial, pleural, and peritoneal. **D′** is through the hindgut and its mesentery. All., allantoic diverticulum; Ao., aorta; RA and LA, RV and LV, right and left atria and ventricles; S8, somite 8; Umb. a. and v., umbilical artery and vein.
[155]

The primitive streak of Stage 10 is only located caudally and will soon disappear altogether. The notochordal plate is starting to become the notochord as it separates from the endodermal lining, only to finish its caudo-rostral development in Stage 11.[156]

With further development of the intraembryonic coelom within the lateral plate mesoderm there is an open connection with the extraembryonic coelom. See figure 1. The rostro-caudal organization of the mesoderm and development of the intraembryonic coelom ensures an open connection between the intra- and extra-coelomic cavities. "In this manner an advantageous arrangement is provided by which the more deeply lying mesoblastic parts of the embryo can be freely reached by coelomic fluid, which at this time is the sole source of nutriment."[157] It will become apparent in the next section that this rudimentary circulation will be superseded by the cardiovascular system proper. Before that superseding completely takes

[155] O'Rahilly & Müller, 2001, p.272
[156] O'Rahilly & Müller, 1987
[157] O'Rahilly & Müller, 1987, p.109

place, the first beating movements of the growing heart actually facilitates the flow of fluid through the coelomic passageways.[158] This is an excellent example of fuzzy boundaries between two subsystems within one greater complex system: the developing heart has its fate set on propelling blood through the blood vascular system, but prior to the development of this new layer of complexity, it is still a working system necessary for the nutritive needs of the embryo which is striving towards the emergence of its mature form. The growing embryo is preparing to take on the complexity of managing its own resources with even less aid from its immediate external environment which is quickly becoming far too restricted to meet all of its needs.

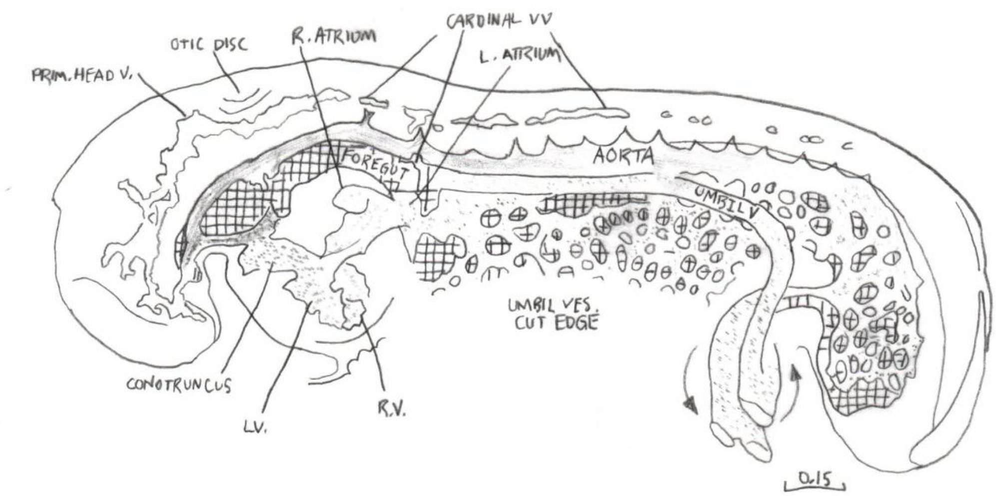
3.4.3 Cardiovascular System

The pericardial cavity is horseshoe shaped during Stage 9 and the cardiogenic plate of Mollier is seen in its ventral splanchnic wall.[159] Stages 9, 10 and 11 generally, but not exactly, correspond to the plexiform phase of the heart, the straight tubular and looped configurations respectively. Blood vessels can be seen forming in the chorion, connecting stalk, umbilical vesicle, amnion as well as the embryo proper.[160] "A transient capillary plexus usually forms prior to the appearance of each major blood vessel…the vascular pattern depends on the local environment rather than on the endothelium, and hemodynamic factors are of major importance."[161] This environmental influence is another piece of evidence of the open complex system which is the developing embryo.

Although the circulation of the nutritive fluids during Stage 11 does not resemble those of the adult form they offer yet another example of hierarchical complex processes at work in the formation of the embryo. The endothelial vessels and plexuses are well represented in figure 2.

[158] O'Rahilly & Müller, 1987
[159] O'Rahilly & Müller, 1987
[160] O'Rahilly & Müller, 1987
[161] O'Rahilly & Müller, 2001, p.206

Figure 2: Ebb-and-flow Circulation of 14 Somite Embryo



[162]

Only in the cardiac region are they differentiated.[163] The fuzzy transition between the system of primitive circulation, that of the coelomic fluid, and the more advanced blood vascular system, that of the endothelial vessels, is seen to start delaminating at Stage 10, moving into Stage 11. The circulation will not become a closed system (in the relative sense) until Stage 12. With the primordium of the myocardium simply being a specialization of the coelomic wall and bathed with coelomic fluid; its beating helps to mix both the fluid within the endothelial tubes as well as the coelomic fluid.[164] The blood-vascular system and coelomic circulations contain basically the same fluid at this time. With further development of the embryo and subsequently the capillary beds with their respective afferent and efferent vessels, the blood vascular system will specialize away from the ebb-and-flow state to fulfill the needs of the embryo.

As stated: "the coelom provides only an elementary type of circulation. It is certainly an improvement on the tissue-culture mechanisms of the prosomatic period, but it will not prove adequate for the larger and more elaborate organism that is to follow."[165] The developing cardiovascular system during Stage 12 is an excellent display of the osteopathic dictum 'the rule of supply and demand dictates'. Up until this point the coelomic fluid has provided even the deeper placed mesoblastic tissues. During the initial stages of development the central nervous

[162] Redrawn and slightly modified from O'Rahilly & Müller, 1987, p.115
[163] O'Rahilly & Müller, 1987
[164] O'Rahilly & Müller, 1987
[165] O'Rahilly & Müller, 1987, p.124

system was adequately supplied by the amniotic fluid especially when it was in its plate, groove, and open tubular phases. With the closure of the rostral neuropore in Stage 11 and its caudal counterpart in Stage 12, the nutritive demands of the massive central nervous system cannot be met without a more elaborate supply. The supply for this demand comes from the blood vascular system. Interestingly there is a correlation between the initial fusion of the neural grooves during Stage 10 and the sprouting of endothelial vessels dorsally from the aortae towards the growing neural tissue during that same Stage.[166] The

> principle items in vascular specialization found at this stage [Stage 12] would include: (1) changes at the venous end of the heart, (2) vascularization of the central nervous system, (3) establishment of the cardinal venous drainage, (4) the hepatic plexus, and (5) alterations in the vitelline plexus resulting in main trunks, representing vitelline arteries and veins.[167]

By Stage 13 the blood circulation is well established, especially the supply system to the central nervous system, while that to the mesoderm that will become the walls of the lungs and intestines only contains numerous small arteries.[168] The driving caudal force from the caudal bud is directly influencing the formation of the venous plexuses of that part of the embryo.[169] A major milestone of the circulatory system occurs during Stage 13: with the umbilical arteries stemming out of the caudal vascular plexus to connect with the chorionic plexus via the connecting stalk, blood cells are starting to be seen within this connection and "the structural basis is now established for interchange between the maternal blood of the intervillous space and the embryonic blood in the capillaries of the villi."[170] The embryo has been working on this task since at least Stage 5 with the initial appearance of the trophoblastic lacunae.

Venous (oxygenated) blood flowing in the opposite direction through the connecting stock courses in the umbilical vein.[171] Emptying into the sinus venosus of the developing heart at this time are the cardinal system of veins from the axis of the embryo; the umbilical veins

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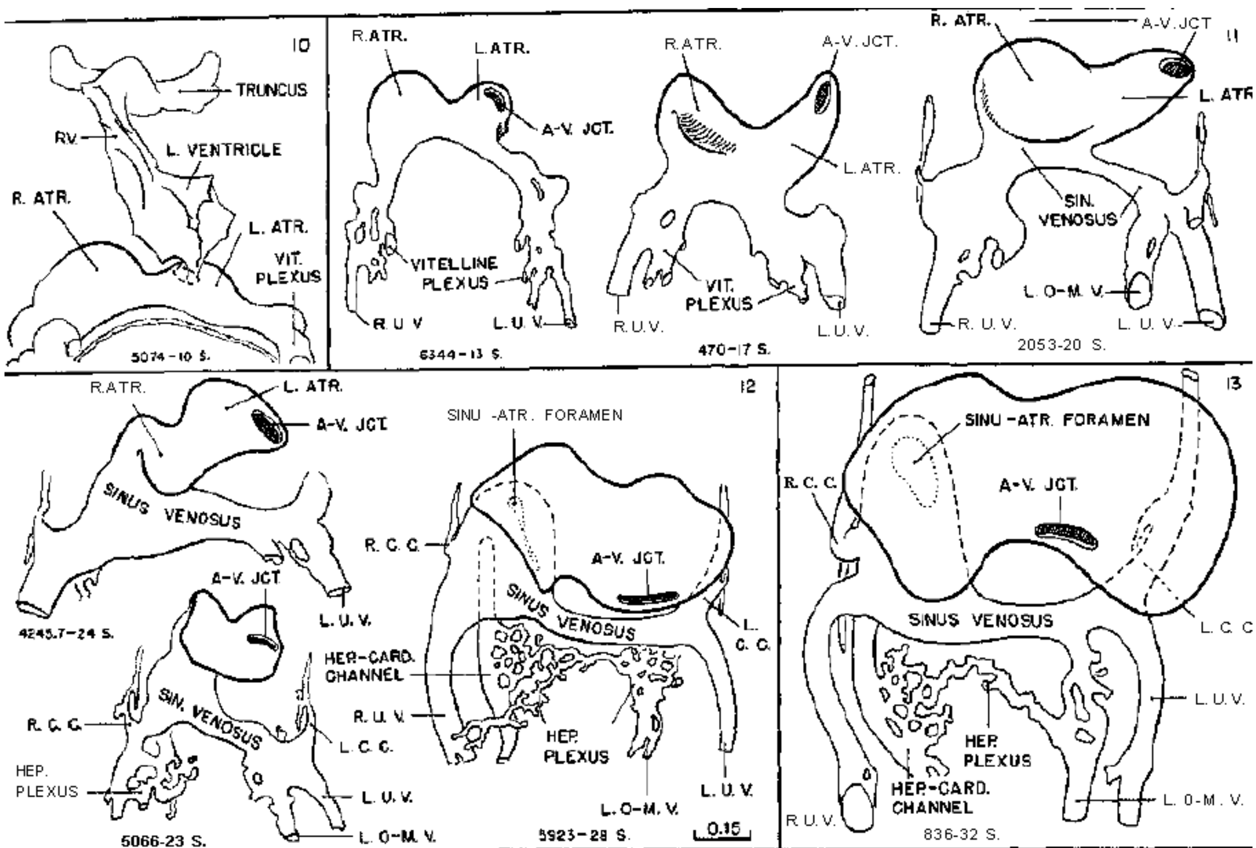
[166] O'Rahilly & Müller, 1987
[167] O'Rahilly & Müller, 1987, p.128
[168] O'Rahilly & Müller, 1987
[169] O'Rahilly & Müller, 1987
[170] O'Rahilly & Müller, 1987, p.143
[171] O'Rahilly & Müller, 1987

from the chorionic villi; and the hepatic system with its bilaterally placed hepatocardiac veins.[172] The development of the venous end of the heart in Stages 10 – 13 is displayed in figure 3.

Figure 3: Venous End of the Heart in Stages 10 – 13



[173]

The hepatic system at this time and moving forward to Stage 15 calls for further attention, but will be discussed in the following section, that of the digestive system. This division is arbitrary.

The major organ of interest in this section will be that of the heart. Extensive details will not be entertained other than those associated generally with the separation of the two sides of the heart which has an obvious profound impact upon the adult anatomy and physiology. By Stage 13 the arrangement of the heart moves from "in series" to "in parallel" such that the left ventricular output will go to the fourth aortic arch on the left while the right ventricular output

[172] O'Rahilly & Müller, 1987
[173] O'Rahilly & Müller, 1987, p.130

will flow to the sixth arch on the left (the ductus arteriosus).[174] The finer adjustments of the internal structure of the heart such as atrial and ventricular septation as well as the development of the major valves is not appropriate for this discussion and will therefore be omitted other than to state that by Stage 18 "the heart is now a composite, four-chambered organ with separation of the pulmonary and aortic blood streams."[175] What should be noted here is the irreparable linkage of structure and function being well displayed in the development of the "in parallel" circulation. Another level of complexity is starting to emerge; that of the air breathing infant after birth. Without the functional separation of the blood vascular stream many months before parturition it would not be possible to divert blood efficiently to the lungs for respiration, and subsequently for life to take place.

3.4.4.0 Digestive System

3.4.4.1 General Remarks

Concurrently with the development of the intraembryonic coelom and cardiovascular systems is of course the digestive system. The entire foregut primordium is represented at this Stage as a thickened plate of endoderm lying rostral to the axis of the body,[176] and depends on the process of the head fold to find its permanent location. The caudal most part of this initial primordium will shift dorsal to the heart after the head fold and once there will represent the tubular part of the foregut spanning the stomodeum to the level of the anterior intestinal portal.[177] The pharyngeal apparatus are developed between Stage 9 and 13[178] and for the purposes of this discussion will be omitted. That is not to take from their formative powers within the embryo as a whole as they are intimately associated with the development of the gastrointestinal tract, but they are outside the scope of this work.

Stage 12 sees a marked increase in the differentiation of the alimentary epithelium and definitive epithelia; fields are recognizable for the liver, gallbladder, lung, stomach and dorsal pancreas.[179] The ventral pancreas may be visualized as early as Stage 13[180] as an evagination

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[174] O'Rahilly & Müller, 2001
[175] O'Rahilly & Müller, 1987, p.226
[176] Severn, 1971
[177] Severn, 1971
[178] O'Rahilly & Müller, 2001
[179] O'Rahilly & Müller, 1987

from the bile duct proceeding through Stages 14 and 15;[181] both the dorsal and ventral pancreas will have fused by Stage 17.[182] The vascular changes within the liver merit the greatest attention to detail as they have a direct relationship with ‘the rule of supply and demand dictates’ precept of the osteopathic philosophy.

3.4.4.2.0 The Liver and Gallbladder

3.4.4.2.1 General Remarks

Late in Stage 11 the hepatic diverticulum has taken on a ‘T’ shape as well illustrated in figure 4.

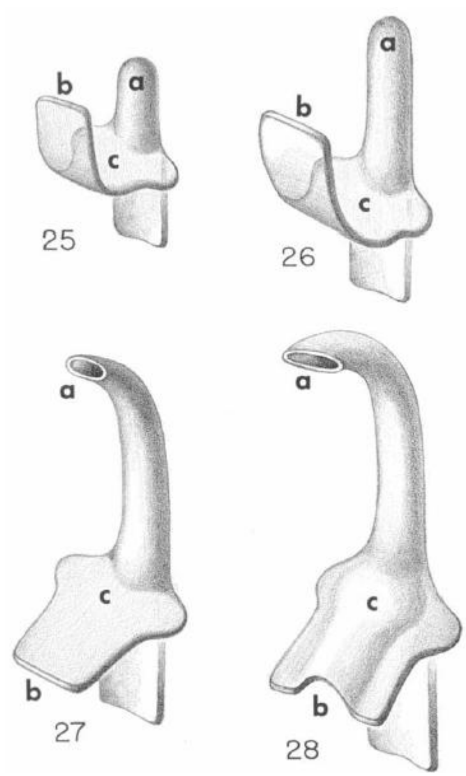

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Figure 4: Development of the Hepatic Diverticulum

Starting in the upper left corner, moving clockwise are seen cartoon illustrations of the development of the hepatic diverticulum. The first illustration represents the 5 somite embryo; the second an 8 somite embryo; the third a 13 somite embryo; the fourth illustration represents a 16 somite embryo

a = Stomodeal area of tubular foregut

b = Leading edge of thickened endoderm where continuous with one-cell layered yolk sac

c = Zone of contact between endoderm and caudal endothelial lining of heart

The invasion by the parenchymal cords of the liver in Stage 12 through 14 is explosive, and during Stages 14 and 15 the cystic duct-gallbladder primordium becomes elongated as does the common bile duct.[184]

[180] O’Rahilly, R. (1978). The timing and sequence of events in the development of the human digestive system and associated structures during the embryonic period proper. *Anatomy and Embryology, 153, p.123-136.*
[181] O’Rahilly & Müller, 1987
[182] O’Rahilly & Müller, 1978
[183] Severn, 1971, p.156

An important link between the liver and coelomic wall is also seen in Stage 11. While some accounts of the development of the liver refer only to the invasion of the hepatic diverticulum into the septum transversum, there is also part of the coelom that "is actively giving off cells that form a condensed mass constituting the early mesoblastic framework of the liver."[185] The mesenchyme from the wall of the coelom will assist in the formation of the stroma of the liver. An interesting arrangement is observed: the delicate hepatic epithelial cells are supported by a system of connective tissue derived from the body wall and therefore intimately associated with it biomechanically. In the adult form then, it seems reasonable to assume that the connective tissue of the soma, being influenced by the abdominal musculature, can and does create both a biodynamic and biomechanical link to the parenchyma of the liver. As was seen with the stomach there is an important epithelial/mesenchymal interaction in the development of the liver which is indicated by their stromal/parenchymal arrangement. This connection cannot be forgotten in both the mechanical manipulation of any viscera as well as biodynamic treatment of the intrinsic autonomy or vitality of the same.

3.4.4.2.2 The Venous Systems

The fuzzy boundary between the development of the cardiovascular system, more specifically the heart, and the liver is exemplified starting around Stage 10 and moving forward with the shifting of the venous end of the heart to the right and evolution of the venous systems of the liver. The appearance of the ductus venosus can be seen starting as a midline vascular channel extending from the sinus venosus to the transverse portal fissure in the Stage 12.[186] Moving into Stage 13 the sinus venosus is the terminal confluence of the cardiovascular system.[187] It is also in very close relation to the hepatocardiac veins which, due to their permeable nature, assist in the passage of coelomic fluid into the large venous channels helping to load the system.[188] See figure 5.

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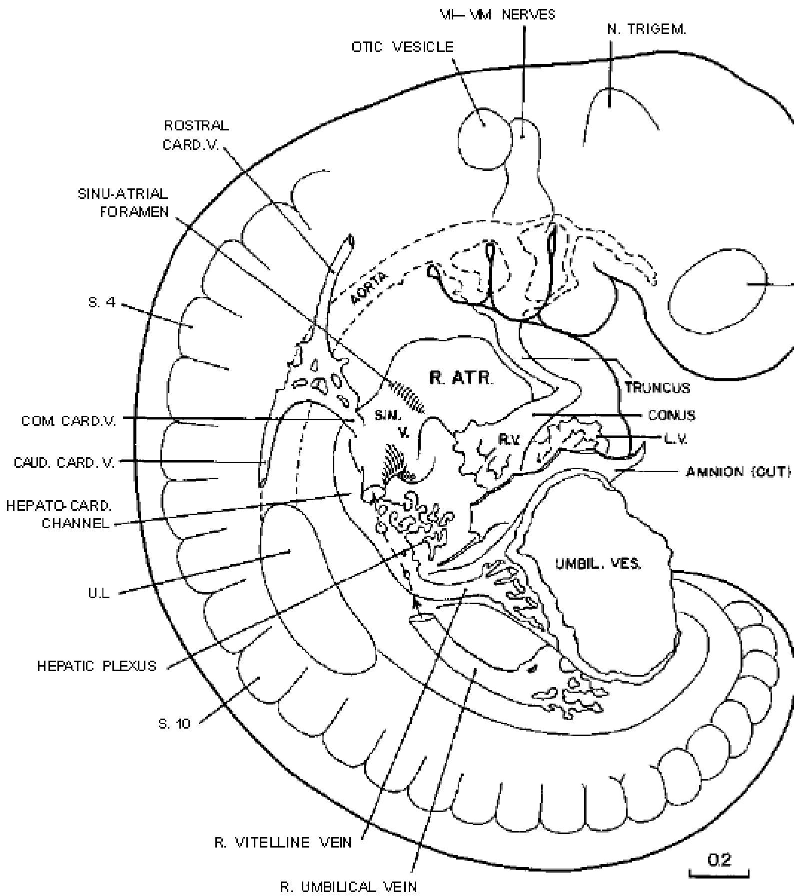
[184] Severn, C. B. (1972). A morphological study of the development of the human liver. II. establishment of liver parenchyma, extrahepatic ducts and associated venous channels. *American Journal of Anatomy, 133, p.85-107.*
[185] O'Rahilly & Müller, 1987, p.110
[186] Severn, 1972
[187] O'Rahilly & Müller, 1987
[188] O'Rahilly & Müller, 1987

Figure 5: Permeability of Hepatocardiac Channels



Reconstruction of 28 somite embryo showing relationship of hepatocardiac channels, sinus venosus and right atrium. The coelomic wall over the rostral part of the hepatocardiac channel is modified to permit coelomic fluid to enter the developing cardiovascular system [189]

The sinus venosus is the central meeting place of all of the major venous channels of the embryo: the cardinal, umbilical and omphalomesentric (vitelline). Moving to the adult form we see the cardinal system being represented by the somatic venous system (generally speaking); the umbilical having degenerated and relegated to the biomechanical tissues with the somatic system of myofasciae; and the omphalomesentric system represented as the now completely intraembryonic portal system of blood flow. During osteopathic manipulation this historic link must be respected as it is important both biodynamically and biomechanically.

An arbitrary example to elaborate that thought might be a biomechanical lesion involving the line of force between the inferior vena cava and adductor longus with the ligamentum teres potentially causing the disturbance. The resultant symptoms or "disease" of this lesion are innumerable as the list must encompass each link of every biomechanical chain throughout the

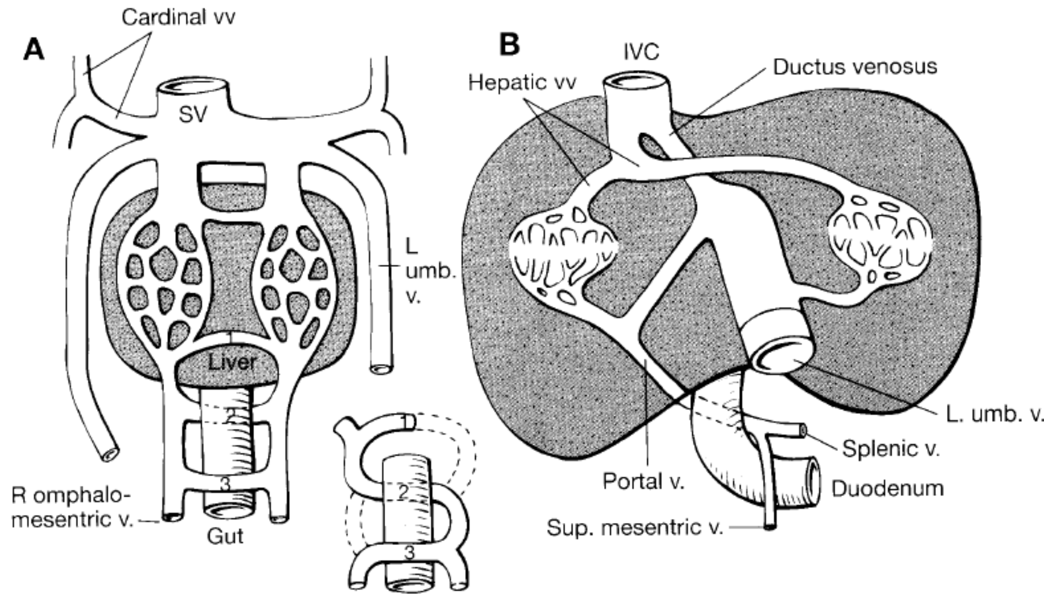
[189] O'Rahilly & Müller, 1987, p.132

myofasciae. For this example, we will use “heel pain”; upon investigation, the heel pain was found to be caused by faulty skeletal biomechanics because of a lesion involving the ligamentum teres in its association with the inferior vena cava. Concurrently, it must be realized that not all heel pain is caused by a lesion of this ligament. Without palpatory direction driven by a complex way of thinking can the edge of chaos be respected between an osteopathic ‘truth’ and ‘sheer conjecture’ AT Still would say. Osteopathic palpation and listening narrows the gap of potential links to align them with the symptoms encountered, but without a cognitive awareness of the ontogeny of the anatomy, the process will not be as efficient as demanded by the osteopathic philosophy.

During Stage13 the hepatic plexus receives all of the blood from the umbilical vesicle “and one might speak of it as a preportal system.”[190] The development of the mature portal system is the result of anastomotic branches of the right and left omphalomesentric veins posterior to the gut tube and subsequent obliteration of the left omphalomesentric.[191] The left hepatocardiac and right umbilical veins also become obliterated; the right hepatocardiac becoming the terminal portion of the inferior vena cava, and the left umbilical vein anastomosing with the liver sinusoids to form the ductus venosus.[192] See figure 6 for a cartoon illustration of this concept.

[190] O’Rahilly & Müller, 1987, p.149
[191] O’Rahilly & Müller, 1987
[192] O’Rahilly & Müller, 1987

Figure 6: Development of Vitelline and Umbilical Veins in the Liver



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A summary of these processes cannot be stated more clearly than from O'Rahilly & Müller:

It can be concluded, first, that the blood vessels of the liver include the intrinsic hepatic plexus that arises *in situ* from cells of the coelomic mesoderm…Secondly, the plexus of the umbilical vesicle empties into this intrinsic network through the vitelline veins. Thirdly, the left umbilical vein anastomoses with some of the peripheral loops of the hepatic plexus to form a direct channel, the ductus venosus, across the base of the liver, emptying into the inferior vena cava. Finally, there are the large hepatocardiac veins that drain the hepatic plexus into the sinus venosus.[194]

[193] O'Rahilly & Müller, 2001, p.265
[194] O'Rahilly & Müller, 1987, p.150

3.4.4.3.0 The Intestinal Canal

3.4.4.3.1 General Remarks

The foregut develops during Stage 9 with the mid- and hind-gut still being combined as a single relatively massive unit.[195] Also established by Stage 9 is the cloacal membrane.[196] The highlight of Stage 10 for the purposes of this discussion is the fact that the midgut is starting to become delimited.[197]

3.4.4.3.2 Stomach and Intestinal Canal

The beginning of the omental bursa during Stage 12 is the marker for the future location of the stomach which is elongating at this Stage.[198] The familiar fusiform enlargement of the stomach is achieved subsequently during Stage 13 with the intestinal canal as a whole becoming larger.[199] As the intestine continues to elongate during Stage 14 it starts to deviate from the midline and thus the initiation of the loops of the small intestine; with the further elongation of the ileum during Stage 15 it can be said that there is a definite intestinal loop.[200] The caecum is also identifiable in Stage 15.[201]

As with the development of the liver and stomach it is important to note the relationship between the intestinal canal and the coelomic epithelium. The entire epithelial tube of the digestive system is surrounded by mesenchyme derived from the coelomic epithelium that overlies it.[202] Again a biodynamic and biomechanical link is seen between the viscera proper and the related somatic wall justifying why mechanical manipulation of the latter can have a profound influence on the former. Figures 7 to 9 display and exemplify the evolution of the digestive system from Stages 15 – 17.

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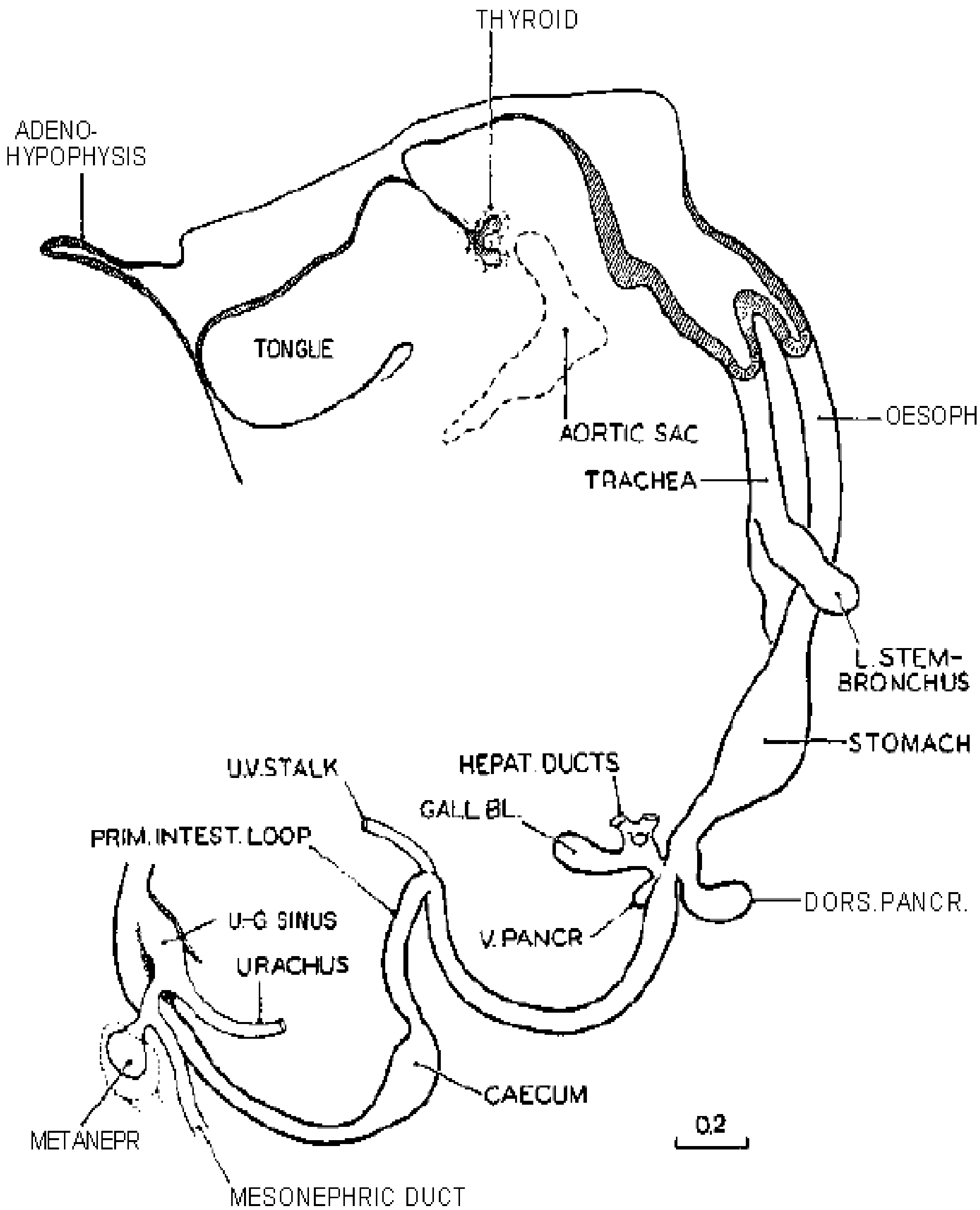
[195] O'Rahilly & Müller, 1987
[196] de Vries, P. A. & Friedland, G. W. (1974). The staged sequential development of the anus and rectum in human embryos and fetuses. *Journal of Pediatric Surgery, 9, p.755-769.*
[197] O'Rahilly & Müller, 1987
[198] O'Rahilly & Müller, 1987
[199] O'Rahilly & Müller, 1987
[200] O'Rahilly & Müller, 1987
[201] O'Rahilly & Müller, 1987
[202] O'Rahilly & Müller, 1987

Figures 7 to 9: Development of the Digestive System in Stages 15 – 17

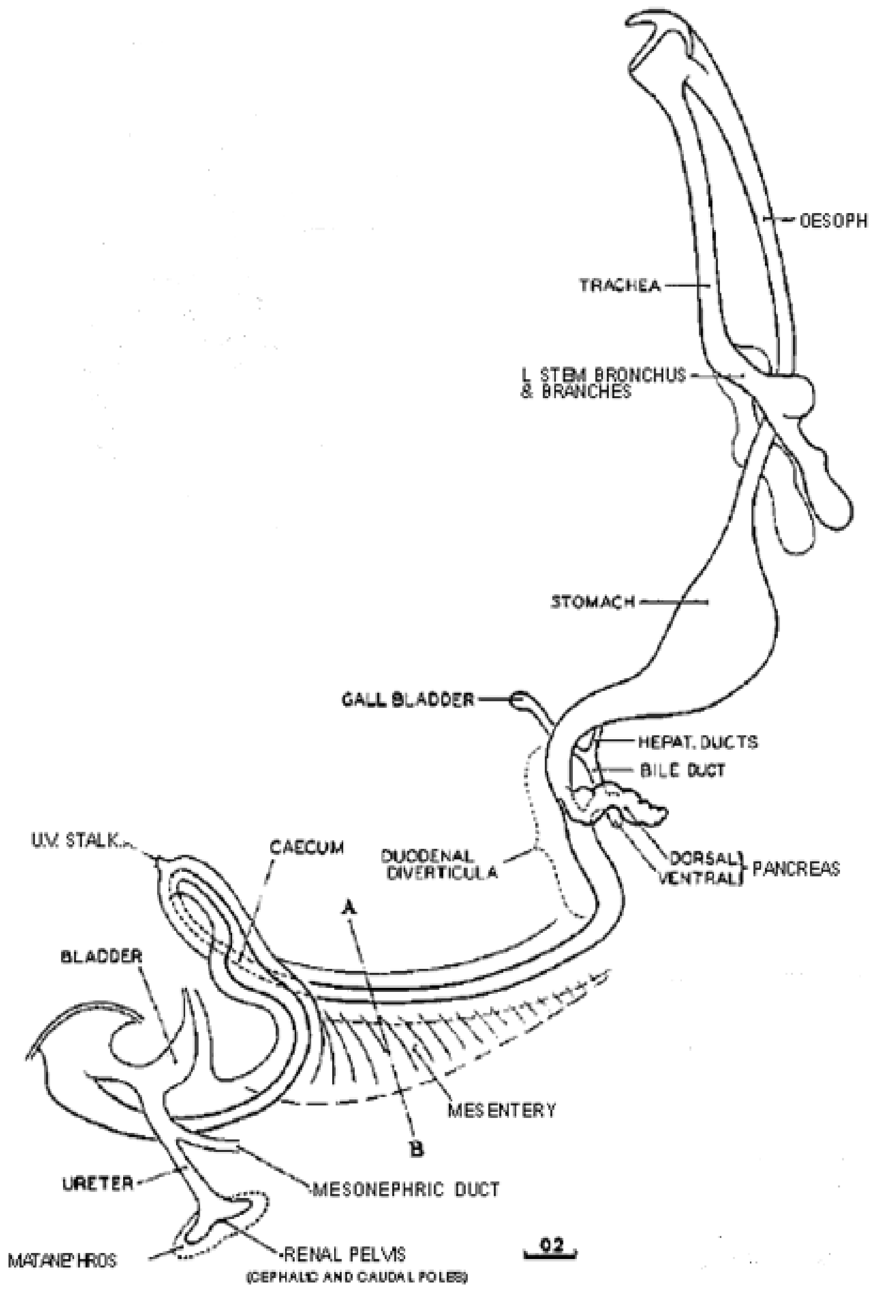
Figure 7: Stage 15



[203]

[203] O'Rahilly & Müller, 1987, p.184

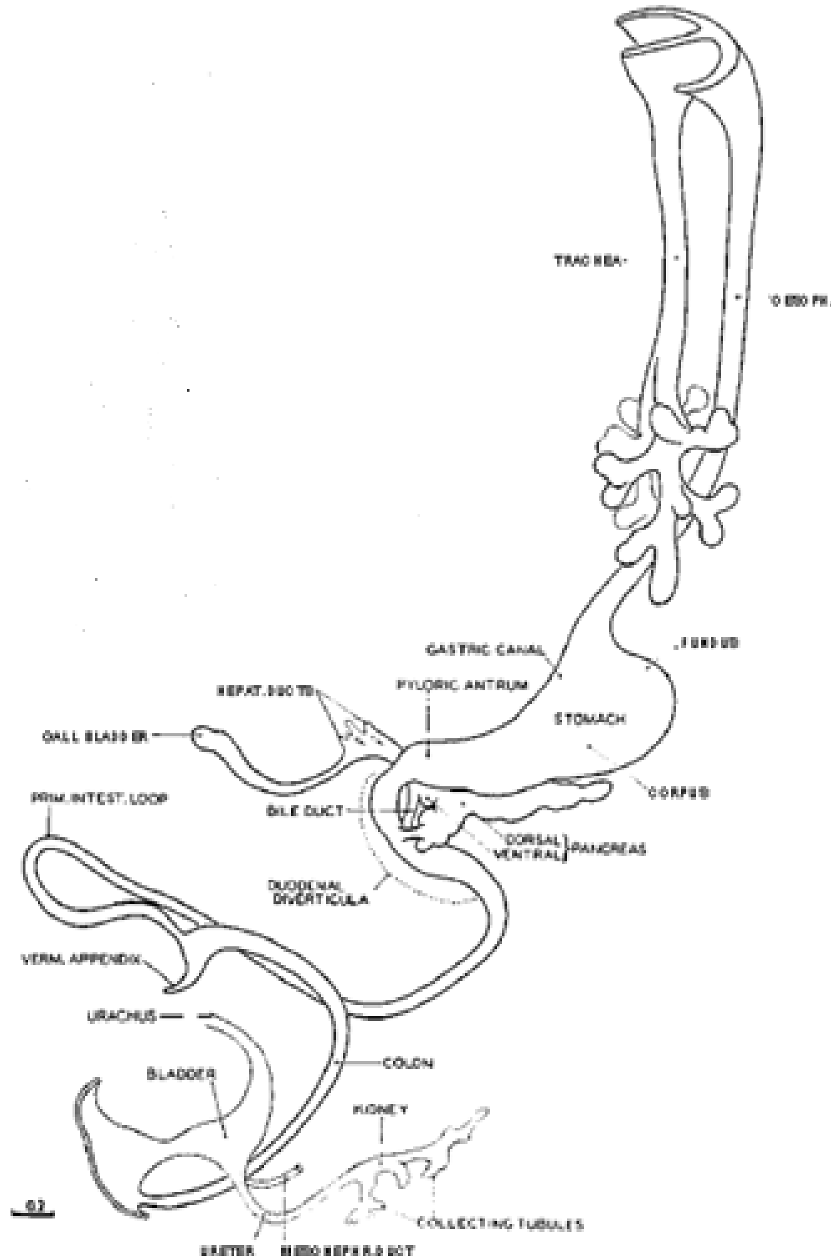
Figure 8: Stage 16



204

204 O'Rahilly & Müller, 1987, p.197

Figure 9: Stage 17



[205]

[205] O'Rahilly & Müller, 1987, p.211

3.5.0 Details Pertaining to Carnegie Stages 16 – 23

3.5.1 General Remarks

In the final Carnegie Stages only the digestive system will be discussed. This is not meant to negate the other concurrently developing systems, but the intent is to focus more on the development of the gastrointestinal canal because of its key role in the ontogeny the peritoneal organs. At this time "a striking feature of the alimentary epithelium is the seeming leadership it exhibits in the delineation of the different parts of the system, and this applies also to such offspring as the pulmonary epithelium, biliary passages, and pancreas."[206] Complexity is again exemplified by the embryology at this point: the embryo is working and interacting with its environment and with itself; not working in its mature role of digestion and absorption, but in a direction towards a state in which these features will emerge and continue to evolve. This evolution respects the process of complexity as it is always present, not ending until death, as the epithelium of the adult gastrointestinal tract continue to renew throughout life. The inherent driving force of the developing gastrointestinal epithelium at this time helps to justify the idea that during listening to the inherent fluidic movements of the visceral system is the result of those embryonic cellular movements.

3.5.2 The Stomach

The greater and lesser curves of the stomach are caused by rapid intrinsic growth of the left side of the stomach during Stages 15 and 16 with the fundus being formed during Stage 17.[207] This growth of the stomach creates the appearance that it rotates around two axes to achieve its final form: one axis is cephalo-caudal which results in the original left side of the stomach becoming its anterior side; the other axis is an anterior/posterior one, resulting in the original caudal part moving to the right and the cephalic part moving to the left.[208] As with any biomechanical movement in the body, the axes around which the movement takes place are dynamic and ever changing. This fact makes apparent the mere conceptual value of envisioning the rotation of the stomach around the two axes just mentioned. In reality it is the differential

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[206] O'Rahilly & Müller, 1987, p.196-7
[207] O'Rahilly & Müller, 2001
[208] Sadler, 2006

growth of the different parts of the stomach combined with the influence of the adjacent organs that determines the position and form of the stomach.

3.5.3.0 Rotation of the Intestine

Just as the development of the liver in Stages 9 – 15 deserved great attention, so does the rotation and evolution of the primary intestinal loop during the final Stages of embryonic development. The exact mechanisms of intestinal rotation are still unknown. Frazer & Robbins,[209] using histologic reconstruction of specimens from the fourth week to third month, and dissected specimens from the third month until birth, contributed greatly to the understanding of the relational movements of the gastrointestinal canal from the fourth week until birth. They arbitrarily divided the process of rotation into three stages; the first is defined as the period from the initial start of rotation ending with to the return of the intestinal canal into the abdomen; the second stage is defined as spanning from the end of the first stage until the caecum is in relation to the posterior abdominal wall; finally, the third stage continues from that point until after birth[210] with the evolution and fusion to the posterior abdominal wall.

3.5.3.1 Stage 1

The first stage of gut rotation is initiated in Stage 15[211] being marked by the movement of the proximal part of the primary gut loop such that it now lies to the right of both the midline and the distal part of the primary gut loop.[212] The amount of this rotation is debated, but classically is stated as being 90°.

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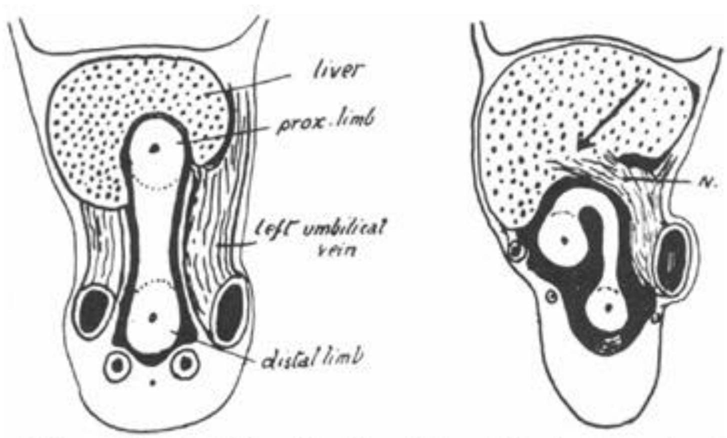
[209] Frazer, J. E. & Robbins, R. H. (1915). On the factors concerned in causing rotation of the intestine in man. *Journal of Anatomy and Physiology, 50, p.75-110.*
[210] Frazer & Robbins, 1915
[211] O'Rahilly & Müller, 2001
[212] Frazer & Robbins, 1915

Based on their reconstructions Frazer & Robbins[213] attribute this rotation to the close relationship between the liver and gastrointestinal canal.

When the secondary left umbilical vein is formed as the result of the vitello-umbilical junction, the new venous channel lies on the visceral surface of the liver and is carried with this across the ventral aspect of the proximal limb of the loop of gut: the vein runs up from the left side of the umbilical opening to the right lobe of the liver, and as this descends it carries down the upper part of the vein, swinging it, as it were, on its lower umbilical end, with the effect of turning the proximal limb over the right.[214]

See figure 10 for a cartoon illustration of this process.

Figure 10: Influence of the Liver on Gut Rotation



Schemes to illustrate the effect of the vitello-umbilical anastomosis and descent of the liver on the proximal limb of the loop, represented as on frontal section. In the first figure the left umbilical vein passes up mainly to the left of the liver but is also sending offshoots below it which join the vitelline system. In the second figure this anastomosis forms now the main left umbilical drainage, and is carried down on the visceral aspect of the liver, the hepatic end of the vein swinging in the direction of the arrow. The result is that the proximal limb is folded over to the right. [215]

This interesting mechanism for movement within the embryo offers insight into the hierarchy of complexity within adult human anatomy for two of the four osteopathic precepts: 'the rule of supply and demand dictates' as well as 'structure and function are irreparably linked'. The first main driving influence of the embryo is that of the central nervous system which necessitates a demand for better nutritive fluid conduction and hence the cardiovascular system. This is achieved through the evolution of that system which intimately involves the liver; consequently

[213] Frazer & Robbins, 1915
[214] Frazer & Robbins, 1915, p.78-9
[215] Frazer & Robbins, 1915, p.78

due to the structural linkage of the liver with the intestinal canal, the former causes the latter to rotate, thus changing its structure.

Two points of fixation to the posterior abdominal wall for the intestinal canal help to govern its growth: the duodenal and colic fixations which fix the proximal and distal parts of the intestinal canal respectively. At the duodenal end the mesoduodenum helps to fix that structure to the dorsal wall of the abdomen; its characteristic right curve is brought about by the growth of the head of the pancreas[216] and biliary systems during Stage 16,[217] making a viable link between these two structures in the adult for at least in the sense of palpating the intrinsic motility. The fixation of the colic angle is produced by a band of thickened mesenchyme within the median mesentery in relation to the superior mesenteric vessels traversing from the level of the duodenum, where it is in relation to the band of Treitz, to the distal end of the intestinal canal in the locale of the colic angle just distal to the caecum.[218] These two relatively fixed ends of the intestinal canal offer anchor points for the explosive growth of the small intestine which enters the umbilical cord during either Stage 16 or Stage 17.[219] This explosive growth is primarily occurring in the proximal limb of the intestinal loop such that the coils are formed to the right side of the distal limb.[220] The main driving force behind this explosive growth is the intestinal endoderm.[221]

3.5.3.2 Stage 2

This stage sees the return of the intestinal loop into the abdominal cavity along with additional rotation; its mechanism is unclear.[222] The approximate degree of rotation is 180° in a counterclockwise direction when viewed from the front.[223] Frazer & Robbins[224] describe a theoretical model based on the pressure relations between the abdominal cavity and amniotic fluid. They hypothesized that with the relative slowing of growth within the liver combined with an increase in the overall size of the abdominal cavity, the relative pressure of the amniotic fluid

[216] Frazer & Robbins, 1915
[217] O’Rahilly & Müller, 1987
[218] Frazer & Robbins, 1915
[219] O’Rahilly & Müller, 2001
[220] Frazer & Robbins, 1915
[221] Blechschmidt, 2004
[222] O’Rahilly & Müller, 2001
[223] Sadler, 2006
[224] Frazer & Robbins, 1915

is increased which pushes the intestinal coils back into the abdomen.[225] Another proposed factor which would allow more room within the abdominal cavity is the degeneration of the mesonephros along the posterior abdominal wall.[226,227] Blechschmidt[228] theorizes that the entire physiologic herniation is actually relative in nature; the abdominal wall simply lags behind in terms of development, and once more advanced, grows around the coils to re-claim them back into the abdominal cavity. As it is not the intention of the author to clarify this debate, the movements of the rotating intestine will be elaborated without judging the driving force behind them.

As the now lengthened proximal portion of the primitive intestinal loop returns to the abdominal cavity it occupies a space inferior to the liver, first passing to the right of the primitive mesocolon.[229] With more intestinal coils returning, their bulk is pushed to the left of the cavity which pushes the primitive mesocolon with it such that it and the colon are in contact with the posterior wall of the abdomen.[230]

Moreover, in going to the left, the coils have passed below the continuity of the abdominal colon with the part still remaining in the umbilical sac, and also below the main mesenteric vessels which also remain in the sac with the colon. Thus, when the caecum returns with these vessels toward the end of the movement, it must lie on top of the coils, between them and the liver. In this way the rotation is partly accomplished, a large part of the small intestine having passed to the left below the upper part of the colon.[231]

The growing mass of small intestine acts as a pressing force such that it pushes the caecum from its initial position between the liver and intestines to one that is to the right of the mesentery; the adjacent part of the colon being placed transversely.[232]

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[225] Frazer & Robbins, 1915
[226] Frazer & Robbins, 1915
[227] Kim, W. K., Kim, H., Ahn, D. H., Kim, M. H. & Park, H. W. (2003). Timetable for intestinal rotation in staged human embryos and fetuses. *Birth Defects Research (Part A), 67, p.941-945.*
[228] Blechschmidt, 2004
[229] Frazer & Robbins, 1915
[230] Frazer & Robbins, 1915
[231] Frazer & Robbins, 1915, p.109
[232] Frazer & Robbins, 1915

3.5.3.3 Stage 3

There is no further rotation in stage 3; the main feature being the extension and fixation of the colon.[233] The extension of the ascending colon is a driving force in pushing the caecum away from the liver and towards its final resting place. The fusion of the ascending and descending parts of the colon is variable. Depending on the amount of fusion of the ascending colon, "the proximal portion of the large intestine, as far as the left part of the transverse colon, may remain attached, along with the jejuno-ileum, to the posterior abdominal wall by a common mesentery."[234] The resulting fusion fasciae are the left and right fasciae of Toldt.

3.6 General Development of the Lymphatic System

Little is known about the intricacies of the development of the lymphatic system which is initiated during the fifth gestational week.[235,236] "Lymphatic primordia probably arise as outgrowths from venous channels, although some maintain that they originate from mesenchymal spaces that become connected secondarily with veins."[237] The first appearance of the lymphatic system are the jugular lymphatics in the locale of the confluence of the pre- and postcardinal veins; these fuse with the axillary to create the jugulo-axillary complex.[238] Other lymphatics follow and, by the end of the embryonic period the jugulo-axillary, mesenteric, ilio-inguinal sacs are present along with the thoracic duct and primordium of the cisterna chyli.[239] Figure 11 displays the developing lymphatic system.

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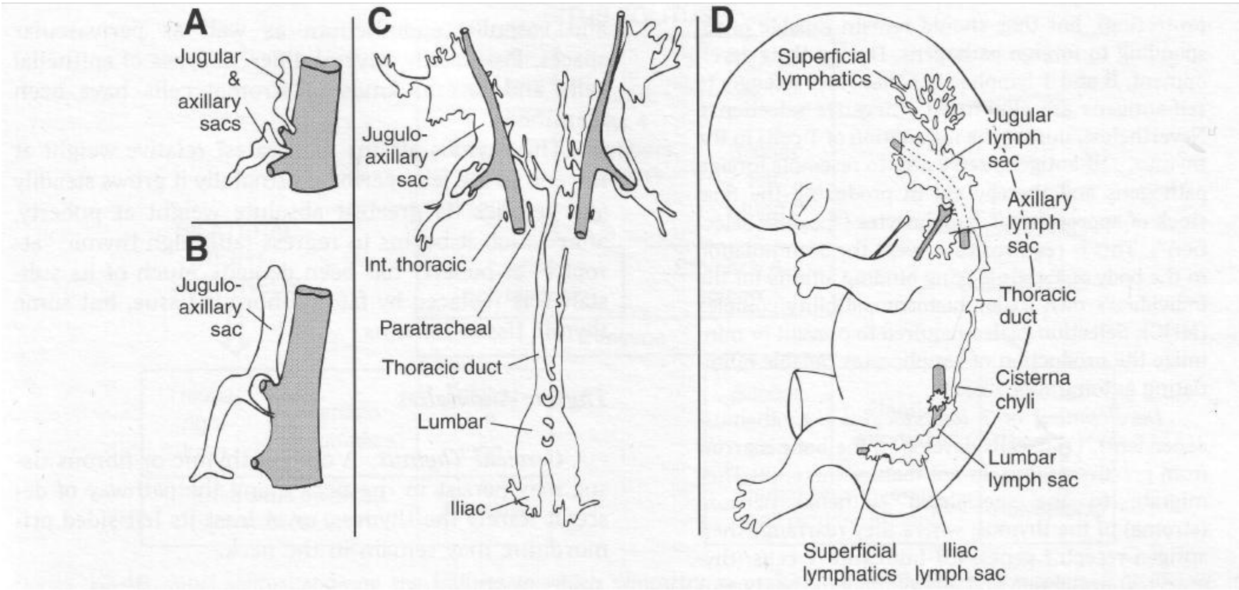
[233] Frazer & Robbins, 1915
[234] Malas, M. A., Aslankoç, R., Üngör, B., Sulak, O. & Candir, Ö. (2004). The development of large intestine during the fetal period. *Early Human Development, 78, p.1-13.* doi: 10.1016/j.earlhumdev.2004.03.001, p.2
[235] O'Rahilly & Müller, 2001
[236] Sadler, 2006
[237] O'Rahilly & Müller, 2001, p.220
[238] O'Rahilly & Müller, 2001
[239] O'Rahilly & Müller, 2001

Figure 11: Development of the Lymphatic System



Development of lymphatic vessels. Graphic reconstructions of the lymphatic vessels from 6 weeks to 8 weeks. The separate jugular and axillary lymph sacs in **A** have united in **B**. In **C**, six bilateral sacs and vessels are indicated. Two median plexuses, the subtracheal and mesenteric, are not shown. The left thoracic duct is being superseded by the right, definitive thoracic duct, which is heading for the left jugular region. **D.** Left lateral view of the lymphatic system at 8 weeks[23]. **A–C** based on van der Putte (1975), **D** on Sabin in Keibel and Mall's *Manual* (1912). [240]

3.7 The Fetal Period

The fetal period is "characterized by maturation of tissues and organs and rapid growth of the body."[241] Rapid increases in length occur during months three to five; weight rapidly increased during months eight and nine.[242] With a growth in length and subsequent muscular activity, biomechanical factors start to play a more significant role in the functioning of the fetus as a whole. The addition of more cells to the fetus and its subsequent increase in weight also play a biomechanical role in the fetus.

Another level of the complexity for the amniotic fluid becomes apparent during the fetal period. The increase in volume of amniotic fluid is substantial, moving from 30mL at 10 weeks; 450mL at 20 weeks; and, 800 – 1000mL at 37 weeks.[243] Its primary role at this time is as a protective cushion until the fifth month when the fetus will begin consuming approximately

[240] O'Rahilly & Müller, 2001, p.221
[241] Sadler, 2006, p.89
[242] Sadler, 2006
[243] Sadler, 2006

400mL per day.[244] The extent this swallowing of amniotic fluid on the development of the gastrointestinal system is not known.[245] While not a topic for discussion here, the importance of maintaining the state of the mother's uterus via manipulation is indicated. Undue biomechanical stresses placed on the mother can have an impact on the supply of amniotic fluid which is turned over every three hours[246] making the osteopathic approach to treatment relative in nature at this time: that is, treatment of the mother.

3.8 Biomechanical Axes Operating in the Embryo

The primitive biomechanical axes operating in the embryo that will resound within the viscera of adulthood are useful in managing the comprehension of the shear explosive growth in complexity at the beginning of Stage 5. What is to follow is an attempt to understand the link between the developmental ontogeny of the tissues and the palpation of their adult form. Osteopathically, functional reference points are available: the original spatial axes of the embryonic disc and the co-existing temporal axis. The first spatial axis of the embryo is the cephalocaudal axis which emerges because of the events relating to the organization of the primitive streak.[247] Further interaction of the migrating primitive streak cells causes the emergence of the next spatial axis: the dorsoventral axis which is both dependent on, and interactive with, the folding of the embryo.[248] The final spatial axis, the laterolateral axis, is dependent on the development of the first two axes and emerges with the development of the limbs.[249] Once the cephalocaudal, dorsoventral and laterolateral axes are established, the mechanical forces through the structure of the fasciae start to become more 'adult-like' and subject to both local and global forces, influencing their further ontogenetic evolution. The temporal axis of the embryo is implied by the complexity of development of the first three spatial axes of the body in that they occur in sequence. Time plays a key factor in both anatomy and physiology and both the patient and osteopath need to respect this axis to obtain the most efficient and realistic outcomes. Without respecting time, the osteopath is not respecting

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[244] Sadler, 2006
[245] Ruckebusch, 1989
[246] Sadler, 2006
[247] Standring, 2005
[248] Standring, 2005
[249] Standring, 2005

complexity, and therefore not working within the intentions of AT Still's philosophy of osteopathy.

Practically speaking, the embryologic axes mentioned are more of an energetic interest with their utility residing in the more esoteric or intuitive methods of palpation and subsequent treatment. Many in the scientific community would cringe at the thought of an osteopath claiming to feel or 'listen' to reverberations of the original spatial axes to use as either a diagnostic or treatment utility. There is however a genetic basis within this claim, nonetheless one that is probably not quantifiable. Experiments have shown that homeobox genes "play a role in cranial-to-caudal patterning of the derivatives of all three germ layers".[250] This makes them a sort of guiding factor in the self-organization of the embryologic processes. "In later stages, homeobox genes seem to provide molecular tags that "remind" cells of where in the embryo they originated".[251] As this conjecture is simply not quantifiable it must be left to the imagination of both the patient and osteopath. Perhaps with much more scientific data pertaining to this aspect of embryology could this conjecture be definitively decided as useful within the paradigm of manual osteopathic treatment or dismissed as quackery.

The concept of more quantifiable axes within human anatomy (biomechanics) and physiology (biochemistry) is large within the osteopathic philosophy as they operate as obvious structural/functional attractors within the global system of the body. Very nice works are published on the axes of movements of the musculoskeletal system including the cranium. The presence of physiologic axes are also well known, for example the hypothalamus/pituitary axis, but are somewhat less manipulatable due to their increased complexity and sensitive nature. The practicing osteopath whether using a biodynamic approach to palpation or a functional one, needs to be aware of the evolution of each of the original axes of their patient. This is no small task. It is a complex one that necessitates a complex way of thinking. Osteopathically, the physiologic axes can only be manipulated via mechanical tensions generated by the fasciae, and the transmission of those tensions which subsequently creates a mechanical stressor on a(n) specific organ(s) creating a change in their physiologic actions. The point that is stressed here is complexity. Without working in this paradigm it is not possible to fully appreciate the

[250] Sadler, 2006, p.84
[251] O'Rahilly, R. & Müller, F. (1996). *Human embryology & teratology (2nd Ed.).* Wiley-Liss: USA, p.93

descriptions regarding the embryology and anatomy of the peritoneal organs as it relates to the osteopathic philosophy and subsequent manipulative treatment based in that philosophy.

Chapter 4: The Concept of Osteopathic Pathology

4.0 The Concept of Osteopathic Pathology

This chapter is an attempt to emphasize how AT Still regarded abnormal anatomy in terms of the mechanical etiology of disease. According to the osteopathic philosophy "…disturbance of function is, as a rule, due to structural changes…"[252] This notion can be elaborated right down to the genetic level, an example being inborn errors of metabolism. Obviously these types of genetic issues are outside of the scope of manual osteopathic work in that they cannot be managed primarily with manual osteopathic means. That is not to say the manual osteopath has no place in treating these conditions, but their status is relegated behind allopathic means of treatment within the hierarchy of medicine in general.

If disturbance in function is the result of structural change then; it seems justified to state that structure governs function, but this is not an accurate view of living physiology as it is too linear. It works on paper, but not in practice. In practice the hierarchical relationship between structure and function is complex: it is a spectrum. The scale of balance can be shifted enough to state that: at least for the given individual on your treatment table, their function is to some degree governing their structure and vice versa. It is a spectrum of complex interacting physiological processes, not a linear relationship. The mechanical nature of this relationship is what AT Still was obsessed with. And rightfully so. It is a very powerful one that can be elaborated to incorporate both the infinitely small (DNA in humans for example) and the infinitely large (his environment). This knowledge would satisfy the requirements of soft complexity science as defined by Davis & Sumara.[253]

Perhaps the easiest example of this principle is that of acute lumbago. The initial attack of idiopathic lumbago can easily prevent the patient from ambulation without sometimes very extreme pain. Their function is governing their structure for the time in this case if, we consider their conscious awareness of pain to represent the element of function, while the totality of musculoskeletal movements required to perform activities of daily living to be the structure. As with all complex processes there is the possibility to revert back to a previous state in which there is a better balance between structure and function. Only when our structure and function are working in a dynamic harmony do we not think about them. We simply don't have to. Much

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[252] Clark, M. E. (1906). *Applied anatomy*. Kirksville: Journal Printing Co. Downloaded from www.archive.org, p.9
[253] Davis & Sumara, 2006

like an acute case of lumbago, the reader may also relate to the example of the structure/function relationship by the state of the gut in various stages of activity: good or bad; acute or chronic.

The ranges of illness that can affect the peritoneal viscera are vast and enumeration and discussion will not be attempted as these are the grounds of the pathology textbooks. What needs to be emphasized is that for manual osteopathic treatment, it is not the disease necessarily that needs to be treated, but the complex process in which the disease may have emerged, that is to be treated. The awareness that the mechanical etiology of disease is not linear saves much frustration in attempts to even tabulate it. The goal of the osteopath is to first rule out any disease or condition that requires pertinent medical attention as it is both irresponsible and unethical not to do so.

After deeming the “pathologic state” appropriate for physical manipulation the osteopath must rely on their knowledge of embryology, anatomy and physiology to diagnose via palpation the mechanical etiology. Rather than making speculations regarding the structure/dysfunction relationships between the peritoneal organs along with their abdominal neighbours, the author would rather instill a philosophical foundation to these relationships. In the clinic while working with the hands is the appropriate place for these discoveries. The word discovery being used here to indicate the possibility of different lesions causing the same ailments in different patients based on their level of structure/function; which, of course, is both dynamic and specific to them.

Chapter 5: Gross Anatomy

5.1 Introduction

> When this great machine, man, ceases to move in all its parts, which we call death, the explorer's knife discovers no mind, no motion. He simply finds formulated matter, with no motor to move it, with no mind to direct it. He can trace the channels through which the fluids have circulated, and he can find the relation of the parts to other parts; in fact, by the knife he can expose to view the whole machinery that once was wisely active.[254]

The section of anatomy to follow will, of course, have its foundation based in morbid anatomy. This is an unfortunate bi-product of the process of learning anatomy. Virtually all gross anatomy was reasonably well documented not with current MRI, fMRI, CT, PET or various other diagnostic imaging technologies that can be applied to the living person, but from the knife, forceps and fingers of a patient and careful dissector. Regarding anatomy AT Still wrote: "a knowledge of anatomy is only a dead weight if we do not know how to apply that knowledge with successful skill."[255] As the osteopath treats the living, a rote memorization of the details of anatomy will become dead weight if they are unable to take that knowledge of morbid anatomy and 'give it life'. Palpation of the patient is a key learning resource in obtaining a further understanding and appreciation of the textbook and dissection based methods of learning anatomy. It is also obligatory to learn this manual skill for the application of osteopathy.

Osteopathic anatomy should be organized in a different manner than that of the textbook of anatomy. The textbook is useful in gaining a complete knowledge of human anatomy as it is currently understood. Osteopathic anatomy uses the information in the textbook, then combines it with palpation skills to identify the structures being sought for treatment. The pitfall with this method is the inability to access certain areas or regions of the human body with precise certainty; for example, you cannot slide a finger through the foramen of Winslow and verify visually you are in that structure by simple palpation. This task is an easy one in the dissecting room. You can however hear the audible movement of fluid of the peritoneum between the lesser and greater peritoneal sacs during osteopathic manipulation of the fasciae in relation to that opening. No one will experience that in the dissecting room. The value to this method is the ability to feel the tissues while they are working: a factor of prime importance if one is to treat

[254] Still, 1902, p.17
[255] Still, 1902, p.20

the living. The skill to listen to the tissues enables the access to those most remote aspects of the body via a system of levers: the fasciae.

The fasciae offer sufficient interconnection of parts via tensions generated by its attachment to the skeleton, the major abdominal wall musculofascial sheets, transverse musculofascial sheets such as the tentorium cerebelli, thoracic diaphragm, suspensory apparatus of the viscera of both the neck and thorax, the levator ani, as well as the volume of the viscera in general: cranial, thoracic and abdominopelvic. An extremely complex interactive system of levers can be created via the fasciae and its attachments for the purpose of both listening and treatment. The fulcrums making these connections possible must first be identified so as to offer the operator something to look for while he/she is listening: to open the mind's eye. To identify them is to know them intimately; another aspect of osteopathic anatomy that this section will attempt to clarify.

Major problems in describing the fasciae span from preservation processes, dissection technique, two-dimensional representation via drawing or photograph, all the way to the lengthy and often confusing verbiage that must be employed in an attempt to link what the reader sees in their mind and what the author and/or artist saw in theirs. Their assortment of structure and nature makes the fasciae a wonderfully three-dimensional, non-linear and dynamic tissue. Not mentioning also its versatility in being able to represent major structural tissues bearing extreme amounts of tension; to the most delicate of meshes binding and supporting. An example of the former being the tractus iliotibialis, while the latter is exemplified by the delicate connective tissue stroma surrounding the hepatocytes of the liver. With all of these qualities understood and well manipulated by a skillful practitioner, it can be easily seen why AT Still spoke so highly of the fasciae: "the fascia proves itself to be the probable matrix of life and death."[256]

[256] Still, 1899, p.89

To organize a concise description of the relations of the peritoneum would, out of necessity, not be very concise. The following premise from AT Still will be used as a guide:

> They must study and know the exact construction of the human body, the exact location of every bone, nerve, fibre, muscle, and organ, the origin, the course and flow of all the fluids of the body, the relation of each to the other, and the function it is to perform in perpetuating life and health. In addition, you must have the skill and ability to enable you to detect the exact location of any and all obstructions to the regular movements of this grand machinery of life. Not only must you be able to locate the obstruction, but you must have the skill to remove it.[257]

The inherent problem with this premise is that an *exact* knowledge of the human body is not attainable when one takes into account each and every anatomic variation or at least those variations that the osteopath would ever encounter in his/her practice. This level of knowledge being either unattainable or simply not recordable for statistical analysis leads to the conclusion that the knowledge gained by the practicing osteopath regarding the construction of the human body is never complete. AT still always studied anatomy; that is no secret. He did not rest content with textbook anatomy, but osteopathic anatomy; that is, in relation to a refined premise of the osteopathic philosophy: the understanding of health and disease while subsequently adjusting the system allowing Nature to make well.

> I feel that twenty-five years of constant study on the parts of man, separated and combined, has prepared me fairly well to enter the higher classes as a beginner to study the active laws of life – to inquire into the hows and whys of the workings and failures of the whole being (man).[258]

Provided one spends the necessary time and effort to study, learn and understand the skeletal, nervous, cardiovascular, fascial, muscular and visceral systems, it can be granted that they know the *exact* construction of the human body. To comprehend the next part of this premise: that of fluids, it becomes necessary to enter into the realm of physiology or 'applied anatomy'. The fluids of the body are numerous and discrete, but are easily comprehended with a complex understanding of each of the relations of the fascial system and its fluid governing ability: where do the fluids reside, and what physical manipulation can change their position? Once normalized, these relations will be governed by Nature back to health: 'Let nature make well'. The final level of comprehension of the *exact* construction of the human body as written by AT Still is to have the ability to relate each and every part as a whole or subsystem to each

[257] Still, 1897, 358-359
[258] Still, 1897, p.232

and every other part simultaneously. A model of this system would serve well for the understanding of component parts of each system or subsystem, but this model is too complex to build in its entirety. It is the mechanistic model of the human form that simply cannot be built, largely due to the complexity of the nervous system. The model that must then be relied on by the osteopath is the patient in their practice. AT Still preached that "you should be familiar with at least ninety per cent of all the human body before you enter our clinics."[259] He must have believed that 90% was a good starting point to apply osteopathic manipulation with some accuracy and efficiency. To complete the premise of this section forces one to enter into the practical or clinical aspects of osteopathy as it encompasses the physical ramifications of abnormal states. This aspect cannot be learned from a book, but only in the clinic.

The 'knowledge' aspect and the 'mechanical' aspect of AT Still's statement above are incredibly different attributes. Comparably, the knowledge aspect is the easy part of the philosophy and can be learned mostly by book. The mechanical part can by no means be taught by book: it is the mechanical skill of treating a patient. It is the mechanical aspect of having an osteopathic understanding of human anatomy that is the most daunting part of the philosophy. This point is emphasized by the fact that the operator must be able to listen to and treat *all* parts of the anatomy before completing that aspect of his/her education. That is by no means an easy task. It is governed by a great number of unknown things: size and strength of the osteopath, interests of the osteopath, location and focus of clinical setting, amount of continued study and so on and so forth. The dictum "practice makes perfect" is directly applicable to the practice of medicine in general and equally applicable in the philosophy of osteopathy. With a vast array of emerging factors that can dictate the efficiency of the mechanical workings of the operator it becomes more difficult to record and objectively study the work being accomplished in the profession.

With the premise of osteopathic anatomy introduced, the section to follow consists of topographical, relational and palpatory anatomy as well as schematics and figures. Descriptive anatomy details are innumerable and available to anyone with internet access (www.archive.org/texts) and minimal research skills, save that of logic. For further reference

[259] Still, 1897, p.178

and directions to descriptive material, the reader is directed to websites such as the one just mentioned; moreover, to the dissecting lab and of course not to forget: the treatment room.

5.2 The Walls

The abdominal viscera are contained within the abdominopelvic cavity which is walled off by the thoracic diaphragm superiorly, the pelvic and urogenital diaphragms inferiorly and the anterior/lateral/posterior abdominal wall continuum as its circumference. Cross sectional examination of various levels of the abdominopelvic cavity in the different planes displays its non-linear disposition. See appendix B – Sectional Anatomy of the Abdomen.

The muscles lining the abdominopelvic cavity include the thoracic diaphragm, quadratus lumborum, iliacus, psoas minor and major, obturator internus, and the collective myofascia of the pelvic and urogenital diaphragms. These are the muscular entities in contact with the plane of subserous fascia which is immediately external to the parietal peritoneum as well as the pelvic fascia. Intimately associated with the muscle walls of the cavity proper are the remaining somatic muscles.

Altered function of the muscular walls will impact the underlying viscera both absolutely and relatively. A most easily demonstrated absolute relationship between the muscular wall of the abdominopelvic cavity could be a small bowel loop strangulation during an inguinal hernia. In the relative, it is easy to see how long standing rib or vertebral lesions can impact the overall supply and drainage of fluids to organs. The related mechanical tension of the spine and ribs is carried to the extremities and head making obvious the global nature of rib and vertebral lesions as a cause for a very large number of pathologies. The importance to note regarding these pathologies is that they are relative in nature. The primary lesion may be the vertebral/rib lesion, but the ailment is identified by the patient as the expression they experience: the result of the interaction of each and any mechanical abnormality of function that is occurring. This may be bowel trouble, heart trouble, knee trouble etc, etc, etc. With complexity thinking it must be acknowledged that whatever “primary lesion” is detected by the operator may or may not actually be primary in nature; it may be secondary, tertiary, quaternary etc, to other lesions present throughout the fascial continuum.

5.3.0 The Peritoneum

5.3.1 General Remarks

The peritoneum is a massive serous membrane with a surface area roughly equaling that of the skin.[260] It is a closed sac only in the male as there is an opening in relation to the Fallopian tube in the female. The general architecture of the peritoneum is a mesothelial sheet supported by a network of connective tissue. "The peritoneum serves to minimize friction and thus facilitate free movement between abdominal viscera; resist or localize infection; and store fat, especially in the greater omentum."[261] As was stressed throughout the section of embryology, the embryo and fetus is a living, growing dynamic biological system; with that, there is a general architecture of the peritoneum, but depending on many intra- and extra-uterine influences, both of internal and external origin, the final disposition of the peritoneum is quite variable. There are of course numerous constant ligaments, but even these display many morphological differences. The author doubts the existence of any textbook of anatomy that contains a description or figure of all the possible configurations of the peritoneum.

5.3.2 External Topographical Anatomy

The topographical anatomy of the peritoneum cannot be treated like a solid organ such as the liver because it is adherent to the entire parietal wall of the abdominal cavity making the outline of that cavity the definition of the topographical anatomy. Consequently only the root of the mesentery and transverse mesocolon will be discussed here.

The root of the mesentery is located along the posterior abdominal wall from the left of the body of L_2 to the right iliac fossa.[262] On the surface of the body the root of the mesentery is located 1 to 1½ inches [2.54cm – 3.81cm] to the left of midline just below the transpyloric plane; it ends at the junction of the right lateral and intertubercular planes.[263] The root of the transverse mesocolon is roughly within the transpyloric plane.[264]

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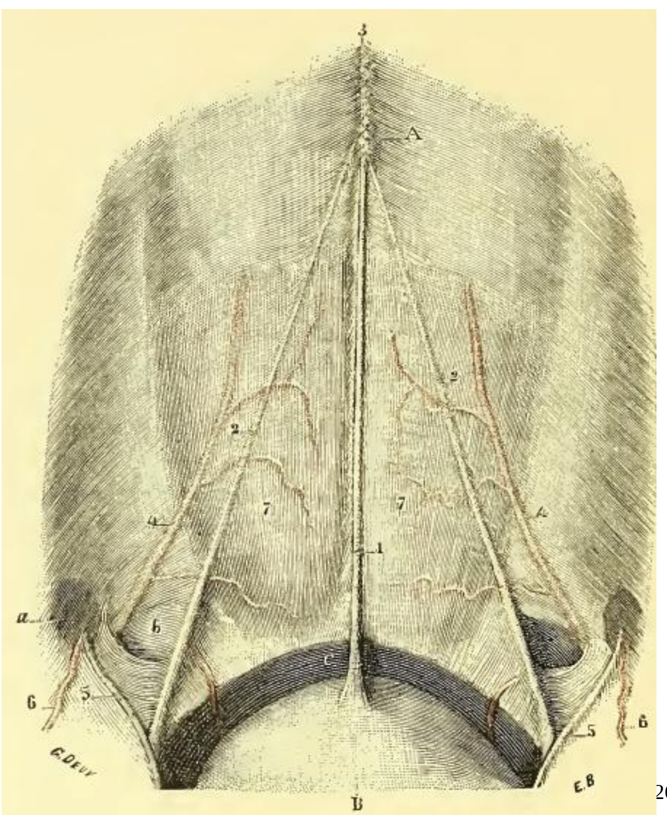
[260] diZerega, G. S. & Rodgers, K. E. (1992). *The peritoneum.* Springer-Verlag: New York.
[261] diZerega & Rodgers, 1992, p.1
[262] Berry, R. J. (1906). *Outlines of applied anatomy with special reference to surface landmarks.* William Green & Sons: Edinburgh. Downloaded from www.archive.org.
[263] Rawling, L. B. (1922). *Landmarks and surface markings of the human body (5th Ed.)* The Macmillan Company of Canada: Toronto. Downloaded from www.archive.org.

5.3.3 Internal Topographical Anatomy

When viewed from is internal aspect the peritoneum displays a variety of folds and fossae corresponding with underlying structures. In the locale of the inferior anterior abdominal wall are located the supravesical, medial, and lateral inguinal fossae which are created by the urachus, medial, and lateral umbilical folds. The supravesical fossae are located on each side between the urachus and medial umbilical fold. The medial inguinal fossae are located on each side between the medial and lateral umbilical folds. The lateral inguinal fossae correspond to the fossae lateral to the lateral umbilical folds covering the deep inguinal ring and are again bilateral. The final fossae of this region are the femoral, which are located inferior and medial to the lateral inguinal fossae and overly the femoral ring. See figure 11.

Figure 12: Internal Topography of the Peritoneum of the Anterior Abdominal Wall



[265]

A – Umbilicus

B – Urinary bladder

1 – Urachus

2 – Medial umbilical fold

3 – Start of falciform ligament of liver

4 – Lateral umbilical fold

a – Lateral inguinal fossa

b – Medial inguinal fossa

c – Supravesical fossa

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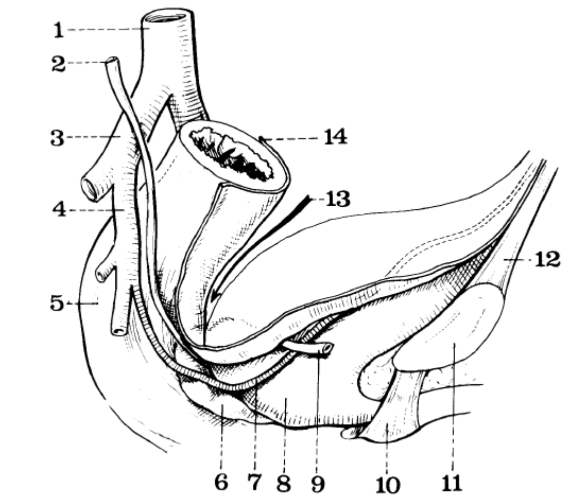
[264] Berry, 1906

[265] Testut, L. (1901). *Traité d'anatomie humaine tome quatrième. (4e Éd.).* Paris: Octave Doin. Downloaded from www.archive.org., p.932

Within the pelvis the peritoneum creates various pouches which are constant topographically: the recto-vesical, utero-vesical, recto-uterine pouch of Douglas, pararectal, paravesical, ovarian fossae of Krause in nulliparity[266], ovarian fossae of Claudius thereafter[267] being dependent on the number of pregnancies, are all included in this category. See figures 13 – 16.

Figures 13 – 16: Internal Topography of the Peritoneum of the Pelvis

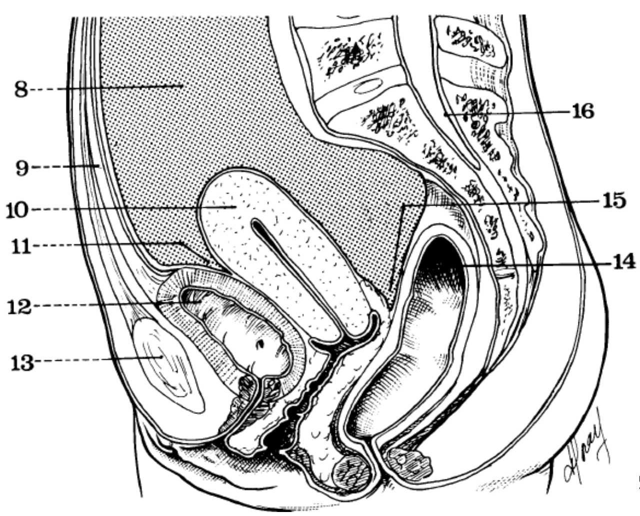


[268]

Figure 13: Recto-vesical Pouch

13 – Recto-vesical pouch

14 – Pre-rectal peritoneum



[269]

Figure 14: Utero-vesical Pouch

11 – Utero-vesical pouch

15 – Pouch of Douglas

[266] Standring, S. (Ed.). (2008). *Gray's anatomy the anatomical basis of clinical practice (40e Ed.).*
[267] Bouchet, A. & Cuilleret, J. (2001). *Anatomie topographique descriptive et fonctionnelle tome 4 l'abdomen la région rétro-péritonéale le petit bassin, le périnée (2e Éd).* Paris: Simep.
[268] Bouchet & Cuilleret, 2001, p.2189
[269] Bouchet & Cuilleret, 2001, p.2241

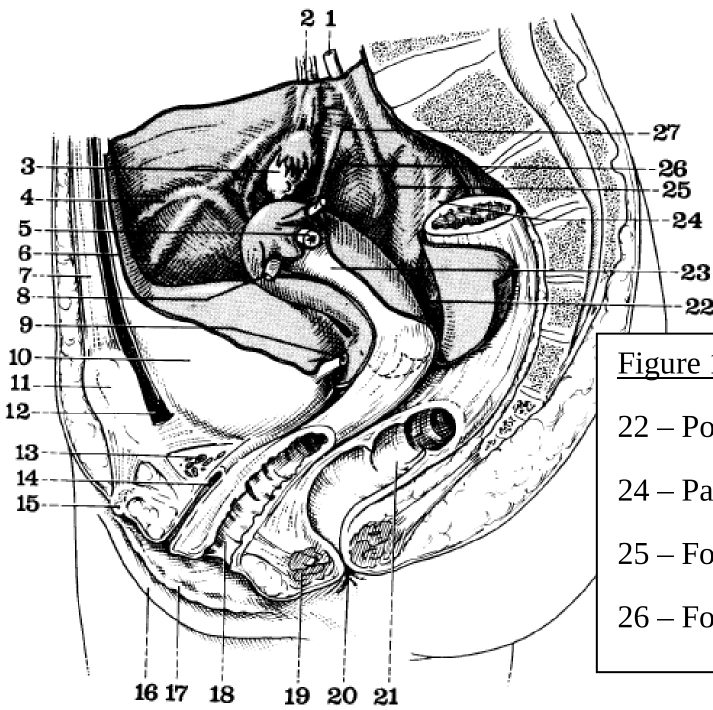


Figure 15: Pouches of Douglas, Krause, Claudius

22 – Pouch of Douglas

24 – Pararectal fossa

25 – Fossa of Krause

26 – Fossa of Claudius

[270]

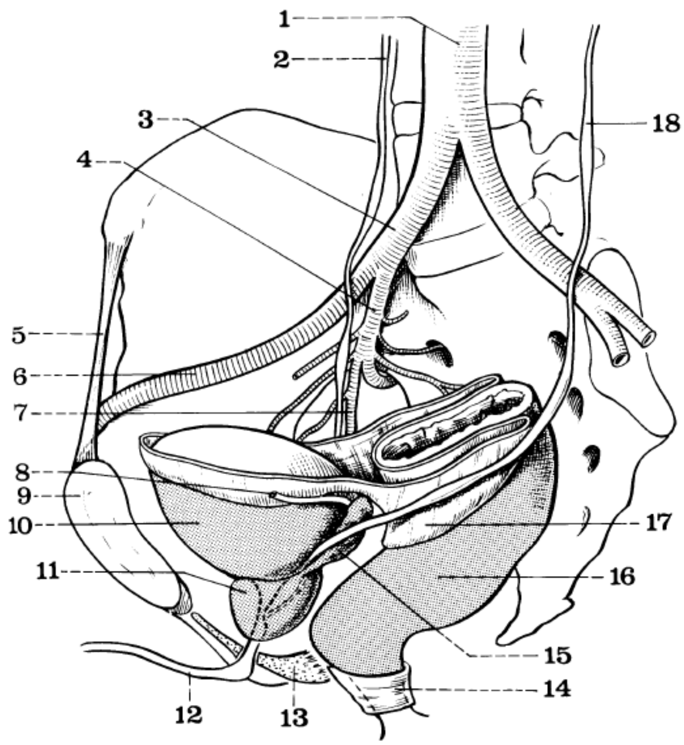


Figure 16: Pararectal Fossa

17 – Pararectal fossa

[271]

[270] Bouchet & Cuilleret, 2001, p.2288
[271] Bouchet & Cuilleret, 2001, p.2189

5.4 Peritoneal Relations of the Viscera

As previously stated the connections of the various viscera to each other as well as the walls of the abdominal cavity are reasonably constant, but by no means identical from person to person. The most constant as well as some of the more common variants appears below in Table 4 which is derived from Piersol[272], Testut[273], Hertzler,[274] and Bouchet & Cuilleret.[275] Figures to accompany Table 4 are found in Appendix C – Peritoneal Relations of the Viscera. Regretfully, a figure for each of the relations could not be found by the author.

Table 4: Peritoneal Relations of the Viscera

Organ	Associated Peritoneum
Abdominal esophagus	Pars condensa of the lesser omentum; esophago-phrenic ligament
Stomach	Lesser and greater omenta; gastro-phrenic, gastro-splenic, gastro-hepatic, and gastro-colic ligaments; gastro-pancreatic fold of Huschke
Duodenum	Root of the transverse mesocolon; root of jejuno-ileum mesentery; hepato-duodenal, duodeno-colic, duodeno-pancreatic, and duodeno-cystic ligaments; lesser and greater omenta; duodeno-renal ligament of Huschke; superior and inferior duodenal folds
Jejunum	Root of jejuno-ileum mesentery; superior and inferior duodenal folds
Ileum	Root of jejuno-ileum mesentery; superior ileocaecal, inferior ileocaecal, ileo-appendicular, and ileoparietal folds; genito-mesenteric fold of Reid; genito-enteric fold of Treitz; ileo-ovarian ligament of Durand

[272] Piersol, G. A. (Ed.). (1913). *Human anatomy including structure and development and practical considerations(4th Ed.).* Philadelphia: J. B. Lippincott Company.
[273] Testut, 1901
[274] Hertzler, A. E. (1919). *The peritoneum vol. 1 structure and function in relation to the principles of abdominal surgery*. C.V. Mosby Company: St. Louis. Downloaded from www.archive.org.
[275] Bouchet & Cuilleret, 2001

Table 4 – Continued

Organ	Associated Peritoneum
Caecum, appendix, ascending colon and hepatic angle	Variable meso-colon; meso-appendix; external and internal ligaments of the colon [supérieur (de Huschke) et inférieur for the French]; superior and inferior ileocaecal folds; ileo-appendicular fold; Appendicular-ovarian ligament of Clado; mesentericoparietal fold of Jonnesco; right phreno-colic, parieto-colic, omento-colo-parietal, reno-colic, duodeno-colic, and hepato-colic ligaments; pleurocolic ligament of Langer
Transverse colon	Transverse mesocolon; gastro-colic, duodeno-colic, hepato-colic and cystico-colic ligaments; greater omentum
Splenic angle and Descending colon	Variable descending meso-colon; left phreno-colic, spleno-colic, and parieto-colic ligaments
Sigmoid colon and rectum	Meso-sigmoid; ligamentum infundibulum of Liepmann; peritoneum of the pouch of Douglas and pararectal fossae
Liver	Right and left triangular ligaments, falciform, coronary, hepato-duodenal, hepato-renal, hepato-cystic, hepato-colic, and gastro-hepatic ligaments; lesser omentum
Gallbladder	Hepato-cystic and duodeno-cystic, and cystico-colic ligaments
Spleen	Gastro-splenic, lieno-renal, and spleno-colic ligaments; suspensory ligament of the spleen; left phreno-colic ligament
Pancreas	Duodeno-pancreatic ligament, Gastro-pancreatic fold of Huschke; posterior surface of the lesser omentum; root of the transverse mesocolon
Right Kidney	Reflection of right coronary ligament of the liver; hepato-renal and reno-colic ligaments; duodeno-renal ligament of Huschke; parietal peritoneum; peritoneal arrangement in relation to hepatic flexure of colon
Left Kidney	Lieno-renal ligament; root of the transverse mesocolon; parietal peritoneum; peritoneal arrangement in relation to splenic flexure of colon

Table 4 – Continued

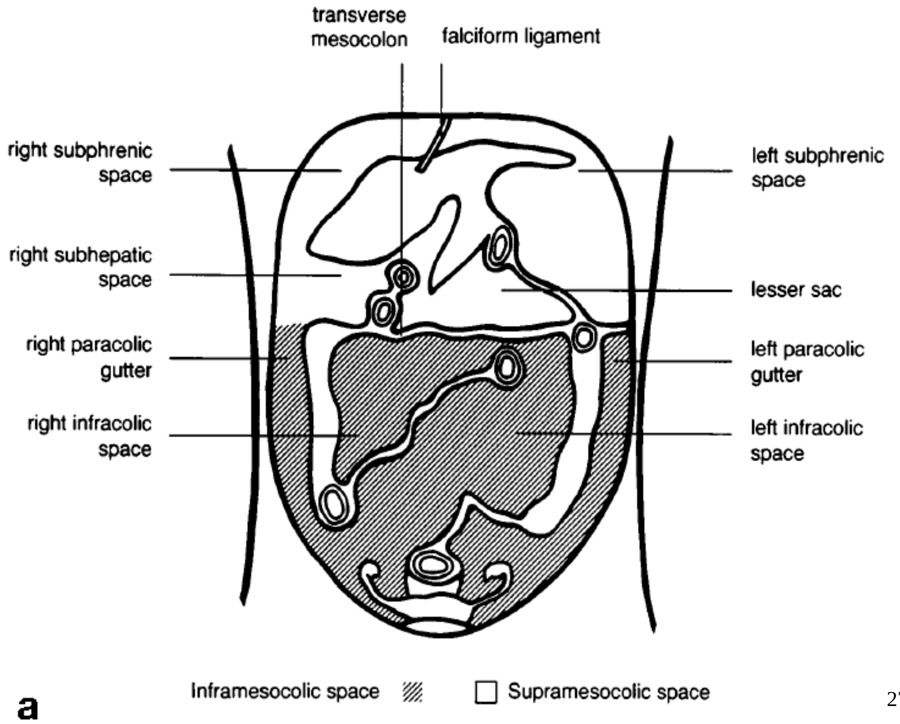
Organ	Associated Peritoneum
Urinary bladder	Two lateral and one anterior false ligaments of the bladder; transverse folds of Waldyer, fold surrounding the urachus
Female internal reproductive organs	Broad ligament; mesovarium; ileo-ovarian ligament of Durand; genito-enteric fold of Treitz; uterolumbar ligament of Vallin; utero-sacral ligament of Douglas; genito-mesenteric fold of Reid; ligamentum infundibulum of Liepmann

5.5 The Peritoneal Cavity

The flow of the peritoneal fluid within the peritoneal cavity is governed by gravity pushing it inferiorly into dependent sites dictated by the anatomy and the negative abdominal pressure created by the pumping of the muscles of respiration.[276] Classically, the peritoneal cavity is divided into supra- and infra- mesocolic compartments by the attachment of the transverse mesocolon. See figure 17.

[276] Healy, J. C. & Reznek, R. H. (1998). The peritoneum, mesenteries and omenta: normal anatomy and pathological processes. *European Radiology, 8, p.886-900.*

Figure 17: Superior / Inferior Division of the Peritoneal Cavity

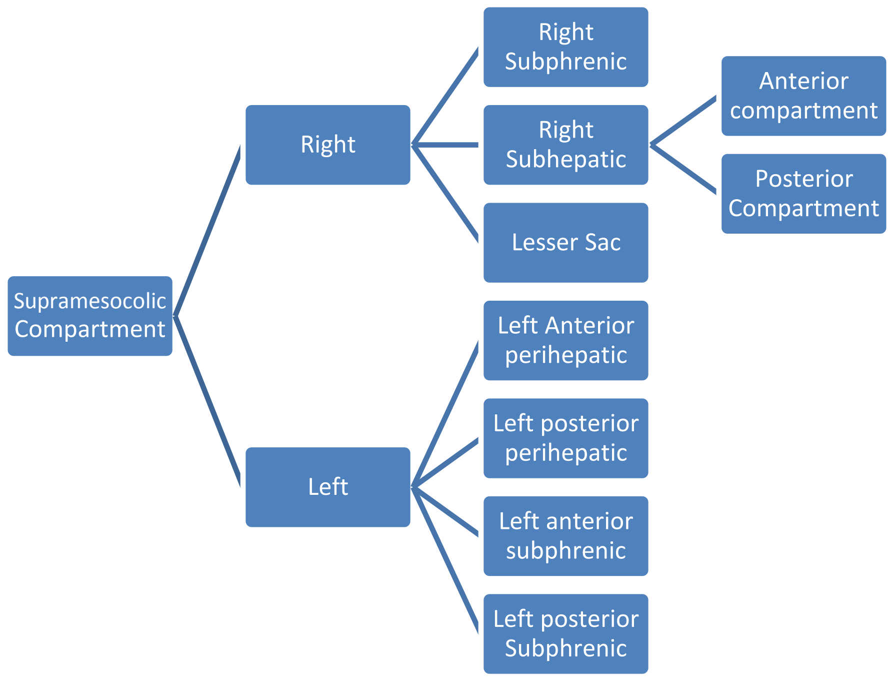


277

[277] Healy & Reznek, 1998, p.887

Chart 1 is based on Healy & Reznek[278] and offers a schematic view of the different sub compartments of the supramesocolic compartment of the peritoneal cavity.

<u>Chart 1: Subdivisions of the Supramesocolic Compartment of the Peritoneal Cavity</u>



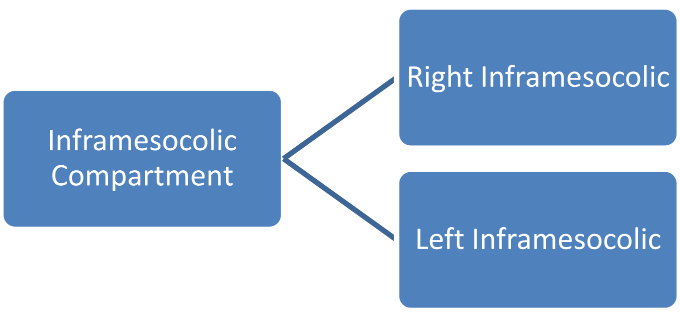
The right subphrenic space is in relation to the liver and thoracic diaphragm between the attachments of the falciform ligament medially and the right coronary ligament posteroinferiorly.[279] The anterior right subhepatic space is limited inferiorly by the transverse mesocolon; the posterior right subhepatic space, or Morrison's pouch, is extended posteriorly to the level of the right kidney.[280] The lesser sac is a placed posteriorly to the stomach between it and the pancreas. The presence of the left gastric artery raises a fold of peritoneum which divides the space into two smaller recesses.[281] This is the gastro-pancreatic ligament of Huschke.

[278] Healy & Reznek, 1998
[279] Healy & Reznek, 1998
[280] Healy & Reznek, 1998
[281] Healy & Reznek, 1998

On the left, the anterior perihepatic space is bound by the falciform ligament, surface of the liver and thoracic diaphragm; the posterior perihepatic space is the gastrohepatic recess following the inferior surface of the lateral part of the left lobe of the liver.[282] The left anterior subphrenic space is located between the stomach and the left hemi-diaphragm; the left posterior subphrenic space is in relation to the superior and inferolateral surfaces of the spleen.[283]

The inframesocolic compartment of the peritoneal cavity is displayed schematically in Chart 2 which is again based on Healy & Reznek.[284]

Chart 2: Subdivisions of the Inframesocolic Compartment of the Peritoneal Cavity



The partition that divides the right and left inframesocolic compartments is the root of the jejuno-ileum mesentery; the right compartment is the smaller of the two being bound inferiorly by the right side of the mesentery; the left is in communication with the pelvis.[285]

In addition to the various divisions of the supra- and inframesocolic compartments, the peritoneal cavity contains the right and left paracolic gutters which are located lateral to the ascending and descending colons respectively. Inferiorly the peritoneum is draped over the contents of the pelvis as was discussed in section 5.3.3 regarding the internal topographical anatomy of the peritoneum. At all times the peritoneal fluid must have the opportunity for movement between the compartments just described. It is possible to correct impairments in this

[282] Healy & Reznek, 1998
[283] Healy & Reznek, 1998
[284] Healy & Reznek, 1998
[285] Healy & Reznek, 1998

movement via manipulation provided there are not permanent long standing peritoneal adhesions blocking the passageways.

5.6 The Peritoneal Fluid

As extrapolated by data from the rat, a formula has been created to generalize the minimum amount of fluid necessary to coat the peritoneal surface; which, in a 75kg person equals 178mL.[286] Along with that average amount of peritoneal fluid is 5 to 20mL of serous exudates which depends largely on the physiologic condition of the person.[287] The amount of peritoneal fluid and exudates within the peritoneal cavity has a direct relationship with both the circulation as well as the state of inflammation.[288] The channels of movement for the fluids within the peritoneal cavity were discussed in the previous section. Suffice it to say here that without a free movement of the peritoneal fluid, the constituents of the associated exudates, which are associated with peritoneal adhesions,[289] also become stagnant, producing a form of positive feedback loop between increased inflammation and adhesion formation: inflammation causes adhesions, adhesions decrease the ability of the cells to deal with the exudate which causes more inflammation leading to increased adhesion; and the cycle continues. As with the other fluids of appreciable amount; the cerebrospinal, pleural, arterial, venous, lymphatic, pancreatic, biliary, extracellular etc., the intervention of the osteopath with physical manipulation of the fasciae makes possible the normalization of these fluids in relation to their containing tissues. The fasciae are utilized for normalization in this case as they represent a common tissue to each of these fluids.

5.7.0 The Stomach

The stomach is perhaps the most precarious organ of the abdominal cavity as it has great capability to change both its position and size depending on its contents and state of activity. The following discussion will deal in essence with the 'textbook' normal stomach; for reference to the size and shape of different types of stomachs the reader is referred first to the literature and

[286] diZerega & Rodgers, 1992
[287] diZerega & Rodgers, 1992
[288] diZerega & Rodgers, 1992
[289] diZerega & Rodgers, 1992

dissecting room, then, as always, to the clinic for palpatory experience which is worth far more than academic knowledge of the various varieties of the stomach.

5.7.1 Topographical Anatomy

The cardiac orifice of the stomach can generally be located opposite T_{11}, corresponding to the left seventh costal cartilage just over 1cm lateral to the xipho-sternal articulation, about 10cm deep.[290] The fundus of the stomach "is roughly indicated by the apex beat of the heart, above and behind which it lies".[291] This fact will come into focus below in the discussion of Traube's space. As the fundus of the stomach is in relation with the left cupola of the diaphragm it reaches as high as the fifth intercostal space in the mammary line. The pyloric orifice can be located opposite L_1 just to the right of midline in the transpyloric plane; and, if you connect the two points just described by a curved line with a left concavity, you will generally have located the position of the lesser curve of the stomach.[292] In a state of moderate distention the greater curve of the stomach intersects the left costal margin at the level of the ninth costal cartilage.[293] These generalities may or may not represent the true position of the stomach and its curves for the many intervening factors produced by life such as peristalsis, content, nervousness etc., have the ability to alter the position of the stomach. For that reason they are employed here only as a starting point or generality for the operator in their palpation; not a static impression of the location of the stomach and its openings. The operator cannot begin palpation already having predetermined exactly where they are supposed to feel for a specific organ or tissue. They must have a good general idea and confirm that educated assumption with actual palpation of the tissue or organ.

Topographically, two other aspects of the stomach must be included. Traube's space as eluded to previously, and the triangle of Labbé. Clinically Traube's space represents the most tympanic note upon percussion as the anterior surface of the stomach and thoracic wall are in close approximation. With appropriate percussion and auscultation techniques Traube's space can be used to distinguish between the three organs in the local; namely, the stomach, heart and

[290] Rawling, 1922
[291] Berry, 1906, p.105
[292] Rawling, 1922
[293] Rawling, 1922

left lung.[294] The superior limit of Traube's space can be described as an irregular line starting at the anterior extremity of the eighth costal cartilage on the left continuing obliquely superior and to the left along the anterior border of the left lobe of the liver to reach the fifth intercostal space just below the apex of the heart; then, the line continues inferiorly and to the left in conjunction with the projected inferior border of the left lung as far as the anterior axillary line before descending almost vertically along the anterior limit of the spleen to reach the eleventh rib just behind its anterior extremity.[295] To determine the lower limit of Traube's space simply connect the starting point with the ending point: the anterior end of the eighth costal cartilage on the left and the left eleventh rib just behind its anterior extremity, following the inferior edge of the costal margin.[296] This description must be qualified in the same manner as those of the topographic anatomy of the orifices of the stomach. Depending on the state of distention a sonorous sound on the left extremity of the space of Traube can be represented by the transverse colon which is in intimate relation with the stomach via the gastro-colic ligament.[297] Once again the palpating hand and not the textbook of anatomy must make the distinction between different tissues and structures.

The triangle of Labbé is another clinically relevant piece of topographical anatomy as it represents the close approximation of the anterior surface of the stomach and the anterior wall of the abdominal cavity. Its first side is represented by an oblique line travelling along the anterior border of the liver at the level of the right ninth costal cartilage to the anterior extremity of the left eighth costal cartilage. Its second side is represented by the inferior border of the costal margin on the left beginning at the eighth costal cartilage. Below, to complete the triangle, a horizontal line is drawn in the locale of the ninth costal cartilages.[298]

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[294] Poirier, P. & Charpy, A. (1901). *Traité d'anatomie humaine tome quatrième premier fascicule (2[e] Éd.).* Masson et C[ie]: Paris. Downloaded from www.archive.org.
[295] Rouvière, H. & Delmas, A. (2002). *Anatomie humaine descriptive, topographique et fonctionnelle tome 2 tronc (15[e] Éd.).* Paris: Masson.
[296] Rouvière & Delmas, 2002
[297] Rouvière & Delmas, 2002
[298] Rouvière & Delmas, 2002

5.7.2.0 Relations of the Stomach

5.7.2.1 General Remarks

The relations of the stomach will depend on the level of distention of that organ as well as the condition of the remaining organs of the abdominal cavity and possibly those of the thoracic cavity. The textbook relations of the stomach will follow.

5.7.2.2 Anterior Surface Relations

Some of the anterior relations of the stomach have been eluded to in the previous section of topographical anatomy. Superiorly and to the left, the anterior portion of the stomach is in relation with the thoracic diaphragm which intervenes between it and the parietal pleura, left lung, the fibrous pericardium and the fifth[299,300] or sixth[301] rib to the eighth[302] or ninth[303,304] rib as well as their intervening intercostal myofascia. The anterior surface of the stomach is also in relation with the digitations of the transversus abdominis and the thoracic diaphragm where they make their attachments to the deep surfaces of the corresponding ribs.[305] Moving to the extreme left of the anterior surface of the stomach where it curves around to become the posterior surface, the anterior surface of the stomach is in relation to the gastric impression of the spleen.[306]

Superiorly and to the right, the anterior surface of the stomach is in relation to the anatomical left lobe of the liver with its left triangular ligament[307] and the quadrate lobe of the liver.[308] “When the stomach is empty, the transverse colon may lie adjacent to the anterior surface.”[309] More inferiorly the stomach is in direct relation with the anterior abdominal wall, or Labbé’s triangle, which is formed in this locale by the rectus abdominis[310] with its accompanying sheath.

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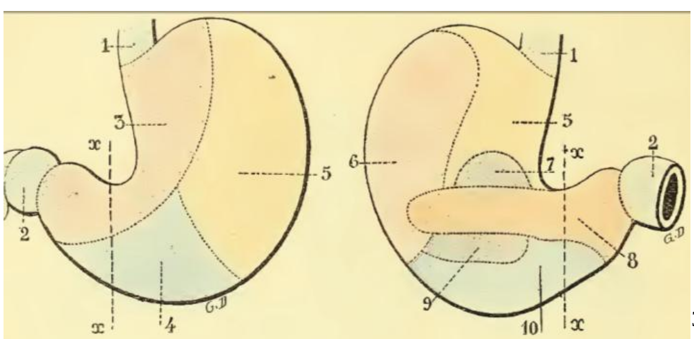
[299] Testut, 1901
[300] Bouchet & Cuilleret, 2001
[301] Standring, 2008
[302] Testut, 1901
[303] Standring, 2008
[304] Bouchet & Cuilleret, 2001
[305] Testut, 1901
[306] Standring, 2008
[307] Rouvière & Delmas, 2002
[308] Standring, 2008
[309] Standring, 2008
[310] Bouchet & Cuilleret, 2001

5.7.2.3 Posterior Surface Relations

Immediately posterior to the stomach is the lesser sac of peritoneum which intervenes between it and the relations to follow. They will arbitrarily be divided into superior, middle and inferior relations. Superiorly the posterior surface of the stomach is in relation to the spleen with its artery and vein as well as the thoracic diaphragm; inferiorly with the pancreas, the root of the transverse mesocolon and the left kidney; the middle relations of the posterior surface of the stomach are the third and fourth parts of the duodenum, the pancreas, and left suprarenal gland.[311] The gastric triangle, bordered inferiorly by the superior aspect of the pancreas, laterally by the spleen and medially by the left suprarenal gland[312] is the internal topographical location that when in the supine position marks the location of the superior pole of the kidney for which it is in relation.

Figure 18: Anterior and Posterior Relations of the Stomach according to Testut



[313]

x-x line – midline of body, 1 – esophagus, 2 – duodenum, 3 – Relation to liver, 4 – Relation to anterior abdominal wall, 5 – Relation to thoracic diaphragm, 6 – Relation to spleen, 7 – Relation to right adrenal gland, 8 – Relation to pancreas, 9 – Relation to right kidney, 10 – Relation to colon and mesocolon

5.7.2.4 Relations of the Lesser Curve

The lesser curve of the stomach is in direct relation with the lesser omentum. Bouchet & Cuilleret[314] describe the lesser omentum as comprising three continuous but distinct segments: the pars condensa, pars flaccida and pars vasculosa. These three segments of the lesser omentum are in relation to the lesser curve as follows: the pars condensa is in relation to the cardia of the stomach; the pars vasculosa is in relation to the hepatic pedicle; while the pars flaccida is situated between them.

[311] Testut, 1901
[312] Bouchet & Cuilleret, 2001
[313] Testut, 1901, p.110
[314] Bouchet & Cuilleret, 2001

5.7.2.5 Relations of the Greater Curve

Superiorly the greater curve of the stomach is fixed to the diaphragm by the gastro-phrenic ligament which links the left pillar of the thoracic diaphragm with the stomach.[315] Continuing inferiorly the greater curve of the stomach is in relation to the spleen via the gastro-splenic ligament and its associated vessels.[316] Finally, the greater curve of the stomach is in relation with the transverse colon via the gastro-colic ligament which will become part of the greater omentum.[317]

5.7.2.6 Relations of the Entrance of the Stomach

The relations to the entrance of the stomach must be modified to include the relations of the final part of the thoracic esophagus and the short abdominal esophagus as the integrity of this whole unit will directly influence the gastroesophageal junction. Another example of a fuzzy boundary is seen; this time in relation to the thoracic and abdominal cavities. As the esophagus travels through the thoracic diaphragm it is engulfed by the fibrous sheath of Treitz and Leimer which can be looked at as being two cones: the bases of each connect to the esophagus while the apices attach to the thoracic diaphragm and parietal peritoneum of their respective sides.[318] Two bilaterally placed muscles intervene between the fibrous sheath of Treitz and Leimer: these are the muscles of Rouget and Juvara. The muscle of Juvara is in relation to the superior part of the cone attaching it to the thoracic diaphragm while the muscle of Rouget is in relation to the inferior part of the cone.[319] See figure 19.

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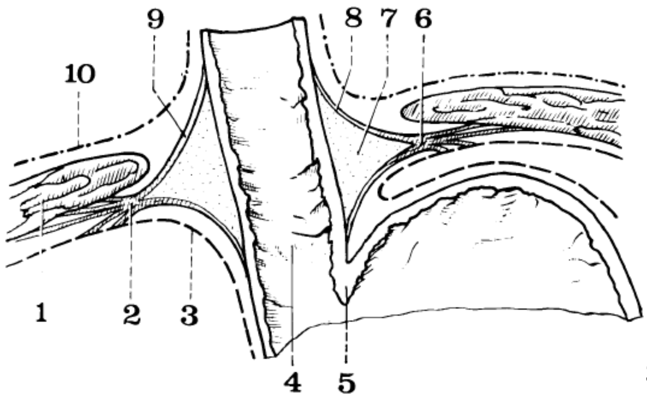
[315] Bouchet & Cuilleret, 2001
[316] Bouchet & Cuilleret, 2001
[317] Bouchet & Cuilleret, 2001
[318] Bouchet & Cuilleret, 2001
[319] Bouchet & Cuilleret, 2001

Figure 19: The muscles of Rouget and Juvara and the sheath of Treitz and Leimer



2 – Right muscles of Rouget and Juvara, 3 – Peritoneum, 6 – Left muscles of Rouget and Juvara, 8 – Left sheath of Treitz and Leimer, 9 – Right sheath of Treitz and Leimer

[320]

The gastroesophageal junction is in relation to the fundus of the stomach on the left with the angle of His intervening.[321] The continuity of the gastro-phrenic ligament to the right encompasses the abdominal part of the esophagus and is here named the esophago-phrenic ligament.[322]

5.7.2.7.0 Relations of the Exit of the Stomach

Technically the exit of the stomach corresponds to its junction with the duodenum. The location of this orifice has been stated previously at of the level of L_1 just to the right of midline within the transpyloric plane. As this specificity does not allow for an appreciable awareness of its relations due to its small size, a piece of the first part of the duodenum as well as a piece of the last part of the pyloric canal are included in the description to follow. The relations of the exit of the stomach can be arbitrarily divided into superior, inferior, anterior and posterior. As always, in life the parts are always moving, making for a less than perfect description than the one to follow.

5.7.2.7.1 Superior and Inferior Relations

The superior relation of the exit of the stomach is the pars flaccida of the lesser omentum with its contained neurovasculature.[323] The inferior relations of the exit of the stomach are the

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[320] Bouchet & Cuilleret, 2001, p.1907
[321] Bouchet & Cuilleret, 2001
[322] Bouchet & Cuilleret, 2001
[323] Bouchet & Cuilleret, 2001

head of the pancreas,[324] the far right extremity of the gastro-colic ligament with its contained neurovasculature[325] as well as regional lymph nodes.[326]

5.7.2.7.2 Anterior and Posterior Relations

The anterior relations of the exit of the stomach are the quadrate lobe of the liver, the neck of the gallbladder to the right and the transverse colon inferiorly.[327] Posterior to the exit of the stomach are the portal vein, hepatic artery[328] and pancreas; the right extremity of the lesser omentum intervening[329]

5.7.3.0 Locating the Stomach in the Decubitus Position

5.7.3.1 General Remarks

Many things can be inferred from plain site regarding the abdominal cavity and its contents provided a good working knowledge of both the container and its contents is attained. For example, it is possible to observe peristaltic movements of the stomach without contacting it, these movements being confirmed as being the stomach via percussion, auscultation and palpation. When endeavouring to locate and palpate the living stomach the operator must be aware of its surrounding visceral and skeletal relationships as well as its relationships with its omental partners: the transverse colon and liver.

The transverse colon always descends with the stomach, and is to be found along its inferior border no matter how low that border may be. The converse is by no means always the case, for the stomach may be normal in position, while the transverse colon forms a great downward loop with its hepatic and splenic ends attached in their normal positions in right and left hypochondria.[330]

The position of the stomach may also be influenced by its other omental partner, the liver, and this influence may be via the contiguous relations of the two organs or the continuous relations of them through the lesser omentum.

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[324] Testut, 1901
[325] Bouchet & Cuilleret, 2001
[326] Rouvière & Delmas, 2002
[327] Bouchet & Cuilleret, 2001
[328] Testut, 1901
[329] Rouvière & Delmas, 2002
[330] Russell, W. (1921). *The stomach and abdomen from the physician's standpoint.* William Wood and Company: Great Britain. Downloaded from www.archive.org, p.70

5.7.3.2 Percussion and Auscultation

With the above mentioned topographical anatomy it is possible to explore the initial palpation of the stomach. Percussion of the stomach is aimed initially at Traube's space. From there, under ideal conditions, the remainder of the stomach can be traced out with percussion.[331] Using the boundaries of Traube's space as stated above, the fundus of the stomach, via its tympanic resonance, can be located with simple percussion with more or less certainty. Auscultation can be used to locate the tympanic part of the stomach by scratching the surface of the abdomen with a finger while listening to the change in intensity of the scratching sound; which, will decrease as the distance from the tympanic part increases.[332] It is possible with this technique in conjunction with percussion to accurately discern the boundaries between the contiguities of the heart, left lung and stomach. In general, "the point which has to be realized is that tympanicity means that the air-containing part of the stomach is in contact with the parietes, while the airless stomach, or the full portion of the viscus, does not give either the tympanic note or the auscultatory phenomena mentioned."[333]

5.7.3.3 Splashing

Splashing is a useful technique in locating the stomach in general and can always be elicited in a dilatation as well as ptosis.[334] This technique can be applied by eliciting a splashing sound of the contents of the stomach via a recoil or tapping with the fingers; and, as with percussion, depends on their being contact between the stomach and parietes, with an appropriate air/fluid relationship.[335]

5.7.3.4 Succession in an Enlarged Stomach

The term 'right border' of the stomach was developed after "it was repeatedly noted at operations…that the dilated organ was carried or thrown to the right while the pylorus remained in its normal position; the result was that… this portion of the stomach, had to be drawn

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331 Russell, 1921
332 Russell, 1921
333 Russell, 1921
334 Russell, 1921
335 Russell, 1921

aside…to expose the pylorus."[336] In the case of an enlarged stomach it is possible to create a succession wave provided the correct manipulation is applied in a latero-lateral or cephalo-caudal direction and there is sufficient air and fluid within the stomach.[337] Using a bimanual palpation the contents of the stomach can be thrown about within the stomach. The succession wave that can be heard can be used to accurately outline the lesser curve of the stomach, the fundus as well as the right border.[338] In cases where a succession wave is thought to have been heard, but question remains, auscultation can be added to enhance the sensorial experience.[339] It is also important to note that in the absence of a succession wave, or when it is confined only to the fundus of the stomach, there is not an enlargement of that organ.

5.8.0 The Small Intestine

The sections dealing with the remainder of the gastrointestinal system proper, the small and large intestine, will not include details on locating them. Their state of distention, sheer length and mobility as well as smaller diameter necessitates the basis for the process of locating them by topographic estimation combined with auscultation and palpation.

5.8.1.0 The Duodenum

5.8.1.1 General Remarks

The duodenum represents the initial part of the small bowel differing from its caudal neighbor in that it is connected with the hepatobiliary and pancreatic ductal systems; the main connection being at the Sphincter of Oddi within the ampulla of Vater. The duodenum varies in its disposition but in general appears 'C' shaped with concavity facing left. The position of the pyloric end of the stomach and the duodenojejunal flexure are reasonably constant in their positions with the duodenum lying between them.[340]

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[336] Russell, 1921, p. 73
[337] Russell, 1921
[338] Russell, 1921
[339] Russell, 1921
[340] Rawling, 1922

5.8.1.2 Topographical Anatomy

The first part of the duodenum corresponds to the position of the pyloric orifice of the stomach: L_1, slightly to the right of midline. The final part of the duodenum corresponds to the duodenojejunal flexure. The flexure marking this junction is located at the inferior border of L_1 2.5cm to the left of midline.[341] The duodenojejunal flexure can be mapped on the surface as a point one inch [2.54cm] to the left of midline in the transpyloric plane.[342] The lowest part of the duodenum, its transverse or third part, is located on a level corresponding to L_3.[343]

5.8.1.3.0 Relations of the Duodenum

5.8.1.3.1 First Part

The most cephalic part of the duodenum is at first intra-peritoneal, only to become secondarily retroperitoneal a short distance later. Anteriorly it is in relation to the visceral surface of the liver and the body of the gallbladder; posteriorly it is in relation to the neck of the pancreas and the hepatic pedicle[344] and right gastro-epiploic artery.[345] The first part of the duodenum is in relation superiorly with the liver at the right edge of its hilum,[346] as well as the gastro-hepatic ligament;[347] while, inferiorly it is in relation to the neck of the pancreas[348] and the far right edge of the greater omentum.[349]

5.8.1.3.2 Second Part

Anteriorly the second part of the duodenum is in relation to the right extremity of the transverse colon, the small intestine,[350] as well as the right colic vessels and fundus of the

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[341] Meyers, M. A. (2006a). The duodenocolic relationships: normal and pathologic anatomy. In: Meyers, M. A. (Ed.). (2006). *Dynamic radiology of the abdomen normal and pathologic anatomy (5th Ed.)* Springer: doi: 10.1007/0-387-21804-1.
[342] Berry, 1906
[343] Standring, 2005
[344] Todd, T. W. (1915). *The clinical anatomy of the gastro-intestinal tract*. Manchester: Longmans, Green & Co. Downloaded from www.archive.org.
[345] Testut, 1901
[346] Todd, 1915
[347] Testut, 1901
[348] Todd, 1915
[349] Testut, 1901
[350] Testut, 1901

gallbladder.[351] Posteriorly it is in relation to the renal and genital vessels, the right kidney with its pelvis and ureter, the psoas major and quadratus lumborum muscles,[352] and the inferior vena cava.[353] The second part of the duodenum is in relation on the right with the right lobe of the liver, the ascending colon and the right kidney;[354] while, to the left is the greater curvature of the stomach and the pyloric canal, the head of the pancreas, common bile and pancreatic ducts, inferior vena cava and the vertebral bodies.[355]

5.8.1.3.3 Third Part

The superior relation of the third part of the duodenum is the head of the pancreas[356] with its inferior relation being the small intestine.[357] The anterior relations are the root of the jejuno-ileum mesentery with the superior mesenteric vessels, the small intestine, pyloric vestibule[358] and the parietal peritoneum lining the posterior wall of the abdominal cavity.[359] Posteriorly are the psoas major muscle,[360] inferior vena cava, abdominal aorta, and the origin of the inferior mesenteric artery.[361]

5.8.1.3.4 Fourth Part

The last part of the duodenum is in relation anteriorly with the pyloric vestibule, the small intestine[362] and transverse mesocolon.[363] Posteriorly it is in relation with the left renal and genital vessels, left crus of the thoracic diaphragm and left psoas major muscle although the left ureter intervenes between the latter two relations.[364]

To the right of the fourth part of the duodenum are the abdominal aorta, root of the jejuno-ileum mesentery and head of the pancreas; while to the left are the left kidney, left colic

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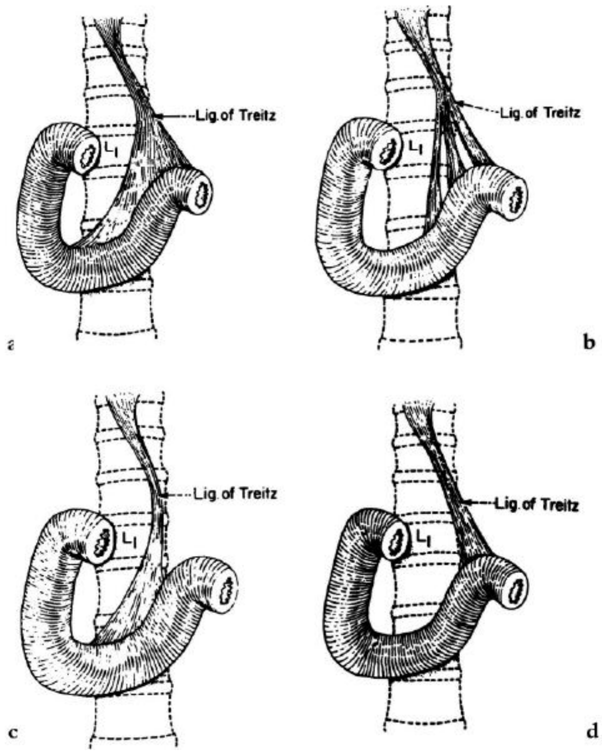
351 Todd, 1915
352 Todd, 1915
353 Testut, 1901
354 Testut, 1901
355 Todd, 1915
356 Todd, 1915
357 Testut, 1901
358 Todd, 1915
359 Testut, 1901
360 Testut, 1901
361 Todd, 1915
362 Todd, 1915
363 Testut, 1901
364 Todd, 1915

artery and inferior mesenteric vein.[365] The left relation of the fourth part of the duodenum deserves greater attention for it does not have a truly contiguous relation with the left kidney.[366] The presence of the duodenal fossae is the reason of the lack of true contiguity. These fossae are considered in section 5.8.1.3.5.

The final relation of the duodenum deserving attention is the muscle/ligament of Treitz. Treitz first described this structure in 1853 "as a thin triangular band ascending behind the pancreas to blend with the dense connective tissue around the stems of the superior mesenteric artery and celiac axis."[367] The textbook definition of the muscle/ligament of Treitz has it attaching to the duodenojejunal junction, but in reality it is often attached to both the third and fourth parts of the duodenum as well.[368] Figure 20 offers four variations of the architecture of the muscle/ligament of Treitz.

[365] Todd, 1915
[366] Testut, 1901
[367] Meyers, 2006a
[368] Meyers, 2006a

Figure 20: Variations of the Muscle / Ligament of Treitz



[369]

This link has obvious implications osteopathically as a mechanical connection between the celiac plexus of nerves and blood supply to the foregut with the fourth part of the duodenum and duodeno-jejunal junction. As was seen in the embryology section this structure also played a role in holding the duodenum posteriorly during the explosive growth of the primary intestinal loop making this link ontologically primitive.

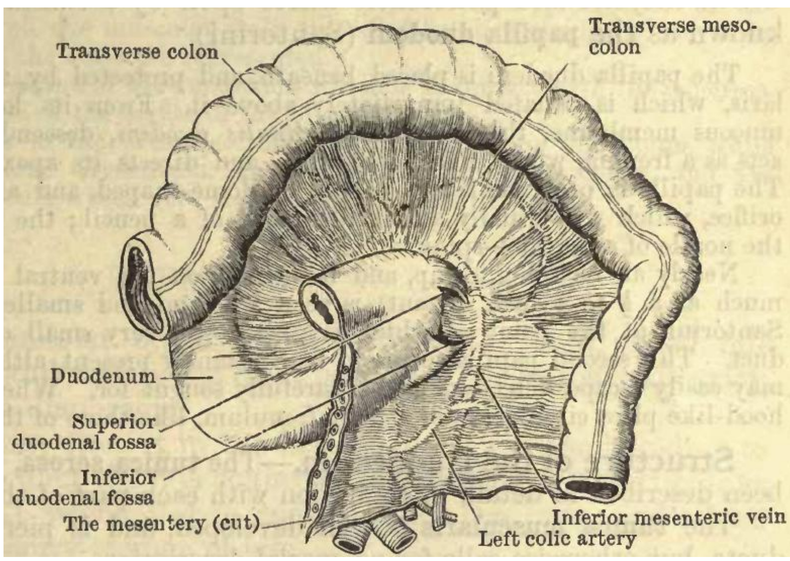
5.8.1.3.5 The Duodenojejunal Fossae

There is potential for several pockets of peritoneum to be formed in the locale of the duodenojejunal flexure. The five classically named fossae are the: inferior and superior duodenal, mesocolic, paraduodenal, and retroduodenal.[370] The inferior fossa is created by an avascular fold of peritoneum from the left aspect of the fourth part of the duodenum to the posterior abdominal wall; the superior, which commonly adjoins the inferior, passes from the

[369] Meyers, 2006a, p.543
[370] Piersol, 1913

duodenojejunal flexure to the posterior abdominal wall on the left.[371] In the free edge of this fold creating the superior recess is commonly found the inferior mesenteric vein and, when combined with the inferior fossa includes a branch of the left colic artery.[372] This configuration is known as the vascular arch of Treitz.[373,374] The mesocolic fossa sits atop the duodenojejunal flexure beneath a fold of peritoneum derived from the posterior layer of the transverse mesocolon and may contain the inferior mesenteric vein.[375] The paraduodenal fossa is formed by the superior branch of the left colic artery as it creates a fold in the posterior parietal peritoneum.[376] The final fossa, the retroduodenal, is an uncommon pouch extending under the third and fourth parts of the duodenum.[377] The general locale of the duodenojejunal fossae is displayed in figure 21.

Figure 21: Locale of the Duodenojejunal Fossae



[378]

The potential for internal herniation into any of these fossae is present, but not a common occurrence. Osteopathically these fossae are important because without a free movement of this part of the small intestine, both the contents of the intestine as well as the fluids of the peritoneal cavity may be hindered in their responsibilities. It is also feasible for large enough restrictions in

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[371] Piersol, 1913
[372] Piersol, 1913
[373] Todd, 1915
[374] Testut, 1901
[375] Piersol, 1913
[376] Piersol, 1913
[377] Piersol, 1913
[378] Robinson, A. (Ed.). (1918). *Cunningham's text-book of anatomy (5th Ed.).* William Wood and Company: New York. Downloaded from www.archive.org., p.1185

this area to have an effect on the drainage of both the biliary and pancreatic ductal systems into the second part of the duodenum via abnormal fascial tensions transmitted through the musculature of the duodenum wall.

5.8.2.0 The Jejunum and Ileum

5.8.2.1 General remarks and Topographical Anatomy

The jejuno-ileum represents the remainder of the small intestine distal to the duodenum and now, having returned to an intraperitoneal position is becoming more refined towards its duties of storage, digestion and absorption. The topography of the jejuno-ileum is extremely variable on account of its mobile nature. It can be summarized as either occupying or potentially occupying every abdominal region below the level of the subcostal plane.

A general disposition of limited value is as such:

usually the upper part of the jejunum lies in the left hypochondrium, the lower jejunum and upper ileum to the right of the median line under the liver, the succeeding portion of ileum to the left of the median line in the lumbar and iliac regions and the terminal portion in the pelvis and right iliac fossa.[379]

The disposition in the infant of the jejuno-ileum can be said to be relatively consistent with the description above with the jejuno-ileum mesentery being arranged as follows: the "upper two-fifths…arranged in transverse folds…the middle fifth…without definite arrangement; the last two-fifths…disposed in the main vertically."[380] While this disposition is extremely variable, especially with the passage of time and the associated movement of the small intestine, it is at least a good starting point for the palpation of the root of the jejuno-ileum mesentery. Radiologic evidence of the movement of an intubated section of the small bowel provides a better appreciation of the mobility of the jejuno-ileum as seen in figure 22 taken from Meyers.[381]

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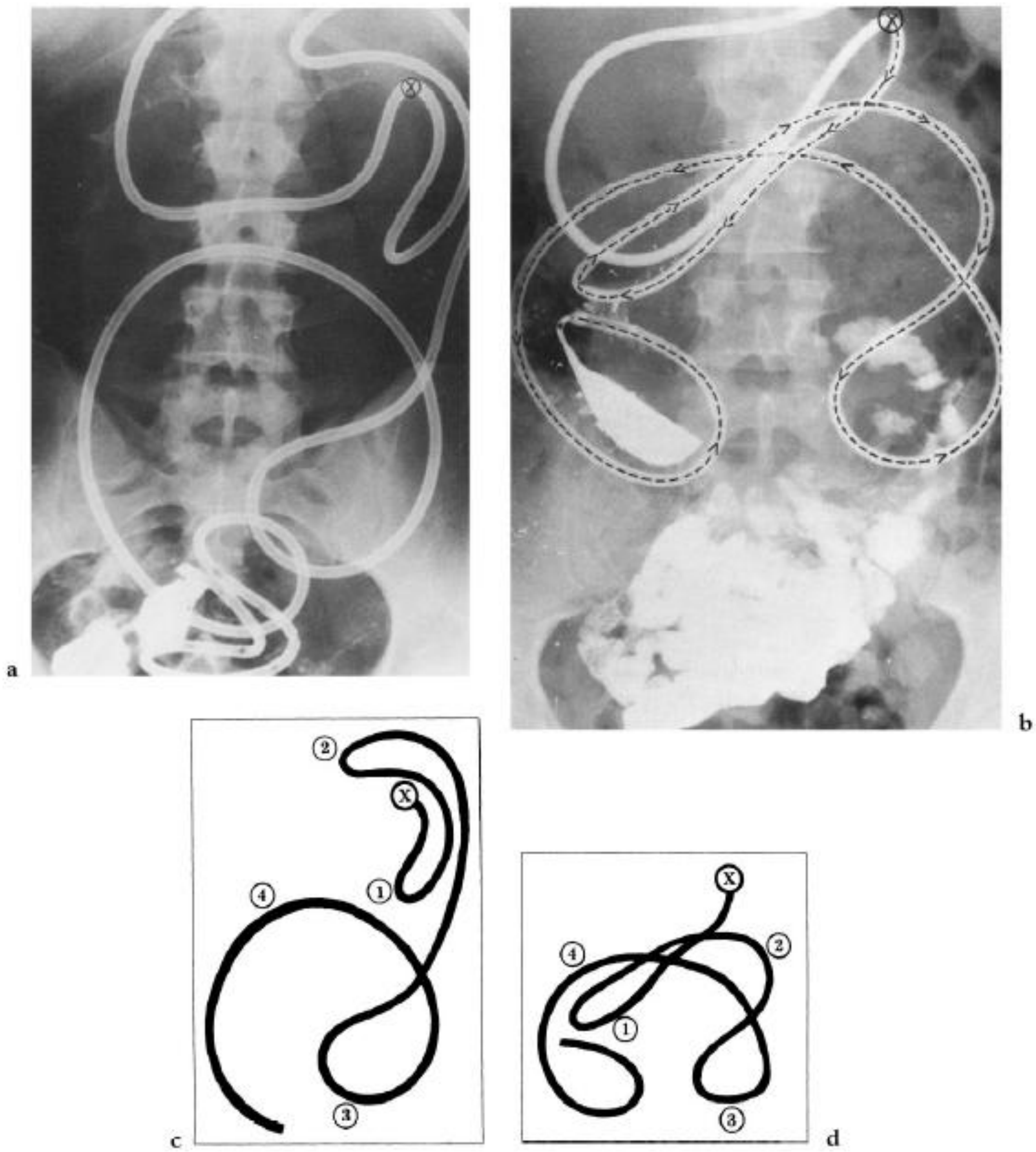
[379] Todd, 1915, p.136
[380] Piersol, 1913, p.1651
[381] Meyers, M. A. (2006c). The small bowel: normal and pathologic anatomy. In: Meyers, M. A. (Ed.). (2006). *Dynamic radiology of the abdomen normal and pathologic anatomy (5th Ed.)* Springer: doi: 10.1007/0-387-21804-1.

Figure 22: Mobility of the Loops of Small Intestine



[382]

Radiographs and tracings of intubated small intestine one day apart showing different disposition of the loops of small intestine. The duodenojejunal junction is marked by an X.

[382] Meyers, 2006c, p.641

The ileocaecal junction can be located at a point just below and to the left of the intersection of the right lateral line with the trans-tubercular line.[383]

5.8.2.2 Relations of the Jejunum and Ileum

The jejunum and ileum are in relation with the muscular walls of the abdominopelvic cavity, all of the structures of the posterior abdominal wall, boney, vascular, nervous etc, and anteriorly with the greater omentum. To the left of the jejuno-ileum are the descending and sigmoid colons; the caecum and ascending colon are in relation to the right. Superiorly the transverse colon with its mesocolon are in relation to the jejuno-ileum. The rectum, urinary bladder and internal genital organs of the female are in relation to the jejuno-ileum inferiorly. With these extensive relations in mind the global ramifications of fluidic or mechanical dysfunction become increasingly apparent.

5.9.0 The Large Intestine

5.9.1 General Remarks

The large intestine includes the caecum, ascending, transverse, descending and sigmoid colons moving into the rectum and anal canal. The main functions of this part of the bowel are water collection, storage and preparation for elimination.

5.9.2 The System of Taeniae Coli

The three longitudinal bands of muscle starting at the base of the vermiform appendix are known as the taeniae coli and are responsible for the generation of the colonic haustrations. The location of the taeniae coli is relatively constant and indicated by their names; taenia libera, taenia omentalis and taenia mesocolica, which are located on the anti-mesenteric, posterolateral and posteromedial borders of the ascending and descending colons respectively.[384] With the relatively free nature of the transverse colon "the taenia are rotated through 90° - anterior being inferior, posteromedial being posterior and posterolateral being superior."[385] The minute connections of the three taeniae to the circular layer of musculature of the colon is well

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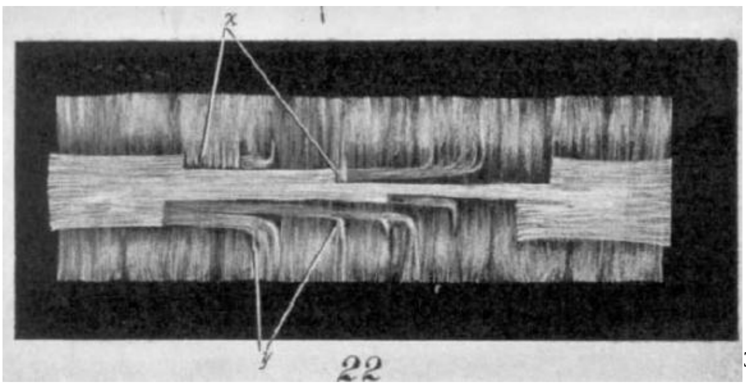
[383] Berry, 1906
[384] Standring, 2005
[385] Standring, 2005, p.1178

illustrated in figure 23 making obvious the mechanical connection between them. Some disturbances of colonic function may potentially have a mechanical cause rooted in the connection of the taeniae to the circular smooth muscle of the colon wall.

Figure 23: Connections of the Taeniae Coli and Circular Layer of Musculature of the Colon



[386]

Portion of a taenia dissected, showing the intermingling of the two layers of muscle fibres.

x – circular fibres entering the taenia and interdigitating with the longitudinal fibers at right angles

y – longitudinal fibers turning sharply and becoming circular

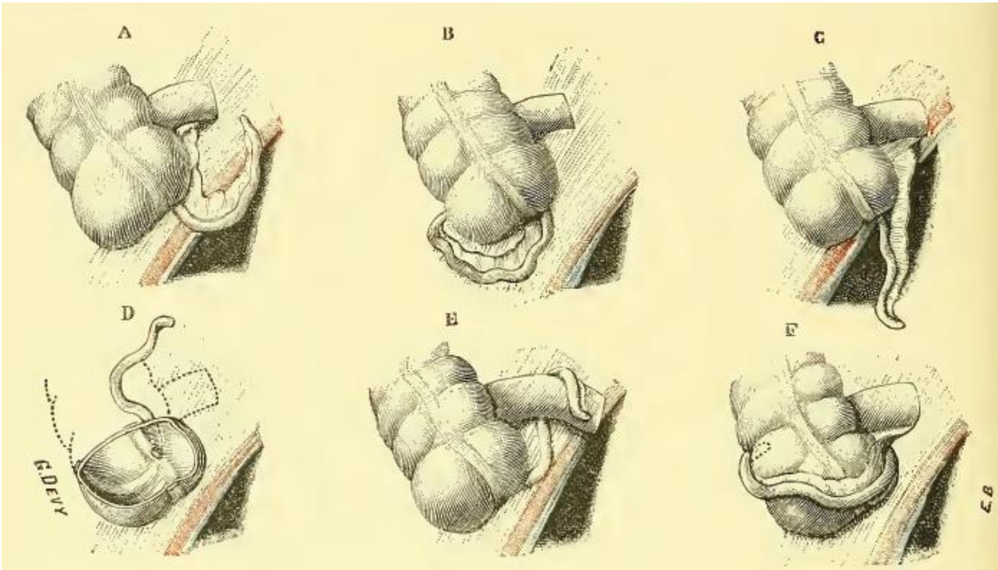
5.9.3.0 Caecum, Vermiform Appendix and Ascending Colon

5.9.3.1 General Remarks

The junction of the small and large divisions of the intestine occurs at the caecum. It marks the inferior most part of the ascending colon connecting to ileum which deposits its contents into it. The vermiform appendix dangles from the caecum, either to the front, back or side depending on the fixation of the caecum. See figure 24.

[386] Lineback, P. E. (1925). Studies on the musculature of the human colon, with special reference to the taeniae. *American Journal of Anatomy, 36, p.357-383.* doi: 10.1001/aja.1000360207. p.381

Figure 24: Variations of Vermiform Appendix Position



[387]

5.9.3.2 Topographical Anatomy

Typically the caecum occupies the right iliac fossa below the level of the plane of the top of the iliac crests. More frequent in the very young the caecum is seen as high as being in contact with the liver; in the very aged it may be as low as occupying the pelvis; rarely in the left iliac fossa or umbilical regions.[388] The base of the vermiform appendix can be located not at McBurney's point,[389] but in the right lateral line at the level of the anterior superior iliac spine or just below it.[390] The ascending colon can be marked out as being lateral to the right lateral line from the level of the intertubercular plane to the superior aspect of the ninth costal cartilage on the right where it turns to the left at the hepatic flexure.[391]

[387] Testut, 1901, p.192
[388] Bouchet & Cuilleret, 2001
[389] Rawling, 1922
[390] Berry, 1906
[391] Rawling, 1922

5.9.3.3.0 Relations of the Caecum, Vermiform Appendix, Ascending Colon and Hepatic Angle

5.9.3.3.1 Caecum and Vermiform Appendix

Anteriorly the caecum is in relation to the anterior abdominal wall and depending on the distention of the surrounding small intestine, loops from that structure may intervene between the anterior face of the caecum and the anterior abdominal wall.[392] Posteriorly the caecum is in relation with the iliopsoas. More specifically the posterior face of the caecum is in relation to the posterior parietal peritoneum, followed by the subserous plane of fascia, then the fascia iliaca with its sub-aponeurotic plane of fascia.[393,394] Contained in the subserous layer in this relation are the external iliac vessels, spermatic vessels, genitofemoral nerve and ureter.[395] The sub-aponeurotic layer in this locale is in relation to the deep circumflex iliac artery, iliolumbar vessels, the lateral cutaneous nerve of the thigh and the femoral nerve.[396] Many links between the digestive, urogenital and somatic systems are present within the fascial planes relating to the caecum.

The external border of the caecum is in relation above with the abdominal wall musculature and right paracolic gutter; below it is in relation with the iliac canal which is covered with the fascia iliaca.[397] The internal border of the caecum is in relation below with the vermiform appendix and ileum[398] as well as the external iliac vessels.[399]

The final relation of the caecum, its inferior end, can be marked by the joining together of the three taeniae coli at the start of the vermiform appendix. Depending on the level of descent into the pelvis, if any, the inferior end of the appendix can reach the femoral canal, making a location for a potential hernia.[400]

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[392] Rouvière & Delmas, 2002
[393] Testut, 1901
[394] Bouchet & Cuilleret, 2001
[395] Bouchet & Cuilleret, 2001
[396] Bouchet & Cuilleret, 2001
[397] Bouchet & Cuilleret, 2001
[398] Bouchet & Cuilleret, 2001
[399] Rouvière & Delmas, 2002
[400] Bouchet & Cuilleret, 2001

The variable position of the vermiform appendix will naturally influence what it is in relation to. The location of its origin is relatively fixed but the location of "the distal half especially is largely a matter of chance. Moreover, the position after death is…no guide to that during life."[401] The appendix can occupy numerous locations: retrocaecal, retrocolic, pelvic, descending, subcaecal, as well as pre- and post-ileal.[402] When it reaches deep enough into the pelvis a peritoneal ligament between it and the right ovary may be formed and is known as the appendicular-ovarian ligament of Clado.[403]

5.9.3.3.2 Ascending Colon and Hepatic Angle

The ascending colon is in relation anteriorly with the abdominal musculature, loops of small intestine[404] as well as the visceral surface of the liver.[405] Posteriorly it is in relation via the transversalis fascia and right fascia of Toldt with the iliacus, psoas, and the inferior pole of the right kidney; the hepatic angle is also in relation posteriorly with the right kidney.[406] Superiorly, the hepatic angle is in relation with the tenth rib and liver anteriorly.[407]

The medial side the ascending colon is in relation with the small intestine, right colic vessels,[408] right ureter, gonadal vessels and inferior extremity of the duodenum.[409] The medial relations of the hepatic angle include the descending duodenum[410] and the inferior extremity of the right adrenal gland.[411] Laterally the ascending colon is in relation with the muscles of the anterolateral abdominal wall, the right paracolic gutter[412] and thoracic diaphragm.[413] The lateral relation of the hepatic angle is the thoracic diaphragm via the right phreno-colic ligament.[414]

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[401] Piersol, 1913, p.1664
[402] Standring, 2008
[403] Bouchet & Cuilleret, 2001
[404] Bouchet & Cuilleret, 2001
[405] Rouvière & Delmas, 2002
[406] Bouchet & Cuilleret, 2001
[407] Rouvière & Delmas, 2002
[408] Bouchet & Cuilleret, 2001
[409] Rouvière & Delmas, 2002
[410] Rouvière & Delmas, 2002
[411] Bouchet & Cuilleret, 2001
[412] Bouchet & Cuilleret, 2001
[413] Rouvière & Delmas, 2002
[414] Rouvière & Delmas, 2002

Superiorly it is in relation with the liver, while inferiorly it is in relation with the loops of the small intestine.[415]

5.9.3.4 The Ileocaecal Fossae

At the junction of the terminal portion of the ileum and the initial portion of the large intestine there are several potential peri-caecal fossae, of which, two are considered constant: the superior and inferior; while, two are considered less constant: the retrocolic and subcaecal fossae.[416] These fossae, excepting the uncommon subcaecal, are displayed in figures 25 – 27. The osteopathic importance of these potential fossae is the potential for peritoneal fluid stasis within. With lengthy stasis comes an increased potential for abnormal peritoneal adhesions that will have both a biomechanical role as well as a fluidic one on the body as a whole.

[415] Bouchet & Cuilleret, 2001
[416] Piersol, 1913

Figures 25 – 27: The Ileocaecal Fossae

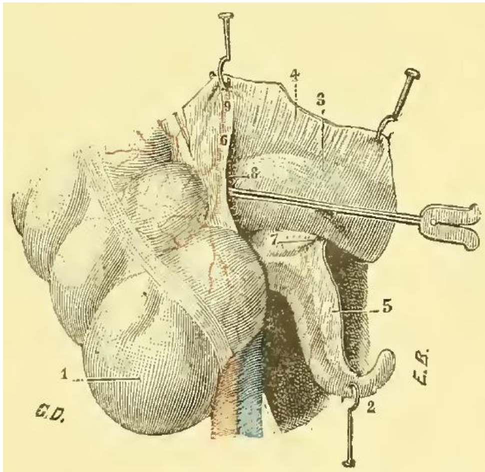

[417]

Figure 25: The Superior Ileocaecal Fossa

8 – Superior ileo-caecal fossa

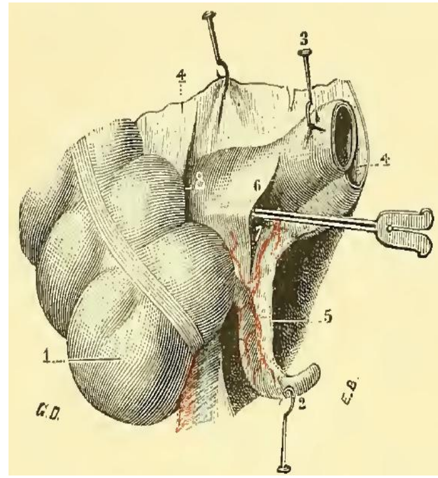
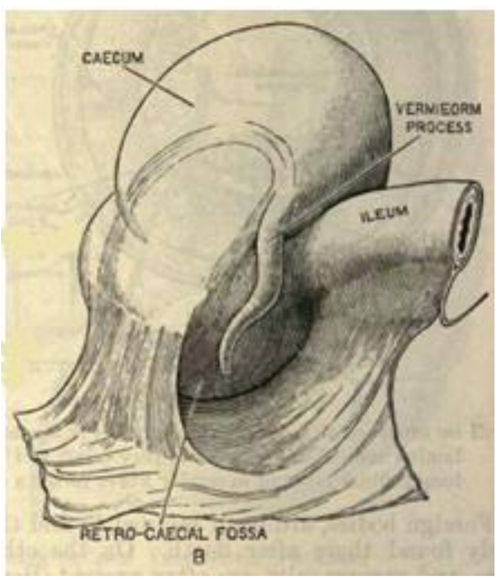

[418]

Figure 26: The Inferior Ileocaecal Fossa

7 – Inferior ileocaecal fossa



[419]

Figure 27: The Retro-caecal Fossa

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[417] Testut, 1901, p.195
[418] Testut, 1901, p.196
[419] Robinson, 1918, p.1218

The superior ileocaecal fossa is roofed by the superior ileocaecal fold of peritoneum housing the ileocolic artery and is bound inferiorly by the terminal portion of the ileum; it opens to the left but depends on the state of distention of the ileocaecal junction.[420] The inferior ileocaecal fossa is "situated in the entering angle formed by the end of the ileum joining the caecum, and is bounded on the right by the first part of the appendix. The meso-appendix shuts it in behind, and in front it is covered by the inferior ileo-caecal fold."[421]

Depending on the final disposition of the caecum the retrocolic fossa may or may not exist. When there are well developed internal and external ligaments of the first part of the large intestine, it is possible for the caecum to lift off the posterior abdominal wall; which, will exemplify the retrocolic fossa.[422] While Piersol[423] distinguishes between retrocolic and subcaecal fossae, Jackson[424] considers them synonymous terms. The subcaecal fossa, according to Piersol,[425] is a small uncommon pouch, lined by parietal peritoneum, and formed within the iliac fascia above the middle of the right iliac fossa.[426]

While not strictly an ileocaecal fossa, the retro-appendicular fossa of Hartmann is in the same locale as the ileocaecal fossae and is important osteopathically if the mobility of the fluids in the area are to be addressed. The retro-appendicular fossa of Hartmann extends between the meso-appendix and the internal parieto-colic fold and may extend well behind the terminal ileum.[427]

5.9.4.0 Transverse Colon

The transverse colon begins at the hepatic angle when it turns to the left of the body. It ends at the splenic angle when it turns to travel inferiorly towards the pelvis. The meeting point of the mid- and hind-gut territory is said to be located at a point marked by the junction of the proximal two-thirds with the distal one-third of the transverse colon.

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[420] Piersol, 1913
[421] Piersol, 1913, p.1666
[422] Piersol, 1913
[423] Piersol, 1913
[424] Jackson, C. M. (Ed.). (1914). *Morris's human anatomy a complete systematic treatise by English and American authors (5th Ed.)*. Philadelphia: P. Blakiston's Son & Co. Downloaded from www.archive.org.
[425] Piersol, 1913
[426] Piersol, 1913
[427] Hertzler, 1919

5.9.4.1 Topographical Anatomy

The hepatic flexure marking the junction of the ascending and transverse segments of the large intestine is located at the level of the ninth costal cartilage[428] in or slightly to the right of the right lateral line.[429] The splenic flexure marking the junction of the transverse and descending segments of the large intestine is at the level of the eighth costal cartilage[430] just left of the left lateral line.[431] Naturally the transverse colon is located between the hepatic and splenic flexures. Its location however is less than straightforward. A general statement regarding its location is that it passes transversely across the abdomen across the second part of the duodenum at the level of L_2.[432] "It is much more common to find the transverse colon forming V- and W-shaped loops which occupy very different regions of the abdomen."[433] With the relations of the transverse colon known its palpation, percussion and auscultation become the most useful tools in locating it.

5.9.4.2.0 Relations of the Transverse Colon

The relations of the transverse colon are classically divided into right and left halves with the transition point being the line of intersection with the superior mesenteric vessels. The former is termed the sub-hepatic or fixed portion of the transverse colon, while the latter is termed the mobile portion of the transverse colon.[434]

5.9.4.2.1 Fixed Portion of the Transverse Colon

The fixed portion of the transverse colon is in relation anteriorly with the anterior abdominal wall separated by the greater omentum[435] as well as the liver.[436] Posteriorly it is in relation with the internal border of the right kidney and renal pelvis laterally; and the head of the pancreas and descending duodenum medially.[437] Superiorly the fixed portion of the transverse

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[428] Rawling, 1922
[429] Berry, 1906
[430] Rawling, 1922
[431] Berry, 1906
[432] Rawling, 1922
[433] Berry, 1906, p.112
[434] Bouchet & Cuilleret, 2001
[435] Bouchet & Cuilleret, 2001
[436] Rouvière & Delmas, 2002
[437] Bouchet & Cuilleret, 2001

colon is in relation with the fundus of the gallbladder[438] and visceral surface of the liver; inferiorly it is in relation with loops of the small intestine.[439]

5.9.4.2.2 Mobile Portion of the Transverse Colon and Splenic Angle

The mobile portion of the transverse colon is in relation anteriorly with the anterior abdominal wall; posteriorly it is in relation to the superior pole of the left kidney, and, due to its long mesocolon is separated near the midline from the body of the pancreas to which it is attached.[440] Superiorly the mobile portion of the transverse colon is in relation to the greater curve of the stomach medially and the posterior aspect of the body/fundus of the stomach laterally; inferiorly it is in relation to the greater omentum and loops of the small intestine.[441]

The splenic angle of the colon is in relation anteriorly with the basal surface of the spleen and posteriorly with the left reno-parietal sinus.[442] Medially the splenic angle of the colon is in relation with the anterior face of the superior pole of the left kidney, left adrenal gland and the tail of the pancreas; laterally it is in relation with the thoracic diaphragm and costo-diaphragmatic recess.[443]

5.9.5.0 Descending and Sigmoid Colon, Rectum and Anus

5.9.5.1.0 Topographical Anatomy

5.9.5.1.1 Descending Colon

The descending colon starts at the splenic angle, the topographical anatomy of which was included with the relations of the transverse colon, and ends where it becomes continuous with the sigmoid colon at the level of the iliac crest. Throughout its extent the descending colon lies to the left of the left lateral line.[444] Posteriorly the descending colon can be mapped as "a line

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[438] Bouchet & Cuilleret, 2001
[439] Rouvière & Delmas, 2002
[440] Bouchet & Cuilleret, 2001
[441] Bouchet & Cuilleret, 2001
[442] Bouchet & Cuilleret, 2001
[443] Bouchet & Cuilleret, 2001
[444] Berry, 1906

drawn vertically upwards to the top of the last rib, from a point situated ½ inch [1.27cm] behind the mid-point along the iliac crest between the anterior and posterior superior iliac spines."[445]

5.9.5.1.2 Sigmoid Colon

The sigmoid part of the large intestine commencing at the level of the left iliac crest and ending at the level of S_3 to become the rectum "describes so varied a course that no definite detained account can be given of its surface marking."[446] The general rule is that the mesentery of the sigmoid colon begins at the level of the left iliac crest at the medial border of the psoas major muscle,[447] but it may also be bound tightly to the iliac fossa "for some distance".[448] The variations of the disposition of this part of the large intestine are many. According to Piersol[449] the most simple form is that of a loop with its proximal end bound down and its distal end freely mobile via the mesosigmoid. An 'M' form is also common for the sigmoid colon[450] with the number of variants quite extensive. Berry[451] states that the sigmoid colon can be found at the point of junction of the middle and outer thirds of a line connecting the left anterior superior iliac spine with the umbilicus; which, for the purposes of palpation can be useful as a starting point for its location.

5.9.5.1.3 Rectum and Anus

The rectum begins at the level of S_3 on the front of the sacrum and continues inferiorly following the curve of that bone as well as the coccyx to its termination at the anus. Its origin can be mapped posteriorly ½ to ¾ of an inch [1.27 – 1.9cm] below a line connecting the two posterior superior iliac spines.[452] The anus is here included for the sake of totality, but in reality does not merit a place within topographical anatomy.

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445 Rawling, 1922, p.58
446 Rawling, 1922, p.58
447 Berry, 1906
448 Piersol, 1913, p.1669
449 Piersol, 1913
450 Piersol, 1913
451 Berry, 1906
452 Rawling, 1922

5.9.5.2.0 Relations of the Descending and Sigmoid Colon, Rectum and Anus

5.9.5.2.1 Descending Colon

The descending colon is in relation anteriorly with the loops of the small intestine which separate it from the muscles of the abdominal wall except inferiorly where it is in contact with those muscles; posteriorly it is in relation to the digits of the thoracic diaphragm attaching to the last two ribs, the quadratus lumborum and the iliac canal.[453] The subperitoneal occupants of the iliac canal include the external iliac and spermatic vessels, genitofemoral nerve and ureter; while, the subaponeurotic occupants include the lateral femoral cutaneous and femoral nerves as well as the iliacus and psoas muscles.[454] Medially the descending colon is in relation to the loops of the small intestine, the greater omentum, descending mesocolon with its related vessels, the inferior pole of the left kidney, left ureter and left gonadal vessels; laterally it is in relation with the left paracolic gutter and muscles of the abdominal wall.[455]

5.9.5.2.2 Sigmoid Colon

The sigmoid colon is in relation anteriorly with the anterior abdominal wall provided there are no loops of the small intestine intervening, the urinary bladder depending on its state of distention, and the deep inguinal ring depending on the distention of the sigmoid colon itself; posteriorly the relations of the sigmoid colon are the left ala of the sacrum, left sacroiliac joint, left ureter and left gonadal vessels.[456] Superiorly the sigmoid colon is in relation to the loops of the small intestine; while, inferiorly it is in relation to a cul-de-sac of peritoneum: between the rectum and bladder in the male, the rectum and uterus in the female.[457] Laterally the secondary mesosigmoid is in relation to the left iliac vessels; medially the primary mesosigmoid is in relation to the aortic bifurcation, left common iliac vein, medial sacral artery and presacral nerves.[458]

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[453] Bouchet & Cuilleret, 2001
[454] Bouchet & Cuilleret, 2001
[455] Bouchet & Cuilleret, 2001
[456] Bouchet & Cuilleret, 2001
[457] Bouchet & Cuilleret, 2001
[458] Bouchet & Cuilleret, 2001

5.9.5.2.3 Rectum and Anus

The posterior relations of the rectum are identical in both sexes and include the sacrum and coccyx, the piriformis muscle and associated neurovasculature and fasciae.[459] In the male the rectum is in relation anteriorly with the posterior/inferior aspect of the urinary bladder with its associated appendages: the prostate, seminal vesicle and vas deferens with the recto-vesical fossa intervening.[460] In the female the rectum is in relation anteriorly with the posterior aspect of the uterus with the recto-uterine pouch of Douglas intervening; inferiorly with the vagina via the recto-vaginal septum.[461]

The lateral relations of the rectum also differ between the sexes. In the male the superior part of the lateral surface of the rectum is in relation with the pelvic colon and loops of small intestine, and, when distended can encroach laterally to be in relation with the ureters as well as the internal iliac vessels with their branches.[462] In the female the superior part of the lateral aspect of the rectum is also in relation to the locale of the ovarian fossa with its contained ovary and contiguous Fallopian tube.[463]

The inferior part of the lateral aspect of the rectum is in relation to the sheath of the internal iliac vessels which constitutes the posterior extremity of the sacro-recto-genital lamina of pelvic fascia.[464] Consequently, this part of the rectum is in relation to the hypogastric plexus of nerves, the ureter and branches of the internal iliac vessels.[465]

5.9.5.3 Sigmoid Fossa

The sigmoid fossa is constant until infancy and may disappear later in life.[466] It is located at the junction of the primary and secondary meso-sigmoid,[467] or at the level of the bifurcation of the common iliac vessels.[468] The direction of its orifice is inferior and to the left. Just as with the paraduodenal and ileocaecal fossae, it is important osteopathically to ensure there is a free

[459] Rouvière & Delmas, 2002
[460] Rouvière & Delmas, 2002
[461] Rouvière & Delmas, 2002
[462] Rouvière & Delmas, 2002
[463] Rouvière & Delmas, 2002
[464] Rouvière & Delmas, 2002
[465] Rouvière & Delmas, 2002
[466] Standring, 2008
[467] Bouchet & Cuilleret, 2001
[468] Jackson, 1914

movement of fluid in relation to the sigmoid fossa. Restrictions of peritoneal fluid flow increase inflammatory conditions and potential for adhesion formation.

5.10.0 The Liver and Gallbladder

5.10.1 General Remarks

The multitude of metabolic functions carried out by the liver is appreciable. Its companion the gallbladder is utilized as a storehouse of bile which is produced by the liver. To examine in detail the metabolic activities and then relate them to the biomechanics of both normal and abnormal conditions is far beyond the scope of this work with the exception of mentioning that there is such a relation. The academic link just mentioned may be avoided with the 'Let nature make well' dictum of the osteopathic philosophy in that, if all parts are correctly related to each other physically, there should be no possibility of physiologic disturbance.

5.10.2.0 The Liver

5.10.2.1 External Topographical Anatomy

"As the liver moves with every respiration and is further considerably altered in position by the distention or otherwise of abdominal viscera…it follows that any rules for the mapping out of the liver can only be an approximation to the truth."[469] In general the anterior border of the liver can be located by drawing an irregular line starting at a point in the left fifth intercostal space three and a half inches [8.89cm] from the midline which cuts the left costal margin at the tip of the eighth costal cartilage, and the right costal margin at the level of the ninth costal cartilage.[470] It can also be marked at a point half way between the umbilicus and xipho-sternal junction between the two points just described.[471] Following the irregular line initiated previously, the anterior border of the liver is marked continuing from the anterior border of the right ninth costal cartilage to follow the inferior edge of the costal margin, and after passing the twelfth rib ascends in the direction of the spinous process of T_{11}.[472]

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[469] Berry, 1906, p.115
[470] Rawling, 1922
[471] Rawling, 1922
[472] Rawling, 1922

The superior edge of the liver can be estimated with reasonable accuracy by drawing a line starting as before in the left fifth intercostal space three and a half inches [8.89cm] from the midline and continuing to the right, cutting the right sixth chondro-sternal joint to reach the superior border of the right fifth costal cartilage in the lateral vertical plane; the sixth in the mid-axillary line, before sweeping posteriorly immediately below the angle of the scapula in the direction of the spinous process of T_8.[473]

5.10.2.2 Internal Topographical Anatomy

The functional segments of the liver are based on the classification system of Couinaud who utilized the segmentation of the hepatic portal branches as well as the intra-parenchymal hepatic veins.[474] Three major fissures and three minor fissures are used as topography in separating the portal segments. The use of this system is primarily surgical, but offers the practicing osteopath additional palpation information that can be amplified via auscultation when manipulation of the intra-hepatic circulation is desired.

The four portal sectors, right and left medial and right and left lateral, are defined by the four main branches of the portal vein and have one of the hepatic veins separating them.[475] See figures 28 and 29.

[473] Rawling, 1922
[474] Standring, 2008
[475] Standring, 2008

Figure 28 and 29: Internal Topography of the Liver

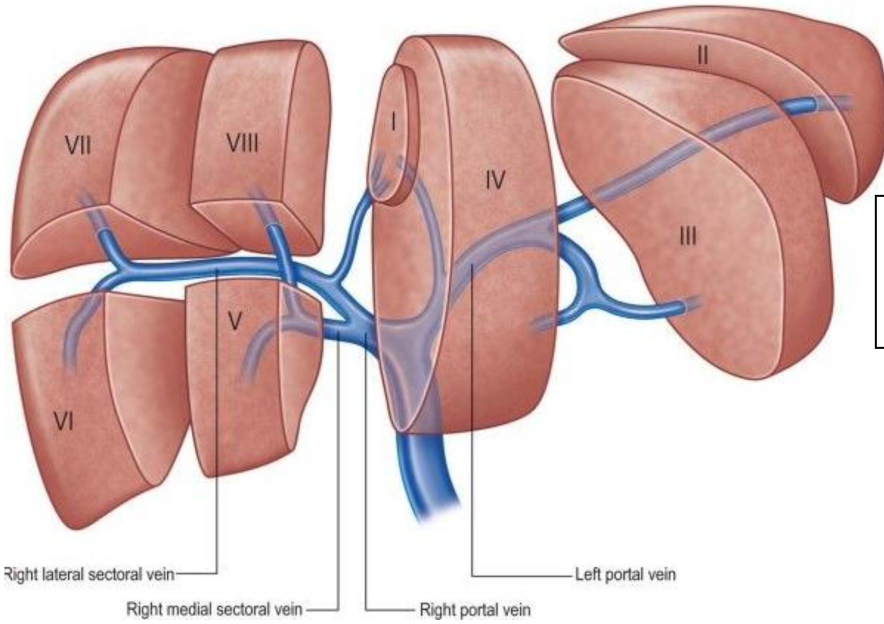

Figure 28: Sectioning of the Liver based on the Portal System

[476]

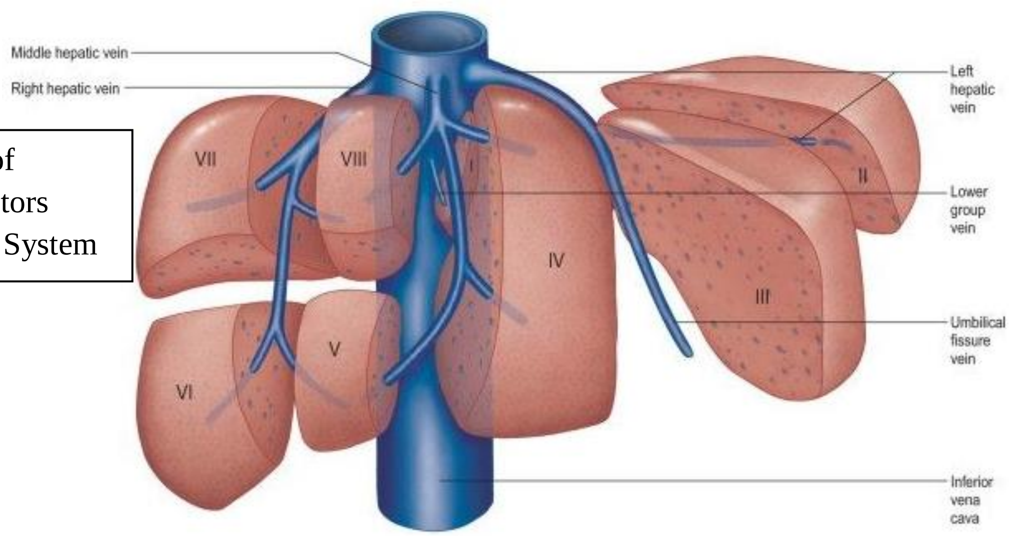

Figure 29: Relation of Hepatic Veins to Sectors created by the Portal System

[477]

The three main fissures separating the sectors and housing hepatic veins are the main portal, the left portal and right portal which contain the middle, left and right hepatic veins respectively.[478] The main portal fissure is mapped out from the tip of the gallbladder to the midpoint of the inferior vena cava; the left portal fissure by a line starting from the anterior edge of the liver

476 Standring, 2008
477 Standring, 2008
478 Standring, 2008

between the falciform and left triangular ligaments to the point marking the confluence of the left and middle hepatic veins; the right portal fissure is located on a diagonal line approximately through the anatomical right lobe from the lateral extremity of its anterior border to the confluence of the left and middle hepatic veins.[479]

The minor fissures of the liver can be seen as indentations on that organ. They are the umbilical and venous fissures as well as the fissure of Gans.[480] The umbilical fissure is located in the left anterior sector containing a significant branch of the left hepatic vein.[481] Continuing from the umbilical fissure on the underside of the liver is the venous fissure which contains the ligamentum venosum.[482] The final minor fissure, the fissure of Gans, is located on the undersurface of the anatomical right lobe of the liver behind the fossa for the gallbladder and often contains a portal pedicle to the right posterior sector.[483]

5.10.2.3.0 Relations of the Liver

5.10.2.3.1 General Remarks

To best understand the relations of the liver it is appropriate to examine cross-sectional anatomy in all three planes. Prior to reading this section it is recommended to spend some time with Appendix B – Sectional Anatomy of the Abdomen as they are suitable cross-sectional material to encompass this study. It is important also to remember the ontogeny of the organs involved as well as the paths taken by them to achieve their final destinations.

If you align paper transverse plates of the abdomen, such as those in Appendix B, in a superior to inferior arrangement and scan them as in a 'flip-book', the liver is seen to regress from view along the right of the sections as almost if it is rotating in an anticlockwise rotation. This progressive displacement of liver tissue is the result of its relation to the gastrointestinal canal; the stomach and duodenum, as well as the transverse and ascending colons with their junction the hepatic angle. The gallbladder being intimately associated with the inferior surface

[479] Standring, 2008
[480] Standring, 2008
[481] Standring, 2008
[482] Standring, 2008
[483] Standring, 2008

of the liver cannot go unnoticed. Also playing a role in this disposition are the right kidney, great abdominal vessels, thoracic diaphragm and pancreas.

If you align paper sagittal plates of the abdomen, viewing them in the same manner as the transverse sections, the liver regresses to the left and eventually disappears. The same contributing factors caused the displacement of liver tissue as listed above; they can now be appreciated in these views. Naturally this rule holds true for coronal sections of the abdomen.

5.10.2.3.2 Particulars of Liver Relations

5.10.2.3.3 Superior, Anterior, Right and Posterior Surfaces

For sake of brevity the relations of the liver will be described as having a superior and inferior surface. The superior surface is the conglomeration of the superior, anterior, and right surfaces of descriptive anatomy which form the anterior/lateral/posterior relations to the thoracic diaphragm and myofascial somatic wall. The main relation of the posterior surface of the liver is to the thoracic diaphragm on both the left and right; on the right the relation is primarily seen as the 'bare area'.[484] The Spigelian lobe is in relation with the right crus of the thoracic diaphragm; while, its papillary process is in relation to the pancreas.[485] To the left and right of Spigel's lobe the posterior surface of the liver is in relation to the fissure for the ductus venosus and inferior vena cava respectively.[486] A minor relation of the posterior surface of the liver is the right adrenal gland.[487]

5.10.2.3.4 Inferior Surface

The inferior surface of the liver, rightfully named the visceral surface, is in relation with a variety of organs and for that reason will be arbitrarily divided into left, right, and quadrate lobe relations. The relations to the left lobe form the gastric and esophageal impressions which mark the location of the anterior part of the stomach and abdominal portion of the esophagus respectively.[488] The rounded tuber omentale is seen projecting from the left lobe and is in

[484] Jackson, 1914
[485] Jackson, 1914
[486] Jackson, 1914
[487] Jackson, 1914
[488] Jackson, 1914

relation to the lesser curve of the stomach, lesser omentum and pancreas.[489] The right lobe is marked by impressions for the right kidney, descending part of the duodenum and hepatic flexure of the colon.[490] The quadrate lobe is in relation to the pylorus and first part of the duodenum.[491] Most intimately associated with the visceral surface of the liver is the gallbladder which rests in its own fossa between the quadrate lobe and duodenal/colic impressions.

5.10.2.4.0 Locating the Liver

5.10.2.4.1 General Remarks

As previously stated the combination of movement with respiration as well as the state of the other abdominal organs will determine the location of the liver and therefore must be kept in mind when attempting to locate it. Typically the error of practitioners is to underestimate the size of the organ.[492]

5.10.2.4.2 Percussion, Palpation and Auscultation

Classically the liver is located with percussion in the midclavicular line as well as the midsternal line where its spans 6 – 12cm and 4 – 8cm respectively.[493] In reality with the topographical and relational anatomy taken into consideration the liver can be percussed wherever it is so desired. Percussion is not alone sufficient to determine the extent of the size and location of the liver and must be combined with palpation and auscultation.

Palpation of the liver is classically described with the patient in the decubitus position with one hand wrapping around the lower part of the thoracic cage posteriorly and the other placed anteriorly in relation to the area of hepatic dullness. When combined with the topographical and relational anatomy, the positional possibilities for palpation of the liver are vast and can be catered to the needs of the operator.

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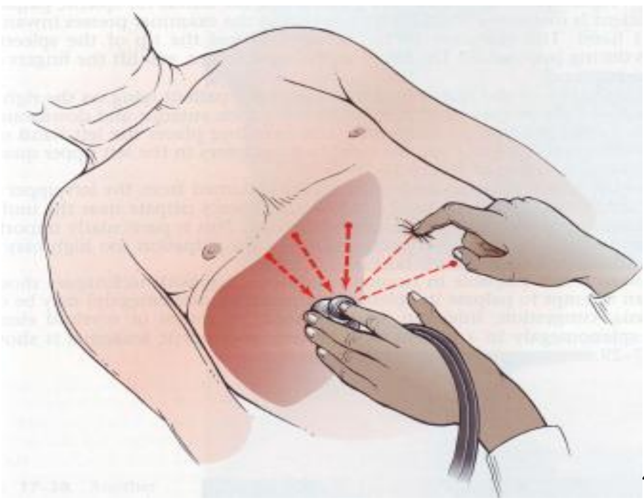
[489] Jackson, 1914
[490] Jackson, 1914
[491] Jackson, 1914
[492] Bickley, L. S. & Szilagyi, P. G. (2003). *Bates' guide to physical examination and history taking (8th Ed.)* Lippincott Williams & Wilkins: Philadelphia.
[493] Bickley & Szilagyi, 2003

Auscultation of the liver regarding the location of the anterior edge is achieved with the scratch test.[494] To perform this test the patient is in the decubitus position; the operator places the stethoscope over the liver just inferior to the costal margin and then with the other hand scratches lightly over the anterior abdominal wall in a semicircle with a constant radius from the diaphragm of the stethoscope.[495] See figure 30. As the scratching finger passes over the edge of the liver the sound will become much more intense.[496]

Figure 30: Scratch Test for locating the Liver


[497]

5.10.3.0 Gallbladder

5.10.3.1 General Remarks

The gallbladder is intimately associated with the visceral surface of the liver. It has a great capacity to move, and, depending on the state of its contents, may or may not correspond to the textbook descriptions of both topographical and relational anatomy. The gallbladder is located by means of topographical anatomy and palpation. Depending on the final development of the gallbladder it may or may not have a mesentery connecting it to the liver.

[494] Swartz, M. H. (2006). *Textbook of physical diagnosis history and examination (5th Ed.).* Saunders Elsevier: Philadelphia.
[495] Swartz, 2006
[496] Swartz, 2006
[497] Swartz, 2006, p.505

5.10.3.2 Topographical Anatomy

When the fundus of the gallbladder is distended it contacts the anterior abdominal wall in the locale of the lateral border of the rectus abdominis between the tips of the ninth and tenth right costal cartilages.[498] The common bile duct on its way to the second part of the duodenum travels as part of the hepatic pedicle in the free edge of the lesser omentum. The topographic anatomy of the lesser curve of the stomach, the pylorus, and the first three parts of the duodenum are used to map out the general position of the hepatic pedicle[499] before palpation is used to locate it with the contained common bile duct, portal vein and common hepatic artery.

5.10.3.3 Relations of the Gallbladder

The gallbladder is intimately related with the visceral surface of the liver where it rests in the fossa named after it. The inferior surface is in contact with the first part of the duodenum and transverse colon; occasionally with the pyloric end of the stomach or small intestine as well.[500]

5.11.0 The Pancreas

5.11.1 General Remarks

The pancreas is a glandular organ situated deeply within the abdominal cavity and has been called the salivary gland of the abdomen.[501] Its function is duo: it is an exocrine organ as well as an endocrine one, associated intimately with both digestive processing and the normalization of blood sugar levels. Organic lesions of the pancreas are detrimental making this organ a high priority in osteopathic manipulation to ensure no stagnation of its related fluids or undue biomechanical stresses are placed upon it.

5.11.2 Topographical Anatomy

As the head of the pancreas is surrounded by the duodenum, the topographical anatomy of that part of the intestine can be used to locate it covering the bodies of the second and upper part of third lumbar vertebrae.[502] The neck of the pancreas is located in front of the disc between

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[498] Rawling, 1922
[499] Rawling, 1922
[500] Jackson, 1914
[501] Piersol, 1913
[502] Berry, 1906

L_1 and L_2 in the transpyloric plane; while the tail reaches as far as the hilum of the spleen lying completely above the transpyloric plane and to the left of the left lateral line.[503]

5.11.3 Anterior Relations of the Pancreas

The line of attachment of the transverse mesocolon traverses the length of the pancreas and divides its relations into superior and inferior parts.[504] Superiorly the anterior surface of the pancreas is in relation with the liver, gastroduodenal, superior pancreaticoduodenal and right gastroepiploic arteries.[505] Inferior to the attachment of the transverse mesocolon the anterior surface of the pancreas decreases in size due to its oblique direction and is in relation to the transverse mesocolon, the superior aspect of the root of the jejuno-ileum mesentery as well as the superior mesenteric vessels.[506]

5.11.4 Locating the Pancreas

The pancreas is very deep and is located by palpation. Its deep position necessitates that it be approached with the greatest caution and gentleness. The adjacent neurovascular structures deserve the greatest care also. Palpation of the pancreas is achieved with some difficulty utilizing the topographical anatomy qualified by the feedback of the palpating hands and can be achieved in the decubitus or lateral decubitus positions.

5.12.0 The Spleen

5.12.1 General Remarks

The spleen holds a place of utmost importance because of its relation to blood in general, but also one of the most sacred fluids of the body: the lymphatic. Its tender glandular nature, tendency for expansion by means of increased volume of blood and intimate relation to the most distensible part of the gastrointestinal canal, the stomach, all play large roles in determining its size, form and function.

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503 Berry, 1906
504 Rouvière & Delmas, 2002
505 Rouvière & Delmas, 2002
506 Rouvière & Delmas, 2002

5.12.2 Topographical Anatomy

The spleen, located in the left hypochondrium as well as the epigastrium, is influenced by its surroundings just as the other organs of the abdominal cavity are. Generally speaking the long axis of the spleen corresponds with the posterior part of the tenth rib.[507] The span of the spleen in terms of ribs is from the superior border of the ninth to the inferior border of the eleventh.[508] The superior pole of the spleen can be marked 1.5 to 2 inches [2.81 – 5.08cm] from the spinous process of T_{10} while the inferior pole reaches the mid-axillary line.[509,510]

5.12.3.0 Relations of the Spleen

5.12.3.1 Phrenic Surface

The phrenic surface of the spleen is in relation with the thoracic diaphragm in the left hypochondrium[511] as well as the associated pneumodiaphragmatic recess and inferior part of the left lung.[512] It has been noted that in cases of an enlarged liver, that organ may also be in relation with the phrenic surface of the spleen, but this is rare.[513]

5.12.3.2 Renal Surface

The renal surface is the smallest of the three splenic surfaces and is in relation to the capsule of the adrenal gland as well as the left kidney.[514,515]

5.12.3.3 Gastric Surface

The gastric surface of the spleen contains its hilum and is for the most part moulded over the stomach.[516] The splenic flexure of the colon is in relation with the gastric surface of the

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[507] Berry, 1906
[508] Rawling, 1922
[509] Rawling, 1922
[510] Standring, 2008
[511] Piersol, 1913
[512] Testut, 1901
[513] Testut, 1901
[514] Testut, 1901
[515] Piersol, 1913
[516] Piersol, 1913

spleen inferior to its relation to the stomach; and, if the pancreas is long enough its tail is also in relation to the gastric surface of the spleen.[517]

5.12.3.4 Base of the Spleen

The base of the spleen is smaller than any of the surfaces just described and is triangular in shape.[518] Its relation is the splenic angle of the colon with the sustentaculum lienis.[519,520]

5.12.4.0 Locating the Spleen

5.12.4.1 General Remarks

The spleen is a dynamic organ whose size is directly related to its volume of blood as well as, to some extent, the relations of the contiguous viscera. When enlarged it expands anteriorly, inferiorly and medially to a point where it may replace the tympany of the stomach and colon with a dull note characteristic of a solid organ.[521]

5.12.4.2 Percussion and Palpation

Percussion of the spleen is performed respecting the topographical anatomy and its potentially increased volume of blood. Classically the spleen is percussed in the last intercostal space on the left in the midaxillary line with a tympanic note being the norm.[522] A note of dullness would indicate an enlarged organ. To determine the lower border of a spleen that is enlarged, but not palpable, the last left intercostal space is percussed during both expiration and deep inspiration.[523] In this case a dull note will be heard during the inspiration phase and will no longer be present during the expiration phase.[524] As with the percussion of the liver many positional variations may be used as long as both the topographical and relational anatomy are respected.

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[517] Piersol, 1913
[518] Piersol, 1913
[519] Testut, 1901
[520] Bouchet & Cuilleret, 2001
[521] Bickley & Szilagyi, 2003
[522] Swartz, 2006
[523] Orient, J. M. (2010). *Sapira's art & science of bedside diagnosis (4th Ed.).* Lippincott Williams & Wilkins: China.
[524] Orient, 2010

Palpation of the spleen is classically performed in the decubitus position with one hand placed posteriorly in relation to the inferior aspect of the thoracic cage and the other placed anteriorly, inferior to the left costal margin.[525] As the spleen is normally a small organ deeply situated its palpation is more difficult than a larger organ such as the liver. An alternate position for palpation of the spleen is the right lateral decubitus position with the left hand in contact with the left costal margin and the right hand contacting the left upper quadrant.[526]

5.13.0 The Kidneys

5.13.1 General Remarks

The kidneys are not strictly a topic of great focus for this discussion, but cannot be ignored in the light of complexity thinking. They are a physical part of the visceral system and interact with their intra-abdominal cousins both mechanically and physiologically. Because of their encapsulation within Gerota's fascia anteriorly and Zuckerkandl's posteriorly, the kidneys are a stable mechanical factor encroaching upon the posterior abdominal wall from their retroperitoneal location.

5.13.2 Topographical Anatomy

The superior and inferior poles of the kidneys can be mapped on the anterior surface of the body as being 1½ to 2 inches [3.81cm – 5.08cm] and 2½ to 3 inches [6.35cm – 7.62cm] from the midline respectively.[527] The hilum of the left kidney is located just inferior and medial to the junction of the transpyloric and left lateral lines or just medial to the anterior extremity of the left ninth costal cartilage.[528] The hilum of the right kidney is located "a finger's breadth internal to the tip of the ninth right costal cartilage."[529]

On the posterior surface of the body the kidneys are located within Morris's quadrilateral which is described as two vertical lines drawn one and three inches [2.54cm – 7.62cm] from the midline; and, two horizontal lines drawn at the level of the spinous processes of T_{11} and L_3.[530]

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[525] Swartz, 2006
[526] Swartz, 2006
[527] Rawling, 1922
[528] Rawling, 1922
[529] Berry, 1906, p.120
[530] Rawling, 1922

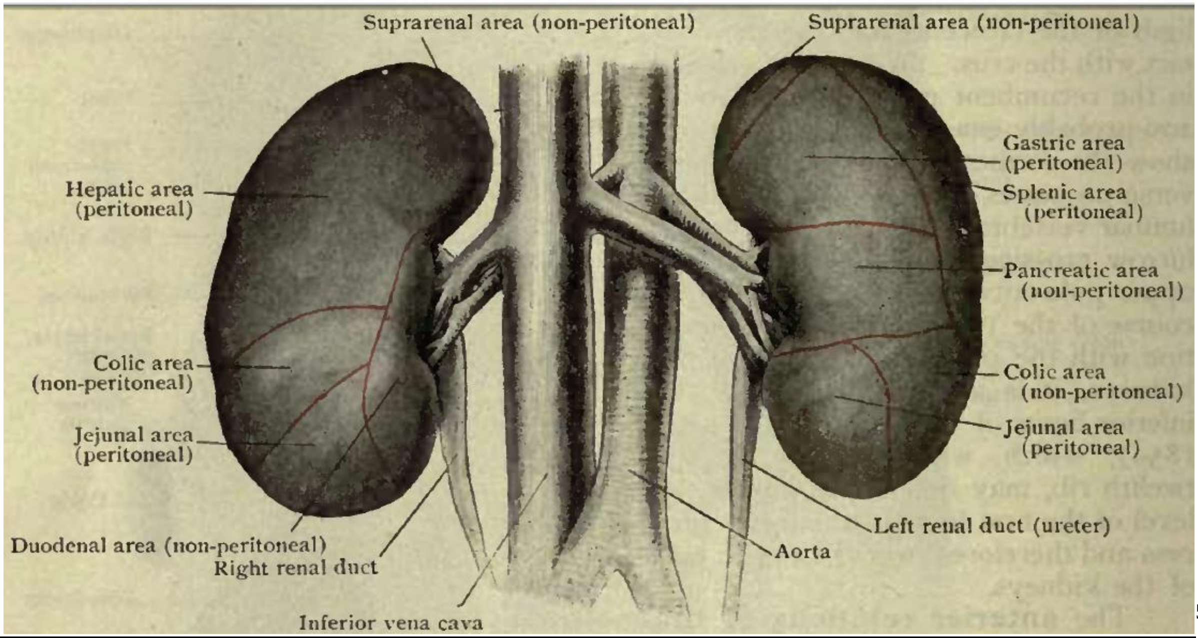
The superior pole of the right kidney is at the level of T_{11}; its inferior pole just inferior to the spinous process of L_2 approximately an inch [2.54cm] above the crest of the ilium.[531] The poles of the left kidney are on a level, on average, one half inch [1.27cm] superior to those of the right kidney.[532] The hilum of the right kidney is located at the level of the spinous process of L_1 approximately 1½ to 2 inches [3.81cm – 5.08cm] laterally; the topographic location of the hilum of the left kidney corresponds to its slightly superior location.[533]

5.13.3.0 Anterior Relations of the Kidneys

"Primarily the entire visceral surface of the kidneys are covered by serous membrane; later this investment becomes only partial, in consequence of the permanent attachment which certain organs, as the pancreas, duodenum, and colon, obtain."[534] In reality the kidneys are encapsulated in fascia only in strict relation to the perirenal fat. When the abdomen is laid open the projection of each kidney can be seen to encroach into the abdominal cavity; this outline of the kidney is what will be used in reference to the anterior relations of the kidneys. The relations of the left and right kidneys differ and as such will be discussed individually. Figure 31 displays the anterior relations of the kidneys according to Piersol.

[531] Berry, 1906
[532] Berry, 1906
[533] Berry, 1906
[534] Piersol, 1913, p.1873

Figure 31: Anterior Relations of the Kidneys according to Piersol



[535]

5.13.3.1 Right Kidney

The anterior surface of the right kidney is in relation to the right adrenal gland, inferior surface of the liver, the second part of the duodenum, hepatic flexure of the colon and usually the small intestine.[536,537] The extent of the relation of the right kidney to the liver is demonstrated by the impression seen on the back of that organ. The relation to the duodenum will depend on its location of fusion to the posterior abdominal wall; the second part is usually in relation to the hilum of the right kidney as well as the medial border of that organ, but can span from the superior to inferior poles in which case the relation will be increased or decreased respectively.[538] The relation of the hepatic angle of the colon will also vary depending on the formation of that part of the intestine, but in general it can be said that the relation is a triangular one covering the inferior and lateral third of the right kidney.[539] The relations of the anterior surface of the right kidney to the attachment of the peritoneum are displayed in figure C35.

[535] Piersol, 1913, p.
[536] Piersol, 1913
[537] Bouchet & Cuilleret, 2001
[538] Piersol, 1913
[539] Piersol, 1913

5.13.3.2 Left Kidney

The anterior surface of the left kidney is in relation to the left adrenal gland, spleen, stomach, the tail of the pancreas, splenic flexure of the colon, and the small intestine.[540,541] The adrenal gland is in relation to the superior and medial aspect of the kidney; the spleen occupying the superior two thirds of the lateral border; below the relation of the spleen is that of the splenic angle of the colon, whose relation will vary depending on the state of fixation of that part, but generally is in relation with the inferior pole of the left kidney.[542] The tail of the pancreas is in relation to the hilum of the left kidney as well as its middle third; the relation to the stomach is bordered by the relations of the splenic angle, adrenal gland and pancreas.[543] Finally, the jejunal coils are in relation to the medial part of the inferior pole of the left kidney.[544] The relations of the anterior surface of the left kidney to the attachment of the peritoneum are displayed in figure C36.

5.13.4.0 Locating the Kidneys

5.13.4.1 General Remarks

With the kidneys held firmly in place by their surrounding fascial capsule their position remains reasonably constant. With that, the embryologic ascent of the kidneys throughout their evolution is not always constant from person to person. A pelvic kidney is a possibility as can be any position moving superiorly to the position in which they normally occupy.

5.13.4.2 Percussion and Palpation

Classic percussion of the kidney is performed with a closed fist striking with the ulnar side no more than 15cm from the body as to not induce pain in normal structures.[545] As there are minimal rules *per se* with percussion techniques a more refined methodical approach can be taken respecting the topographic and relational anatomy. Palpation of the adult kidney is not usually possible in the usual sense excepting very thin people as well as the very young.

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[540] Piersol, 1913
[541] Bouchet & Cuilleret, 2001
[542] Piersol, 1913
[543] Piersol, 1913
[544] Piersol, 1913
[545] Orient, 2010

Bimanual palpation of either kidney is achieved by placing one hand posteriorly between the crest of the ilium and the costal margin with the other anteriorly just inferior to the costal margin.[546] Deep palpation is absolutely necessary which demands the patience of the operator as to not enter too deeply too quickly.

5.14.0 The Urinary Bladder

5.14.1 General Remarks

The urinary bladder occupies a place on the floor of the abdominopelvic cavity situated inferior to the peritoneal sac with its relations differing in some respects between the sexes. It is intimately connected with the back of the pubic bones and, depending on its state of distention may rise to a varying degree above the superior rami of the pubic bones and pubic symphysis. Palpation is the means used for locating the urinary bladder.

5.14.2.0 Relations of the Urinary Bladder

5.14.2.1 Undistended State in the Male

The undistended bladder can be described as having two surfaces: superior and inferior. Anteriorly the inferior border is intimately associated in the male with the pubic rami and symphysis, the prostate and pelvic floor; and, posteriorly the seminal vesicles and their ampullae.[547] Laterally the urinary bladder is separated from the lateral pelvic wall by the paravesical fossae; while, superiorly it is in relation to loops of the small intestine.[548]

5.14.2.2 Distended State in the Male

The inferior relations of the urinary bladder do not change in the distended state as they are firmly fixed to the pelvis via the pubo-prostatic and pubo-vesical ligaments.[549] As the urinary bladder starts to fill it expands both posteriorly and laterally before beginning to rise superiorly where its potential relations change. The state of distention of the rectum also is a factor in determining the relations of the distended urinary bladder. When completely distended,

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[546] Swartz, 2006
[547] Piersol, 1913
[548] Piersol, 1913
[549] Piersol, 1913

the urinary bladder becomes in temporary contact with the anterior abdominal wall above the level of the pubic symphysis.[550]

5.14.2.3 Female Urinary Bladder

The relations of the urinary bladder are similar to the male in that it is attached to the posterior pubic rami and symphysis, but in lieu of the connections to the seminal vesicles etc, it is in relation to the anterior wall of the vagina. Also, on account of the absence of the mass of the prostate, the urinary bladder in the female sits lower in the pelvis being in relation superiorly with the fundus of the uterus.[551]

5.15.0 The Uterus, Fallopian Tubes and Ovaries

5.15.1 General Remarks

The relations of the female internal organs of generation will for the most part be treated like the kidneys in that they are a mechanical influence on the state of the abdomen, but not necessarily a great focus for this discussion.

5.15.2 Relations of Uterus, Fallopian Tubes and Ovaries

The inferior part of the uterus is relatively fixed via its connections with the cervix and vagina, while its superior part is quite mobile and is directly influenced by the state of distention of the urinary bladder and rectum.[552] When both the urinary bladder and rectum are markedly distended, the uterus may by pushed up above the level of the pubic symphysis.[553] Superiorly the uterus is in relation with the loops of the small intestine.

The Fallopian tubes course in the free border of the broad ligament. They are in relation posteriorly with the posterior abdominal wall with its associated neurovascular structures and anteriorly with the loops of small intestine. The ovaries will vary in their position depending on the position of the uterus and surrounding organs[554] as well as the situation of nulli-, primi-, multi- or grand multiparity. They are typically situated in the ovarian fossa of Krause with the

[550] Piersol, 1913
[551] Piersol, 1913
[552] Piersol, 1913
[553] Piersol, 1913
[554] Piersol, 1913

broad ligament being situated anteriorly to them.[555] When there is a condition of multiparity the ovaries tend to occupy a more inferior position within the fossa of Claudius.[556]

5.16.0 The Abdominal Aorta

5.16.1 General Remarks

"I am, as I have been for fifty years, fully established in the belief that the artery is the father of the rivers of life, health, and ease, and its muddy or impure water is first in all disease."[557] To not have a free and pure movement of the circulatory system is in direct violation of one of the precepts of the osteopathic philosophy: 'the rule of supply and demand dictates'.

The tabular reference below follows the logical order of the foregut, midgut and hindgut. All of the major branches of the abdominal aorta are represented. Variants are not. This table is based on Gray[558], Piersol[559] and Rouvière and Delmas.[560] Figures of the arterial system are located in Appendix D – Neurovasculature and Lymphatics. The topographical information regarding the visceral branches is taken from Anson & McVay.[561] Caution needs to be raised regarding the fact that Anson & McVay's study was based on the cadaver, not the living. Table 5 displays nicely their collected data.

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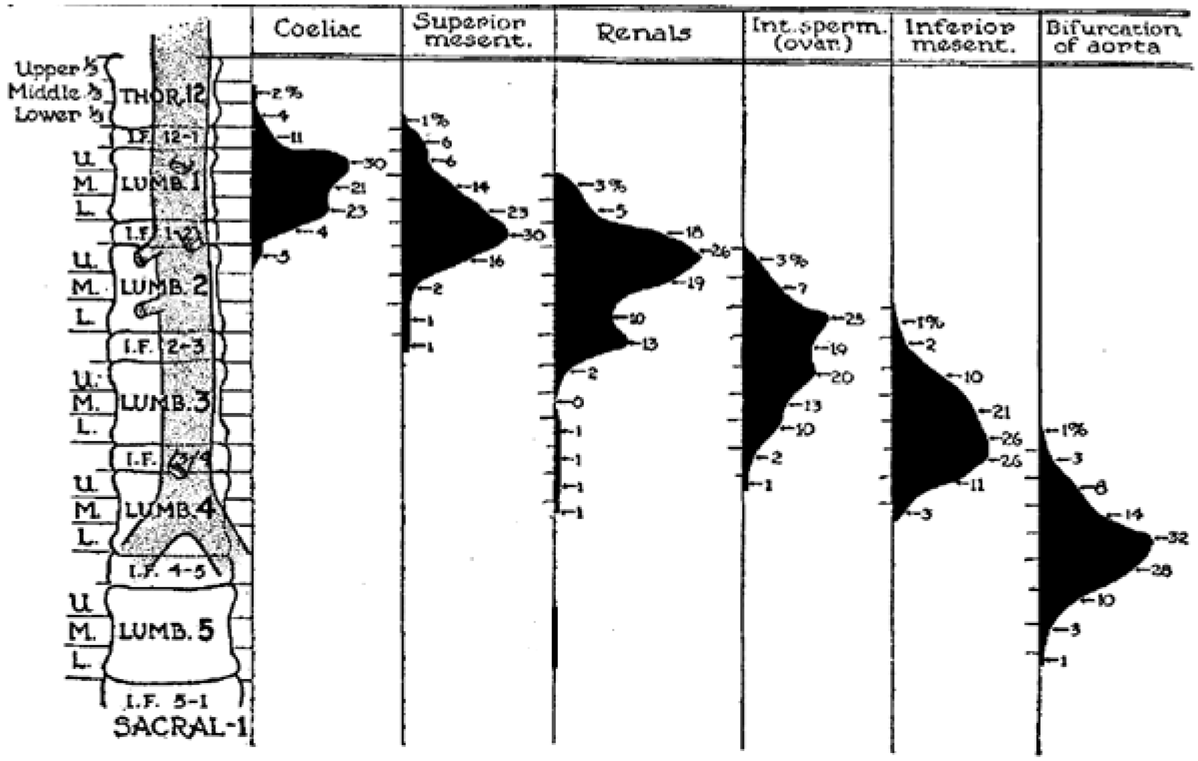
[555] Testut, 1901
[556] Bouchet & Cuilleret, 2001
[557] Still, 1897, p.33
[558] Gray, H. (1908). A*natomy Descriptive and Surgical (17th Ed.).* (J. C. DaCosta & E. A. Spitzka, Eds.). Philadelphia: Lea & Febiger. Downloaded from www.archive.org.
[559] Piersol, 1913
[560] Rouvière & Delmas, 2002
[561] Anson, B. J. & McVay, C. B. (1936). The topographical positions and the mutual relations of the visceral branches of the abdominal aorta. a study of 100 consecutive cadavers. *The Anatomical Record.* doi:10.1002/ar.1090670103.

Table 5: Visceral Branches and Bifurcation of Aorta in Relation to Vertebrae



[562]

[562] Slightly modified from Anson & McVay, 1936, p.9

5.16.2 Box 3: Outline of the Abdominal Aortic System

Celiac Trunk (L_1)
- Splenic Artery
  - Pancreatic branches
  - Pancreatica magna
  - Short gastric branches
  - Left gastro-epiploic artery
  - Branches to lymphatics nodes
  - Terminal branches
- Left gastric artery
  - Esophageal branches
  - Gastric branches
  - Small hepatic branch
  - Anterior fundic branches
- Common Hepatic Artery
  - Pyloric branch
  - Gastro-duodenal artery
    - Superior pancreatico-duodenal branch
    - Right gastro-epiploic artery
  - Right terminal branch
    - Cystic branch
    - Left terminal branch

The Superior Mesenteric Artery (Middle of L_1 to superior third of L_2)
- Inferior pancreatico-duodenal artery
- Intestinal branches
- Ileo-colic artery
- Right Colic artery
- Middle colic artery

Inferior Mesenteric Artery (Middle of L_3 to disc between L_3/L_4)
- Left colic artery
- Sigmoid branches
- Superior haemorrhoidal artery

Inferior Phrenic Arteries
- Superior suprarenal branches

Suprarenal Arteries

Renal Arteries (Most variable: Middle of L_1 to middle of L_4, average is disc between L_1 and L_2)
- Ureteral branch
- Inferior suprarenal branch

Spermatic Arteries (Lower third of L_2 to upper third L_3)
- Testicular
- Epididymal branches
- Ureteral branch
- Cremasteric branch

Ovarian Arteries (Lower third of L_2 to upper third L_3)
- Ureteral branches
- Tubal branches
- Ligamentous branches
- Ovarian branches

Lumbar Arteries

Middle Sacral Artery

Common Iliac Arteries

5.16.3.0 Relations

5.16.3.1 Posterior and Anterior

The posterior relations of the abdominal aorta are the anterior longitudinal ligament of the first four lumbar vertebrae and left lumbar veins.[563] Anteriorly the abdominal aorta is in relation to the solar plexus, left lobe of the liver, stomach, transverse colon, splenic vein, pancreas, left renal vein, third portion of the duodenum, coils of small intestine which are separated from it by the peritoneum,[564] as well as the lesser omentum and root of the jejuno-ileum mesentery.[565]

5.16.3.2 To the Right and Left

The abdominal aorta is in relation on its right with the thoracic duct and cisterna chyli, right crus of the thoracic diaphragm, inferior vena cava[566] as well as azygos vein and right semi-lunar (celiac) ganglion.[567] To the left of the abdominal aorta and in relation to it are the left crus of the thoracic diaphragm, fourth part of the duodenum, coils of small intestine[568] as well as the sympathetic chain and left semi-lunar (celiac) ganglion.[569]

5.17.0 The Veins

5.17.1.0 The Inferior Caval System

The evolution of the inferior caval system was explored indirectly throughout chapter 3 of this memoir. It was seen that the terminal part of the inferior caval system evolved from the right hepatocardiac channel. It has reasonably little variations that will not be discussed here. The other tributaries to the inferior vena cava originating in the cardinal system become less constant the further from the main trunk they become. This seems logical both based on their size as well as recalling that during the development of these tributaries much influence was introduced by the environment on the growing embryo and fetus. It is necessary to keep this

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[563] Piersol, 1913
[564] Piersol, 1913
[565] Gray, 1908
[566] Piersol, 1913
[567] Gray, 1908
[568] Piersol, 1913
[569] Gray, 1908

important aspect of anatomy in mind for palpation and subsequent manipulation of this system. Figures of the venous system are located in Appendix D – Neurovasculature and Lymphatics.

5.17.1.1 Topographical Anatomy

The main trunk of the inferior vena cava is formed by the union of the left and right common iliac veins to the right of midline either at the level of the disc between L_4 and L_5, or the level of the body of L_5.[570] It ascends to the level of L_1 before bending to reach the fissure of the liver between the Spigelian and right lobes where it continues cephalically in that fissure to reach and pierce the thoracic diaphragm[571] at the level of T_8. Anteriorly the union of the two common iliac veins can be estimated one inch [2.54cm] inferior to and ½ inch [1.27cm] to the right of the umbilicus.[572]

5.17.1.2 Relations

The inferior vena cava is situated to the right side of the lumbar vertebrae lying against the originating fibres of the psoas major and minor muscles inferiorly, and the right crus of the diaphragm superiorly.[573] The abdominal aorta is in relation with the left side of the inferior vena cava excepting the superior part when the right crus of the diaphragm intervenes.[574] As it ascends the inferior vena cava crosses the right lumbar and renal arteries, is associated with the medial aspect of the right kidney, and, at the level of L_3 is in relation to the posterior aspect of the third part of the duodenum as well as the head of the pancreas.[575] Upon reaching the liver the inferior vena cava sits between the right and Spigelian lobes within the fissure bearing its name, occasionally being completely surrounded by the parenchyma of the liver.[576]

The inferior vena cava is firmly adhered to the liver within its fissure being connected by fibrous bands[577] making it very important osteopathically as it creates a strong biomechanical link between the parenchyma of the liver and the inferior vena cava. Long lever tensions from the somatic system can feasibly affect both the visceral and cardiovascular systems via this

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[570] Piersol, 1913
[571] Piersol, 1913
[572] Rawling, 1922
[573] Piersol, 1913
[574] Piersol, 1913
[575] Piersol, 1913
[576] Piersol, 1913
[577] Piersol, 1913

tension. Without removing the relational lesion(s), the effects on this important link between the somatic and visceral systems cannot be normalized.

5.17.2.0 The Portal System

The portal system receives blood from the entire gastrointestinal system as well as the pancreas, spleen and gallbladder; the main trunk, the portal vein, is formed by the union of the superior mesenteric and splenic veins. Both the entrance and exit to this system is via a capillary bed and thus prone to circulatory dysfunction. The physiologic connection of the portal system is of utmost importance to the economy of the body as its contained blood transports materials of an intermediate state of processing between the raw materials contained in the gastrointestinal canal and the systemic circulation where the now processed material can be used by the body. With dysfunction at this point in the nutritive system the body has potentially lost its fight to utilize acquired nutrients before it has even begun to try as those nutrients are hindered before the refining process has even begun. This part of the circulatory system is a remarkable example of the osteopathic dictum ‘the rule of supply and demand dictates’ and its manipulation yields far reaching potentials.

5.17.2.1 Portal-Systemic Anastomoses

To accomplish its goal the portal system must direct all of its blood into the parenchyma of the liver. Consistent with the concept of fuzzy boundaries within complex systems the portal system has direct anastomoses with the systemic circulation. These connections offer a potential route for blood if there are congestive lesions involving the portal system. The four points of portal-systemic anastomosis as compiled by Moore, Dalley & Agur[578] are shown in Table 6.

[578] Moore, K. L., Dalley, A. F. & Agur, A. M. R. (2010). *Clinically orientated anatomy (6th Ed.).* Lippincott Williams & Wilkins: USA.

Table 6: Anastomoses of Portal and Systemic Circulations

Portal Part of Anastomosis	Systemic Part of Anastomosis
Left gastric vein	Azygos vein
Inferior and middle rectal veins	Superior rectal vein
Paraumbilical veins	Epigastric veins
Twigs from veins in the locale the fusion of the retroperitoneal organs for example: the colic, splenic and portal veins	Retroperitoneal veins of the posterior abdominal wall

5.17.2.2 Relations of the Portal Vein

The portal vein is intimately associated with the free edge of the lesser omentum along with the common bile duct and hepatic artery, both of which lie anterior to it, artery on the left, duct on the right.[579] At its origin the portal vein is in relation to the posterior surface of the head of the pancreas and sits to the left of the inferior vena cava.[580] Before gaining its position in the lesser omentum the portal vein ascends posterior to the first part of the duodenum; after traversing the free edge of the lesser omentum, it enters the transverse fissure of the liver.[581]

5.18.0 The Lymphatics

The lymphatics in general follow the cardiovascular system and those of the abdomen are no exception. The description to follow will encompass only the thoracic duct as it is a very constant structure. The lymphatic drainage of the viscera of the abdominal cavity will be treated as a pictorial review in Appendix D – Neurovasculature and Lymphatics. This is meant not to give the reader a solidified map of the lymphatic drainage of the viscera; the author's intentions are quite the opposite, to give a general outline of the flow of lymph away from the viscera which in reality will be governed by the biomechanical and fluidic state of the patient. During

[579] Piersol, 1913
[580] Piersol, 1913
[581] Piersol, 1913

dissection and even during operation[582] these lymphatic nodes are elusive. This fact emphasizes the fluidic nature necessary for their palpation during treatment.

5.18.1.0 The Thoracic Duct

The thoracic duct commences at the level of L_2 as the confluence of the left and right lumbar lymphatic trunks.[583,584] Immediately superior to the confluence of the left and right lumbar lymphatic trunks is the cisterna chyli spanning from the confluence to T_{11} where the thoracic duct gradually diminishes in caliber.[585]

5.18.1.1 Abdominal Relations

While in the abdominal cavity the thoracic duct is in relation posteriorly with the bodies of T_{12}, L_1 and L_2 before it passes between the two crura of the thoracic diaphragm; anteriorly it is in relation with the abdominal aorta, while to the right is the azygos vein.[586]

5.19.0 The Nerves

The very thought of separating out even a single part of the nervous system violates the holistic nature of that system; but, this is of necessity if one is to discuss the connections between structure and function of the nervous tissues. It is common to see within the text of anatomy the segregation of the central and peripheral nervous systems along with the sub-classification of the autonomic system. It cannot be stressed enough here that the complexity of *this* system, the nervous one, has a broad fuzzy boundary with that of every other system in the human body.

Table 7 tabulates the effects of stimulation of the autonomic nervous system on the various organs of the body. The fuzzy boundary between the peripheral autonomic system in its relation to the peritoneal viscera will be discussed here. The discussion is limited to the peripheral connections of the autonomic system with minor comments regarding the central connections. The biomechanics of the cranium in relation to the neuroendocrine system in the

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[582] Standring, 2008
[583] Piersol, 1913
[584] Standring, 2008
[585] Piersol, 1913
[586] Piersol, 1913

context of the peritoneal viscera are acknowledged, but will not be discussed. Figures of the nervous system are located in Appendix D – Neurovasculature and Lymphatics.

Table 7: Effects of Stimulation of the Autonomic Nervous System

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Eye		
Pupil	Dilated	Constricted
Ciliary muscle	Slight relaxation (far vision)	Constricted (near vision)
Glands	Vasoconstriction and slight secretion	Stimulation of copious secretion (containing many enzymes for enzyme-secreting glands)
Nasal		
Lacrimal		
Parotid		
Submandibular		
Gastric		
Pancreatic		
Sweat glands	Copious sweating (cholinergic)	Sweating on palms of hands
Apocrine glands	Thick, odoriferous secretion	None
Blood vessels	Most often constricted	Most often little or no effect
Heart		
Muscle	Increased rate Increased force of contraction	Slowed rate Decreased force of contraction (especially of atria)
Coronaries	Dilated (β_2); constricted (α)	Dilated
Lungs		
Bronchi	Dilated	Constricted
Blood vessels	Mildly constricted	? Dilated
Gut		
Lumen	Decreased peristalsis and tone	Increased peristalsis and tone
Sphincter	Increased tone (most times)	Relaxed (most times)
Liver	Glucose released	Slight glycogen synthesis
Gallbladder and bile ducts	Relaxed	Contracted
Kidney	Decreased output and renin secretion	None
Bladder		
Detrusor	Relaxed (slight)	Contracted
Trigone	Contracted	Relaxed
Penis	Ejaculation	Erection
Systemic arterioles		
Abdominal viscera	Constricted	None
Muscle	Constricted (adrenergic α) Dilated (adrenergic β_2) Dilated (cholinergic)	None
Skin	Constricted	None
Blood		
Coagulation	Increased	None
Glucose	Increased	None
Lipids	Increased	None
Basal metabolism	Increased up to 100%	None
Adrenal medullary secretion	Increased	None
Mental activity	Increased	None
Piloerector muscles	Contracted	None
Skeletal muscle	Increased glycogenolysis Increased strength	None
Fat cells	Lipolysis	None

[587]

[587] Guyton, A. C. & Hall, J. E. (2006). *Textbook of medical physiology (11th Ed.).* Elsevier Saunders: China, p.754

5.19.1.0 Efferent Pathways

5.19.1.1.0 Sympathetic System

The sympathetic system is derived from the intermedio-medial and intermedio-lateral columns of the spinal cord from segments T_1 to $L_{2/3}$, entering the peripheral system via the white rami communicantes.[588] The grey rami communicantes are responsible for carrying the post-ganglionic fibres into the spinal nerves for distribution. The segmental distribution of the sympathetic system, taken from Williams,[589] is displayed in Table 8.

Table 8: Sympathetic Supplies

Head and Neck	T1 – 5
Upper limb	T2 – 5
Lower limb	T10 – L2
Heart	T1 – 5
Bronchi and lungs	T2 – 4
Oesophagus (caudal part)	T5 – 6
Stomach	T6 – 10
Small intestine	T9 – 10
Large intestine to splenic flexure	T11 – L1
Splenic flexure to rectum	L1 – 2
Liver and gallbladder	T7 – 9
Spleen	T6 – 10
Pancreas	T6 – 10
Kidney	T10 – L1
Ureter	T11 – L2
Suprarenal	T8 – L1
Testis and ovary	T10 – 11
Epididymus, ductus deferens, seminal vesicles	T11 – 12
Urinary bladder	T11 – L2
Prostate and prostatic urethra	T11 – L1
Uterus	T12 – L1
Uterine tube	T10 – L1

[588] Williams, P. L. (Ed.). (1995). *Gray's anatomy the anatomical basis of medicine and surgery.* Churchill Livingstone: Great Britain.
[589] Williams, 1995, p.1306

Once the neurons reach the sympathetic trunk on each side they will either: 1) synapse with neurons in the sympathetic chain ganglia at the same level, 2) ascend or descend, but not both, within the sympathetic chain before synapses are made within one or more ganglia at different levels in the chain, or finally 3) the sympathetic chain ganglia may be traversed completely without synapse such that the neuron will enter a peripheral ganglia to make its connection(s).[590] This last route is the one taken by the splanchnic nerves, greater, lesser and least and will be the topic of greatest discussion here along with the nerve plexuses and chain ganglia of the autonomic system.

5.19.1.1.1 The Sympathetic Trunk and Splanchnic Nerves

The sympathetic trunks are bilaterally placed strands of gangliated nervous tissue of neural crest origin. The superior most ganglia of the sympathetic trunk is in relation with C_2, but the trunk extends rostrally as a plexus surrounding the internal carotid artery as it enters the cranium. Inferiorly they extend to reach the anterior surface of the coccyx where they unite to form Walter's ganglion.

In the cervical region the sympathetic trunk lies between the prevertebral fascia posteriorly in the carotid sheath anteriorly, its typical arrangement consisting of three ganglia. In the thoracic region the sympathetic trunk lies in relation to the parietal pleura anteriorly and the heads of the ribs posteriorly. There are usually 12 thoracic ganglia in each sympathetic trunk. Each sympathetic trunk enters the abdominal cavity between the intermediate and lateral parts of the diaphragmatic crura of the homolateral side.[591] The sympathetic trunk within the abdominal cavity is termed the lumbar part and most typically consists of four ganglia which are in relation with the lumbar vertebral bodies posteriorly and the great abdominal vessels anteriorly. The sacral portion of the sympathetic trunk begins as the trunks pass posterior to the common iliac artery of the homolateral side. Its usual number of ganglia is four which lie medial to the anterior sacral foramina.[592]

The splanchnic nerves of the abdomen are comprised of the greater, lesser, least, and lumbar, of which there are four. The greater splanchnic nerve originates from thoracic

[590] Williams, 1995
[591] Piersol, 1913
[592] Piersol, 1913

sympathetic trunk ganglia 5 to 9 or 10. This general statement would work well with the statement that there are four roots of the nerve from the sympathetic trunk which descend upon the vertebral bodies. In reality the spinal origin of the greater splanchnic nerve may reach the first thoracic ganglion and have between 1 to 8 roots.[593] At is origin within the posterior mediastinum is the ganglion of Lobstein[594] placed at the level of the disc between T_{11} and T_{12}.[595] The greater splanchnic nerve enters the abdomen between the medial and intermediate parts of the homolateral diaphragmatic crura[596] to terminate in the celiac and aortico-renal ganglia as well as the adrenal gland.[597]

The lesser splanchnic nerve typically derives from sympathetic trunk ganglia 9 and 10 or 10 and 11, pierces the homolateral diaphragmatic crura with the greater splanchnic nerve to end in the aortico-renal ganglion. The least splanchnic nerve is derived from the lowest thoracic ganglia, enters the abdomen in company of the sympathetic trunk, ending in the renal plexus.[598]

The four lumbar splanchnic nerves originate from the lumbar sympathetic trunk traveling within the extraperitoneal tissues. The first lumbar splanchnic originates from the first lumbar ganglia of the sympathetic trunk and terminates in the celiac, renal and intermesenteric plexuses.[599] The second lumbar splanchnic nerve originates from the second and third lumbar ganglia to end within the inferior part of the intermesenteric plexus.[600] The third lumbar splanchnic nerve takes origin from the third or fourth lumbar ganglia, travels anteriorly to the common iliac vessels, to merge with the superior hypogastric plexus.[601] The fourth lumbar splanchnic nerve arises from the last lumbar ganglia and ends within the superior hypogastric plexus or the hypogastric nerve.[602]

The sacral, or pelvic, part of the sympathetic trunk is not responsible for the origin of the pelvic splanchnic nerves, that responsibility is placed on the parasympathetic system. Branches

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[593] Williams, 1995
[594] Bouchet & Cuilleret, 2001
[595] Jackson, 1914
[596] Piersol, 1913
[597] Williams, 1995
[598] Williams, 1995
[599] Williams, 1995
[600] Williams, 1995
[601] Williams, 1995
[602] Williams, 1995

from the first two sacral ganglia ascend to join the inferior hypogastric plexus or the hypogastric nerve.[603]

5.19.1.1.2 Autonomic Ganglia and Plexuses

The two major autonomic plexuses concerned with the peritoneal organs are the celiac and hypogastric. The various named ganglia of the celiac plexus include the right and left celiac ganglia with their aortico-renal extensions, the left and right posterior renal ganglia of Hirschfeld, and the superior and inferior mesenteric ganglia. They are placed within the extraperitoneal connective tissue in relation to the crura of the thoracic diaphragm, great vessels, and adrenal glands as well as the peritoneum. From these ganglia a collection of plexuses arise, passing along the major arterial branches, and usually being named after those arteries. This situation can create much apparent separation but in reality they are one continuous system.

The main plexus of those just eluded to include is the celiac. Secondary plexuses from the celiac include: the phrenic, hepatic, left gastric, intermesenteric, suprarenal, renal, testicular or ovarian, superior and inferior mesenteric. The continuation of the aortic plexus inferiorly embedded within the extraperitoneal connective tissue represents the superior hypogastric plexus. At the bifurcation of the aorta the superior hypogastric plexus sends the hypogastric nerves, which are usually plexiform in nature, coursing along the medial aspect of the internal iliac arteries to become the left and right inferior hypogastric plexuses.[604] Much like with the celiac plexus, the peripheral continuation of the inferior hypogastric plexuses follows the arterial system. The named plexuses include the haemorrhoidal, superior and middle rectal, vesical, prostatic, cavernous, and uterovaginal plexuses[605] depending on the sex of the individual.

Perhaps the most important aspect of the anatomy of this part of the autonomic nervous system is its relation to the extraperitoneal connective tissue. This plain of fasciae is vast and can both influence and be influenced by the biomechanics of the visceral and somatic systems. It represents a type of fuzzy boundary between the two. A normalization of the relationship between the autonomic nervous system of the abdomen and its embedding fascia is of utmost importance if the free flow of both fluids and nerves to the peritoneal organs is to be achieved.

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[603] Williams, 1995
[604] Williams, 1995
[605] Williams, 1995

Regardless if the lesion causing biomechanical chain originated within the extraperitoneal system of fasciae directly or if long fascial tensions from another segment of the body are responsible, the intent remains the same: to normalize the tissue responsible for the lesion, allowing a free flow of fluids and nervous impulses. With a free flow of both the fluids and nervous impulses of the combined neurovasculature of the peritoneal organs the osteopathic philosophy states that Nature will make the system well and a diseased state will not ensue.

5.19.1.2.0 Parasympathetic System

The parasympathetic system is derived caudally from the sacral parasympathetic nucleus, S_{2-4}, and cephalically from the midbrain (Edinger-Westphal nucleus) and hindbrain (superior and inferior salivatory nuclei, dorsal vagal nucleus and the nucleus ambiguus).[606] The sacral nucleus leading to the pelvic splanchnic nerves, the dorsal vagal nucleus and nucleus ambiguous, leading to the vagus nerve are of prime interest in the discussion of the peritoneal organs.

5.19.1.2.1 The Vagus Nerves

The course and relations of the right and left vagus nerves differs as does their peripheral termination. Upon exiting the cranium via the jugular foramen the vagus nerves travel inferiorly within the carotid sheath of the homolateral side. They then descend through the superior mediastinum, followed by the posterior mediastinum, giving off numerous branches along their course. The branches of distribution, taken from Williams,[607] are displayed in Table 9.

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[606] Williams, 1995
[607] Williams, 1995, p.1252

Table 9: Branches of Distribution of the Vagus Nerves

In the jugular fossa	Meningeal Auricular
In the neck	Pharyngeal Branches to carotid body Superior laryngeal Recurrent laryngeal (right) Cardiac
In the thorax	Cardiac Recurrent laryngeal (left) Pulmonary Oesophageal
In the abdomen	Gastric Coeliac Hepatic Renal

With the vast innervation pattern of the vagus nerves, the possibilities for both local and reflex phenomena involving these structures are great, especially when the connections with the sympathetic side of the autonomic system are taken into account.

The trunk of the right vagus nerve, which now contains fibres from both the left and right vagi[608] enters the abdominal cavity via the esophageal opening in the thoracic diaphragm being in relation to the posterior aspect of the esophagus. It then forms a plexus in relation to the posterior aspect of the stomach, ending in the right celiac ganglion. The loop that is formed as the right vagal trunk and the right greater splanchnic nerve connect with the right celiac ganglion is known as the *anse mémorable de Wrisberg.*[609] See figure D10. Mechanical tensions between the two aspects of this connection must be normalized for there to be no undue stress on this part of the autonomic system. Since both the greater splanchnic nerve and the right vagal trunk do not originate within the abdominal cavity potential links of dysfunction must be investigated all along the line of path of both nervous trunks, to start at least.

608 Williams, 1995
609 Testut, L. (1899). *Traité d'anatomie humaine tome troisième (4e Éd.).* Paris: Octave Doin. Downloaded from www.archive.org.

The trunk of the left vagus nerve enters the abdominal cavity also via the esophageal opening in the thoracic diaphragm, but this time in relation to the anterior aspect of the esophagus. The trunk terminates within the anterior gastric plexus mixing with fibres from the sympathetic system as well as the right vagus, also sending hepatic branches within the lesser omentum to the liver.[610]

The anterior and posterior gastric plexuses formed by the left and right vagal trunks along with the connections to the celiac ganglia are but a schematic view of the termination of these nerve trunks. In reality the nerves are in relatively free communication and, by no means in a connection with the celiac ganglia necessary before the fibres are sent to their respective organs.

5.19.1.2.2 The Pelvic Splanchnic Nerves

The pelvic splanchnic nerves are contained within the ventral rami of sacral spinal nerves 2 – 4 and join the pelvic sympathetic system.[611] Once within the hypogastric plexuses the fibres of the pelvic splanchnic nerves ascend out of the pelvis within the sympathetic system to supply the sigmoid and descending colon, the splenic angle and the terminal part of the transverse colon.[612]

5.19.2 Afferent Pathways of the Gastrointestinal System

The afferent pathways are not separate pathways *per se* as they travel within parts of the efferent system just described. The afferent innervation of the esophagus distally to the transverse colon comes from the vagus nerves with cell bodies in the nodose ganglion and projecting centrally to the nucleus of the solitary tract.[613] The remaining part of the gastrointestinal tract has its afferent innervation coming from the pelvic splanchnic nerves.[614] Within the sympathetic side of the autonomic system, visceral afferents travel in the splanchnic nerves projecting to segments $T_5 – L_2$ with their cell bodies being located in the dorsal root

[610] Jackson, 1914
[611] Williams, 1995
[612] Williams, 1995
[613] Al-Chaer, E. D. & Willis, W. D. (2007). Neuroanatomy of visceral pain: pathways and processes. In: Pasricha, P. J., Willis, W. D. & Gebhart, G. F. (Eds.). (2007). *Chronic abdominal and visceral pain theory and practice.* Informa healthcare: New York.
[614] Al-Chaer & Willis, 2007

ganglia with connections within the spinal cord being made in laminae I, II, V and X.[615] Further projections are diffuse and will not be discussed here other than to state that most are carried within the spinothalamic, spinohypothalamic, spinosolitary, spinoreticular, and spinoparabrachial tracts as well as the dorsal columns[616] which sheds some light on the complexity of their central connections.

5.19.3 The Enteric Nervous System

The enteric nervous system consists of Meissner's and Auerbach's plexuses situated under the mucosa and between the circular and longitudinal muscle layers respectively. Parasympathetic pre-ganglionic and sympathetic post-ganglionic fibres connect with the enteric nervous system such that they can be modulated by central sources.[617] Further classification of enteric plexuses groups the neurons according to functionality into: intrinsic primary afferent neurons, interneurons, motor, secretomotor, and vasomotor neurons.[618] The understanding of these different neuronal plexuses with their pharmacology is the place of allopathic medicine. In terms of manual osteopathic manipulation treatment of the enteric system is relative. The manipulative goal is the removal of all undue biomechanical stressors being transmitted through the system of fasciae that will have a local impact on this part of the nervous system followed by a normalization of both the intrinsic motility of the gastrointestinal canal as well as the extrinsic connections with the sympathetic and parasympathetic parts of the autonomic nervous system. If manipulation achieves these parameters, each of the osteopathic precepts will be respected: the openness of the system, the interrelationship of structure and function, the supply and demand of fluids and nerve impulses, and finally letting Nature take its course unimpeded towards health.

5.19.4 Convergence of Visceral and Somatic Afferent Pathways

With both the visceral and somatic nociceptive afferent neuronal cell bodies residing within the dorsal root ganglia of the spinal nerves, a potential meeting place, or fuzzy boundary, between the somatic and visceral nervous systems begins. The potential for interconnection of

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[615] Al-Chaer & Willis, 2007
[616] Al-Chaer & Willis, 2007
[617] Wilson-Pauwels, L., Stewart, P. A. & Akesson, E. J. (1997). *Autonomic nerves basic science clinical aspects case studies.* B.C. Decker: USA.
[618] Benarroch, E. E. (2007). Enteric nervous system functional organization and neurologic implications. *Neurology, 13, p.1953-7.*

these two systems continues within the substance of the spinal cord. This is important osteopathically as it offers a common point for intervention into both systems.

Figures D26 and D27 offer a visual aid in understanding how the somatic and visceral pain fibres connect within the spinal cord and exemplifies the potential for interconnection. Somatic afferents connect with well defined regions of the dorsal horn with rostro-caudal extensions extending two to three segments, whereas visceral afferents have a less defined terminal arborization of their fibres within the spinal cord with rostro-caudal extensions spanning five to ten segments.[619]

According to Ruch's convergence-projection theory the

> dorsal horn neurons (or higher in the brain) usually respond to somatic stimuli and rarely respond to stimuli from visceral tissue. Upon persistent afferent input evoked by visceral stimulation, activity in this neuronal circuit is interpreted as arriving over somatic primary afferents and the pain is perceived as originating in somatic tissue.[620]

Initially visceral pain is diffuse and in the midline, but as stimulation increases pain is felt in the somatic distribution of the dorsal root ganglia. A normalization of the tissues both in relation to and connected with the dorsal root ganglia can have widespread manifestations crossing many bodily systems.

5.20 The Fasciae

"This life is surely too short to solve the uses of the fascia in animal forms."[621] With a seemingly innumerable amount of uses, the fasciae must then also be the root of an innumerable amount of disuses or more specifically, dysfunctions. "Thus a knowledge of the universal extent of the fascia is almost imperative, and is one of the greatest aids to the person who seeks cause of disease."[622]

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[619] Traub, R. J. (2007). Spinal mechanisms of visceral pain and sensitization. In: Pasricha, P. J., Willis, W. D. & Gebhart, G. F. (Eds.). (2007). *Chronic abdominal and visceral pain theory and practice.* Informa healthcare: New York.
[620] Traub, 2007, p.88
[621] Still, 1899, p.165
[622] Still, 1899, p.167

As this philosophy has chosen the fascia as a foundation on which to stand, we hope the reader will chain his patience for a few minutes on the subject of the fascia, and its relation to vitality. It stands before the philosopher as one of, if not the deepest living problems ever brought before the mind of man.[623]

To start this section of anatomy, that of the fasciae, with three brief quotes from AT Still is an attempt to emphasize where AT Still placed the fasciae in the hierarchy of osteopathic philosophy: first. Without a normalization of the fasciae in relation to the tissues being treated the fourth precept of the osteopathic philosophy cannot be satisfied. Nature will not be able to make well. Even when treatment respects the openness of the system, the relationship between structure and function, and the concerns of supply and demand, if the fasciae cannot perform, every other tissue will necessarily be affected and Nature will not be able to flourish in perfect harmony.

The fascial planes or fasciae really constitute, in the non-dissected condition, a sheet of connective tissue varying in thickness and density according to locality. This covers and invests all the so-called higher structures; *i.e.*, muscles and tendons, bursae, vessels, lymph nodes, nerves, viscera, ligaments, joints, and even cartilage and bones, these last by close adhesion to perichondrium and periosteum between the attachments of the muscles.[624]

Various sheets of loose areolar and fatty fasciae also exist in various potential spaces and, while not necessarily continuous in the *usual* sense, are connected to the larger sheets of fasciae via various trabeculae.[625]

For the purposes of this discussion the arbitrary separation of the fasciae into subcutaneous and subserous planes as elaborated by Gallaudet[626] will be followed. There is an obvious limitation to this classification as he does not separate out the dura mater; but, in the light of complexity that shortcoming can be ignored with the acknowledgement that *any* segregation of systems is in reality a fallacy. Also, the dura mater is not a topic of discussion here, another arbitrary decision as the author does not want to exclude that tissue and its many biomechanical and fluidic manifestations along with their physiologic correlations.

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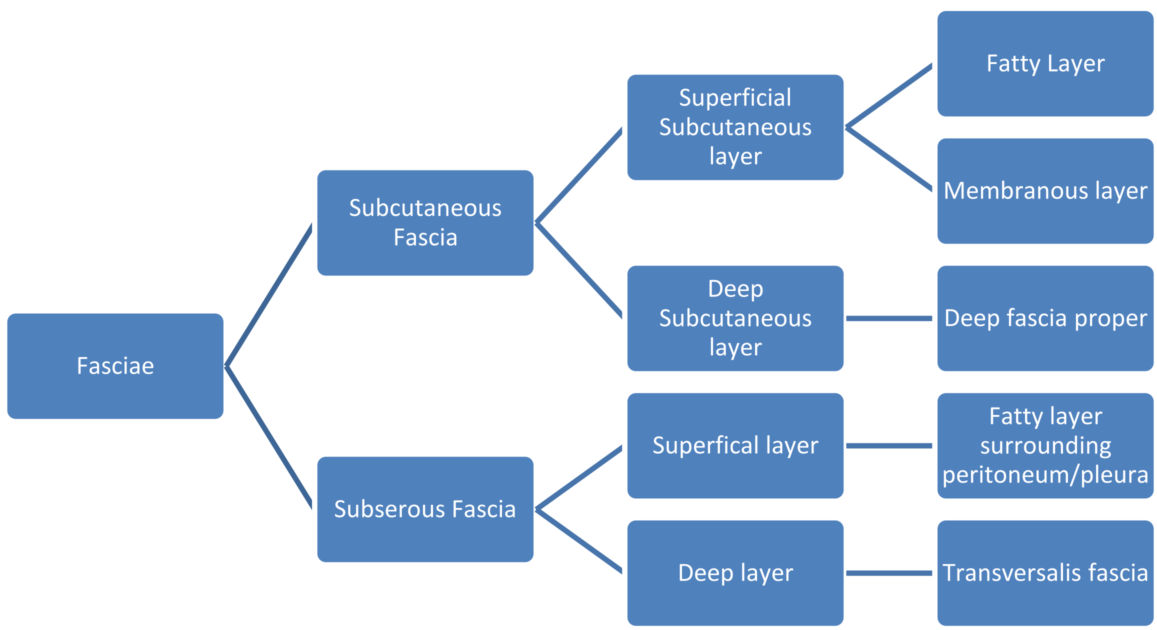
[623] Still, 1899, p.162
[624] Gallaudet, B. B. (1931). *A description of the planes of fascia of the human body with special reference to the fascia of the abdomen, pelvis and perineum.* Columbia University Press: New York, p.1
[625] Gallaudet, 1931
[626] Gallaudet, 1931

Appreciable figures of the fasciae are rare. The operating theatre, dissection laboratory, or osteopathic clinic, are the most appropriate settings in which to gain an appreciation of the fasciae. The author has made the decision to include no figures of the fasciae. The rationale for this decision was to not offer a two dimensional picture for the mind's eye prior to palpation. If each of the relations of the muscles, vessels, organs, etc. are well known, the fasciae seems to fall into place without the need for a figure. The author feels this method is the most useful in creating a space of emergence for the treatment of the peritoneal organs.

Chart 1 is an overview of Gallaudet's[627] classification of the fasciae. See text for further elaboration.

Chart 3:Overview of Gallaudet's Classification of the Fasciae



A description of each of the terminal branches of Chart 3 as well as examples of named fasciae of those branches pertaining to the abdominal cavity are displayed for sake of both brevity and clarity in Boxes 4 – 8. These boxes do not necessarily represent all of the named

[627] Gallaudet, 1931

fasciae in relation to the peritoneal organs as there is truly no boundary between any of the named fasciae. Fasciae is a whole and complete functioning dynamic unit.

Box 4: Fatty Layer

- Fatty layer that can be split into several laminae through which pass superficial neurovasculature and lymphatics[628]
    - Camper’s fascia

Box 5: Membranous Layer

- Placed between fatty layer and deep fascia proper; only contains fat in moderately fatty subjects[629]
    - Scarpa’s fascia, part of suspensory ligament of the penis/clitoris

[628] Gallaudet, 1931
[629] Gallaudet, 1931

Box 6: Deep Fasciae Proper

- Continuous throughout body with varying regional thickness; covers all muscles (excepting superficial head muscles and palmaris brevis), all large vessels, nerves and lymphatics with nodes as well as certain glands[630]
    - linea alba; xiphoid and chondro-xiphoid fascia; ligaments of Poupart, Gimbernat, Cooper; the ilio-pectineal band; the external oblique aponeurosis and pillars as well as Colles' pillar; the conjoint tendon; the fasciae of Nicaise, Hesselbach, Aman-Jean, Halban, Fredet, Denonvilliers, Thompson, Gallaudet; Henle's ligaments, anteriorly and posteriorly; the autochthonous fasciae of the intrinsic back muscles; the sheath of rectus abdominis; the round ligament; Spigel's line; the round ligament of the umbilicus; the endo- and exo- thoracic fascia; pubo-vesical and pubo-prostatic ligaments; etc.
- Collectively these fasciae constitute the major biomechanical links of the somatic wall of the abdomen and help to govern its biomechanics in close association with the myofasciae of the head and extremities.

Box 7: Superficial Subserous Layer

- This layer varies greatly depending on locale.
    - umbilico-vesical fascia of Farabeuf, presacral fascia; the fasciae of Zuckerkandl, Gerota, Toldt (right and left), Treitz, Abernethy, Mackenrodt; the lateralconal fascia; pre-pancreatic fasciae (*sous et sus mésocolique*); the fibrous sheath of Treitz and Leimer; areolar tissue in relation to the spaces of Bogros and Retzius respectively; areolar tissue in relation to the kidneys, etc.

[630] Gallaudet, 1931

Box 8: Transversalis Fascia

- This fascia is tremendous. The osteopathic links to this particular part of the fascial system make it worthy of a more detailed description.
- In general this layer of fascia lines the entire inner surface of the abdominopelvic cavity with its name derived from the transversus abdominis muscle; but, it takes on regional names as applicable to the region in which it is studied.[631]
- In the region of the inguinal canal the transversalis fascia is prolonged into the scrotum as the internal spermatic fascia; it is prolonged into the thigh with the femoral vessels.[632]
- A three-way fascial link is created at the level of the inguinal ligament between the transversalis fascia, fascia lata and the fascia innominata of Gallaudet which is in relation to the external oblique muscle.[633]
- Superiorly fascial links between the transversalis fascia and the endothoracic fascia are made where the aorta, esophagus, azygos vein, sympathetic trunk and splanchnic nerves pass through (technically behind regarding the aorta) the thoracic diaphragm.[634]
- Also in relation to the thoracic diaphragm there is a fascial link made between the transversalis fascia and the endothoracic fascia in connection with the bilateral medial and lateral lumbocostal arches as well as the single median lumbocostal arch.[635]
- The transversalis fascia in relation to the inferior vena cava is unique in that it does not enter into connection with the endothoracic fascia where the inferior vena cave enters the thorax, but there the fibres turn to make connections with the central tendon of the thoracic diaphragm.[636]
- Where the inferior vena cava is embraced by the substance of the liver the transversalis fascia does not envelope it entirely, but leaves bare the hepatic side[637] where fibrous bands of connective tissue attach it to the fissure in the liver bearing its name.[638]

[631] Singer, E. (1935). *Fasciae of the human body and their relations to the organs they envelop. 2006 reprint.* AstroLogos Books: New York.
[632] Gallaudet, 1931
[633] Gallaudet, 1931
[634] Gallaudet, 1931
[635] Gallaudet, 1931
[636] Gallaudet, 1931
[637] Gallaudet, 1931
[638] Piersol, 1913

The complexity of the fascial system becomes readily apparent by the shear volume of eponymous fascias in relation to the abdominal cavity alone. Each of these fasciae have a different biomechanical role within the economy of the body and it is up to the operator to observe and palpate these fasciae during osteopathic manipulation.

Chapter 6: An Osteopathic Approach to the Peritoneal Viscera

6.1 Introduction

"If you can learn all of osteopathy in four years I will buy you a farm, and a wife to run it and boss you."[639] It is in this spirit that the author presents this chapter. It represents not a fixed model of treatment for the peritoneal organs, but a philosophical outlook based within the paradigm of complexity thinking. The ultimate goal is to establish for the reader a space of emergence for their own treatment. Many of the tools to create such a treatment are found throughout chapters three and five and constitute a strong foundation of knowledge for the osteopathic manipulation of the peritoneal viscera.

"Once in the operating-rooms, you are in a place where printed books are known no more forever. Your own native ability, with nature's book, are all that command respect in this field of labor."[640] This fact brings to light the inability to learn osteopathy from a book past its philosophical aspects thus supporting the underlying premise of this chapter. AT Still wrote that to gain an understanding of even a single bone in its entirety "would open and close an eternity."[641] The author believes this statement to be true for the peritoneal organs as well. As such the general plan is this: a general safety assessment followed by a discussion of palpation. The final section in this chapter will introduce manipulation, again from a philosophical standpoint. Manipulation is out of the scope of this work as it is to be learned in the clinic. The time spent reading such a chapter would much more appropriately be applied with the hands in action, feeling the tissues and how they react to your touch.

6.2 Food Fundamentals According to Bean

The intake of food and liquid must be a priority in the management of the peritoneal viscera as that is their realm of physiology; it is what they do, process and assimilate. The enormous amounts of knowledge regarding the numerous aspects of nutrition intake are outside of the scope of this work. Clinically, the author refers to a Doctor of Naturopathic medicine for areas of nutrition other than the general message given in the quotes of Bean to follow, who was an osteopathic physician who specialized in diet as it related to health and disease.

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[639] Still, 1897, p.375
[640] Still, 1897, p.179
[641] Still, 1897, p.404

"There is a false idea prevalent that a meal should be a balanced meal; that it should contain all the elements in about the same proportions in which they are found in the body. Nothing can be more absurd, and yet hundreds of people never question the sensibleness of the idea…The chemical balance of each individual body differs every hour. In the morning it is not what it is in the evening. One day it is not what it is the next. When one is ill it is in no way similar to when he is well. It varies with the occupation, and whether the individual is out or in doors. It varies with light or heavy, cool or warm clothing. It varies with the chest expansion, the amount of natural sleep, and many other things pertaining to the life and habits of each individual.[642]

With that:

knowing the chemical needs of the body in a general way, we can place food at its disposal from which it will supply its demands. The different elements of the body should be offered to it in foods that furnish these elements in a form easily used by the body. Those foods which contain the least number of different elements are the most suitable for this purpose, because they are the most stable, decompose and ferment less easily than complex foods, and are more easily digested. The body needs and makes use of all the different kinds of foods, but it is not necessary to supply them all at one meal. It is not even necessary to supply all of these elements every day of twenty-four hours. So there is no necessity of what is recognized as a balanced ration – a balanced meal.[643]

It is obvious that Bean respected the philosophy of complexity thinking and therefore is accepted here by the author. Outside of correcting grossly incorrect food and liquid intake, for example the common patient who drinks "four or five" extra-large coffee cups from his/her local coffee drive-through each day, or has a habit of drinking 0mL of pure water each day, or consumes trans-fat filled deep-fried foods on a very regular basis with little to no dietary fibre, etc., etc., the author claims no expertise in the field of corrective nutrition. The common sense approach as outlined by Bean is followed by him, generally with good results, otherwise external expertise is sought as previously stated.

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[642] Bean, E. H. (1916). *Food fundamentals a view of ill-health as caused by wrong habits of living and a discussion of food based on experience from the viewpoint of an osteopathic physician.* Published by the author: Ohio. Downloaded from www.archive.org, p.32-3

[643] Bean, 1916, p.33-4

6.3.0 General Cardiovascular Safety Assessment

6.3.1 General Remarks

This section is in no way a conclusive guide to cautions and contra-indications to osteopathic manipulation. It does not recommend or suggest that these be the only guiding factors in whether or not osteopathic manipulation of the peritoneal organs is necessary or appropriate. The clinical sense of the practicing osteopath governed by the legislation under which they practice is what must guide clinical decision making. The two tests that follow offer a starting point for mechanical reasoning regarding the cardiovascular system on a gross level. Musculoskeletal examination details are voluminous and will not be entered here.

When respecting 'the rule of supply and demand dictates,' the manipulation of the cardiovascular system either directly or indirectly is indicated. For that reason a general assessment of that system is considered clinically responsible. Both the arterial and venous systems can be tested in the general sense and with more specific investigation being warranted in some cases, a referral to the allopathic system for legal reasons may be necessary. These legalities are country/region specific and therefore will not be entertained here. With that, the two gross general tests of the cardiovascular system to follow are the systolic/diastolic blood pressure and the central venous pressure. More refined tests of the cardiovascular system can be found in a variety of sources such as Orient,[644] Swartz,[645] LeBlond, DeGowin & Brown,[646] and Bickley & Szilagyi[647]. It is obvious that a patient with uncontrolled high or low blood pressures needs to be examined further to rule out underlying pathologies that may constitute a caution or contraindication to physical manipulation.

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[644] Orient, 2010
[645] Swartz, 2006
[646] LeBlond, R. F., DeGowin, R. L. & Brown, D. D. (2009). *DeGowin's diagnostic examination (9th Ed.).* McGraw-Hill: New York.
[647] Bickley & Szilagyi, 2003

6.3.2 Blood Pressure

"Blood pressure levels fluctuate strikingly through and 24-hour period, varying with physical activity, emotional state, pain, noise, environmental temperature, the use of coffee, tobacco, and other drugs, and even the time of day."[648] As such, readings of the systolic/diastolic blood pressure need to be combined with appropriate questioning, environment and positioning of the patient. Prior to taking blood pressure readings the patient should not smoke or have any caffeinated beverages at least 30 minutes prior to the readings and should be quietly resting in a warm room for at least 5 minutes before the test is undertaken.[649] When using the brachial artery an appropriately sized bladder and cuff must be used and be placed directly on the skin, approximately 2.5cm proximal to the crease of the antecubital fossa, with the arm at the same level as the heart.[650] The bell of the stethoscope is placed over the brachial artery and the bladder is inflated to a pressure 30mmHg over the point at which the pulse of the radial artery disappears and then slowly deflated at a rate of 2 – 3mmHg per second.[651] The systolic pressure is represented by the pressure at which the first two consecutive beats can be heard, the diastolic being represented by the disappearance of sounds immediately after they become muffled.[652]

6.3.3 Central Venous Pressure

The central venous pressure test is a useful measure of the venous pressure at the level of the right atrium because of its direct cephalic continuity with the superior caval system.[653] The column of blood present within this segment of the venous system is normally, in the erect position, 10cm; this level thus corresponds with the state of veins being filled below and collapsed above.[654] Naturally the height of this column of blood will differ markedly with the position of the patient throughout this test and it should be noted that in the decubitus position all of the peripheral veins are full.[655] This fact creates the possibility of raising or lowering the limbs while observing the superficial venous systems and the overall state of the limb useful in an initial assessment of the venous side of the cardiovascular system.

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[648] Bickley & Szilagyi, 2003, p.255
[649] Bickley & Szilagyi, 2003
[650] Bickley & Szilagyi, 2003
[651] Bickley & Szilagyi, 2003
[652] Bickley & Szilagyi, 2003
[653] LeBlond, DeGowin & Brown, 2009
[654] LeBlond, DeGowin & Brown, 2009
[655] LeBlond, DeGowin & Brown, 2009

The angle of Louis is the standard reference point for performing the central venous pressure test; the distance between a transverse plane created at this level, and the apex of the pulse of the internal jugular vein, being the value determined during the test.[656] The right internal jugular vein is preferred in this test as it offers a more direct column of blood than on the left. In general and subject to much variation, the following values are used with this test: At a 45° inclination, the upper limit of normal to see the pulsation of the internal jugular vein is 4cm – 5cm above the angle of Louis; at a 30° inclination the upper limit of normal is 6cm; and, in the decubitus position it is normal for the pulse of the internal jugular vein to be equal to or lower than the angle of Louis.[657] If the veins of the neck are distended in the 90° seated position it is assumed that the right atrial pressure exceeds 15mmHg[658] and needs to be further investigated prior to manipulation of the cardiovascular system.

6.4.0 Palpation

6.4.1 General Remarks

The osteopathic physician develops a specialized sense of touch which is as important to him in practice as is the trained sense of taste in the professional tea-taster, the sense of smell to the professional cheese buyer, the sense of color in the metallurgist or the sense of hearing to the leader of an orchestra. The osteopathic touch compares in a large measure with the same specialized sense developed by the blind. It is upon this specialized sense of touch that the osteopath by palpation depends for a diagnosis of tissue tone and anatomic relationships.[659]

This refinement in palpation is barely touched upon in the early text books of osteopathy[660,661,662,663,664,665,666,667,668,669,670] other than to state that diagnosis is made by palpation,

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656 Swartz, 2006
657 Swartz, 2006
658 Swartz, 2006
659 Webster, G. V. (1921). The feel of the tissues. 1947 reprint. *Academy of Applied Osteopathy Yearbook, p.32-3.*
660 Still, 1897
661 Still, 1899
662 Riggs, W. L. (1900). *Theory of osteopathy.* New Science Publishing Co.: Des Moines. Downloaded from www.archive.org.
663 Goetz, E. W. (1900). *A manual of osteopathy with the application of physical culture baths and diet.* Published by the Author: Cincinnati. Downloaded from www.archive.org.
664 Still, 1902
665 McConnell, C. P. (1902). *The practice of osteopathy*. Published by the Author: Kirksville. Downloaded from www.archive.org.
666 Tasker, D. L. (1903). *Principles of osteopathy.* Baumgardt Publishing Co.: Los Angeles. Downloaded from www.archive.org.

or that something must be palpated before a correction is made. Throughout the process of the emergence of osteopathy in the cranial field, finally published from Dr. Sutherland in 1939, deeper aspects of palpation began to gain a place within the osteopathic community. The works of Becker[671,672,673,674] and Frymann[675,676,677,678] added much to the concept of osteopathic palpation as well as how to work towards becoming proficient at it. More recent works on palpation by Allen & Stinson[679,680] have continued in the footsteps of Becker and Frymann.

What the literature cannot add to the osteopath's repertoire is experience. What the literature can add to the palpatory repertoire of the osteopath is the knowledge of anatomy and physiology needed to accurately interpret the information coming into their hands. This fact was an inspiring one for the author in the creation of chapters 3 and 5 in this memoir. With time, the combination of knowledge and palpatory experience will allow the osteopath to work with their palpatory intuition guiding them through treatment. This level of treatment is only attainable through continued study and work in the clinic. Dr. Becker stated that it took him three to five years to develop his sense of diagnostic touch such that he could rely upon it in the clinic.[681] This period of time occurring after his osteopathic training and having already being a practicing

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[667] Hulett, G. D. (1903). *A text book of the principles of osteopathy.* Journal Printing Company: Kirksville. Downloaded from www.archive.org.
[668] Hazzard, C. (1905). *The practice and applied therapeutics of osteopathy (3rd Revised Ed.).* Journal Printing Company: Kirksville. Downloaded from www.archive.org.
[669] Clark, 1906
[670] Still, 1910
[671] Becker, R. E. (1963). Diagnostic touch: its principles and application. *Academy of Applied Osteopathy Yearbook, p.32-40.*
[672] Becker, R. E. (1964a).Diagnostic touch: its principles and application: part II. *Academy of Applied Osteopathy Yearbook, p.153-160.*
[673] Becker, R. E. (1964b). Diagnostic touch: its principles and application: part III. *Academy of Applied Osteopathy Yearbook, p.161-166.*
[674] Becker, R. E. (1965). Diagnostic touch: its principles and application part IV trauma and stress. *Academy of Applied Osteopathy Yearbook Volume 2, p.165-177.*
[675] Frymann, V. M. (1963a). Palpation – its study in the workshop part I. *Academy of Applied Osteopathy Yearbook, p.16-20.*
[676] Frymann, V. M. (1963b). Palpation – its study in the workshop part II. *Academy of Applied Osteopathy Yearbook, p.20-22.*
[677] Frymann, V. M. (1963c). Palpation – its study in the workshop part III. *Academy of Applied Osteopathy Yearbook, p.22-25.*
[678] Frymann, V. M. (1963d). Palpation – its study in the workshop part IV. *Academy of Applied Osteopathy Yearbook, p.26-30.*
[679] Allen, P. V. B. & Stinson, J. A. (1992a). The development of palpation part I. In: Beal, M. C. (1992). *The principles of palpatory diagnosis and manipulative technique*. American Academy of Osteopathy: Ohio.
[680] Allen, P. V. B. & Stinson, J. A. (1992b). The development of palpation part I. In: Beal, M. C. (1992). *The principles of palpatory diagnosis and manipulative technique*. American Academy of Osteopathy: Ohio.
[681] Becker, 1965

physician of manipulative osteopathic technique. The underlying premise to any and all osteopathic palpation is 'practice makes perfect'.

6.4.2 Starting Point for Osteopathic Palpation

Inspection is so much the prelude to palpation that the former should be classed, not independently, but as an initial step in the latter. Along with sight is the sense of smell which has various diagnostic implications.[682] The value of sound to palpation is emphasized in the information gained both with and without the stethoscope. Only after the faculties of sight, smell and sound are saturated with data does physical palpation commence.

As palpation is an interaction and that interaction will change the tissues being inspected it seems logical to demand a superficial to deep progression. Information gained by superficial touch and palpation include, but are not limited to: temperature changes, skin drag, texture, and turgor; the fluid status of a tissue, and tenderness.[683] Deeper palpation can yield much information about both soft and bony tissues as well as joints. Combining his/her foundation of knowledge with palpation is what will turn these palpatory findings into 'osteopathic palpation'. Without a knowledge of the connections of the sympathetic nervous system in the innervation of the sweat glands for example, will lead the operator nowhere in terms of locating the cause of dysfunction if the palpatory findings display moisture changes in the skin which is segmentally isolated. Again, it cannot be stated enough that time, experience and continued study are the only ingredients in honing the skill of osteopathic palpation.

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[682] LeBlond, DeGowin & Brown, 2009

[683] DiGiovanna, E. L. (2005). Palpation. In: DiGiovanna, E. L., Schiowitz, S. & Dowling, D. J. (2005). *An osteopathic approach to diagnosis and treatment (3rd Ed.)* Lippincott Williams & Wilkins: USA.

6.4.3 Higher Levels of Palpation

Frymann[684] offered the following analogy between osteopathic palpation and the relative motion between a street car and its passengers:

> A street car is beginning to move. You are standing on the street. You decide to board the street car. You begin to run to approximate your momentum to that of the street car. You jump on the moving vehicle. If the automatic adjustor [central nervous system] is working well you will quickly attune your momentum to that of the street car and you will be riding with it. You will feel its inherent motion as it turns cornors, you will feel the tensions within it as it labors up a steep hill, or the release of tension as it coasts down a hill. This motion is just as active within the passenger as it is within the vehicle. How do we know this? If the street car suddenly stops where do the passengers go? They are thrown forward with the same momentum that they had assumed from the motion of the vehicle. No break was applied to them so they went on moving as before until some mechanical obstacle appeared in the way or the momentum had been expended. So it is in perceiving the motion within the human body. We must "jump on" and become attuned to the inherent momentum of the body, ride with it and become a part of it. This motion is like eternity, it has no beginning and no end: it is as perpetual as the tides of the ocean. It can change in pattern, in amplitude, in intensity, it can be diverted from one course to another, but it can never stop as long as life continues.[685]

This "motion"; this "potency"; this "vitality"; this "thing" that is perceived by the trained osteopathic hand is, in the opinion of the author directly linked to the fourth osteopathic dictum: it is the perceived sum of the interactions between the patient and Nature. How the patient copes structurally with this process links together the other three osteopathic dictums outlined in chapter 2: they will function properly if they are structurally adequate to deal with Nature; all supplies and demands will be met if the lines of communication and tubes of distribution are unhindered by the osseous system with its fascial attachments; and, harmony with Nature allows for this "motion"/"potency"/"vitality"/"thing" to move forward with time managing its resources and correcting any restriction or imbalance that may emerge provided it does not overwhelm the homeostatic mechanisms of the body. "It is dynamic. It is rhythmic. It is a quiet feeling of total interchange with the universe in which it lives."[686]

According to Hazzard[687], "palpation is our most important method of examination, the trained touch revealing to the Osteopath most of the lesions which he regards as the causes of

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[684] Frymann, 1963b
[685] Frymann, 1963b, p.21
[686] Becker, 1965, p.168
[687] Hazzard, 1905

disease."[688] Two things in the previous statement need qualification: "…most important…" and "…which he regards…". The former implies more than one method of examination with the latter exemplifying the subjectiveness of palpatory observation. Both of these facts must always be bourn in mind if the intrinsic subjectiveness of palpation is to somehow be objectified by the palpating hands. Becker stressed that a palpatory diagnosis is used in addition to other methods of diagnosis such as laboratory tests and diagnostic instruments[689,690] and not in place of them.

The divergence of the global osteopathic community from the American community has placed osteopaths other than those trained within the United States of America with limited access to such laboratory and diagnostic instrumentations, provided those practitioners have not also studied allopathic medicine. Complexity thinking offers routes to establish relationships within the greater healthcare community such that all necessary modes of diagnosis should be exhausted. As this point is a political/legal one it will not be entertained further here by the author.

The final note on higher levels of palpation is this: "it is a self-taught process. The steps of where and how to do this can give guidance but the physician himself is the final arbiter as to methods and results."[691] Continued study and experience will see the emergence of this process within each individual.

6.5 Osteopathic Manipulation of the Peritoneal Viscera

"Do not copy anybody's movements. Learn the principles, then apply them in the manner most satisfactory to yourself and helpful to the patient."[692] Combining the preceding statement with the notion that palpation is individualistic and cannot be developed from literature alone leads to a sort of conundrum: it is not possible to learn either how to palpate or to manipulate osteopathically from the written word. It must be experienced directly. This conundrum was faced by AT Still to a greater degree than anyone since. He was the first; the first self-proclaimed osteopath. He learned by doing, out of necessity he operated in a complete space of emergence.

[688] Hazzard, 1905, p.8
[689] Becker, 1963
[690] Becker, 1964a
[691] Becker, 1963, p.34
[692] Tasker, 1903, p.290

For a moment, the author asks the reader to pause and reflect: you are in the American Midwest just past the midway point of the 19th century. You are a rural doctor faced with a patient stricken with an illness that you have failed to cure in the past by standard medical means; the ones you learned in medical school. You have a new theory as to the cause of disease and its treatment. How do you proceed ethically?

Obviously there is no answer to this question. What can be speculated is that this young doctor, AT Still, did something and obtained a result that was to a degree better than he had previously obtained with his training and experience. The degree of improvement over the traditional methods that AT Still obtained is arbitrary. It was for the next two decades that he developed his new philosophy of treatment before he announced to the world that he had even discovered something. It was just short of another two decades after that, that he opened a school to teach others this discovery. Over the course these four decades much evolution occurred both in the philosophy of osteopathy as well as osteopathic manipulation. It continues to evolve to this day and will continue to evolve into the future.

To date there is no osteopathic book that is efficient in displaying techniques for treatment because to write such a book requires the realm of process to be left and procedure entered. Only the philosophical aspects of osteopathic manipulation can be discussed on paper. Suggestive techniques can be listed and elaborated, but are always that: suggestive, and never conclusive. To achieve a state of conclusiveness requires feedback that the manipulation performed was appropriate and effective. It simply is not adequate to know a variety of movements and manipulations without having the experience of applying them. The philosophy of osteopathy, *which includes the ability to perform osteopathic manipulation* is complex, making attempts to propagate it with written words futile; the student must out of necessity learn by doing.

AT Still claimed that “to get good results, your head full of anatomy must guide your hands to correctly adjust from the abnormal to the normal with the exactness required for a perfect articulation. Brute force is dangerous. Hands off unless you know your business.[693] This “business” is a knowledge of the osteopathic philosophy and anatomy. In lieu of either

[693] Still, 1910, p.288

creating novel manipulative techniques or simply cutting and pasting the works of others, the author has strived in previous chapters to investigate and discuss the “business” necessary for treatment. To perform osteopathic manipulation requires an openness entering into the interaction with the patient. The author has argued that this openness is analogous to the ‘space of emergence’ that Osberg & Biesta[694] claim results in the most efficient and deepest form of learning for students. The operator is in fact learning each time they place their hands on a patient. They are learning more about palpation and they are learning more about manipulation. Both of these aspects are measured empirically via the results obtained in the clinic.

To conclude this section of manipulation the author would like to offer another quote from AT Still which exemplifies the difficulties in communicating how to perform osteopathic manipulation:

“He must not be a blacksmith only, and only able to hit large bones and muscles with a heavy hammer, but he must be able to use the most delicate instruments of the silversmith in adjusting the deranged, displaced bones, nerves, muscles, and remove all obstructions, and thereby set the machinery of life moving. To do this is to be an Osteopath.”[695]

[694] Osberg & Biesta, 2007
[695] Still, 1897, p.360

Chapter 7: Conclusions

7.0 Conclusions

This journey has been an interesting one. It has solidified the author's faith in both complexity thinking and the philosophy of osteopathy. The initial goal of this memoir was to explore both the philosophy of osteopathy as elaborated by AT Still, as well as the paradigm of complexity, with the intension to link them together and generate a model of treatment for the peritoneal viscera with a strong base in osteopathic philosophy while at the same time respecting the paradigm of complexity. In retrospect this approach was linear and it is not surprising that not only did this tidy model not come to fruition, but as the process of this memoir continued, the goal of the memoir evolved. What emerged from the acquisition of knowledge pertaining to the osteopathic philosophy and paradigm of complexity was the creation of a base of knowledge of the embryology and anatomy of the peritoneal viscera with the aim of creating a space of emergence for the treatment of the peritoneal viscera.

The author's investigations into the osteopathic philosophy started with the works of the philosophy's discoverer, AT Still. Anyone who has read these works as a relative neophyte to the osteopathic philosophy will empathize with the author regarding the challenge to understand the message AT Still was trying to communicate. Time and added experience in both anatomical studies as well as in the clinic put into perspective what AT Still was writing. It also emphasized that what AT Still was trying to communicate was complex. It could not be stated objectively, only described as processes. With that, AT Still opted to employ many lengthy analogies and did not rest with accepted theories or philosophies making what he was communicating unique. Only after investigating the paradigm of complexity could these descriptive processes be put into perspective. The desire to attempt to formulate an all encompassing definition of the philosophy of osteopathy was abandoned and it was accepted that the osteopathic philosophy is a complex process.

The author's investigations into the paradigm of complexity led him to what Davis and Sumara[696] have termed complexity thinking. In brief, it is a new way of thinking based on many concepts within the field of complexity science: process, emergence, hierarchy, interaction, attractors, systems etc., that does not become tied down to absolutes. This way of thinking turned out to be precisely what the author found during the in-depth review of both the works of

[696] Davis & Sumara, 2006

AT Still and the early osteopathic literature in general. In turn, this catalyzed his understanding of both complexity and osteopathy. Becoming well versed in the osteopathic philosophy aided in understanding how complex processes operate; and, becoming well versed in the paradigm of complexity aided in understanding the philosophy of osteopathy. A truly emergent form of learning took place.

With the thought of developing a tidy model of treatment of the peritoneal viscera according to the osteopathic philosophy and rooted in the paradigm of complexity abandoned as impossible, the author focused on creating a foundation of knowledge for each of the philosophy of osteopathy, the paradigm of complexity, the embryology, and the anatomy of the peritoneal viscera as they relate to manipulative treatment. Topographical, relational, and palpatory anatomy were stressed with the hope that this foundation could be combined with the concept of osteopathic palpation to lead both the author and reader to a space of emergence of treatment of the peritoneal visceral. It is impossible for one person to enumerate all of the mechanical etiologies of disease as defined by the philosophy of osteopathy. This is the place of the osteopathic community in general, and, the author hopes that this memoir has added to that collective knowledge so that we can all “Dig On”.

Appendix A: First Definitions of Osteopathy

- Osteopathy is that science which consists of such exact, exhaustive and verifiable knowledge of the structure and functions of the human mechanism, anatomical, physiological and psychological, including the chemistry and physics of its known elements, as had made discoverable certain organic laws and remedial resources, within the body itself, by which nature under the scientific treatment peculiar to osteopathic practice, apart from all ordinary methods of extraneous, artificial, or medicinal stimulation, and in harmonious accord with its own mechanical principles, molecular activities, and metabolic processes, may recover from displacements, disorganizations, derangements, and consequent disease, and regain its normal equilibrium of form and function in health and strength.[696]

- Osteopathy is the science of treating disease through a technical manipulation by which the operator intelligently directs the inherent recuperative resources within the body itself to the restoration of health. It rests upon the theory that every diseased condition not due to a specific poison is traceable to some mechanical disorder, which if corrected, will allow nature to resume perfect work.[697]

- Osteopathy is that science or system of healing which emphasizes, (a) the diagnosis of diseases by physical methods with a view to discovering, not the symptoms but the causes of disease, in connection with misplacements of tissue, obstruction of the fluids and interference with the forces of the organism; (b) the treatment of diseases by scientific manipulation in connection with which the operating physician mechanically uses and applies the inherent resources of the organism to overcome disease and establish health, either by removing or correcting mechanical disorders and thus permitting nature to recuperate the diseased part, or by producing and establishing anti-toxic and anti-septic conditions to counteract toxic and septic conditions of the organism or its parts; (c) the application of mechanical and operative surgery in setting fractured or dislocated bones, repairing lacerations and removing abnormal tissue growths or tissue elements when these become dangerous to organic life.[698]

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[696] Pressly, M. W. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.212.*
[697] Hardin, M. C. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213.*
[698] Littlejohn, J. M. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213.*

- Osteopathy: A system of medicine characterized by the non-use of drugs for internal administration and the substitution therefore of sanitation, psychiatry and the scientific manipulation of the body to effect the prevention and cure of diseases, using the bones mechanically as bases, levers and fulcrums upon, or by the means, of which disordered parts of the bodily mechanism are restored to normal position and function and nerve force and circulation are stimulated or inhibited. The tenets of the system deprecate the excessive use of operative surgery and teach patient perseverance in assisting nature to remove the cause and products of disease through natural channels. They insist on a reliance upon the *vis medicatriæ naturæ*.[699]

- Osteopathy: The newer practice of medicine in which the physician discards the internal administration of drugs and relies upon the scientific manipulation of the body, aided by hygiene and psychiatry, to effect the prevention and cure of disease, using the bones mechanically as a means by which disordered pars are restored to normal position and function.[700]

- Osteopathy: A therapeutic system of stimulation and inhibition through specific organic reflexes by manipulation tending to normalization of circulation and function, recognizing and using as adjuncts every cognate therapy, condemning the use of any curative agent with life-depressing sequel, affecting alike normal and abnormal centers dangerous to idiosyncratic patients.[701]

- Osteopathy [osteon, bone; pathos, suffering]: A system of treatment of disease by manipulation by which displacements of structures such as bones, ligaments and vessels or of viscera such as the uterus and stomach, are corrected, contraction and relaxation of muscles relieved and nerves and nerve centers stimulated or inhibited. As a result the circulation of the blood is controlled, the activity of the viscera regulated and anatomical derangements corrected, thus allowing a free flow of blood, lymph and nerve force to every part of the body, which is necessary to perfect health.[702]

[699] McIntyre, H. H. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213.*
[700] McIntyre, 1902, p.213
[701] Bowling, R. W. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213*.
[702] Clark, M. E. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213.*

- Osteopathy is that branch of the healing art which alleviates and cures disease, without the administration of drugs, by the proper directing of the inherent recuperative fluids and forces of the body. 1. By the manipulative adjustment of deranged tissues which have produced pathological changes by either directly or indirectly interfering with the normal blood, lymph or nerve supply to the parts of the body organism. 2. By the direct or reflex mechanical stimulation or inhibition of nerve fibers and centers, to increase or decrease functional activity as the condition may require.

  Its tenets thus differ from those of the older schools of medicine in relation to (1) Etiology of disease, primary significance being given to minor anatomical lesions, particularly spinal, which would not be considered as causal factors by other schools; (2) manner of affecting functional activity, the drug therapist using a chemical agency to affect metabolism and function, the osteopath affecting these in a direct or reflex manner by scientific mechanical manipulation.[703]

- Osteopathy: A system of therapeutics which, recognizing that the maintenance and restoration of normal function are alike ultimately dependent on a force inherent in bioplasm, and that function perverted beyond the limits of self-adjustment is dependent on a condition of structure perverted beyond those limits, attempts the re-establishment of normal function by manipulative measures designed to render to the organism such aid as will enable it to overcome or adapt itself to the disturbed structure.[704]

- Osteopathy is a school of mechanical therapeutics based on several theories. I. Anatomical order of the bones and other structures of the body, is productive of physiological order, i. e., ease or health in contra-distinction to disease or disorder which is usually due, directly, or indirectly, to anatomical disorder. 2. Sluggish organs may be stimulated mechanically by way of appropriate nerves (frequently by utilizing reflexes) or nerve centers. 3. Inhibition of over-active organs may be effected by steady pressure substituted for the mechanical stimulation mentioned above. 4. Removal of causes of faulty action of any part or organ is the keynote of the science.[705]

- Thus the word [osteopathy] has come to mean that science which finds in disturbed mechanical relations of the anatomical parts of the body causes of the various diseases to which the human system is liable; that science which cures disease by applying technical knowledge and high manual skill to the restoration of any or all disturbed mechanical relations occurring in the body.[706]

- Osteopathy means that science or system of healing which treats disease of the human body by manual therapeutics for the stimulation of the remedial and resisting forces within the body itself, for the correction of misplaced tissue and the removal of obstructions or interferences with the fluids of the body, all without the internal administration of drugs or medicines.[707]

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[703] Willard, A. M. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.213.*
[704] Hulett, G. D. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.214.*
[705] Case, C. M. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.214.*
[706] Hazzard, C. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.214.*
[707] Teall, C. C. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.214.*

- Osteopathy is a scientific system of mechanical adjustment of any abnormal condition that may exist in the human organism.[708]

- Osteopathy is the science of curing disease by manipulations without the use of drugs, these manipulations being directed to the overcoming of abnormalities of structure, to the readjustment of the parts of the human body so that there shall be no interference with the functioning of any part, and to the regulation of the functioning powers of each organ of the human body.[709]

- Osteopathy is a scientific method of healing by skillful manipulation of the human body, based on a thorough knowledge of anatomy and physiology, by which the operator is enabled to trace effects to their cause and remove them, thus restoring harmony throughout the body – which is health –[710]

- Osteopathy is that school of medicine whose distinctive method consists in (1) a physical examination to determine the condition of the mechanism and functions of all parts of the human body, and (2) a specific manipulation to restore the normal mechanism and reestablish the normal functions. This definition lays stress upon (1) correct diagnosis. The osteopath must know the normal and recognize any departure from it as a possible factor in disease. There is not one fact known to the anatomist or the physiologist that may not be of vital importance to the scientific osteopath. Hence a correct diagnosis based upon such knowledge is half the battle. Without it scientific osteopathy is impossible and the practice is necessarily hap-hazard or merely routine movements. The definition lays stress upon (2) removal of the cause of disease. A deranged mechanism must be corrected by mechanical means specifically applied as the most natural and only direct method of procedure. This work is not done by any of the methods of other schools. After the mechanism has been corrected little remains to be done to restore function; but stimulation or inhibition of certain nerve centers may give temporary relief and aid nature. The adjuvants used by other schools, such as water, diet, exercise, surgery, etc., are the common heritage of our profession and should be resorted to by the osteopath if they are indicated.[711]

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[708] Collier, J. E. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.253.*
[709] Ashmore, E. F. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.253.*
[710] Duffield, B. A. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.253.*
[711] Booth, E. R. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.253.*

- 1. Osteopathy is a physical method of treating disease without drugs.

  2. Osteopathy is applied physiology

  3. The cell is the unit of the body which inherits its vitality. This vitality is kept up by pabulum received from the blood, while the waste is carried away by the lymph and venous steams.

  The differentiated cell to be able to trophize properly must receive a nerve. Every cell has the inherent capacity to recuperate after injury, and as the nervous system controls the circulation of the blood it follows that any abnormality of position or size of any tissue or any change in the chemical constitution of the tissue leads to disease.

  The nervous system yields most readily to mechanical stimuli, therefore "Osteopathy is the art of treating disease by physical and mechanical means; the science of aiding the vital processes by means of stimulation or inhibition of nerves, and by the removal of lesions or obstructions.[712]

- Osteopathy is a complete system of healing, wherein only food and water is allowed to enter the stomach, and all natural means are employed to place a diseased body under such conditions as will permit nature to effect a cure, including the most effective dietetic and hygienic measures, such as suggestion, fasting, exercise and hydro-therapy; special use being made of manipulations that normalize the tonicity of muscles, the flow of blood and lymph, the transmission of nerve force and the functioning of bodily organs by replacing deranged anatomical structures, stretching and pressing muscles, vessels and nerves, freeing the movements of joints and correcting dislocations and subluxations.[713]

- Osteopathy: A system, method or science of treating disease manually, which emphasizes (a) that disease of any tissue is the result of anatomical misplacements which obstruct the natural force of the body, thereby causing a weakened condition in that tissue to which the force should be directed; (b) that to relieve disease all misplaced anatomy must be adjusted, thus removing any obstruction to the natural forces, allowing them to be brought to bear on the wakened tissue, and (c) after all obstructions are removed mechanical stimulation or inhibition of nerves and nerve centers, and of the circulation, to the weakened tissue until a normal condition is brought about.[714]

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[712] Hofsess, J. W. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.253-4.*
[713] Young, C. W. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*
[714] Runyon, S. H. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*

- Osteopathy is that science or system of healing which, using every means of diagnosis, with a view to discovering, not only the symptoms, but the causes of disease, seeks by scientific manipulations of the human body, and other physical means, the correcting and removing of all abnormalities in the physical relations of the cells, tissues and organs of the body, particularly the correcting and misplacements of organs or parts, the relaxing of contracted tissues, the removing of obstructions to the movements of fluids, the removing of interferences with the transmission or nerve impulses, the neutralizing and removing of septic or foreign substances from the body; thereby restoring normal physiological processes, through the re-establishment of normal chemical and vital relations of the cells, tissues and organs of the body, and resulting in restoration of health, through the automatic stimulation and free operation of the inherent resistant and remedial forces within the body itself.[715]

- Osteopathy: A method of treating disease characterized, in diagnosis, by manual examination intended to discover abnormalities of position in bones or of tension in muscles and ligaments which might interfere with the free passage of nerve impulses or of the nutrient fluids; and in therapeutics, by manipulations calculated to remove the discovered abnormalities.[716]

- Osteopathy is the science which reasons on the human system from a mechanical as well as a chemical standpoint, taking into consideration in its diagnosis, heredity, the habits of the patient, past and present; the history of the trouble, including symptoms, falls, strains, injuries, toxic and septic conditions, and especially in every case a physical examination by inspection, palpation, percussion, auscultation, etc., to determine all abnormal physical conditions; the treatment emphasizing scientific manipulation to correct mechanical lesions, to stimulate or inhibit and regulate nerve force and circulatory fluids for the recuperation of any diseased part, using the vital forces within the body; also the habits of the patient are regulated as to hygiene, air, food, water, rest, exercises, climate and baths, such means as hydropathy, electricity, massage, antidotes and antiseptics and suggestion sometimes being used as adjuncts.[717]

- Osteopathy is a system of medicine, characterized by a close adherence to the physiological axiom that perfect health depends on a perfect circulation and perfect nerve control in every tissue of the body. Its pathology emphasizes physical perversions of tissue relations as causes of disease. Its diagnosis is mainly dependent on the discovery of physical lesions by means of palpation. Its therapeutics comprehends (1) manipulation, including surgery, for purposes of readjusting tissue relations; (2) scientific dietetics; (3) personal and public hygiene.[718]

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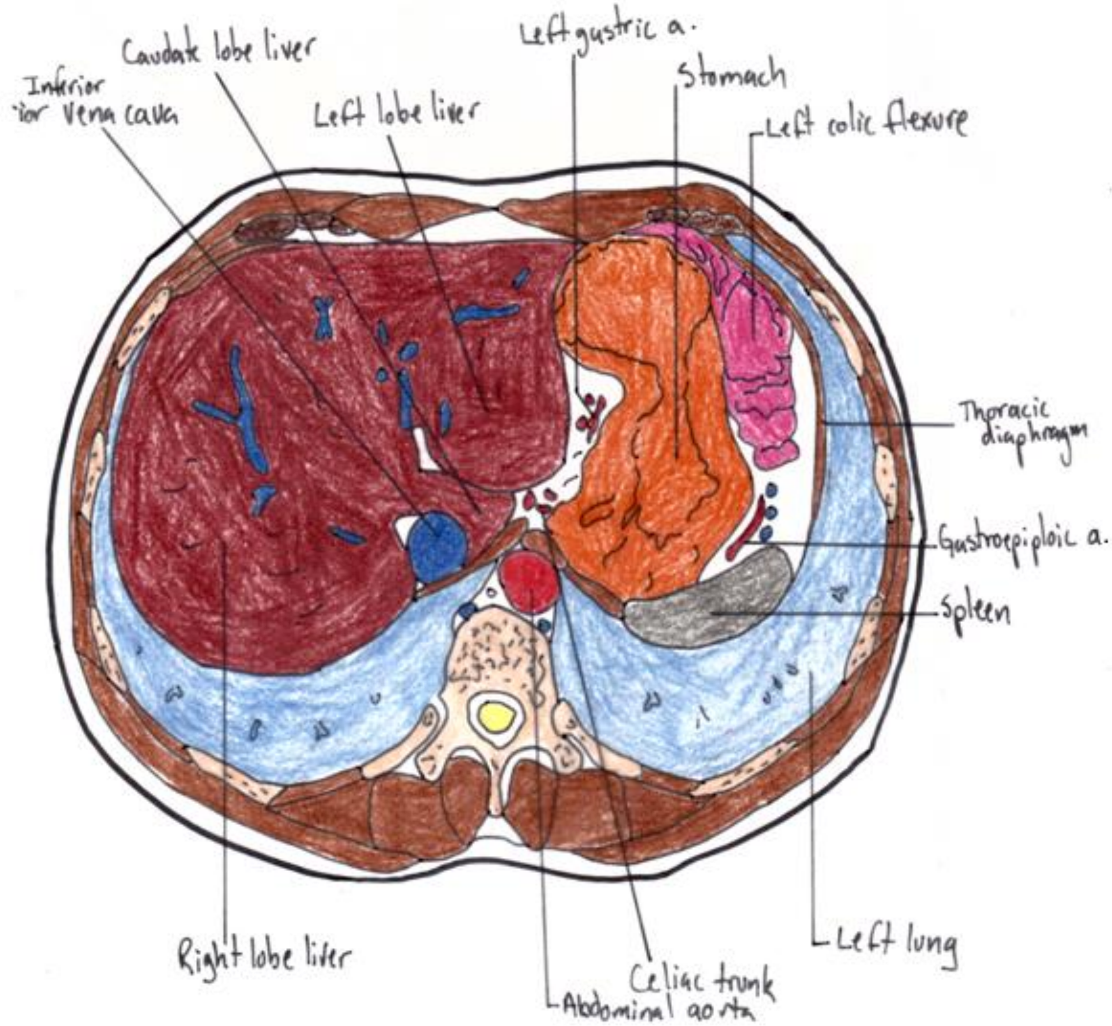
[715] Hulett, C. M. T. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*
[716] Fassett, F. J. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*
[717] Reid, C. C. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*
[718] Tasker, D. L. (1902). Untitled article. *The Journal of the American Osteopathic Association, 1, p.254.*

Appendix B: Sectional Anatomy

Transverse sections based on CT images

Sagittal and coronal sections based on MRI images



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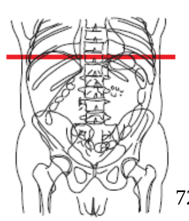

720

Figure B1

719 Redrawn and modified from Moeller, T. B. & Reif, E. (2007). *Pocket atlas of sectional anatomy computed tomography and magnetic resonance imaging volume II: thorax, heart, abdomen and pelvis (3rd Ed.).* Thieme: New York, p.85

720 Moeller & Reif, 2007, p.84

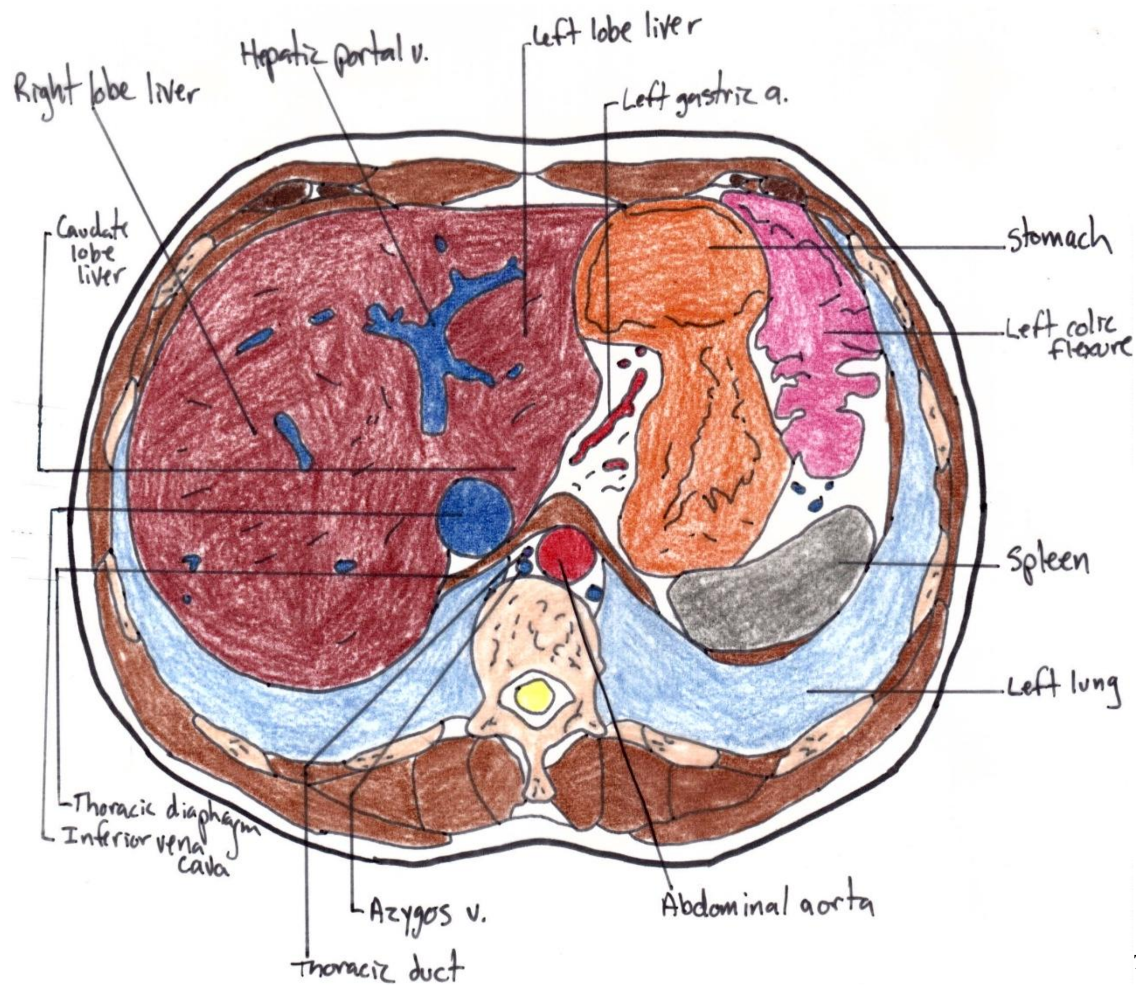

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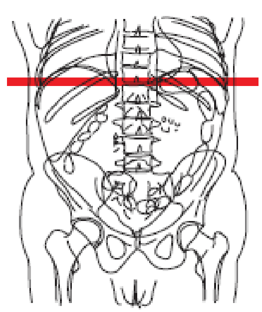
Figure B2

\  722

[721] Redrawn and modified from Moeller & Reif, 2007, p.87
[722] Moeller & Reif, 2007, p.86

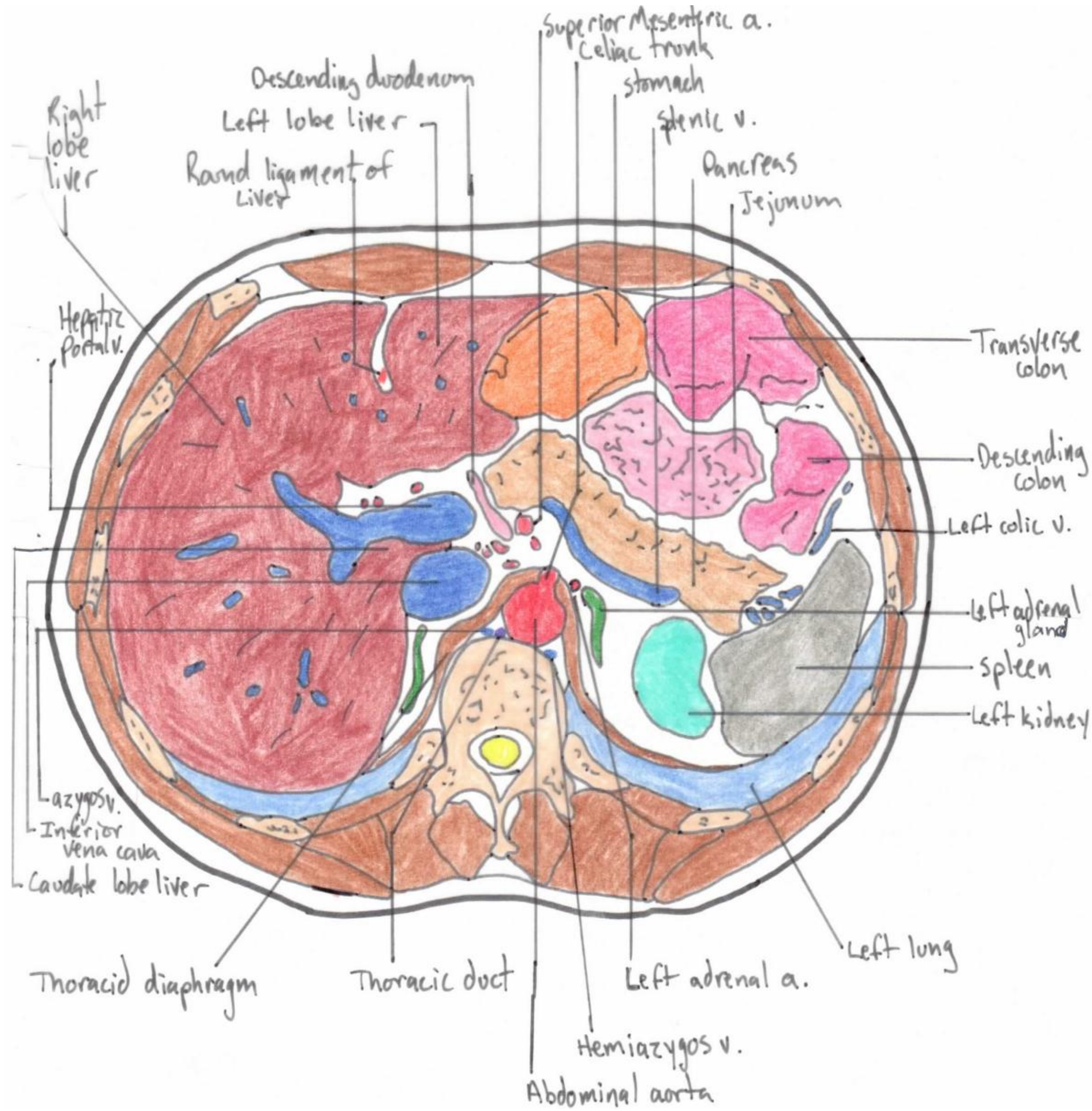


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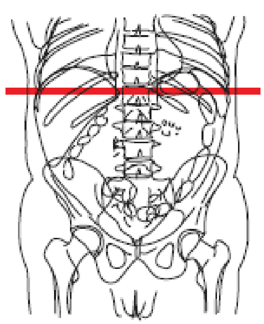
Figure B3



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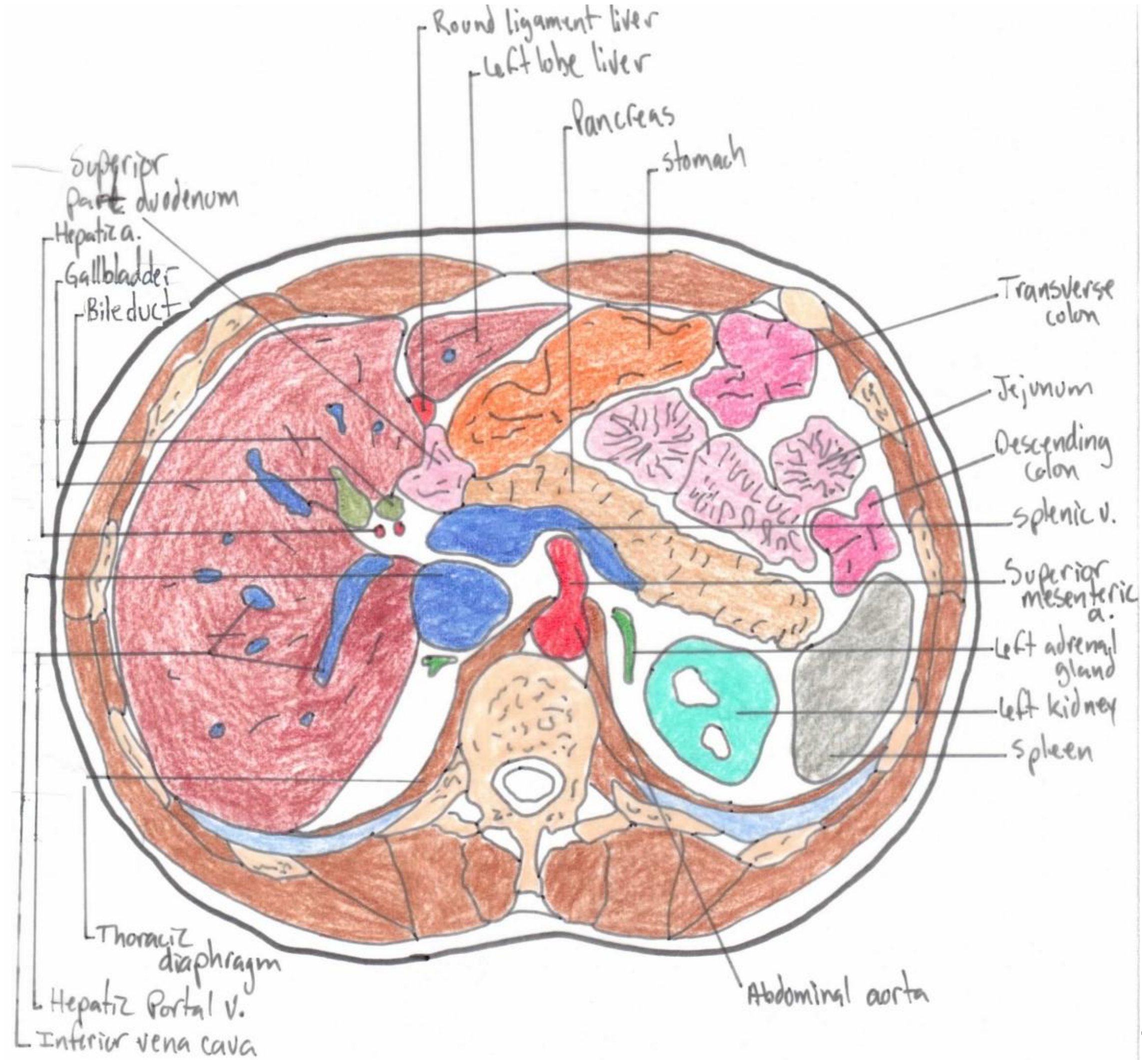
723 Redrawn and modified from Moeller & Reif, 2007, p.89
724 Moeller & Reif, 2007, p.88



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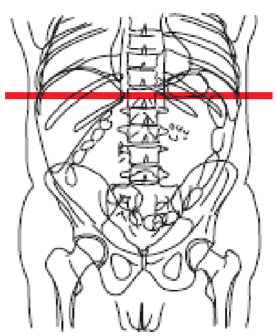

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Figure B4

725 Redrawn and modified from Moeller & Reif, 2007, p.91

726 Moeller & Reif, 2007, p.90

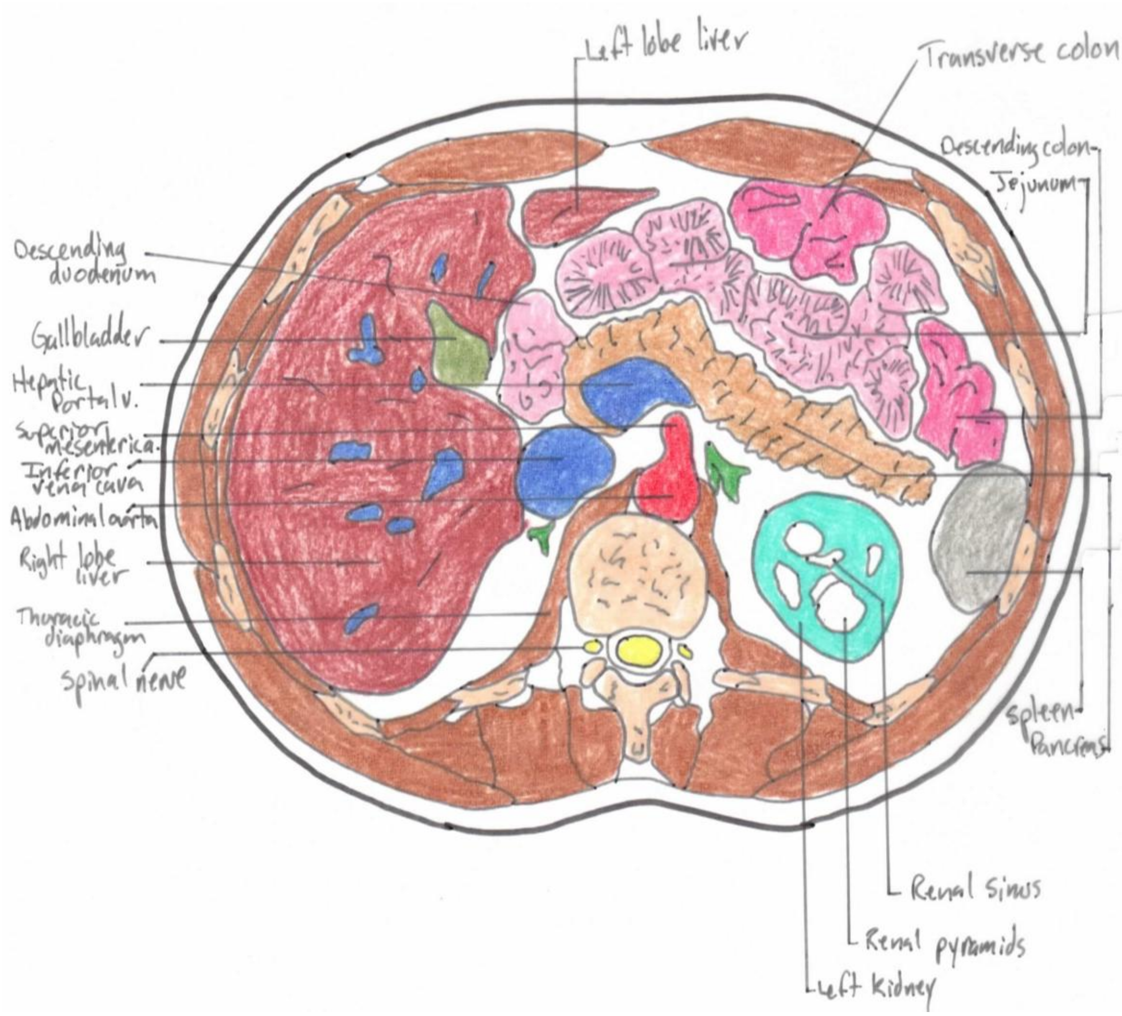

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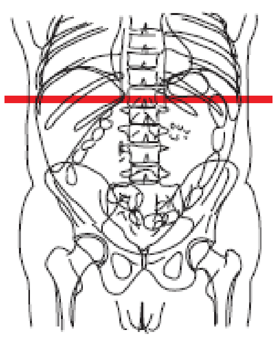
Figure B5



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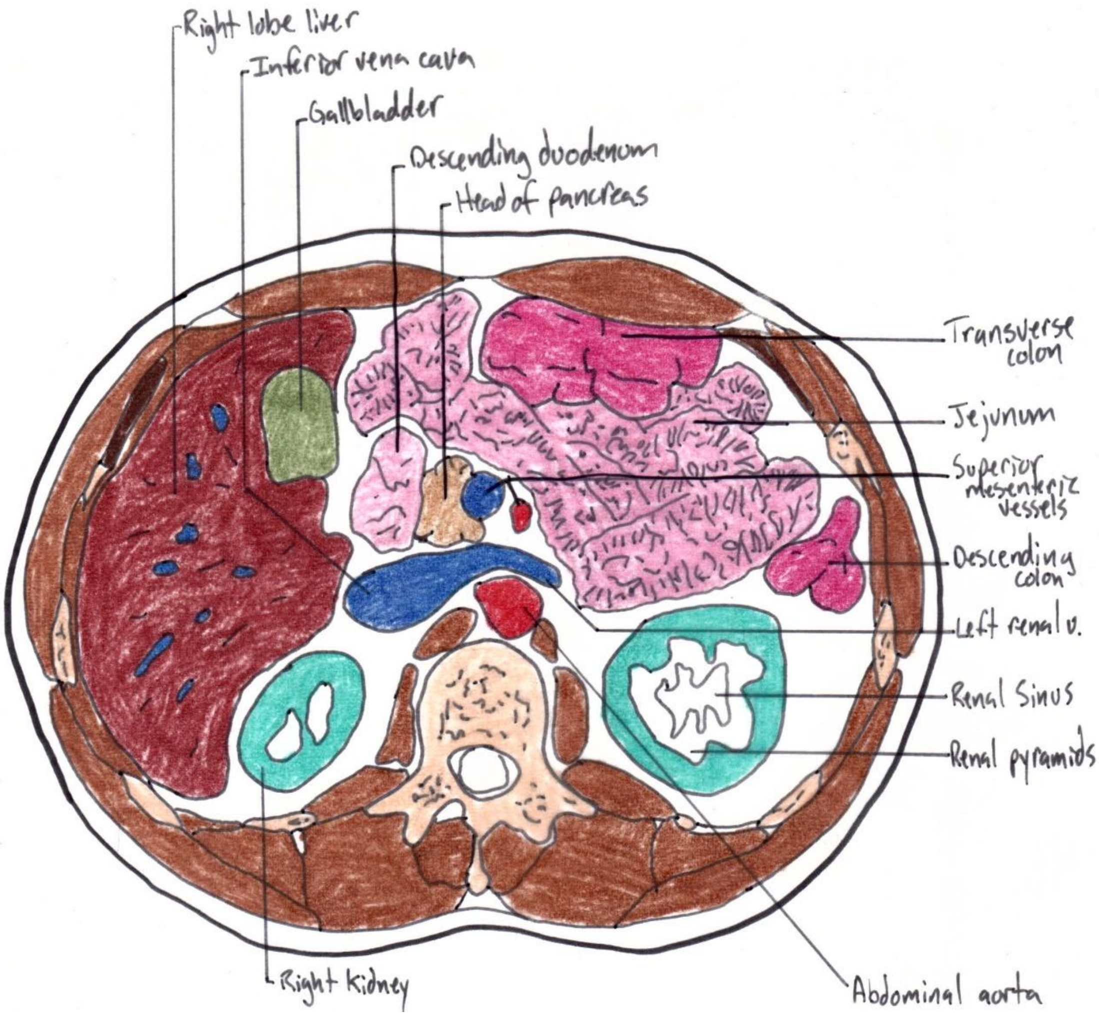
[727] Redrawn and modified from Moeller & Reif, 2007, p.93
[728] Moeller & Reif, 2007, p.92



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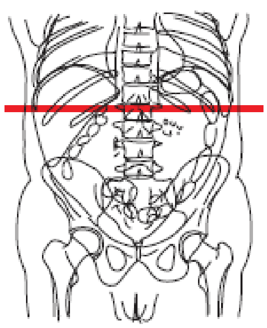

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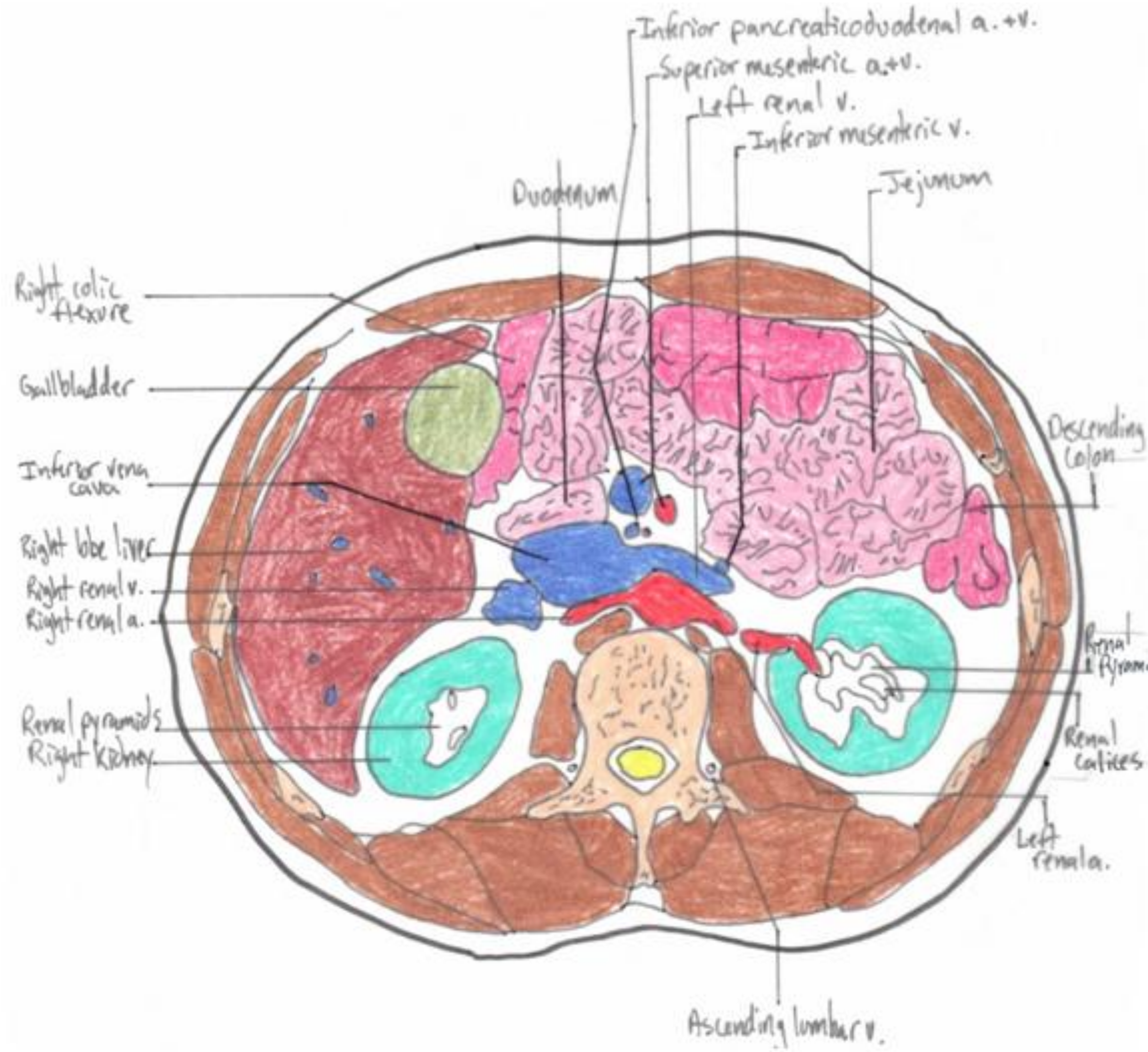
Figure B6

729 Redrawn and modified from Moeller & Reif, 2007, p.95
730 Moeller & Reif, 2007, p.94



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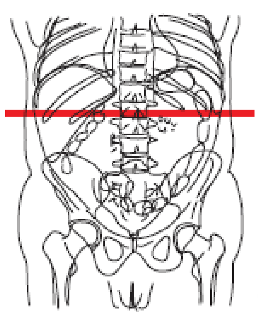

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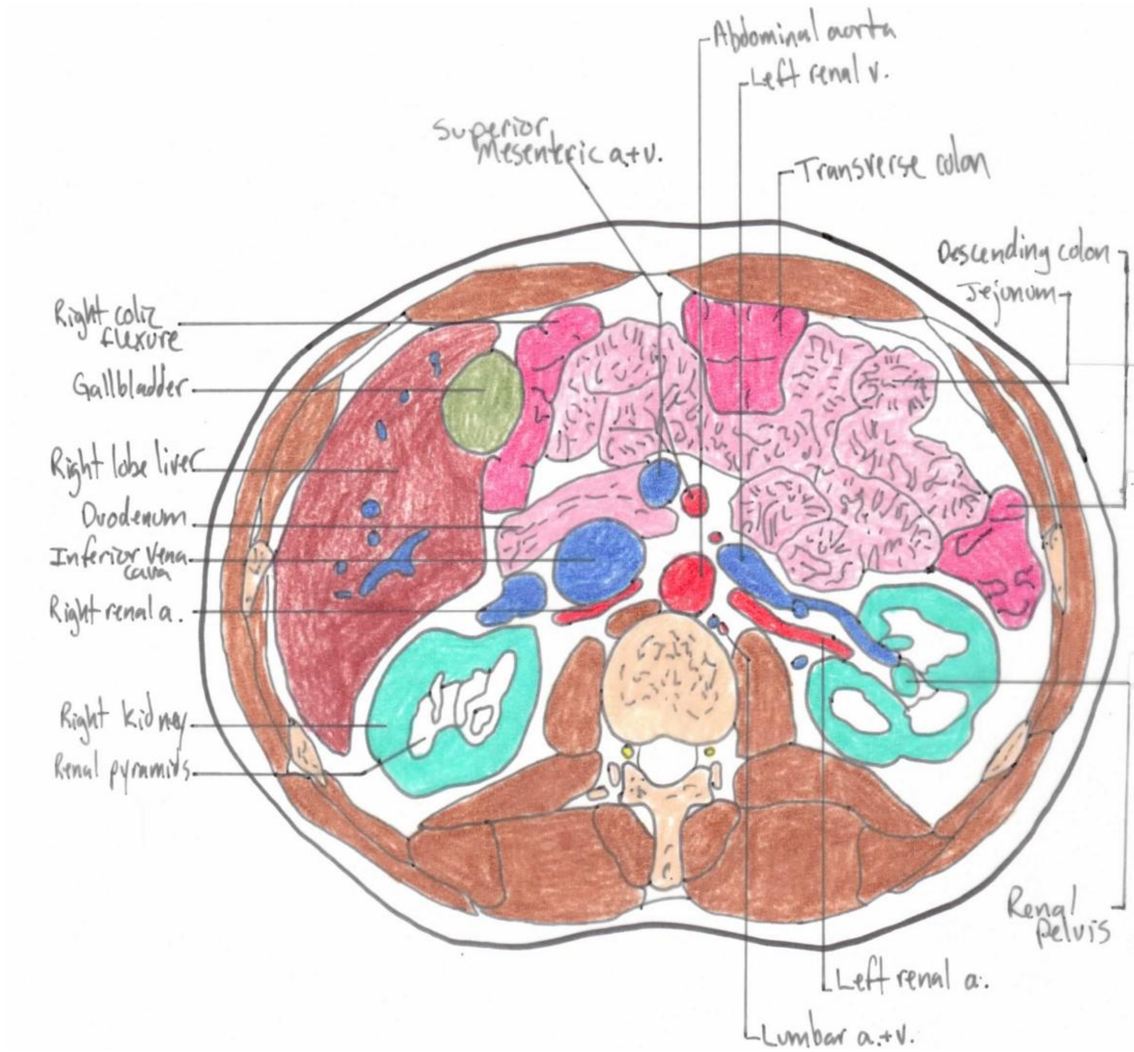
Figure B7

[731] Redrawn and modified from Moeller & Reif, 2007, p.97
[732] Moeller & Reif, 2007, p.96



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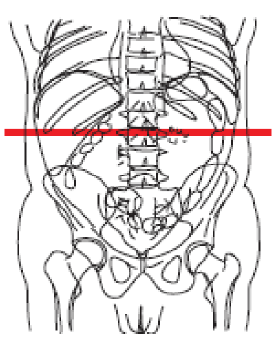

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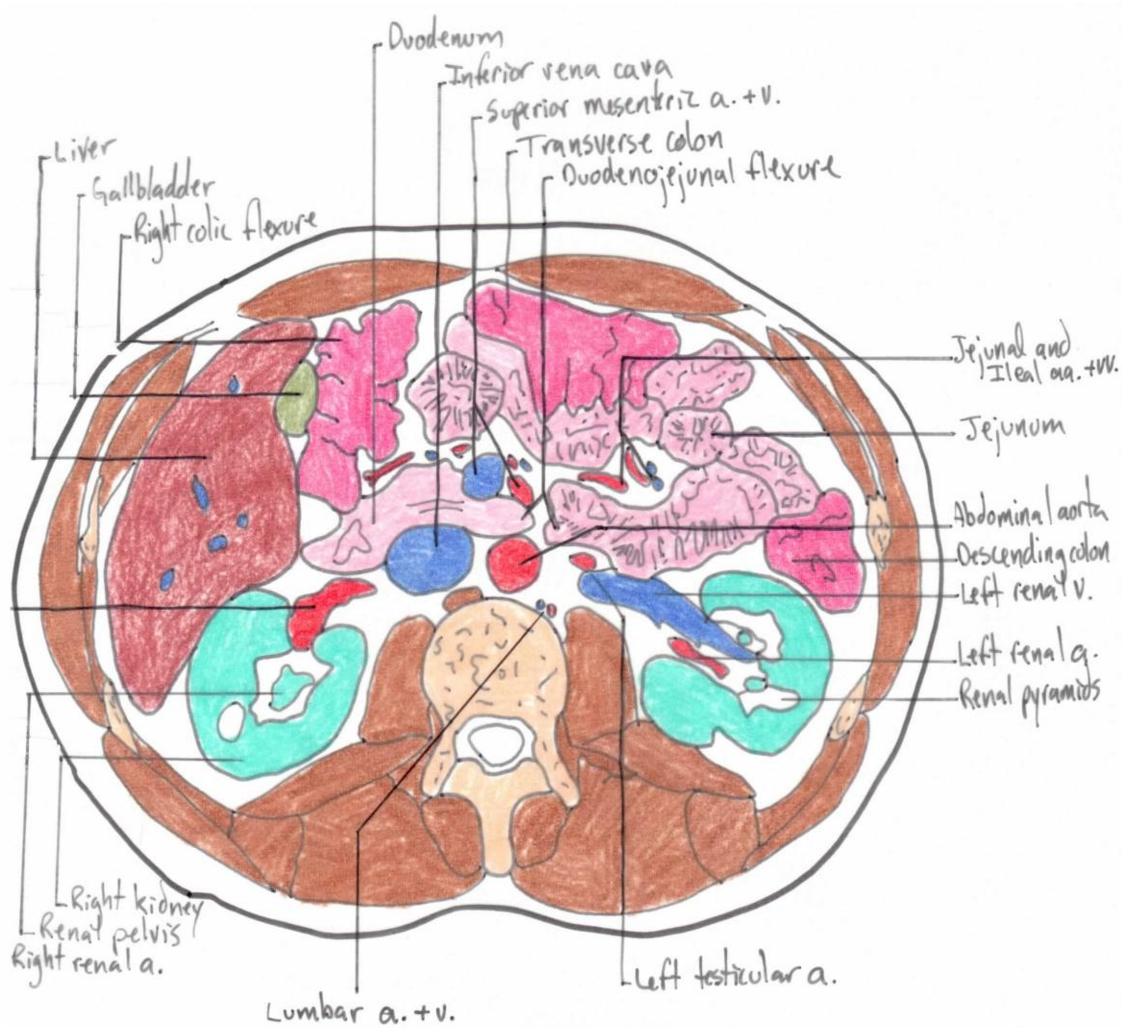
[734] Moeller & Reif, 2007, p.98



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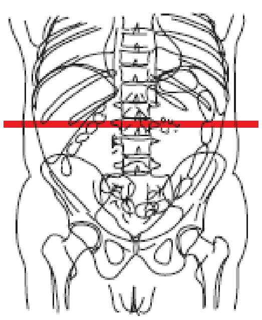

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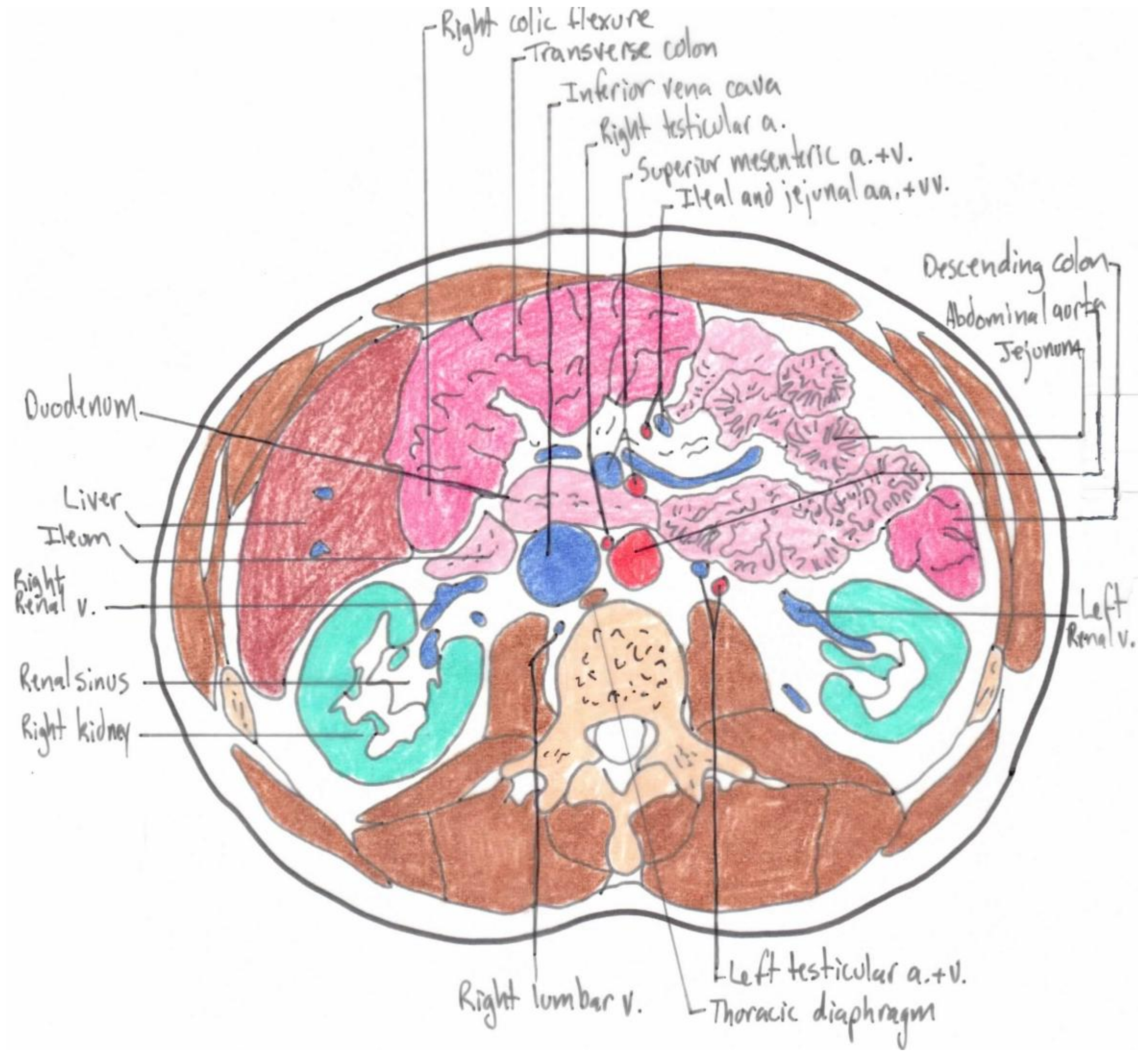
Figure B9

[735] Redrawn and modified from Moeller & Reif, 2007, p.101
[736] Moeller & Reif, 2007, p.100



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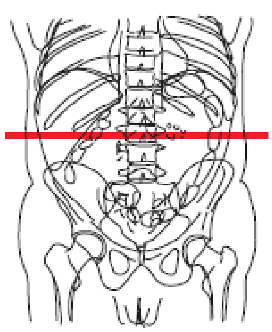
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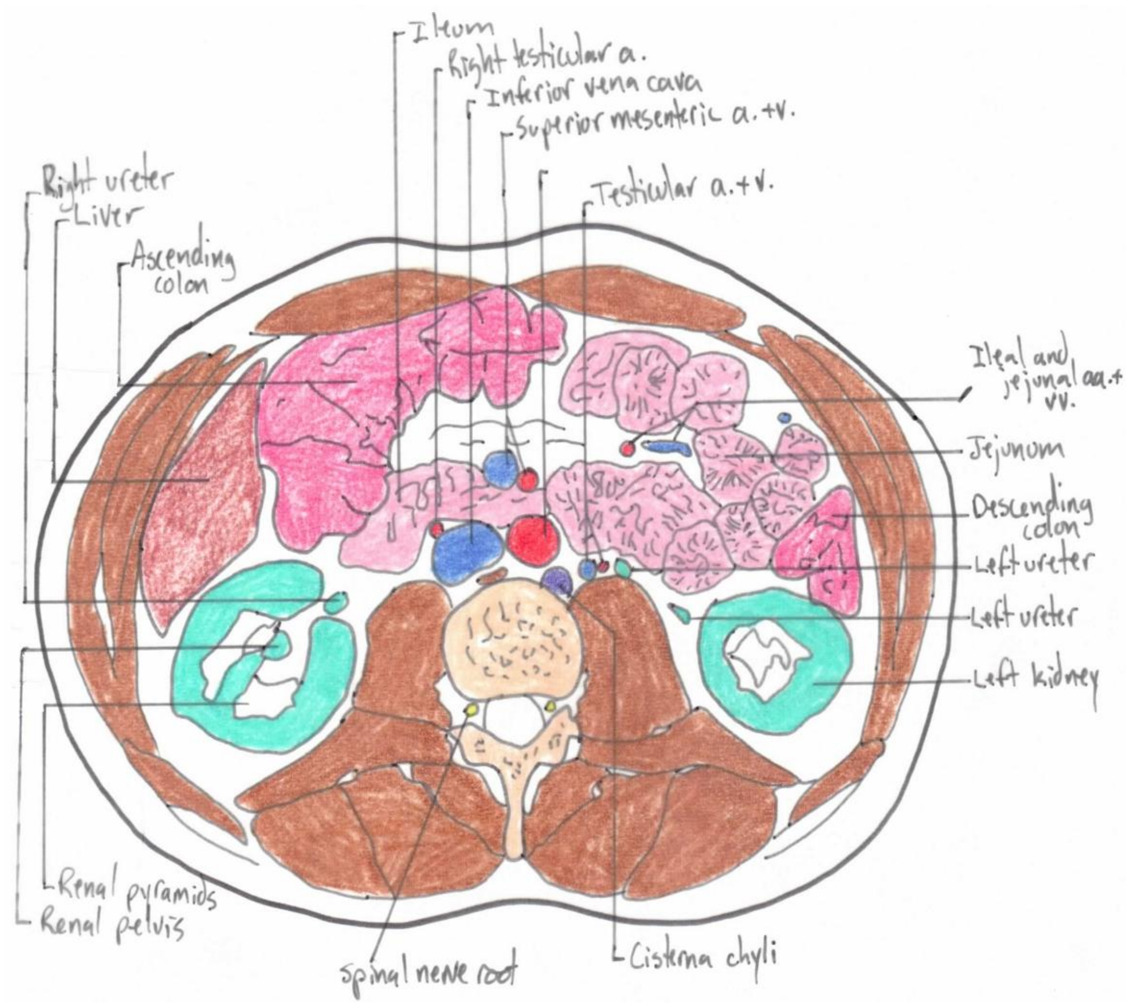
Figure B10

[737] Redrawn and modified from Moeller & Reif, 2007, p.103
[738] Moeller & Reif, 2007, p.102



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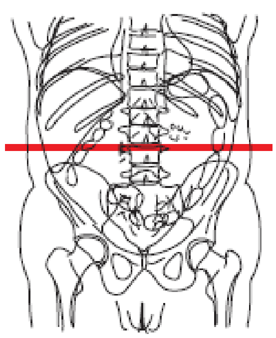

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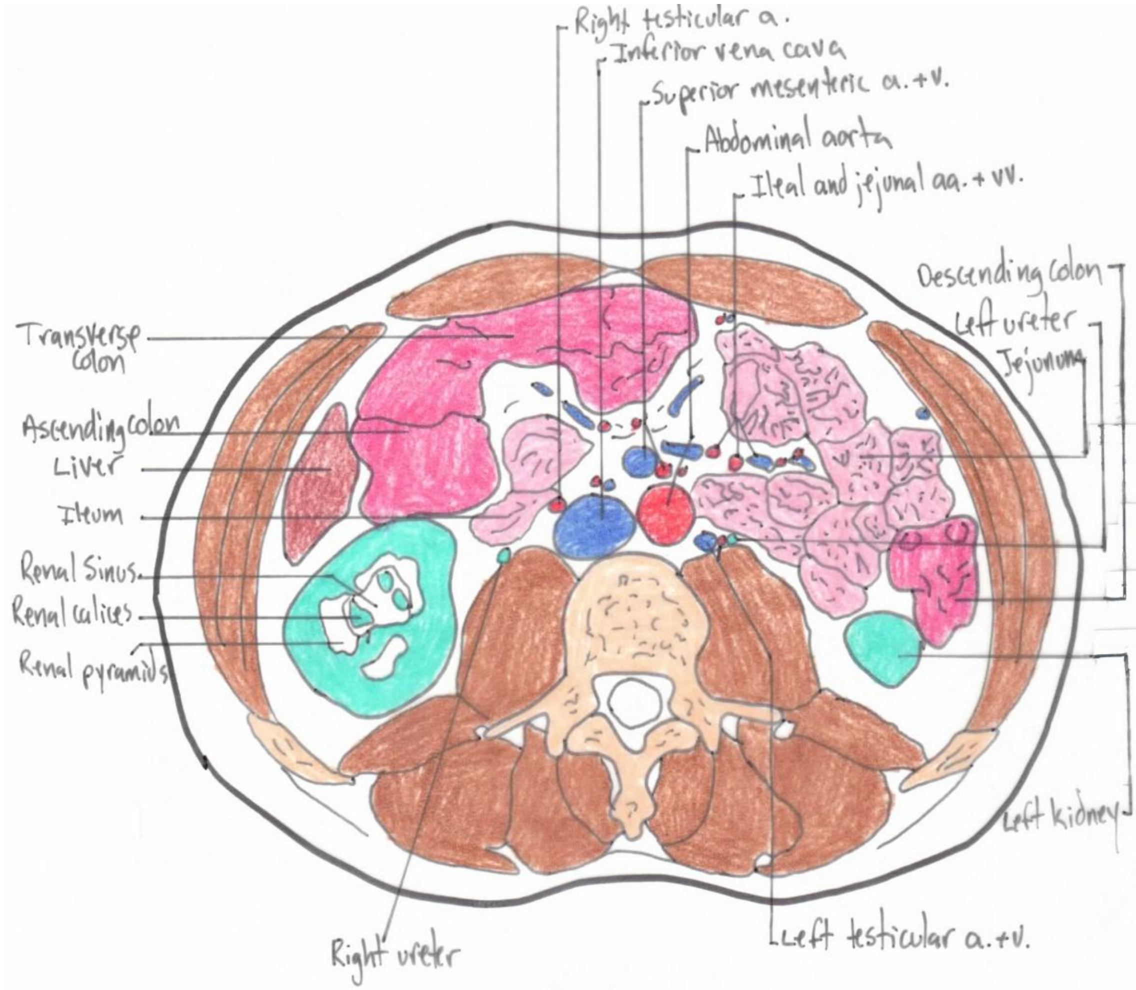
Figure B11

739 Redrawn and modified from Moeller & Reif, 2007, p.105
740 Moeller & Reif, 2007, p.104



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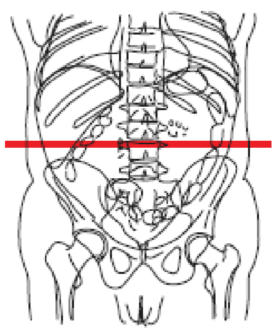

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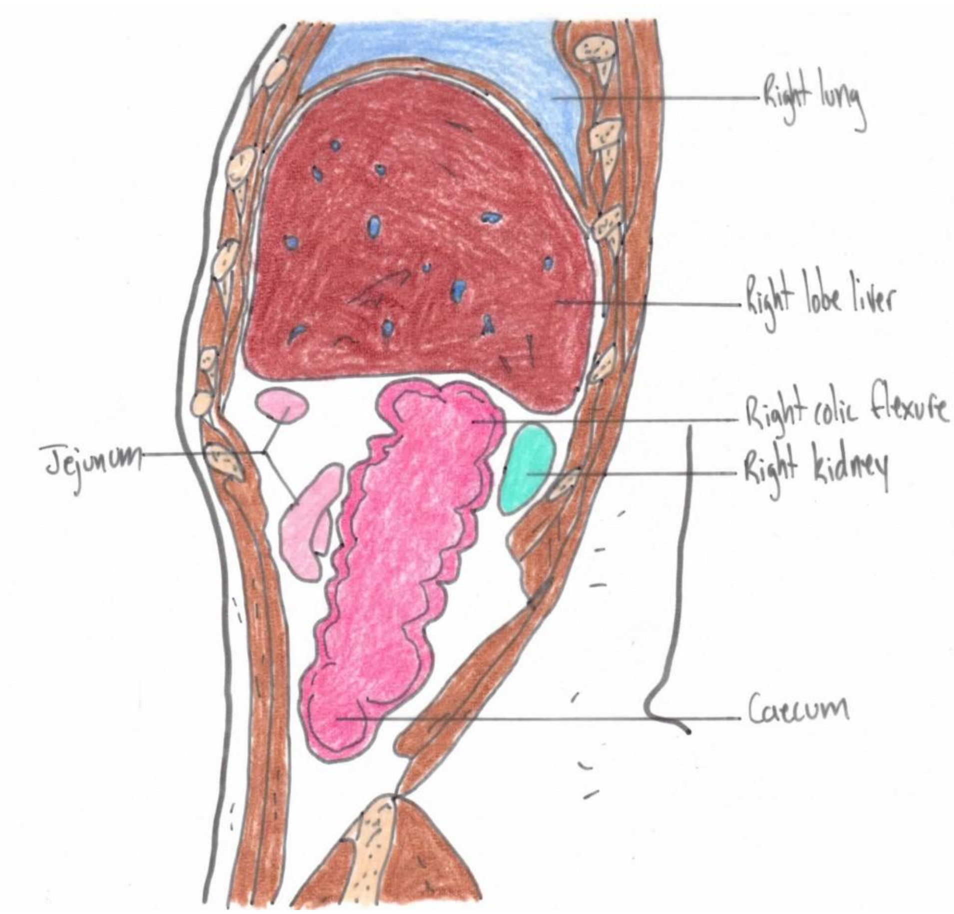
[741] Redrawn and modified from Moeller & Reif, 2007, p.107
[742] Moeller & Reif, 2007, p.106



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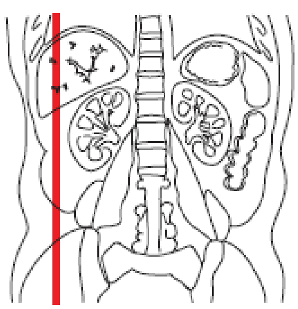

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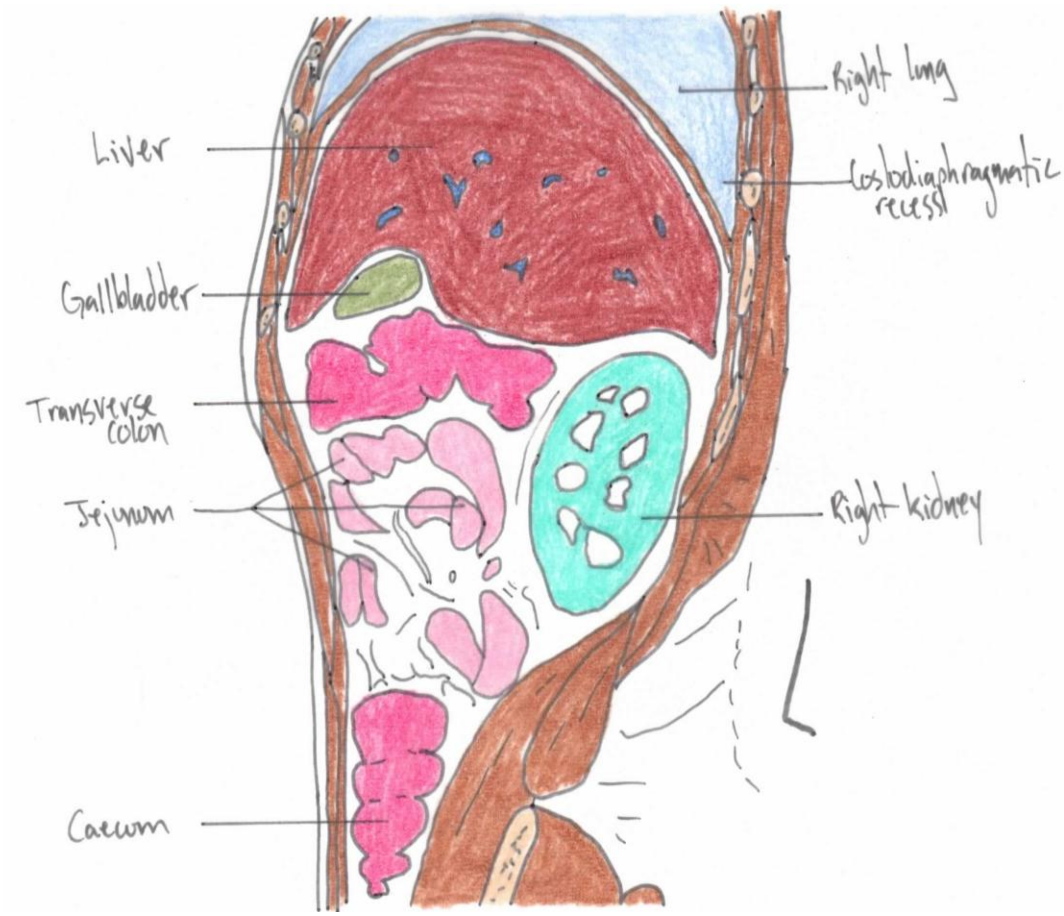
Figure B13

743 Redrawn and modified from Moeller & Reif, 2007, p.133
744 Moeller & Reif, 2007, p.132



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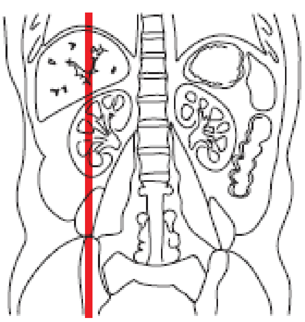

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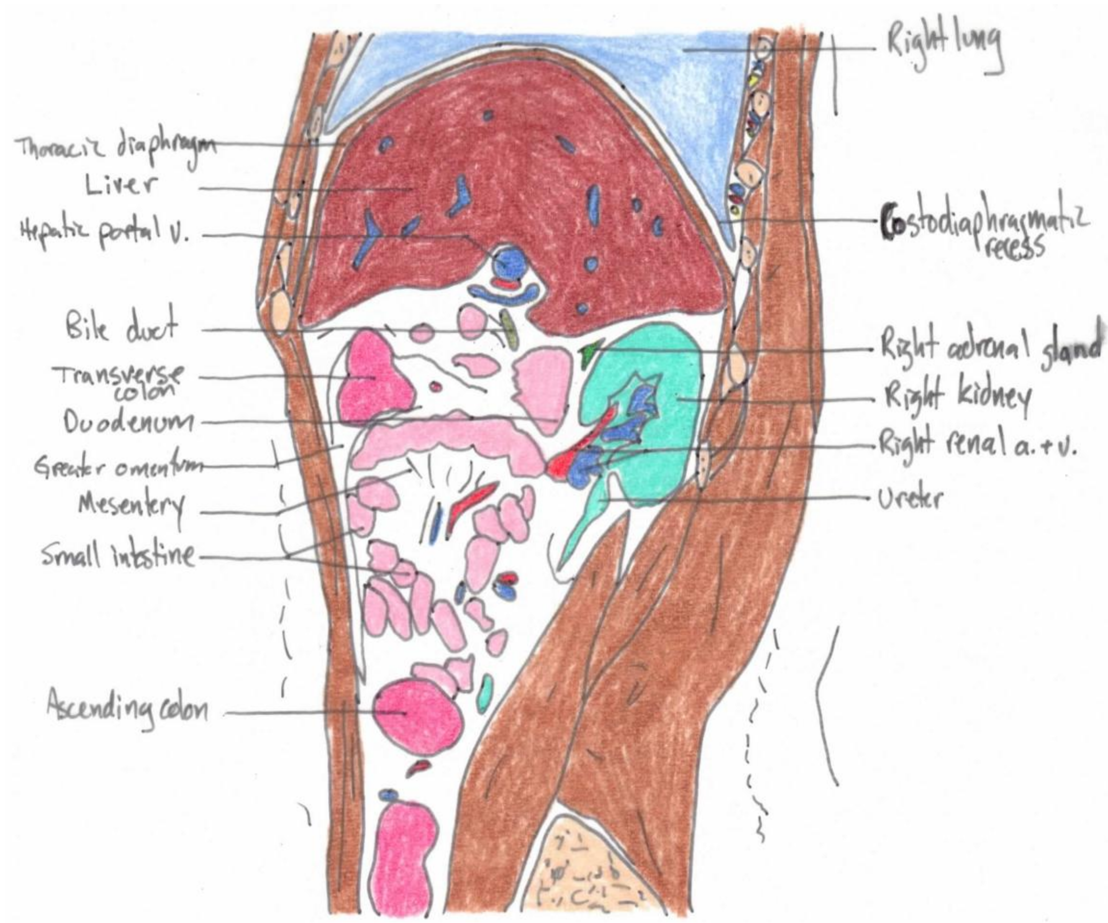
745 Redrawn and modified from Moeller & Reif, 2007, p.135
746 Moeller & Reif, 2007, p.134



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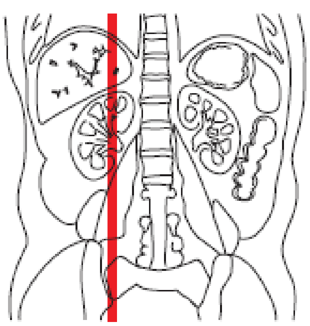
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Figure B15

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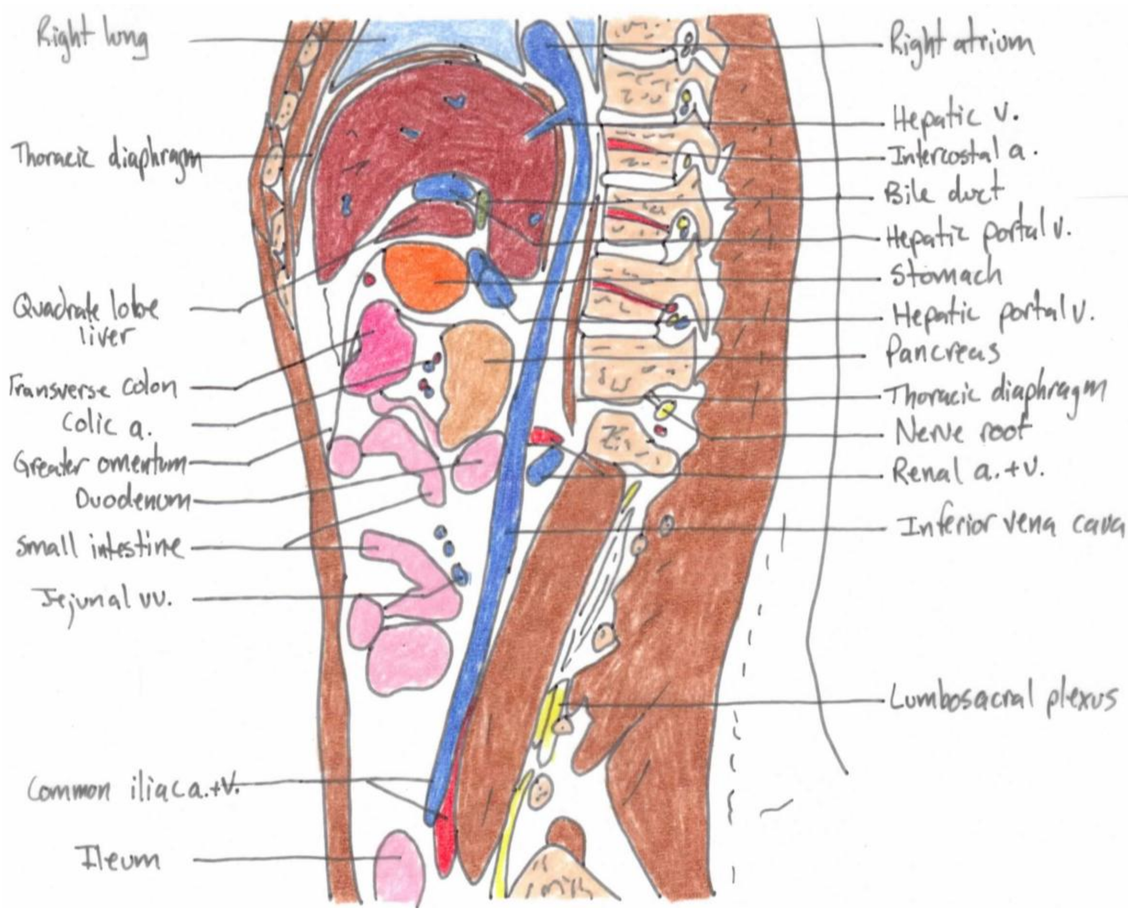
[747] Redrawn and modified from Moeller & Reif, 2007, p.137

[748] Moeller & Reif, 2007, p.136



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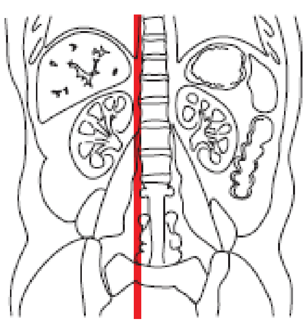

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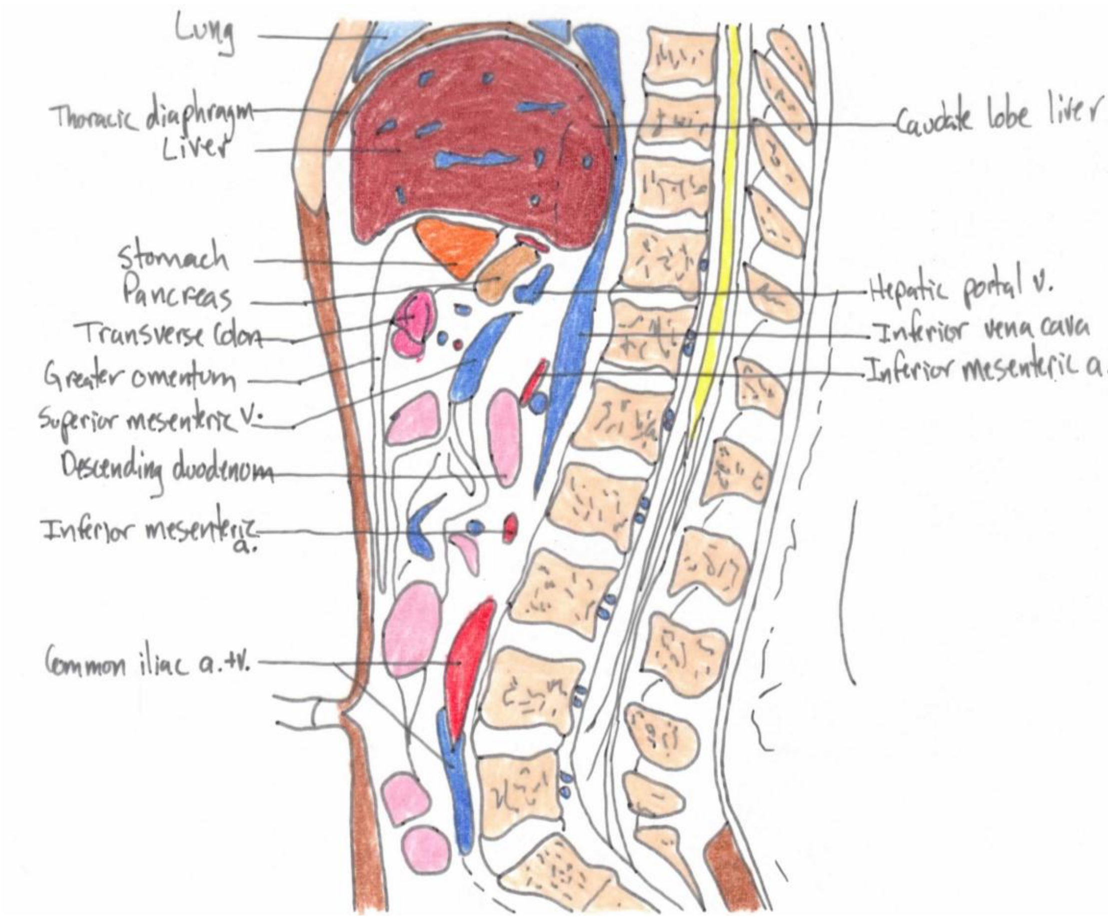
749 Redrawn and modified from Moeller & Reif, 2007, p.139
750 Moeller & Reif, 2007, p.138



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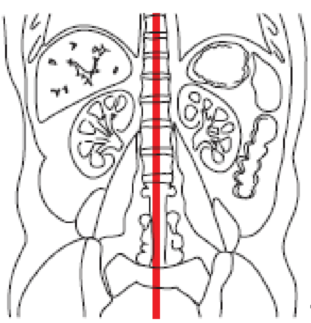
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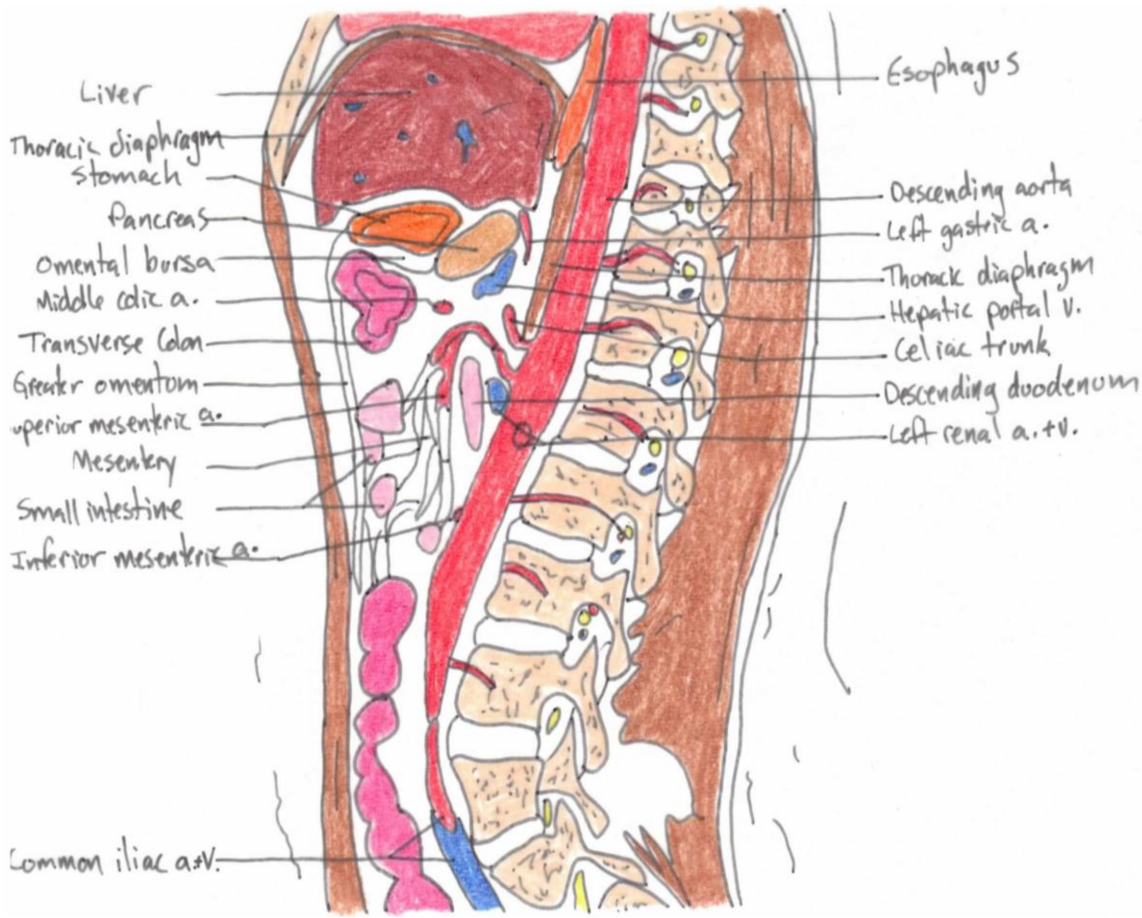
[752] Moeller & Reif, 2007, p.140



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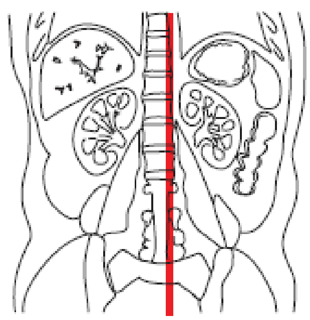

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Figure B18

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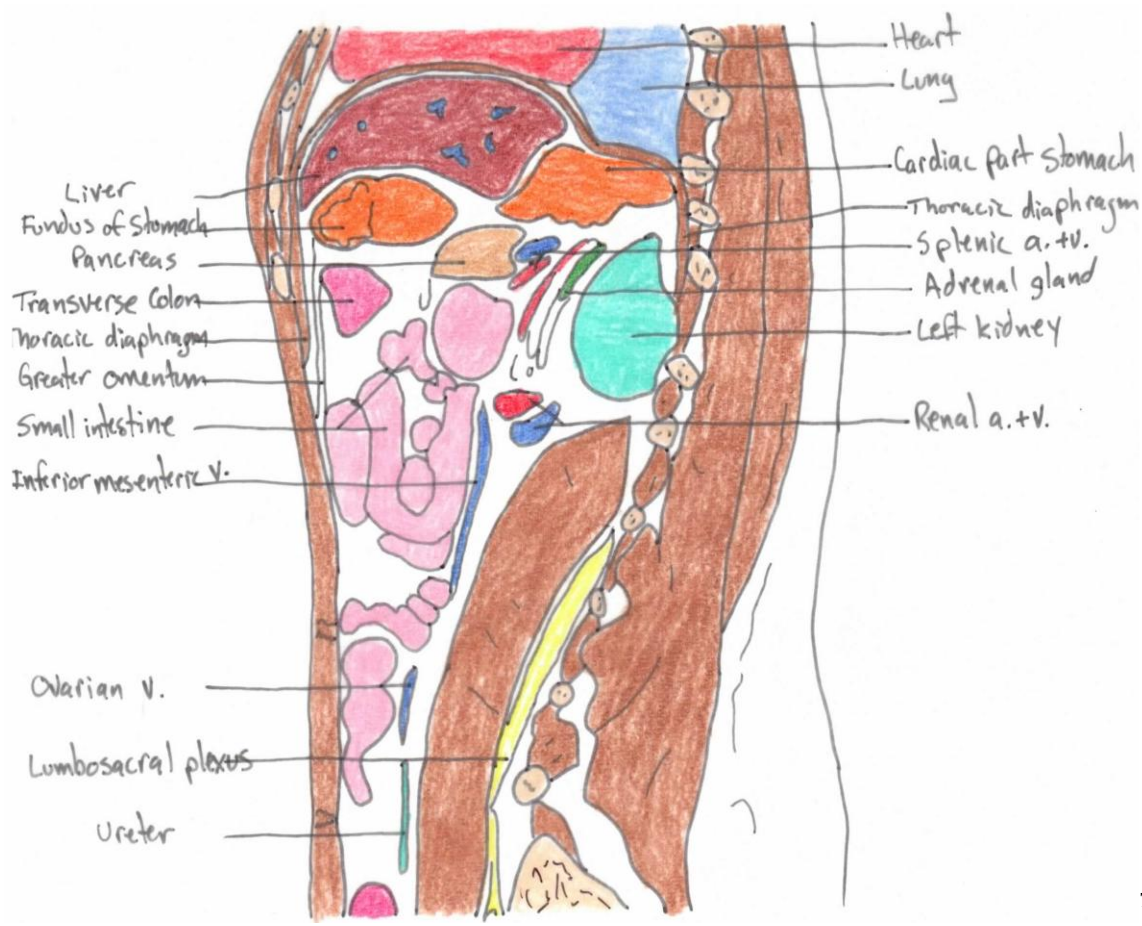
[754] Moeller & Reif, 2007, p.142



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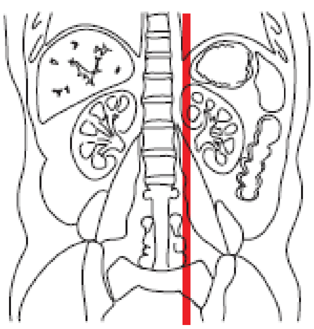

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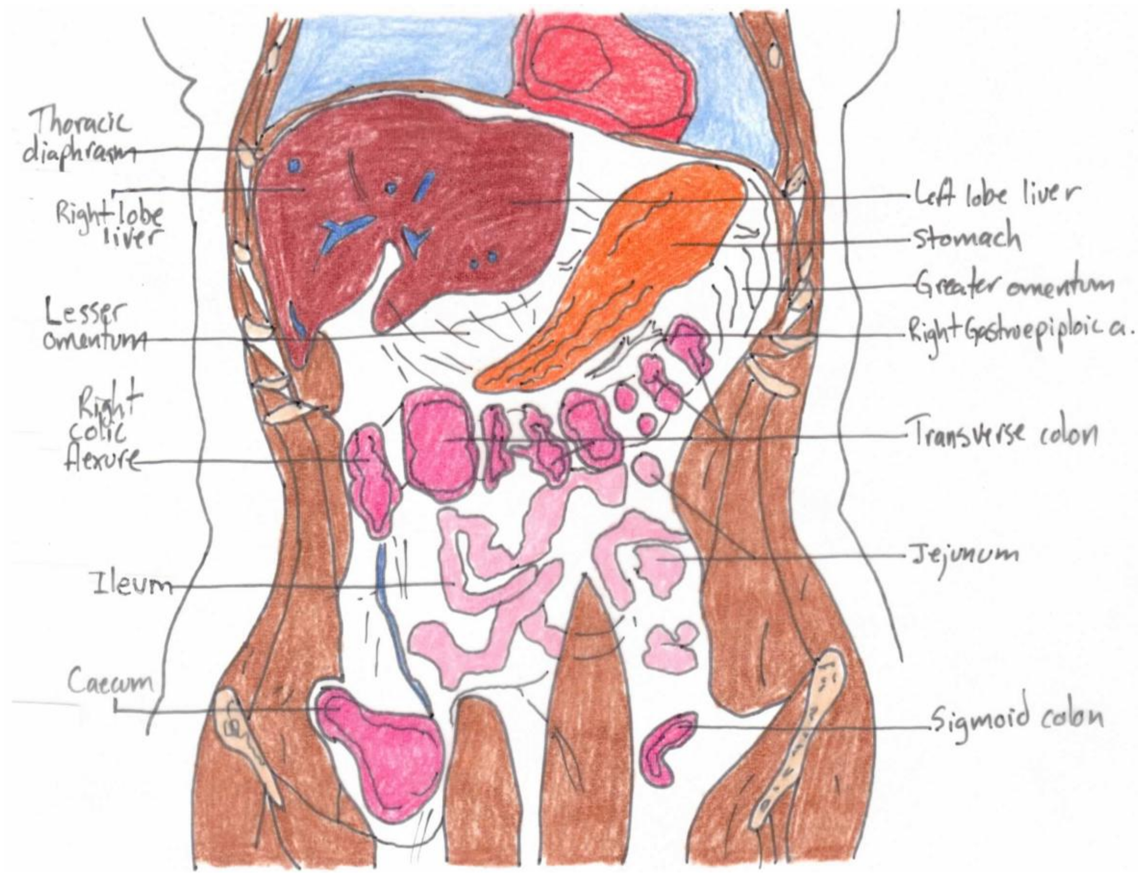
Figure B19

755 Redrawn and modified from Moeller & Reif, 2007, p.145
756 Moeller & Reif, 2007, p.144



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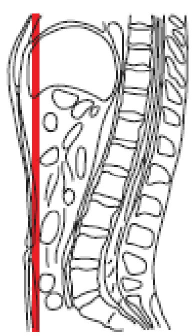

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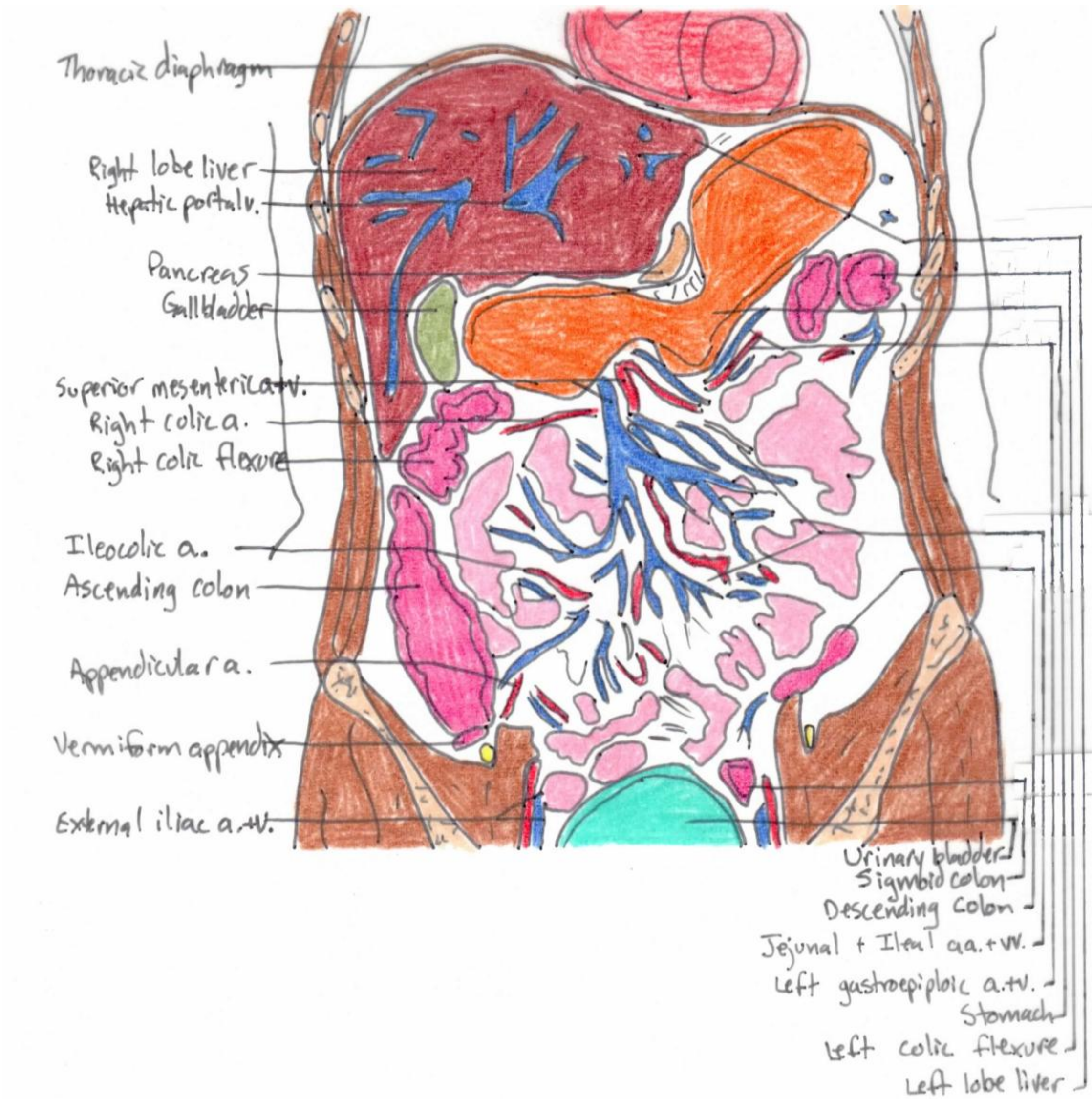
Figure B20

757 Redrawn and modified from Moeller & Reif, 2007, p.151
758 Moeller & Reif, 2007, p.150



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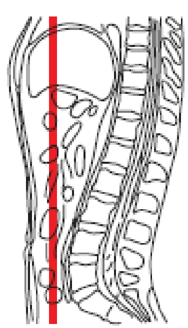

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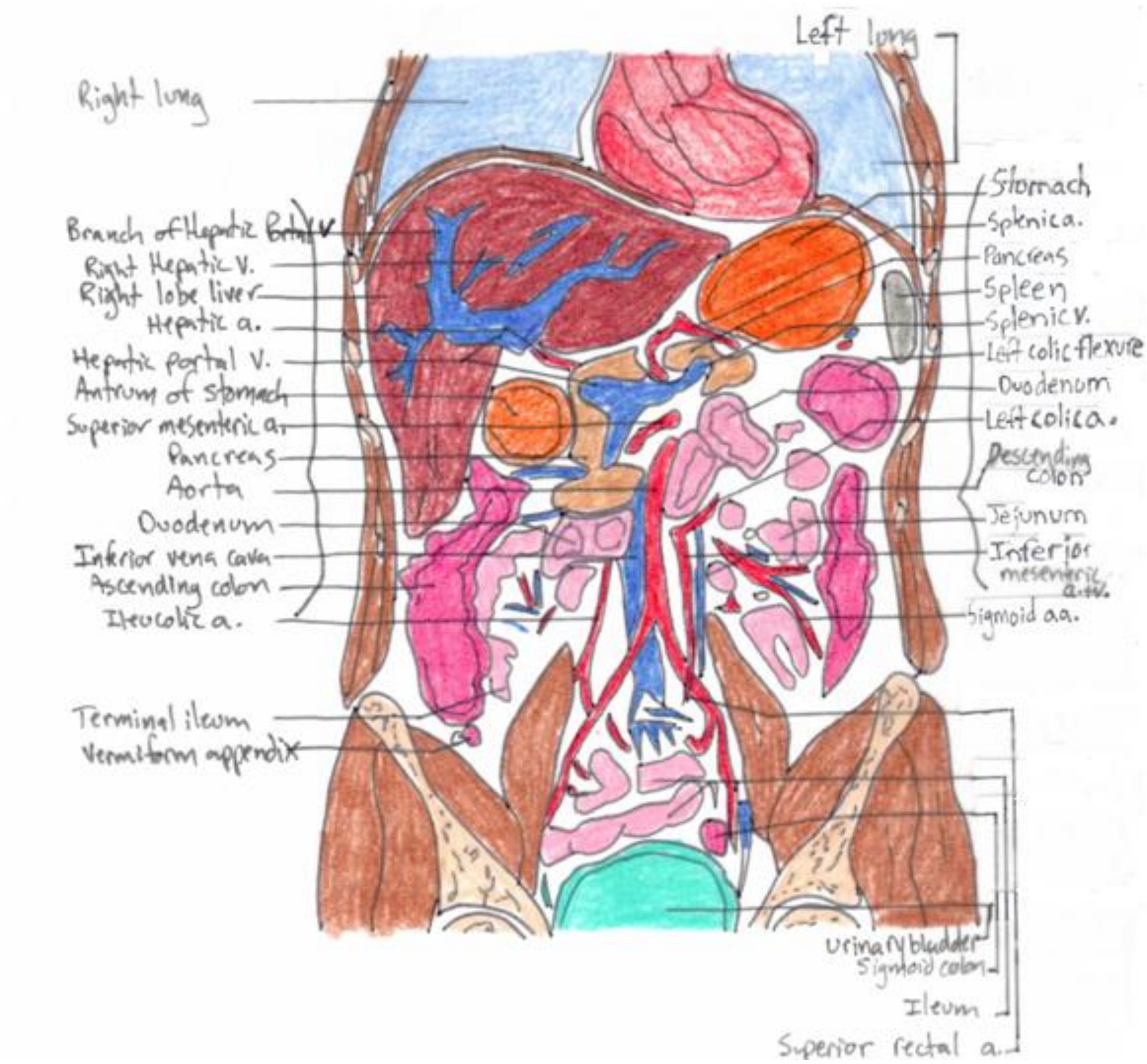
[760] Moeller & Reif, 2007, p.152



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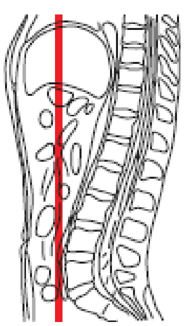
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Figure B22

761 Redrawn and modified from Moeller & Reif, 2007, p.155
762 Moeller & Reif, 2007, p.154

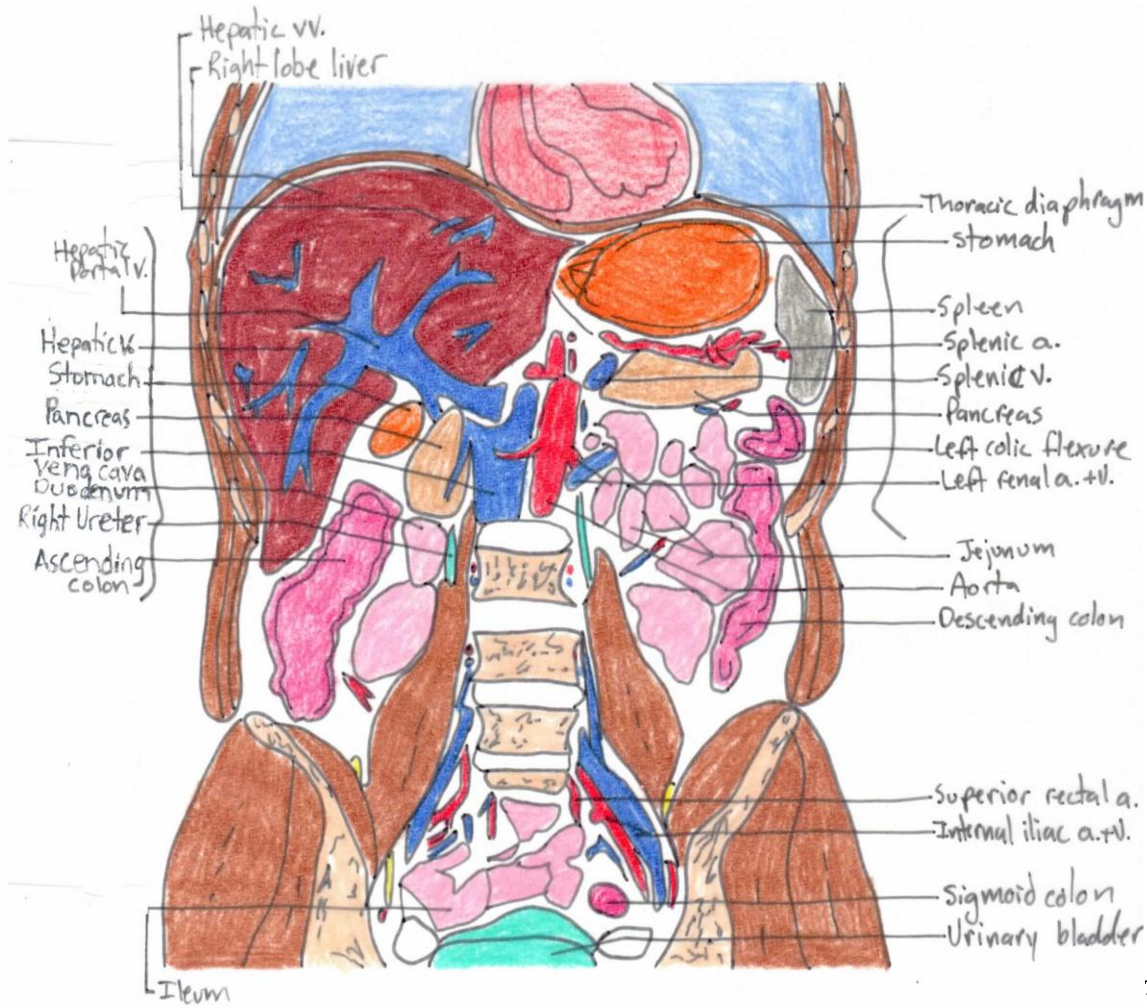

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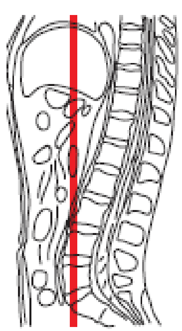
Figure B23



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763 Redrawn and modified from Moeller & Reif, 2007, p.157
764 Moeller & Reif, 2007, p.156

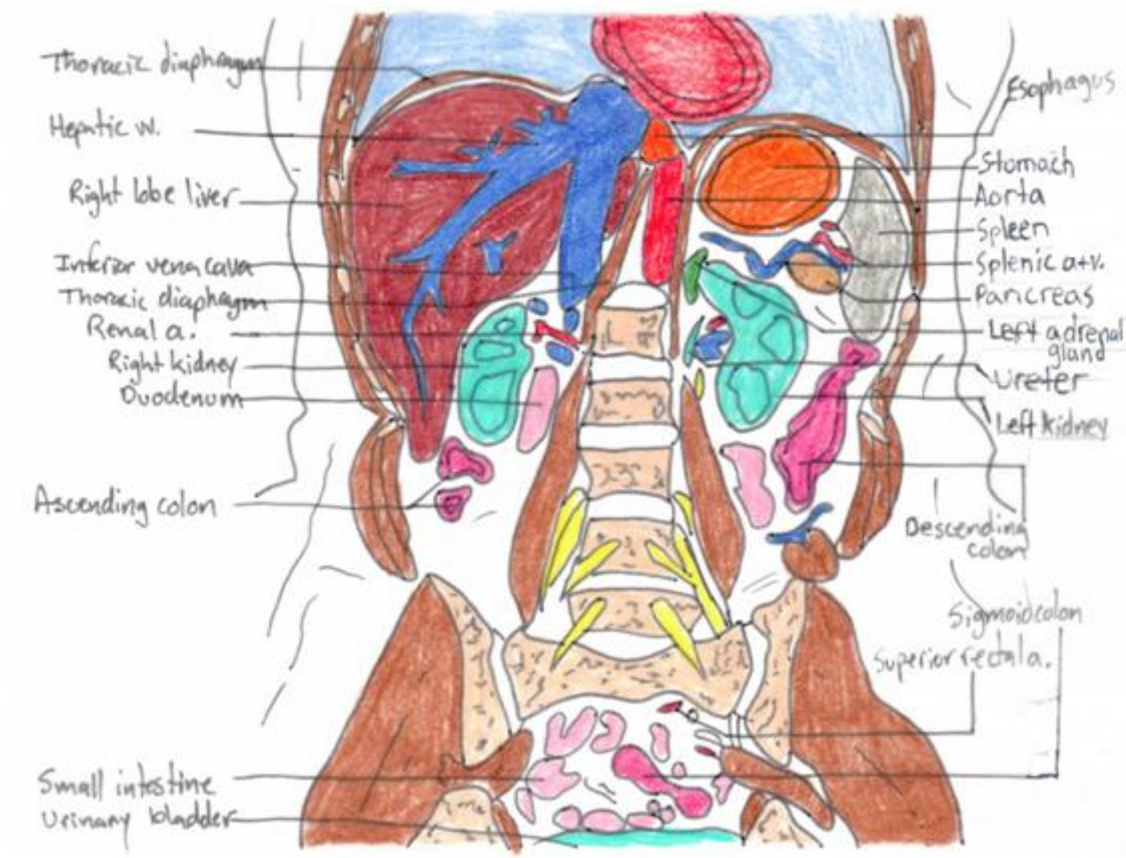

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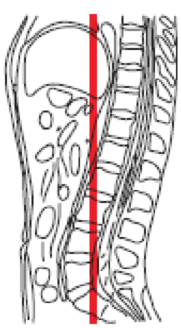
Figure B24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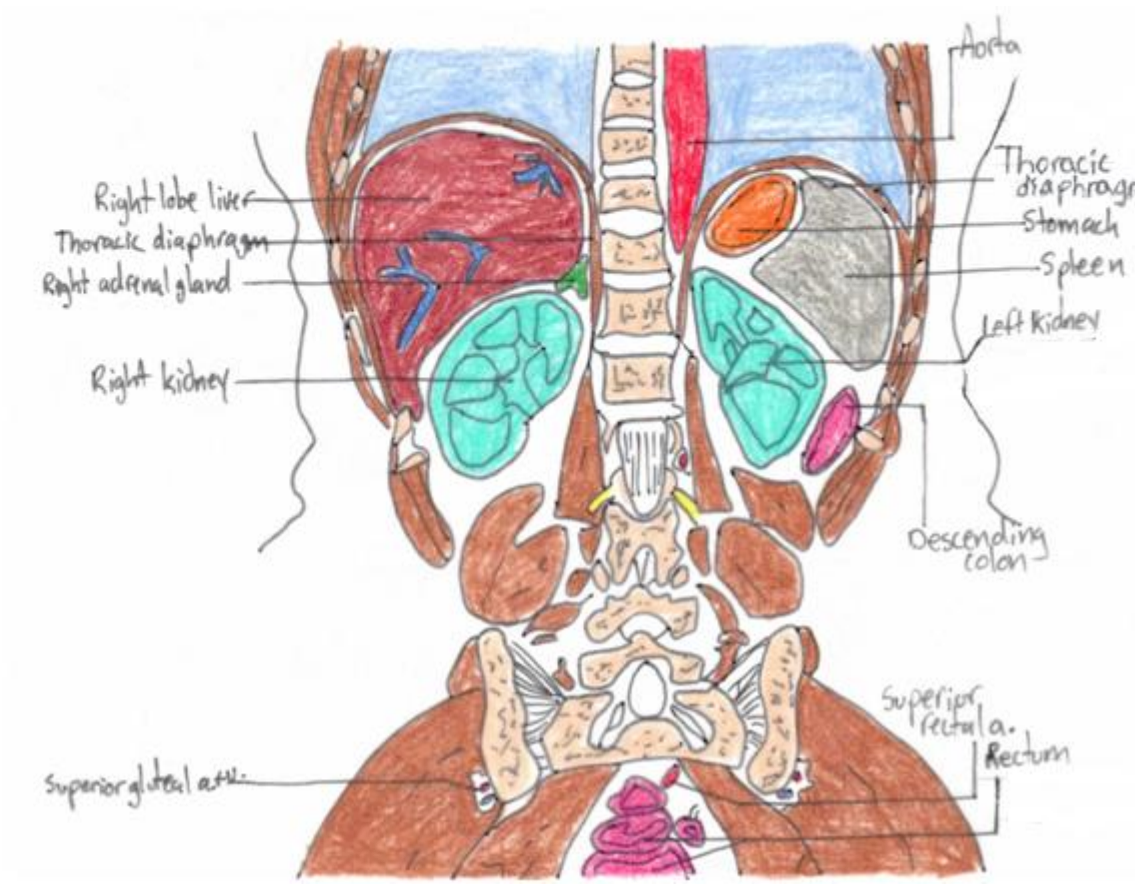
765 Redrawn and modified from Moeller & Reif, 2007, p.159
766 Moeller & Reif, 2007, p.158



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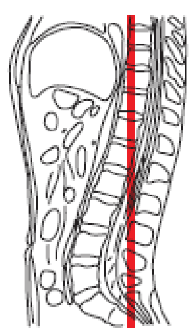
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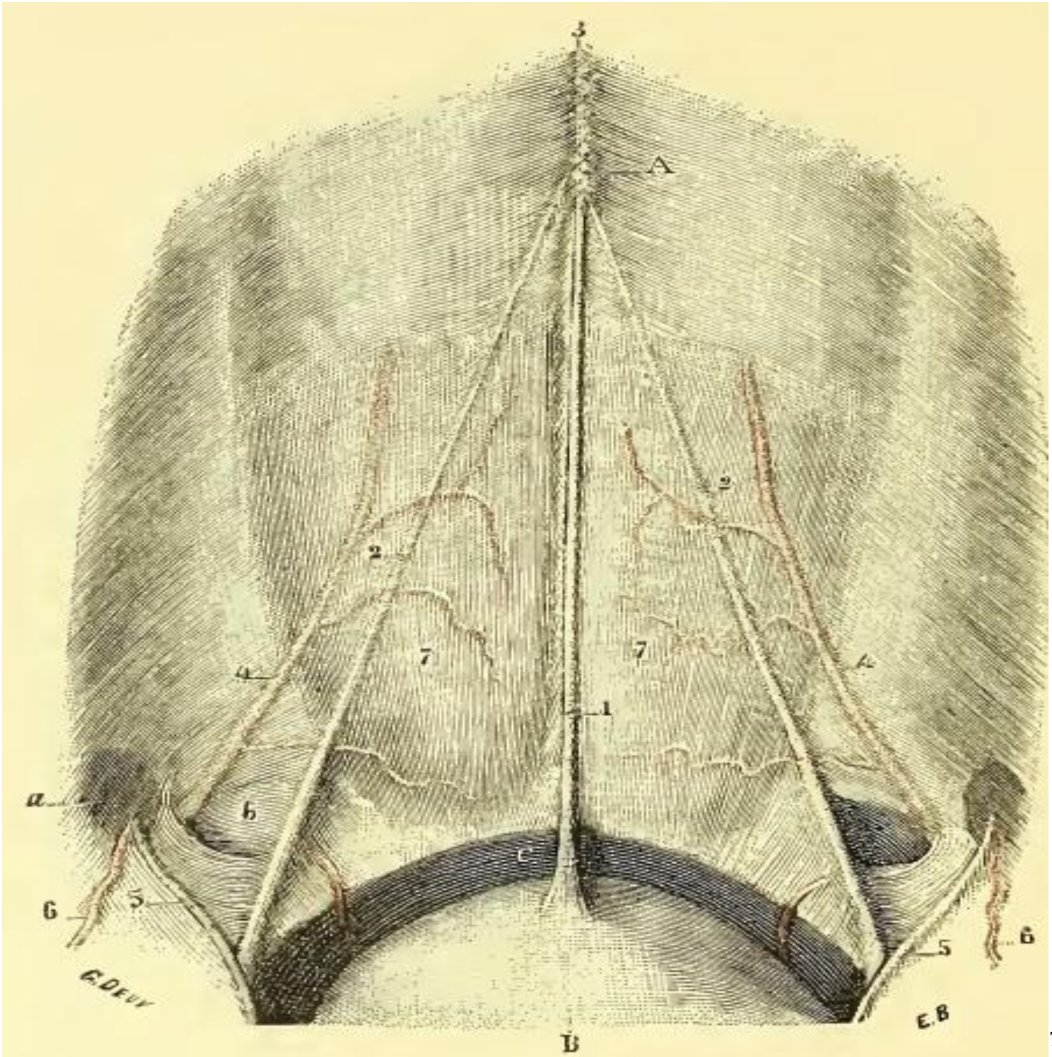
Figure B25

[767] Redrawn and modified from Moeller & Reif, 2007, p.161
[768] Moeller & Reif, 2007, p.160

Appendix C: Peritoneal Relations of the Viscera

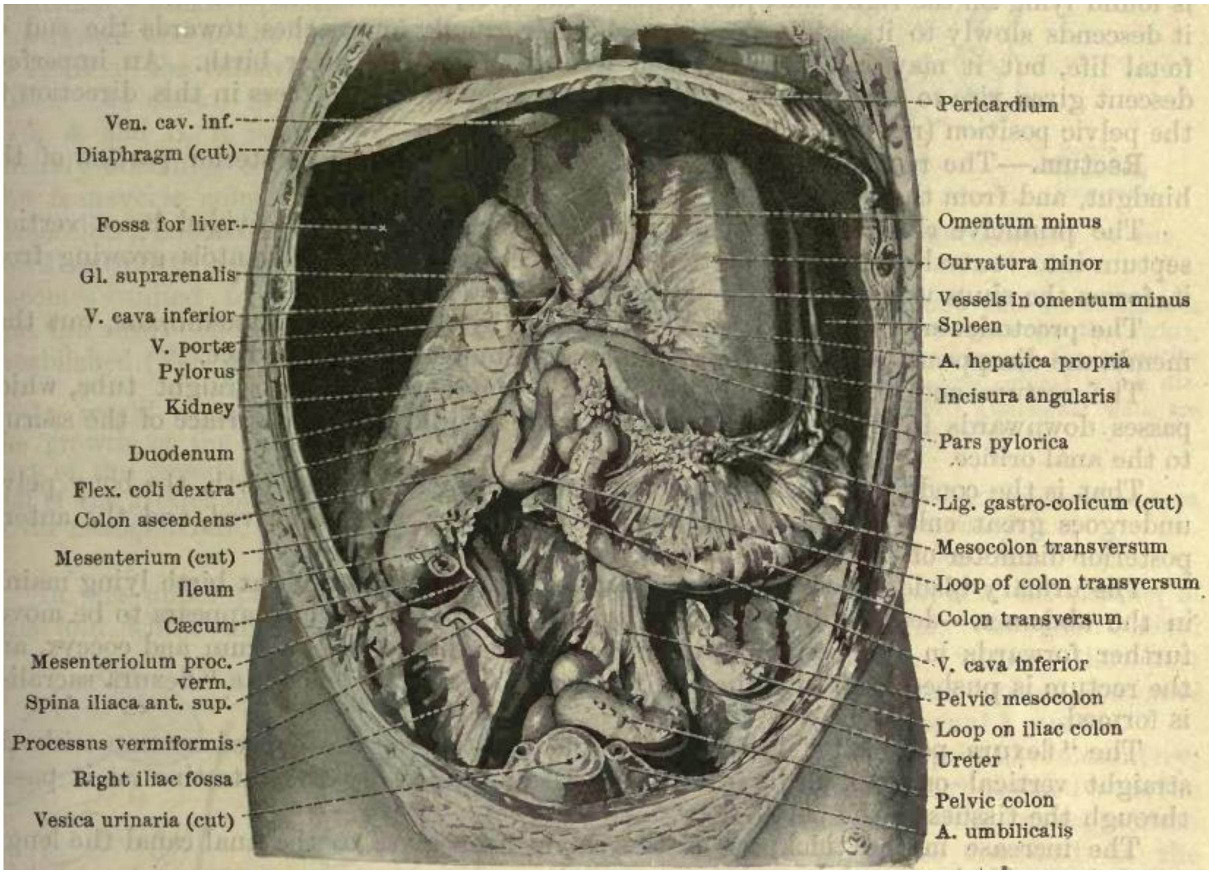


[769]

A – Umbilicus
B – Urinary bladder
1 – Urachus
2 – Medial umbilical fold
3 – Start of falciform ligament of liver
4 – Lateral umbilical fold
5 – Vas Deferens
6 – Spermatic artery
7 – Peritoneum covering rectus abdominis
a – Lateral inguinal fossa
b – Medial inguinal fossa
c – Supravesical fossa

Figure C1: Relations to the posterior aspect of the anterior abdominal wall

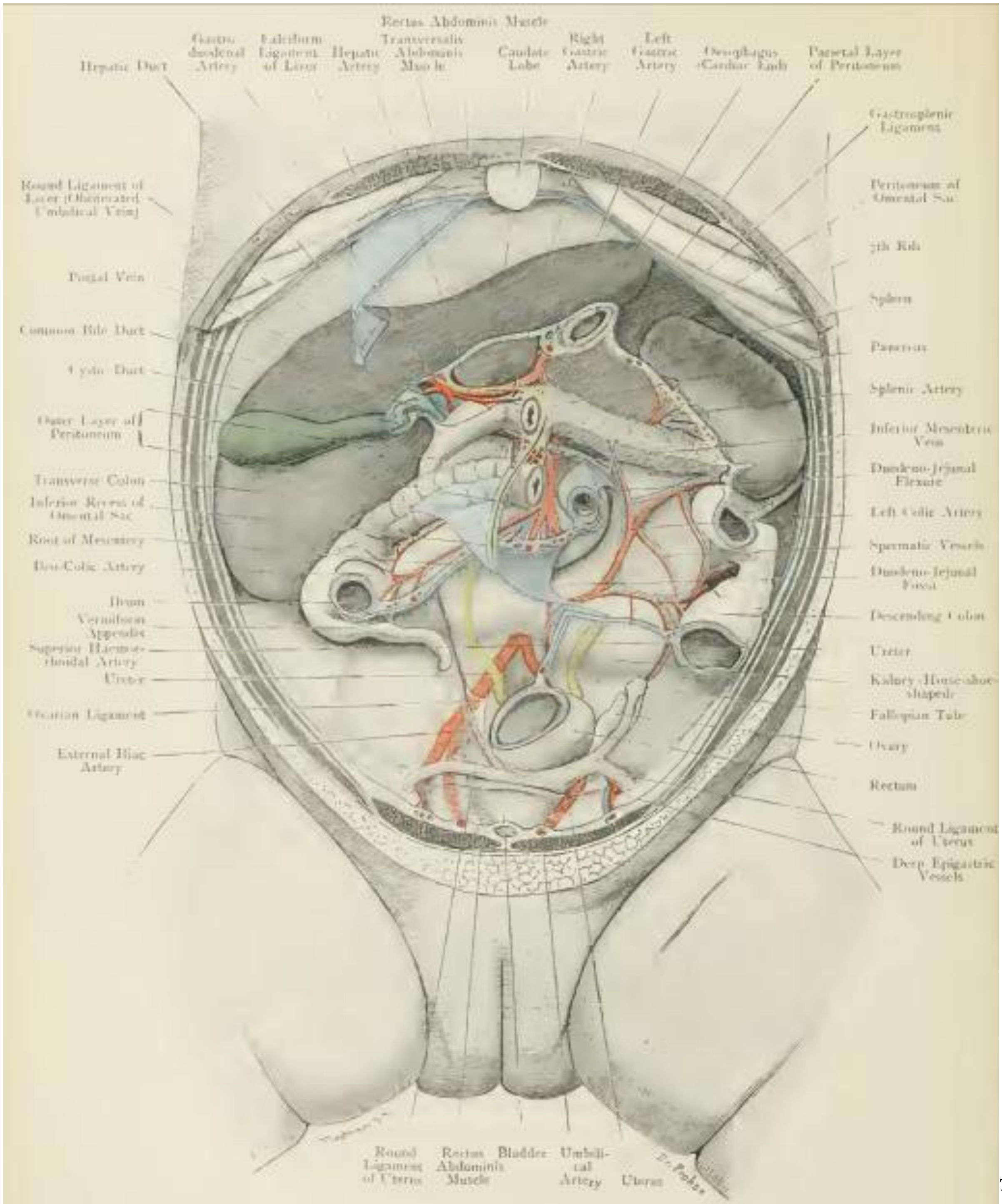
[769] Testut, 1901, p.932



[770]

Figure C2: Typical disposition of the peritoneum and abdominal visceral in the newborn

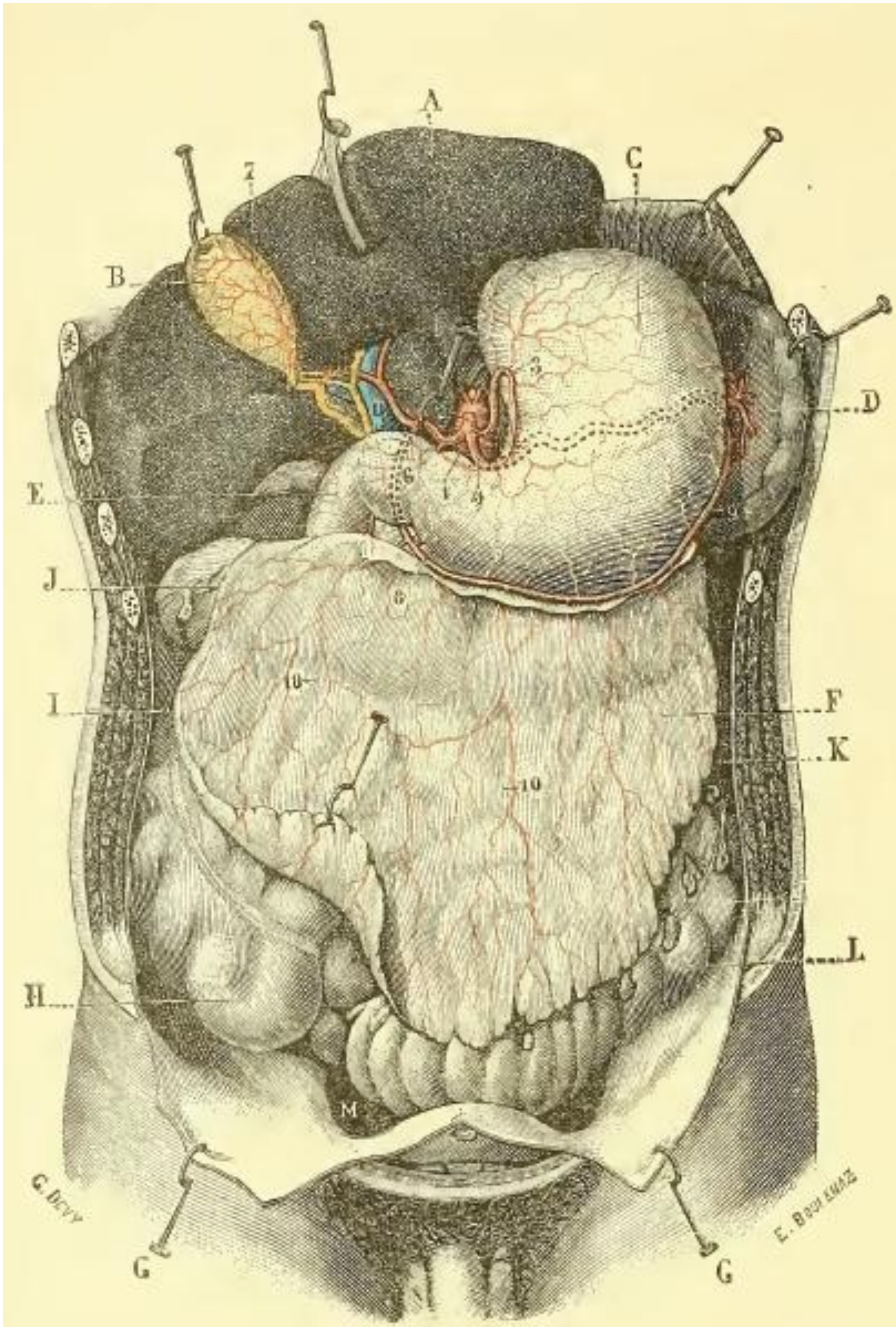
[770] Robinson, 1918, p.1251



[771]

Figure C3: Peritoneum and Viscera of an infant: anterior abdominal wall, stomach, small intestine, left part of transverse colon, sigmoid flexure, mesenteries and wall of omental sac have been removed

[771] Bardelben, Haeckel, Frohse & Ziehen, 1906, figure 127.



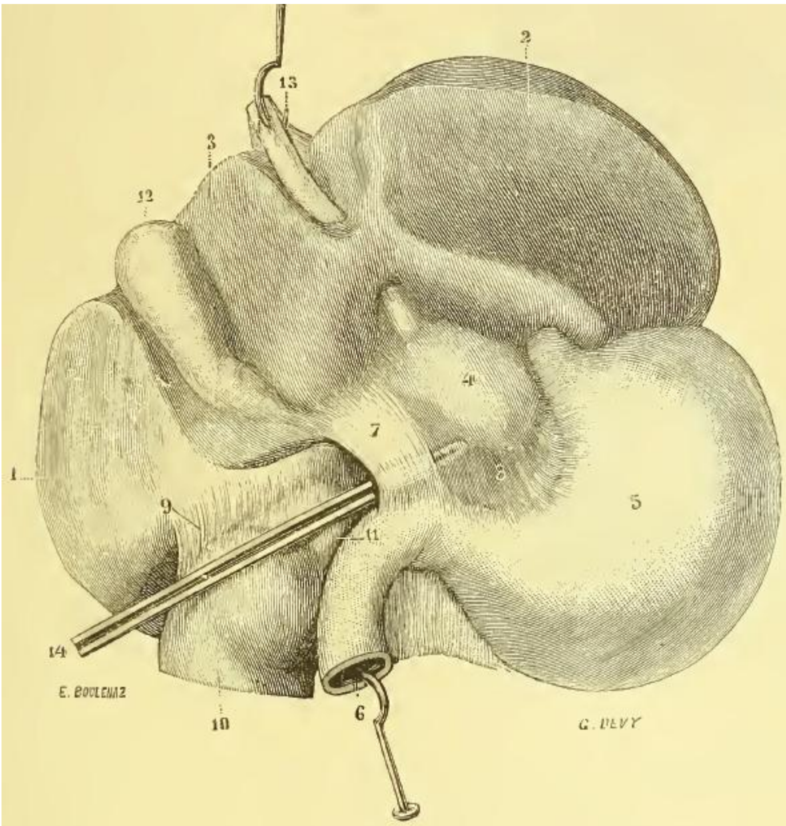
[772]

A – Liver turned up, B – Gallbladder,

C – Stomach, D – Spleen turned to the side,

Figure C4: Position of greater omentum after removal of the anterior abdominal wall

[772] Testut, 1901, p.948



[773]

Figure C5: Lesser omentum

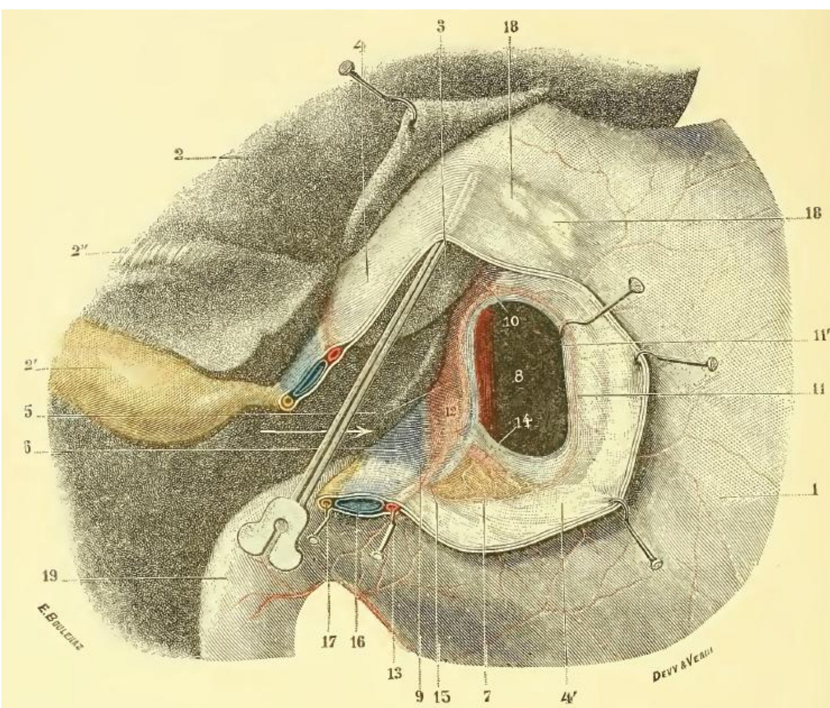
4 – Spigel's lobe seen through the gastro-hepatic omentum

7 – Hepatic pedicle within gastro-hepatic ligament

8 – Pars flaccida of lesser omentum

9 – Hepato-renal ligament

14 – Instrument in foramen of Winslow, extending into lesser sac



[774]

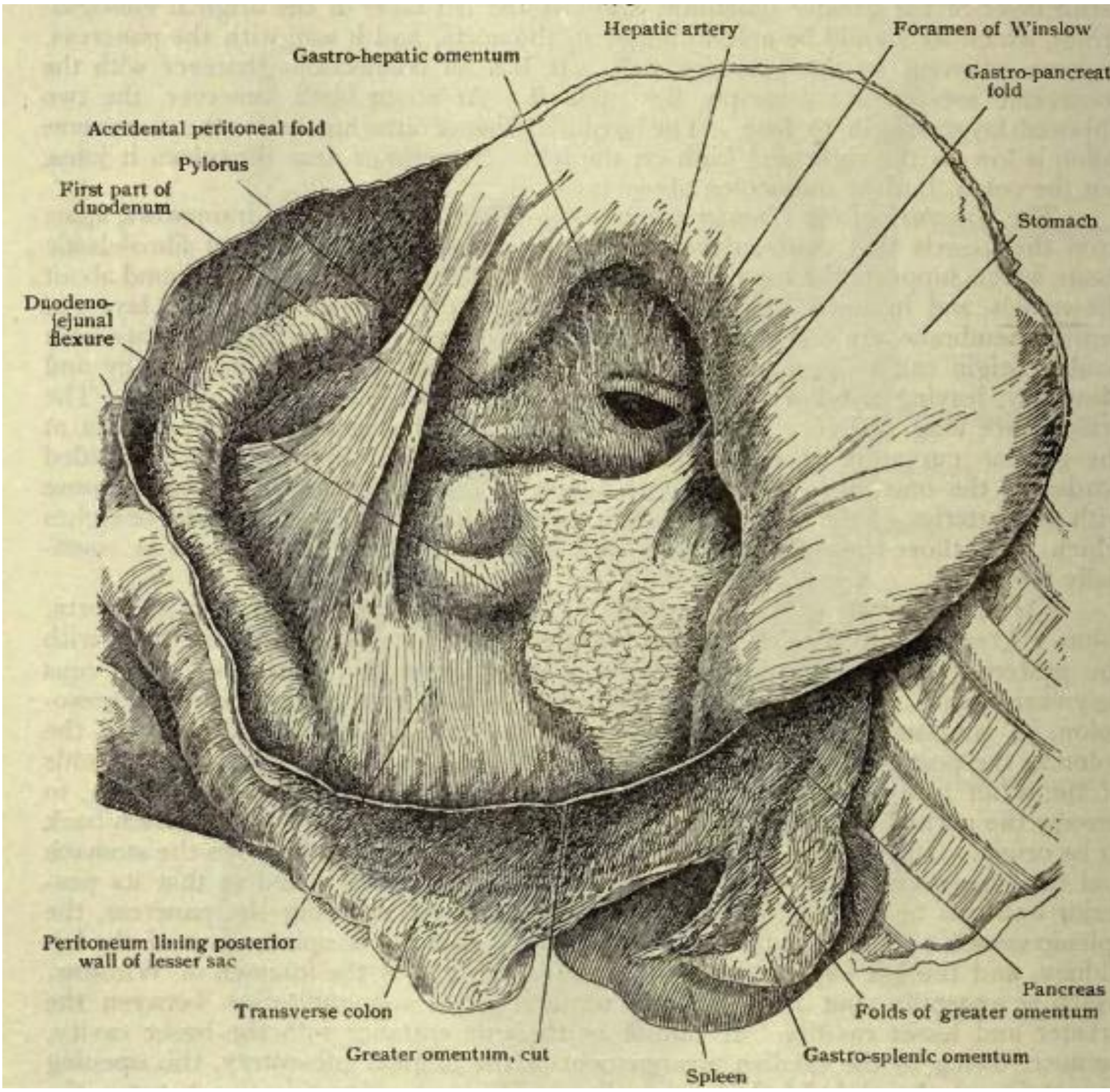
Figure C6: Opening into the lesser sac

4, 4' – Gastro-hepatic omentum

9 – Duodeno-pancreatic ligament embracing the hepatic artery

10 – Gastro-pancreatic ligament of Huschke

[773] Testut, 1901, p.941
[774] Testut, 1901, p.946

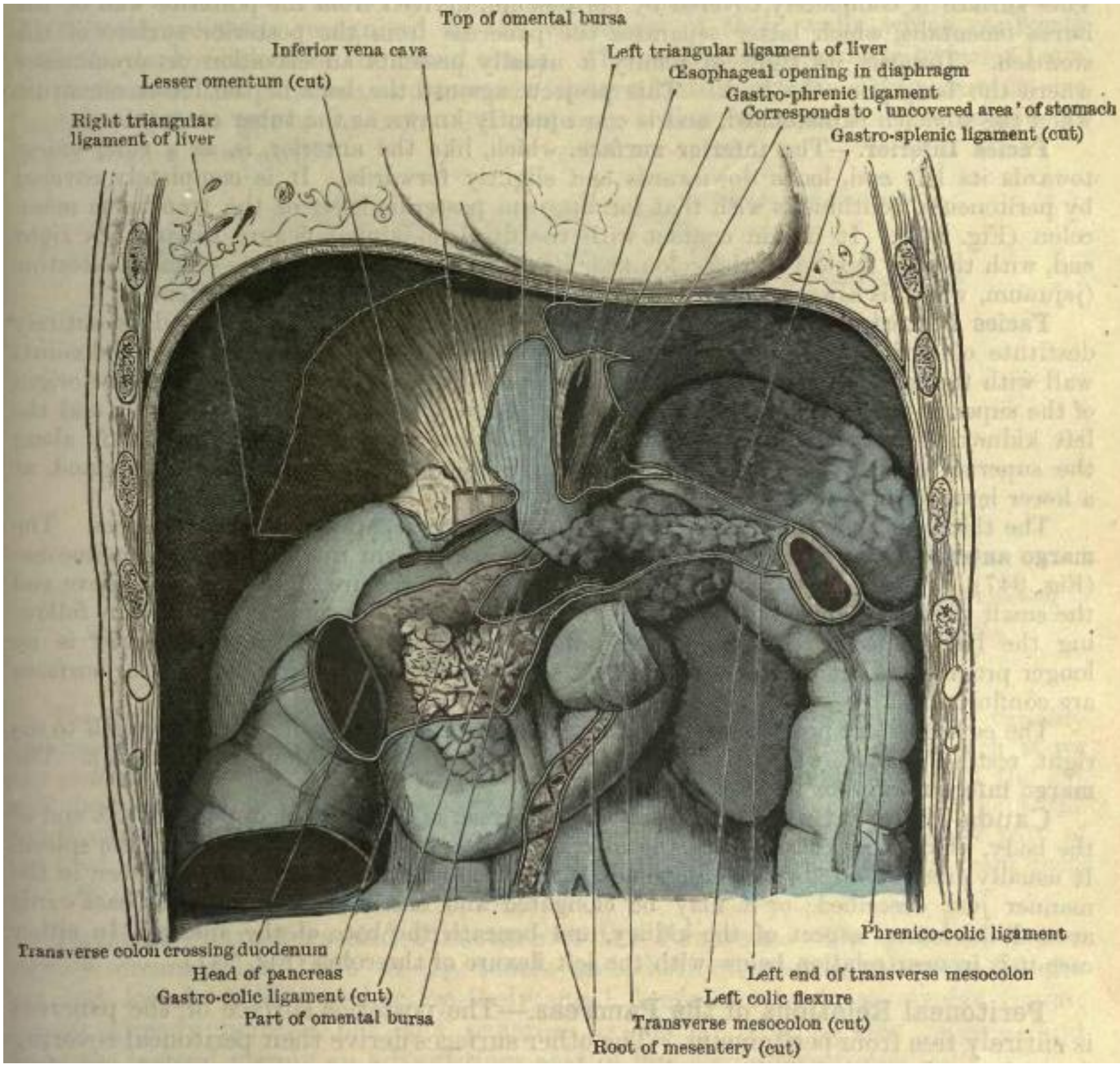


[775]

Figure C7: Foramen of Winslow

The specimen is decubitus, view from the left. The stomach has been turned up so as to expose the foramen of Winslow from the left side.

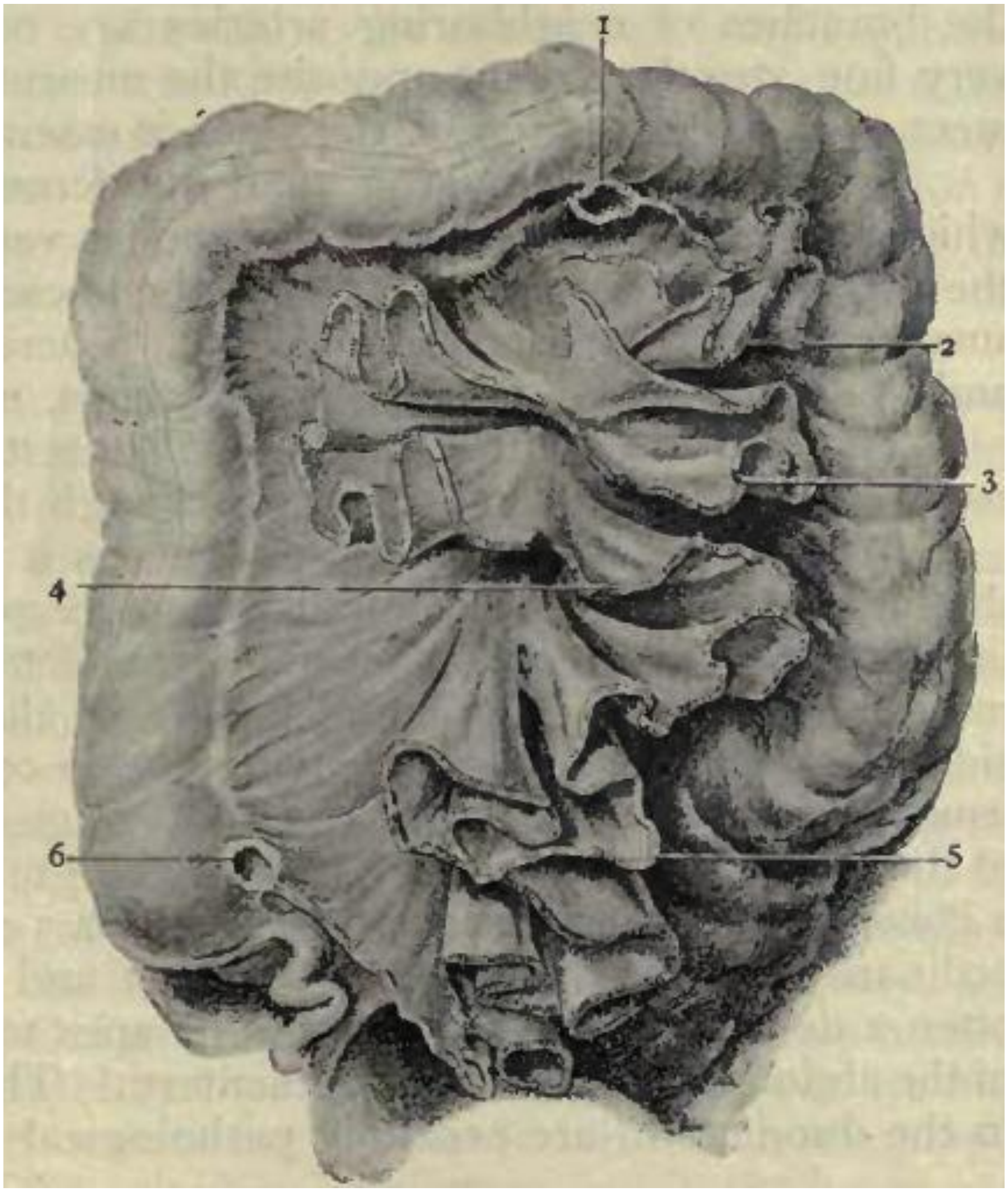
[775] Piersol, 1913, p.1750



[776]

Figure C8: Peritoneal relations in the superior aspect of the abdomen

[776] Robinson, 1918, p.1205



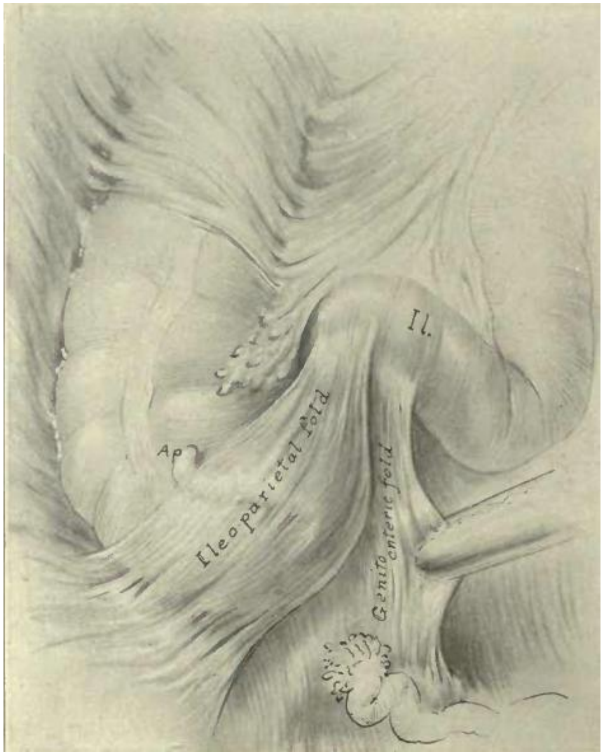
777

Figure C9: Typical disposition of the jejuno-ileum mesentery

2,3,4 – Jejunum

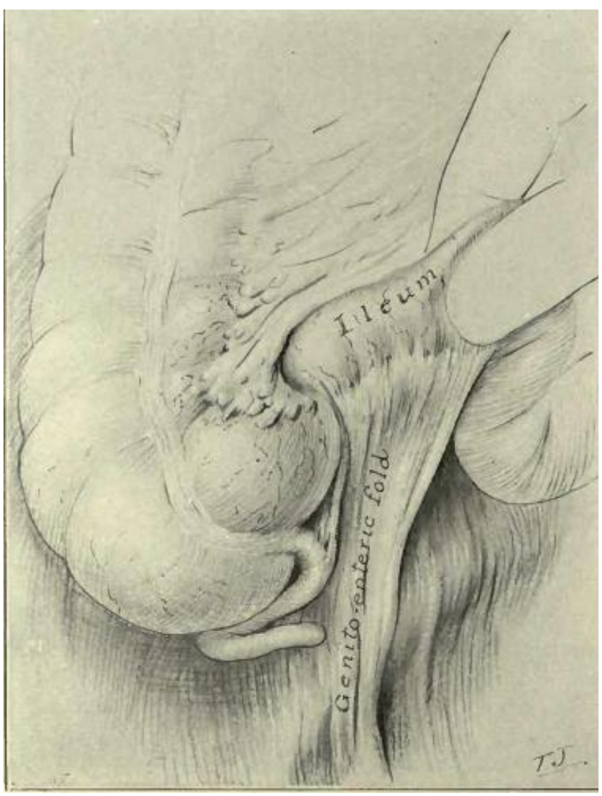
5 – Ileum

777 Piersol, 1913, p.1654



[778]

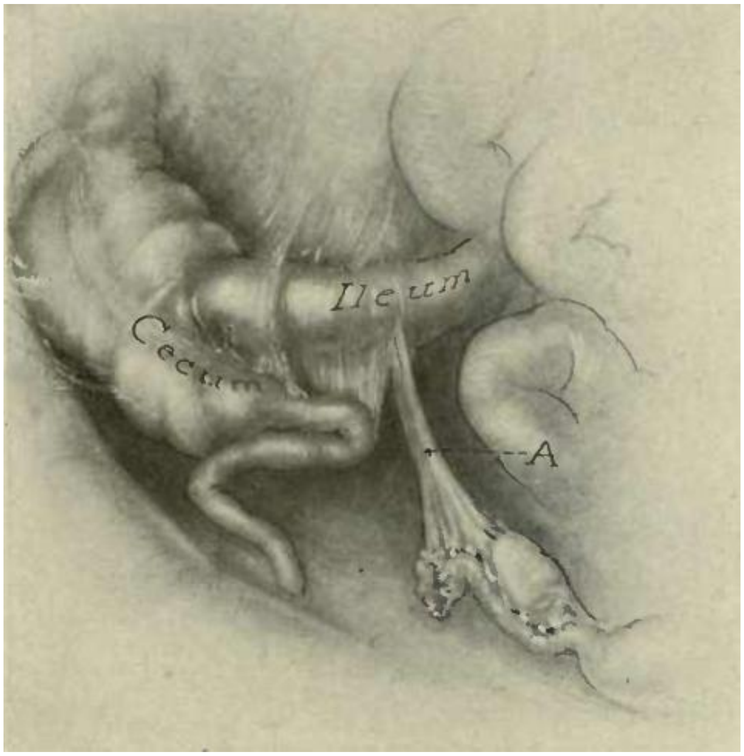
Figure C10: The ileoparietal fold and the genito-enteric fold of Treitz



[779]

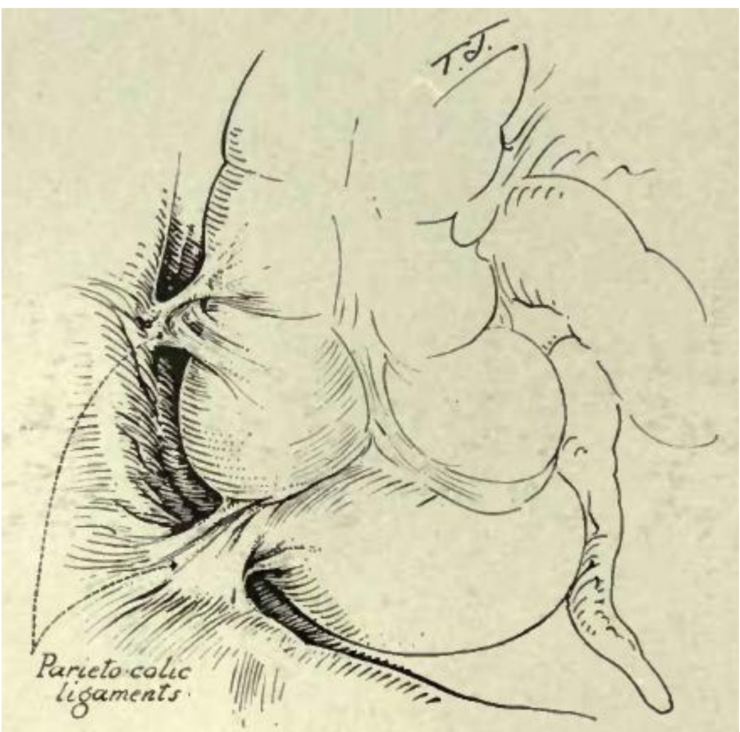
Figure C11: The genito-enteric fold of Treitz

[778] Hertzler, 1919, p.180
[779] Hertzler, 1919, p.144



780

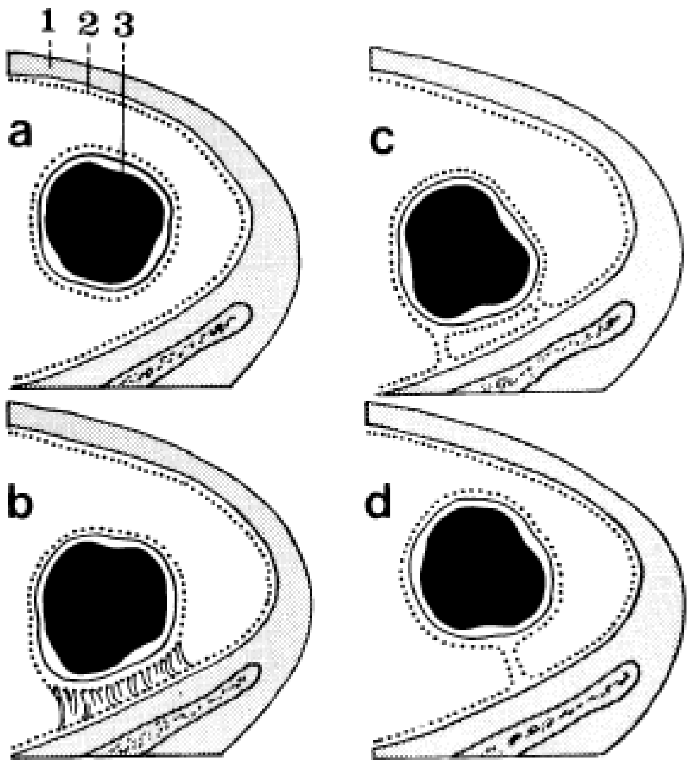
Figure C12: The ileo-ovarian ligament of Durand



781

Figure C13: Parieto-colic ligaments

780 Hertzler, 1919, p.145
781 Hertzler, 1915, p.192



[782]

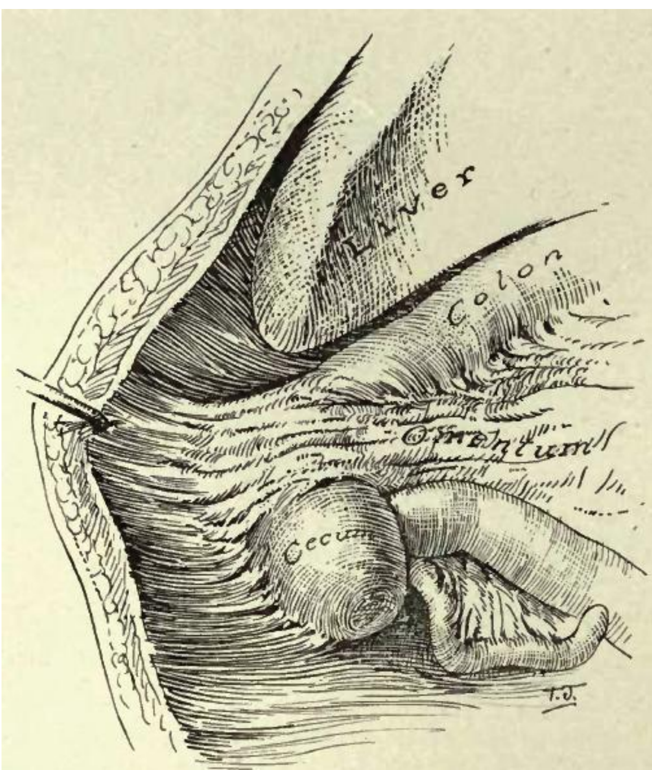
Figure C14: Variations of caecal attachment

A – Intra-peritoneal with no mesentery

B – Completely fixed to posterior abdominal wall

C – Presence of retrocaecal fossa

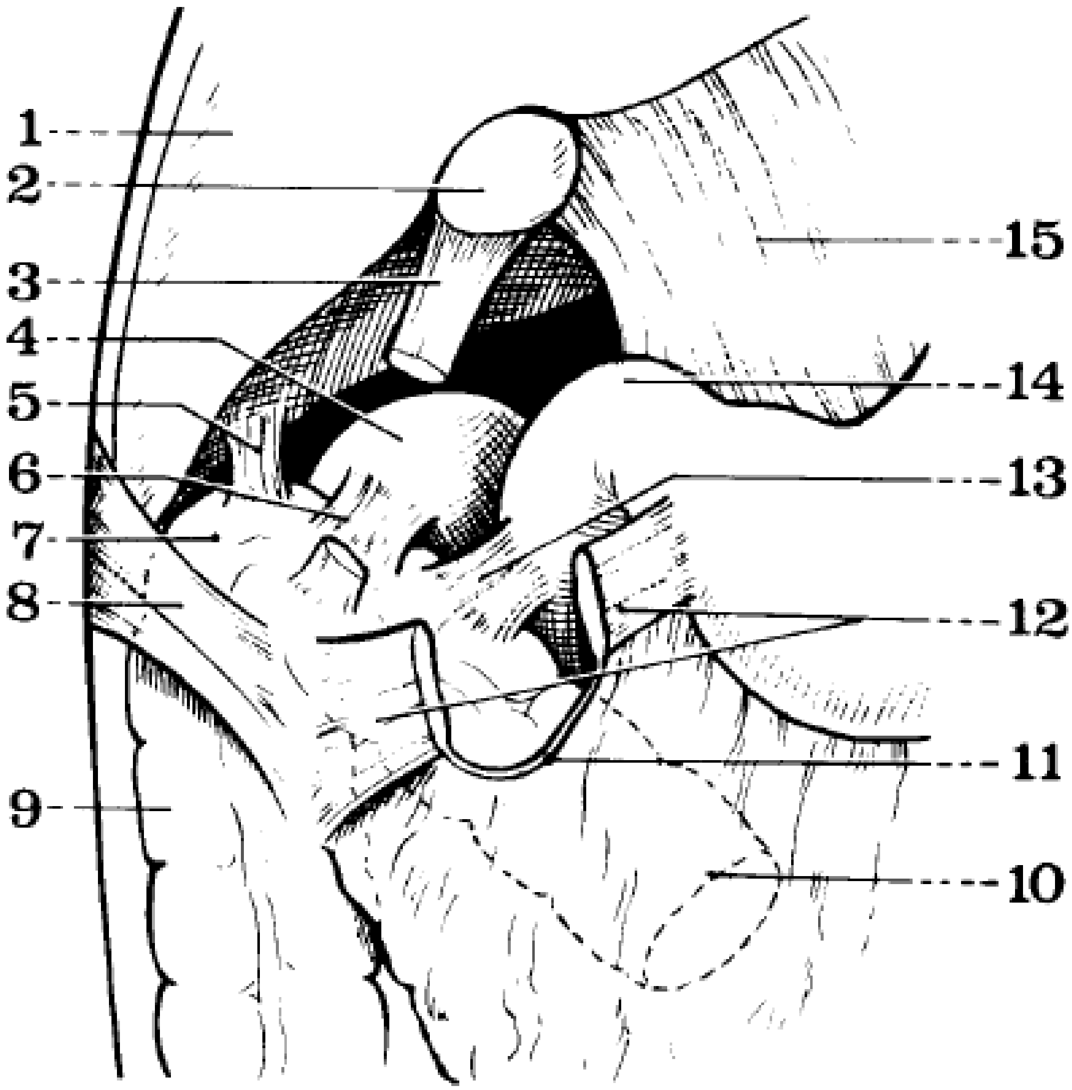
D – Full mesentery



[783]

Figure C15: Omento-colo-parietal ligament

[782] Bouchet & Cuilleret, 2001, p.2034
[783] Hertzler, 1919, p.158



[784]

Figure C16: Fixation of the Hepatic Angle

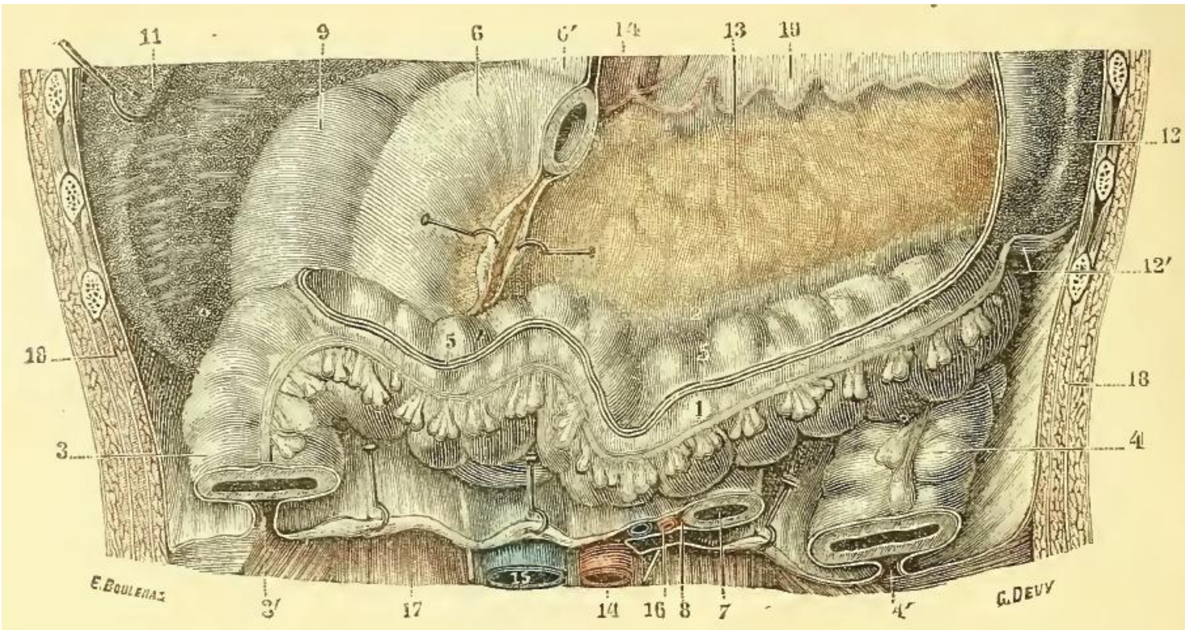
3 – Sectioned cystico-colic ligament, 5 – Hepato-colic ligament,

6 – Reno-colic ligament, 8 – Right phreno-colic ligament

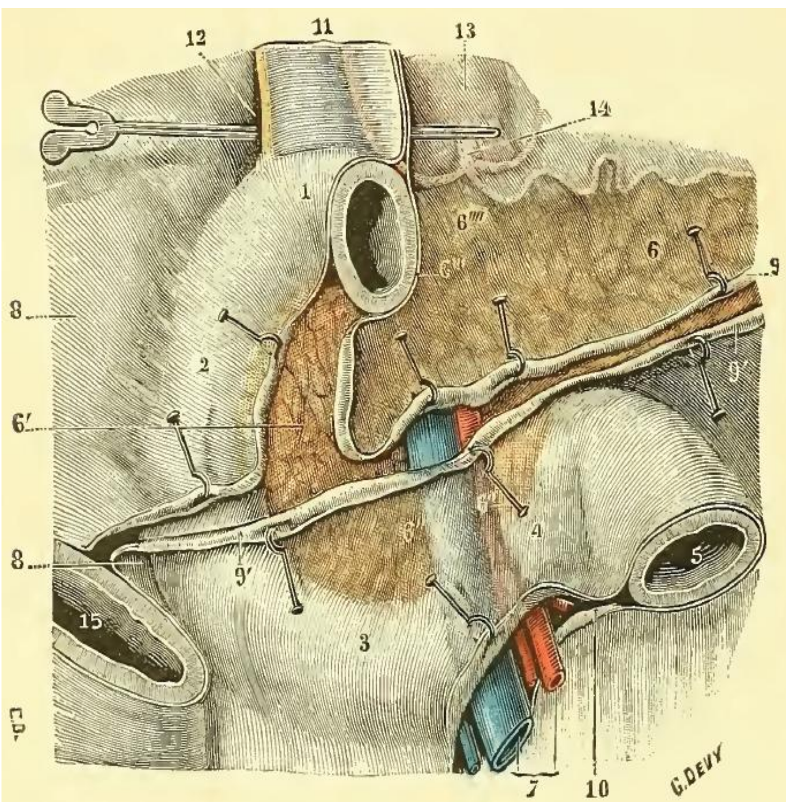
11 – Right extension of greater omentum, 12 – Sectioned Omento-colo-parietal ligament,

13 – Duodeno-colic ligament

[784] Bouchet & Cuilleret, 2001, p.2045



[785]



[786]

Figure C17 (Above): Transverse Mesocolon

2 – Transverse mesocolon, 5 – colic insertion of greater omentum, 6’ – gastro-hepatic omentum, 8 – mesentery, 12’ – Left phreno-colic ligament

Figure C18 (Left): Relations of pancreas and transverse mesocolon

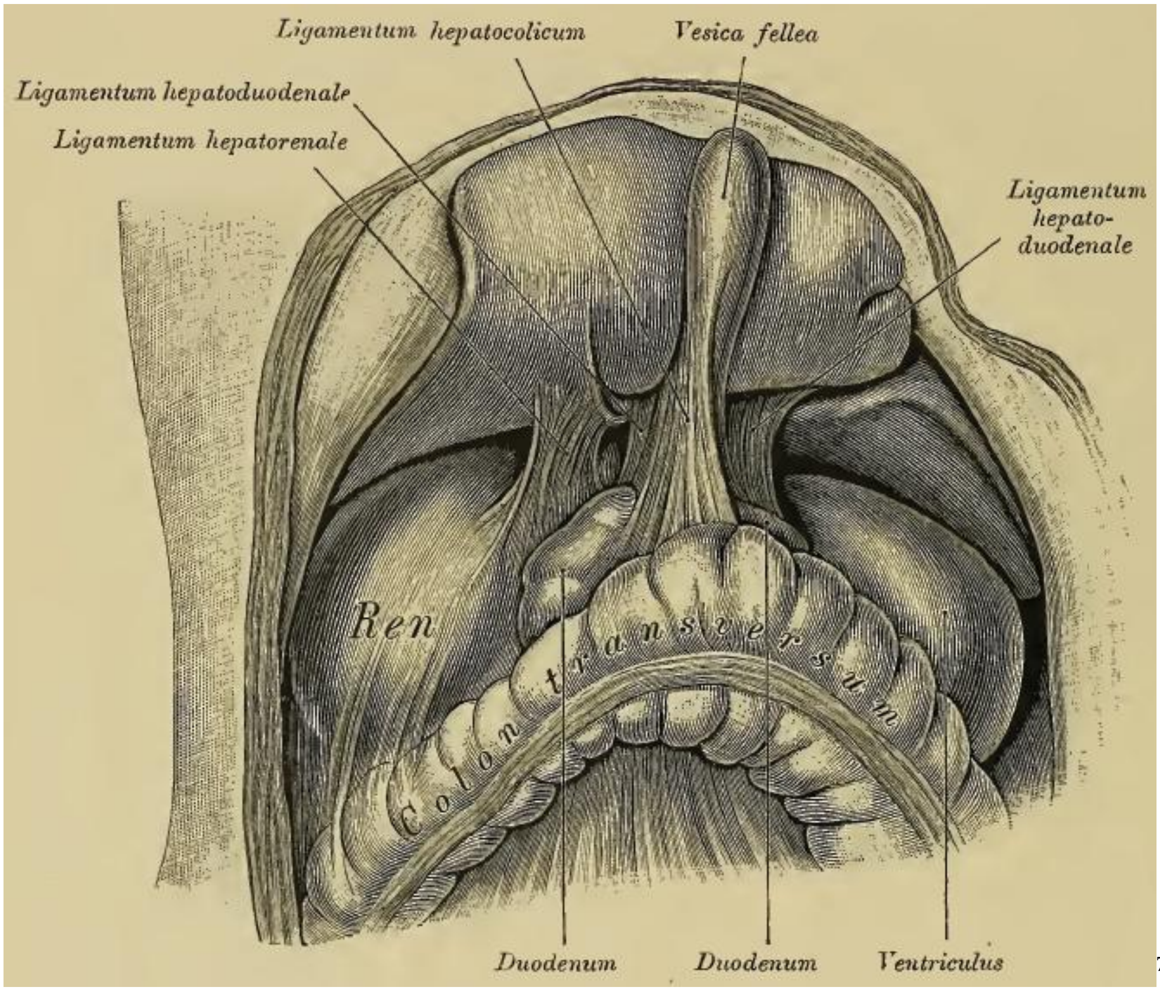
9, 9’ – Superior and inferior layers of the transverse mesocolon

10 - Mesentery

11 – Gastro-hepatic omentum

12 – Foramen of Winslow

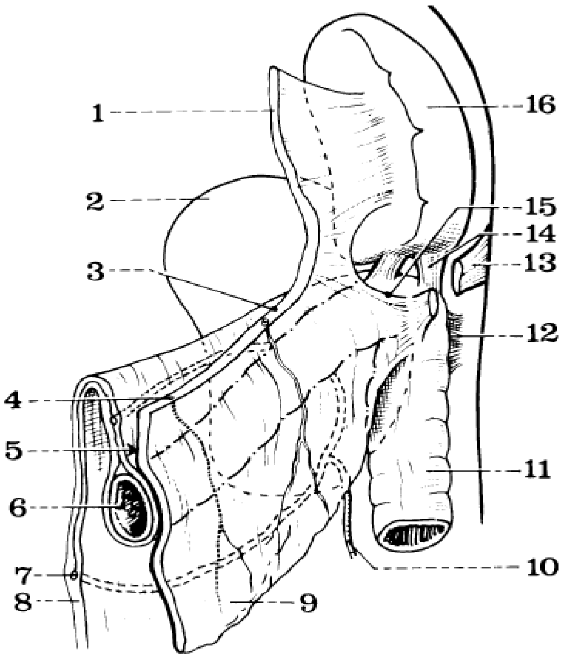
[785] Testut, 1901, p.938
[786] Testut, 1901, p.338



[787]

Figure C19: Peritoneal connections of the liver to the right kidney, duodenum, and transverse colon

[787] Heitzmann, C. & Zuckerkandl, E. (1905). *Atlas der deskriptiven anatomie des menschen neunte, vollständig umgearbeitete auflage zweiter band.* Wilhelm Braumüller: Wien, p.378 Downloaded from www.archive.org.



[788]

Figure C20: Connections of the splenic angle

1 – Sectioned gastro-splenic ligament

3 – Sectioned gastro-colic ligament

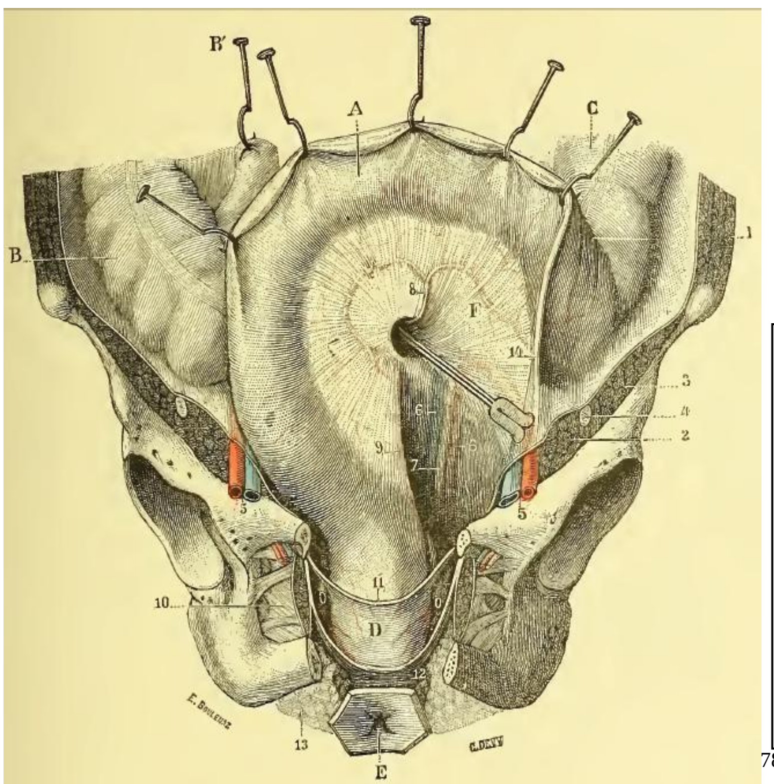
9 – Greater omentum

12 – Parieto-colic ligament

13 – Sectioned left phreno-colic ligament

14 – Spleno-colic ligament

15 – Viscero-colic connection



[789]

Figure C21: Connections of the sigmoid mesocolon

F – Sigmoid mesocolon

11 – Cut peritoneum at the level of the vesico-rectal cul-de-sac

14 – Peritoneal fold fixing the sigmoid colon to the pelvic inlet

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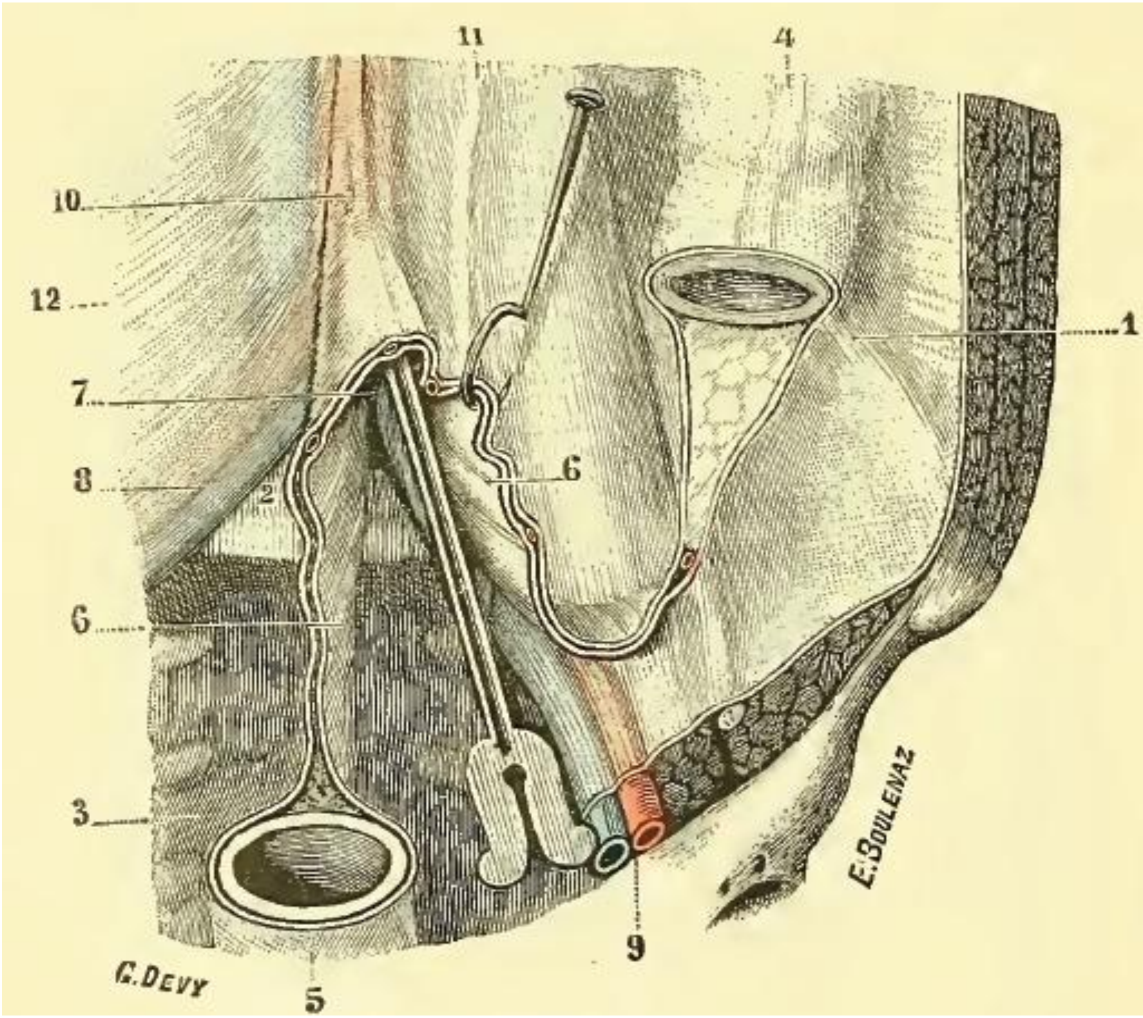
[788] Bouchet & Cuilleret, 2001, p.1992
[789] Testut, 1901, p.211



[790]

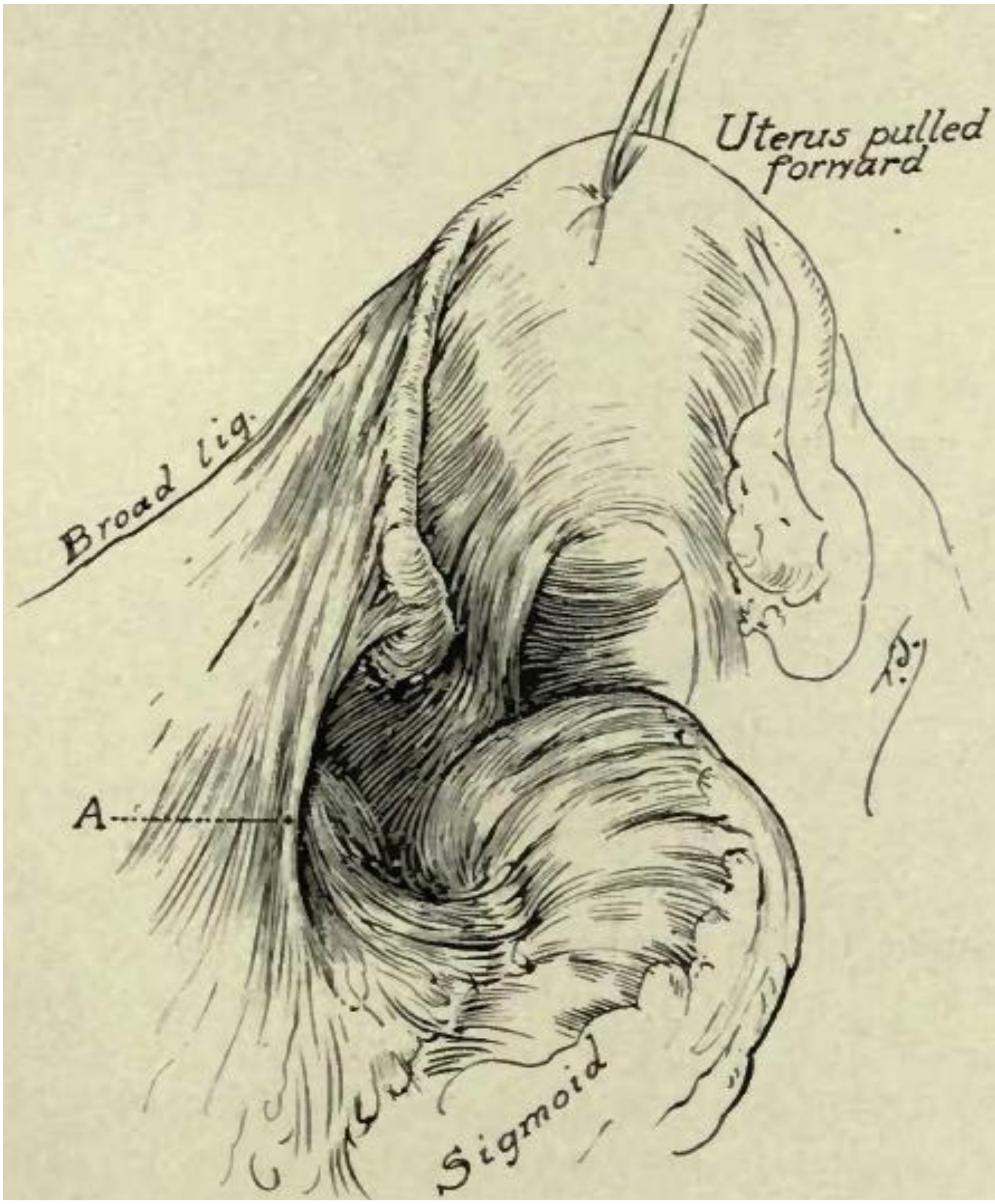
Figure C22: Line of insertion of sigmoid mesocolon after removal of the sigmoid colon

6 – Sigmoid mesocolon

7 – Sigmoid fossa

12 – Left layer jejuno-ileum mesentery

[790] Testut, 1901, p.210

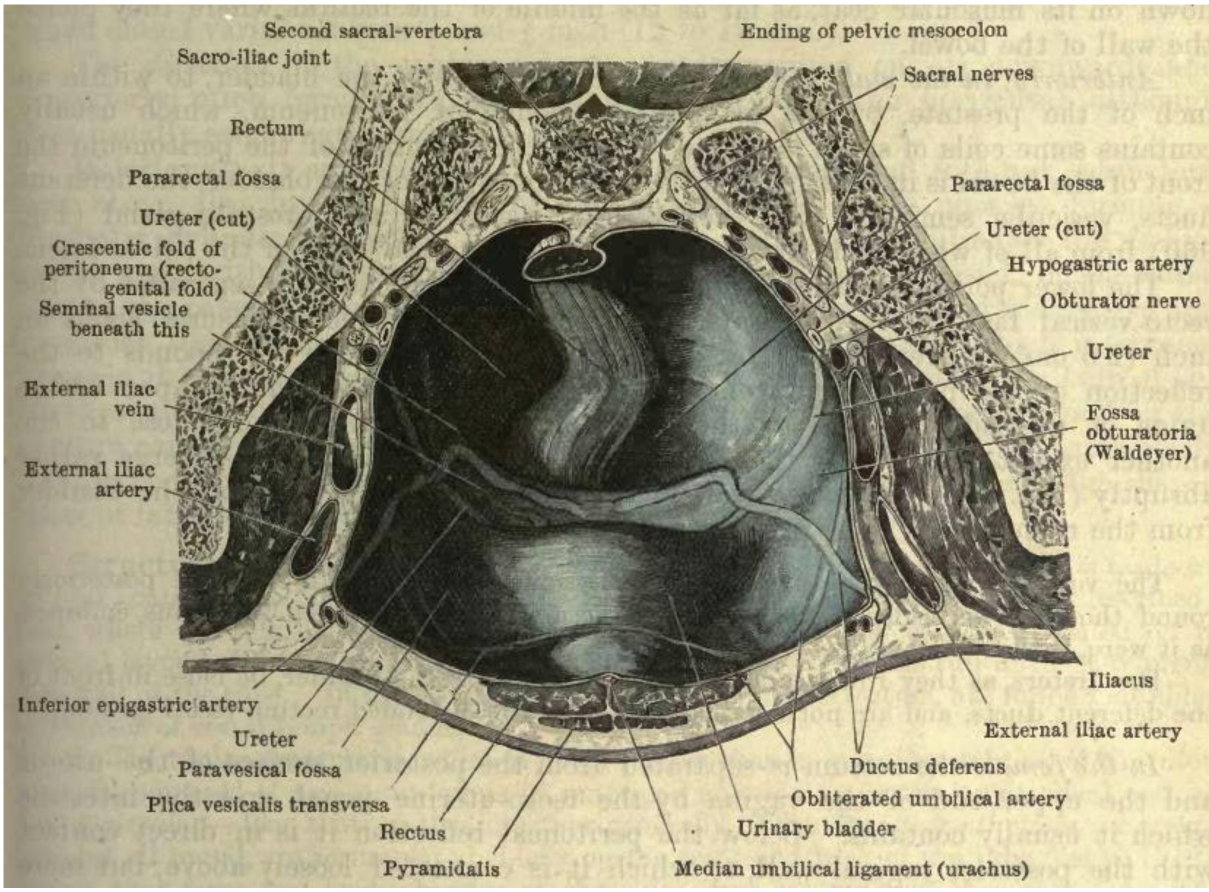


791

Figure C23: The ligamentum infundibulum of Liepmann made prominent by forcefully drawing the uterus anteriorly and inferiorly

A – Ligamentum infundibulum of Liepmann

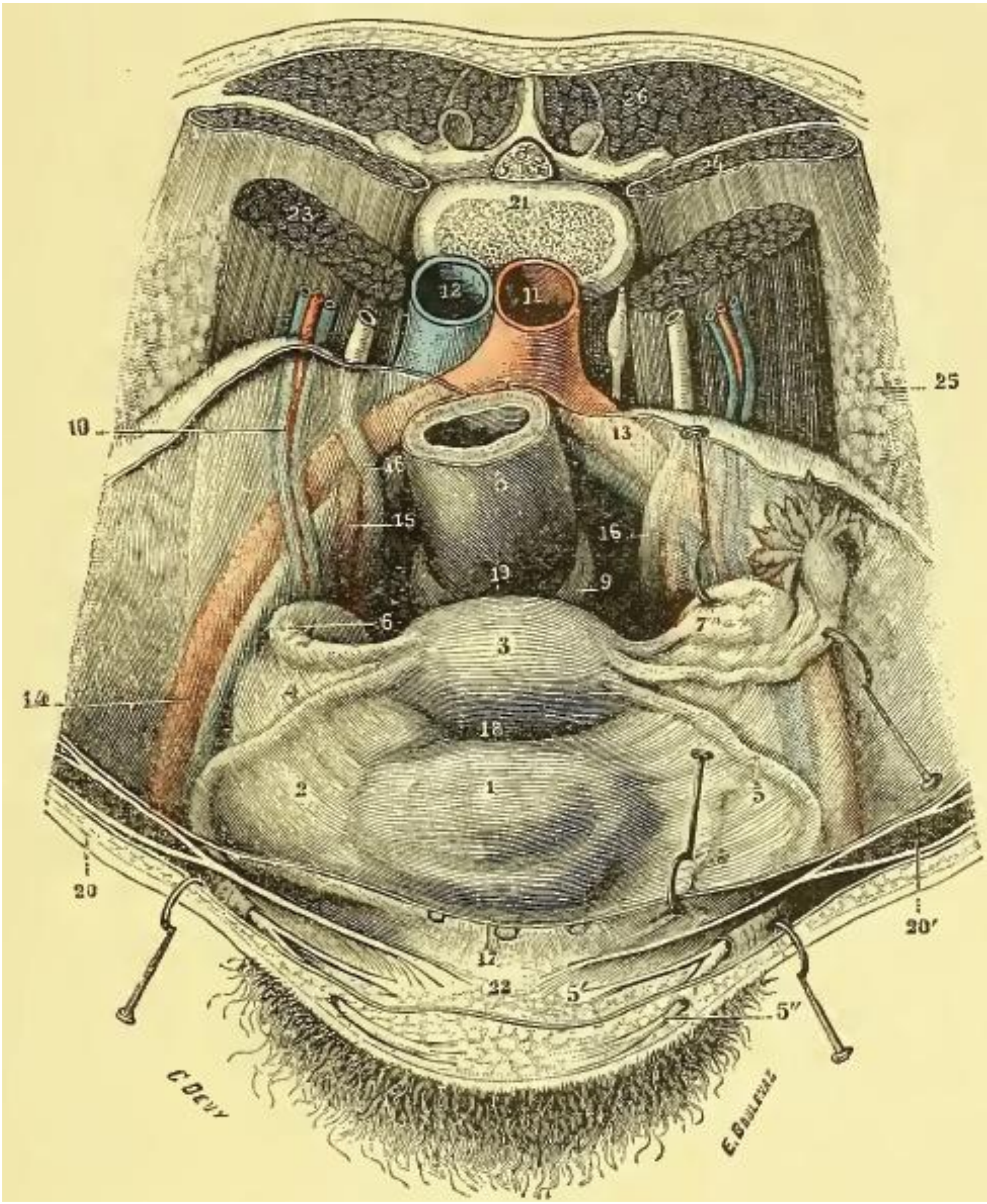
791 Hertzler, 1919, p.147



[792]

Figure C24: Peritoneum of the male pelvis

[792] Robinson, 1918, p.1227

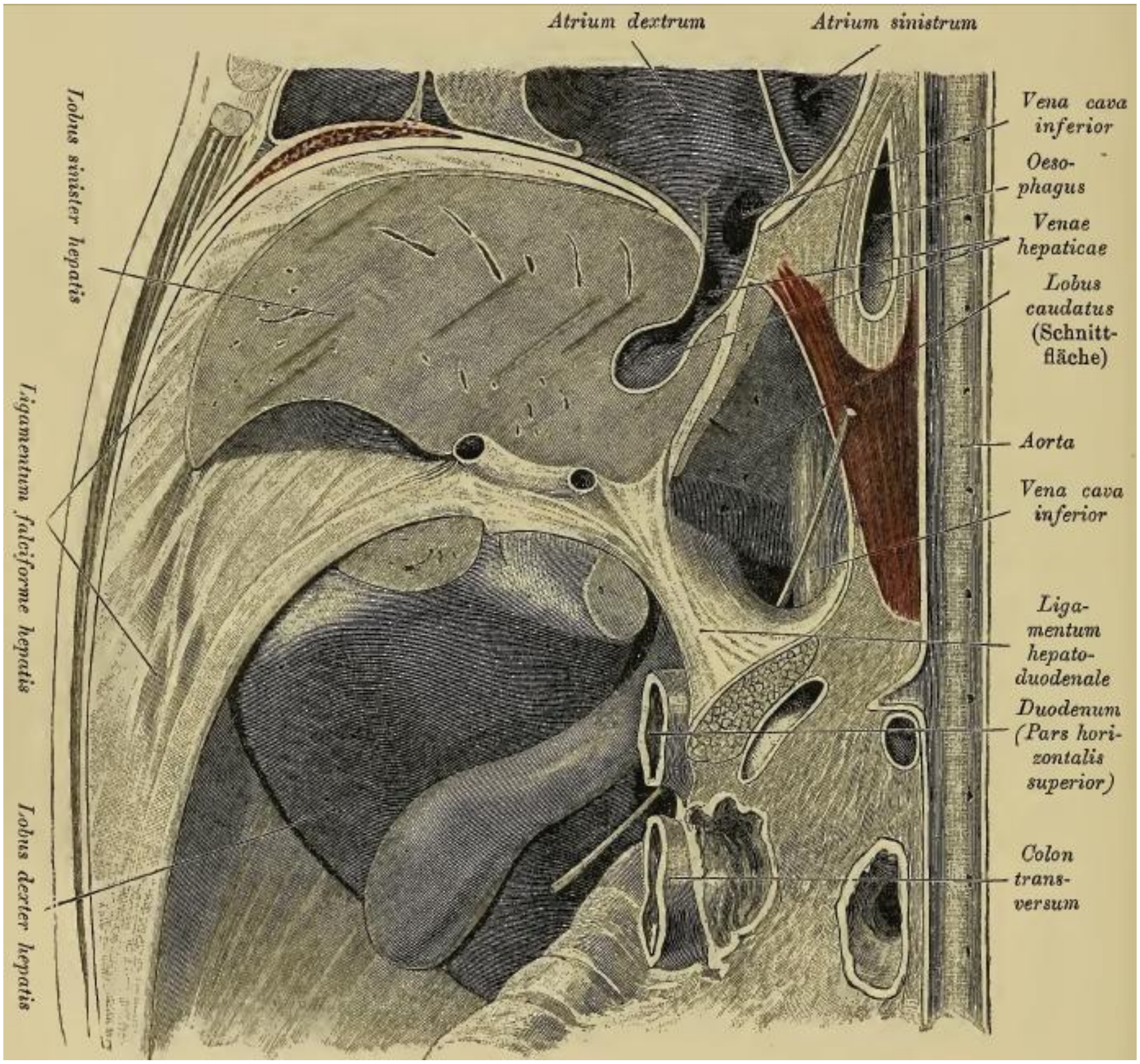


[793]

Figure C25: Peritoneum of the female pelvis

2 – Paravesical fossa, 4 – Broad ligament, 5 – Round ligament, 9 – Utero-sacral ligament of Douglas, 17 – Cut edge of peritoneum, 18 – Vesico-uterine cul-de-sac, 19 – Pouch of Douglas, 25 – Superficial subserous layer of fascia in relation to the psoas major muscle

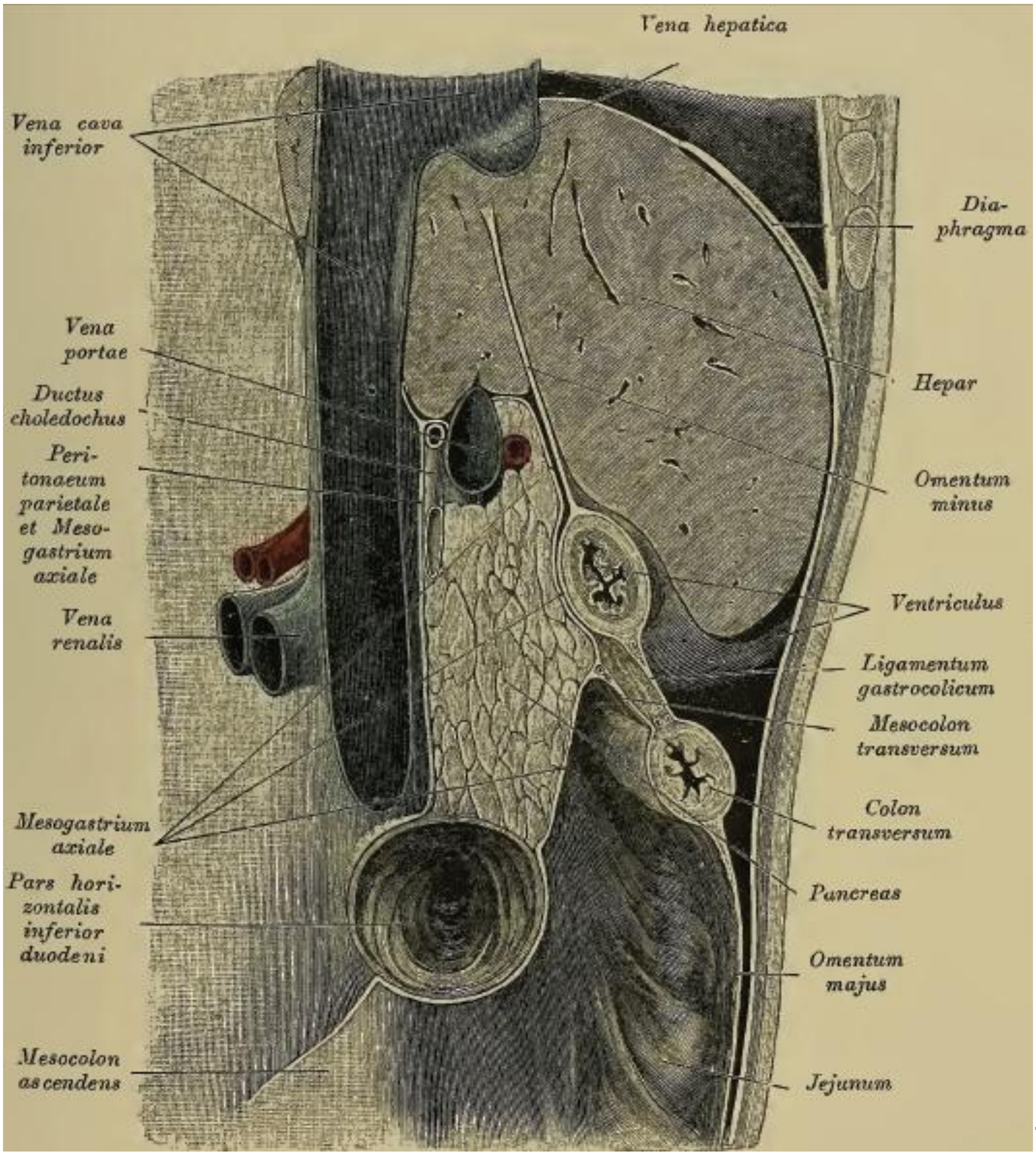
[793] Testut, 1901, p.785



[794]

Figure C26: Preparation displaying the peritoneal connections of the liver after sectioning of the left lobe, viewed from the left side. The boundaries of the foramen of Winslow are also displayed. Note also the venous connection between the hepatic veins, inferior vena cava and right atrium.

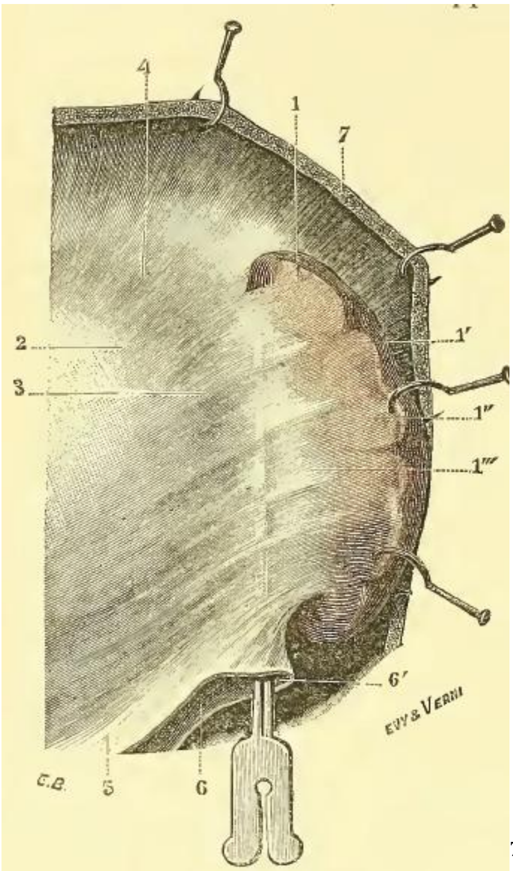
[794] Heitzmann & Zuckerkandl, 1905, p.382



[795]

Figure C27: Preparation displaying the continuity of the greater omentum, transverse mesocolon and lesser omentum. Note also the relationship to the portal vein and inferior vena cava

795 Heitzmann & Zuckerkandl, 1905, p.385



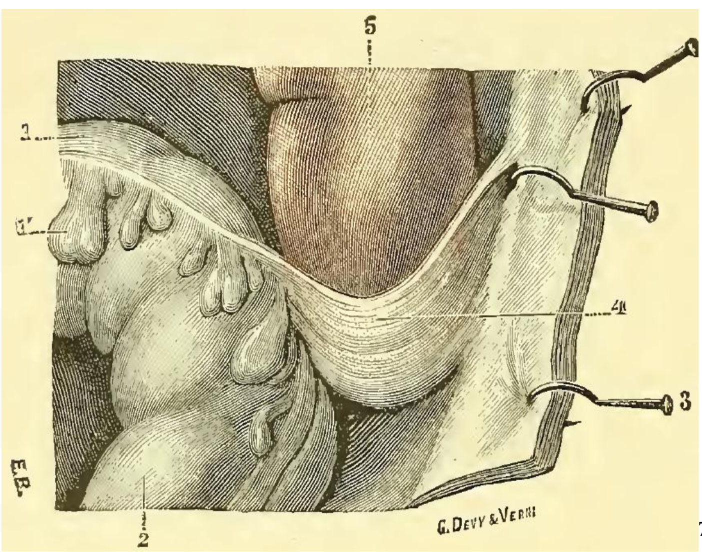
[796]

Figure C28: Peritoneal connection between the stomach, spleen, and diaphragm

3 – Gastro-splenic ligament

4 – Gastro-phrenic ligament

5 – Gastro-colic ligament



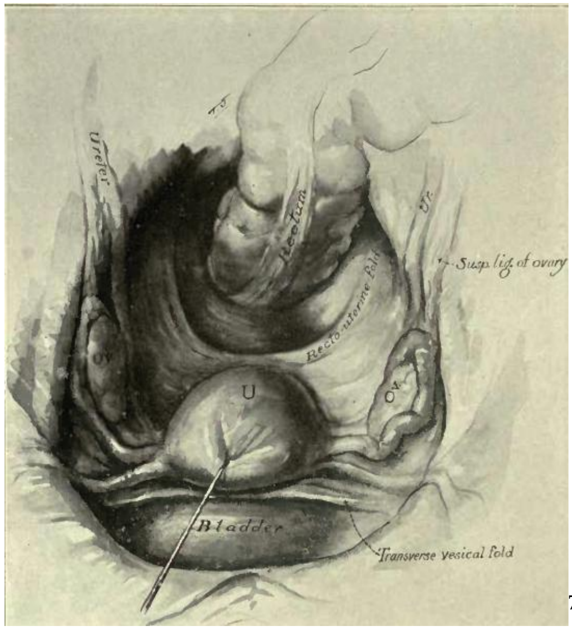
[797]

Figure C29: Sustentaculum lienis

4 – Left phreno-colic ligament or sustentaculum lienis

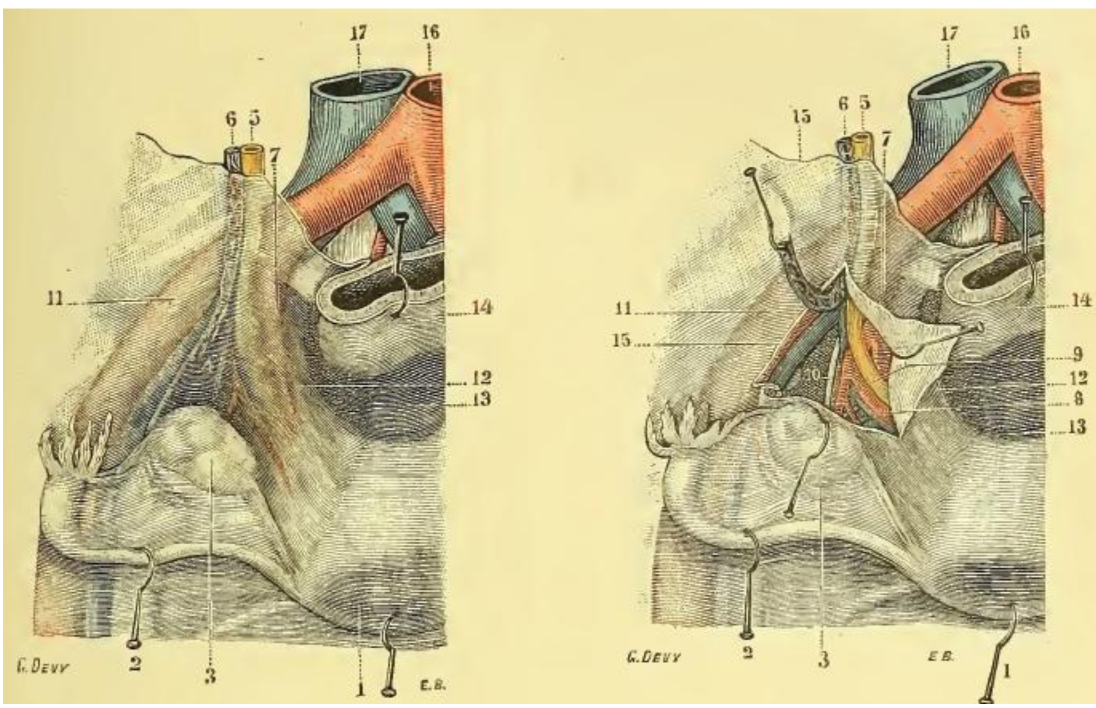
5 – Spleen supported by the left phreno-colic ligament

[796] Testut, 1901, p.952
[797] Testut, 1901, p.364



[798]

Figure C30: Recto-uterine fold and the transverse vesical folds of Waldyer

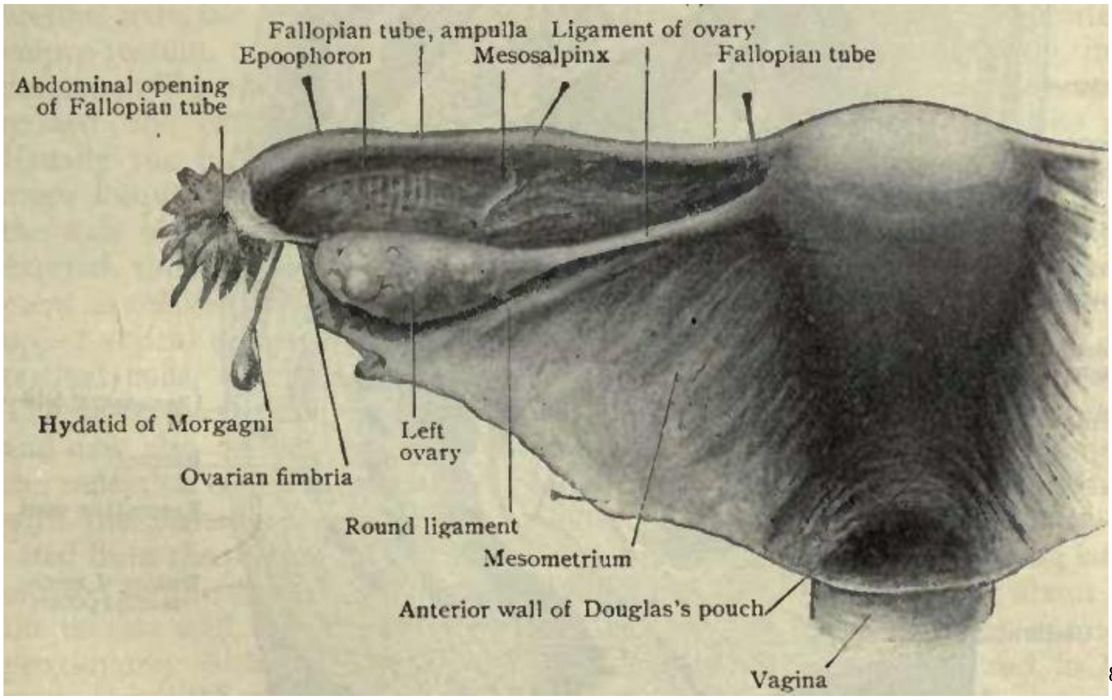


[799]

Figures C31 and C32: Relationship of ovary to ovarian fossa *in situ* and after sectioning of the overlying peritoneum and ovarian vessels.

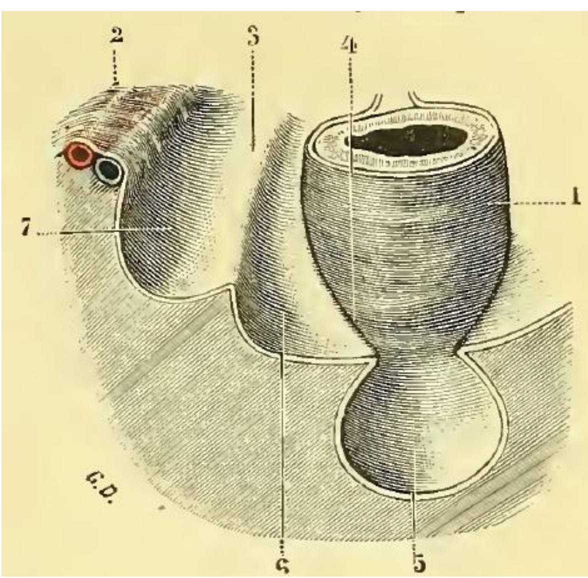
4 – Ovarian fossa, 12 – Utero-sacral ligament of Douglas, 13 – Pouch of Douglas, 15 – Cut edge of peritoneum

[798] Hertzler, 1919, p.140
[799] Testut, 1901, p.791



[800]

Figure C33: Female internal reproductive organs seen from behind and made tense by stretching



[801]

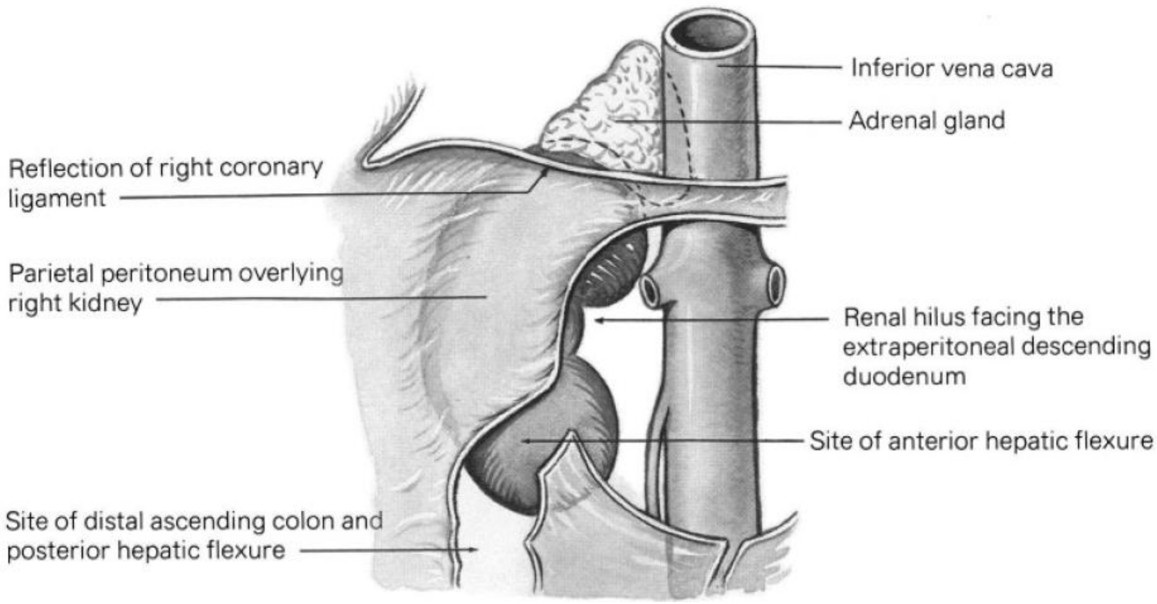
Figure C34: Schematic review of the Lumbo- and sacro-uterine ligaments

3 – Utero-lumbar ligament of Vallin

4 – Utero-sacral ligament of Douglas

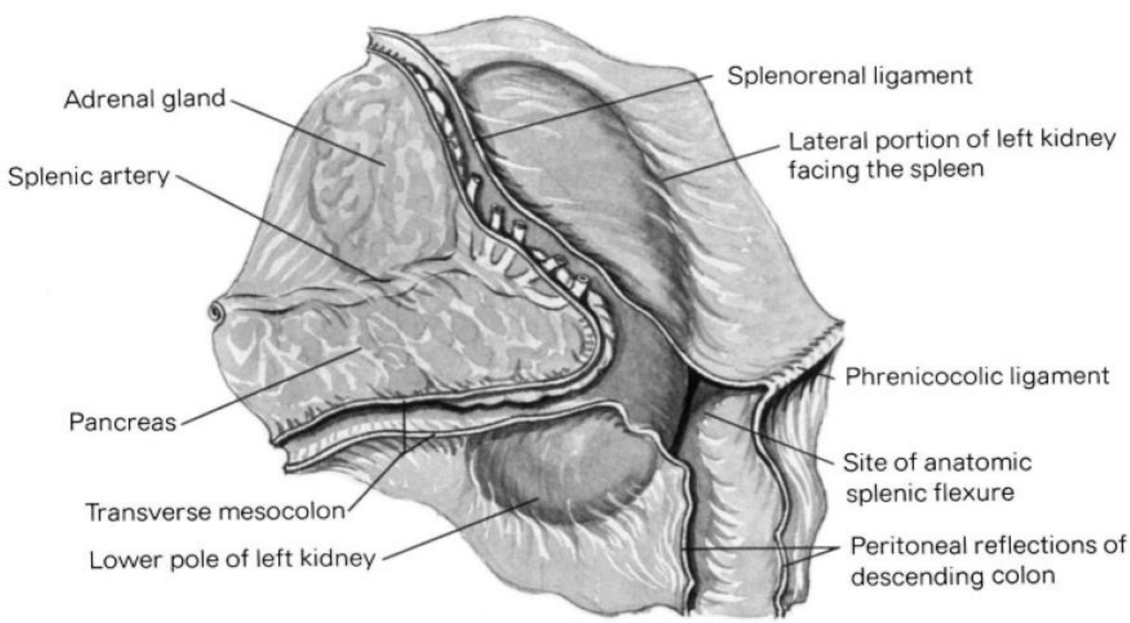
5 – Pouch of Douglas

[800] Piersol, 1913, p.2005
[801] Testut, 1901, p.823



[802]

Figures C35 (above) and C36 (below): The relationships of the right and left kidneys to the attachment of the peritoneum to the posterior abdominal wall.

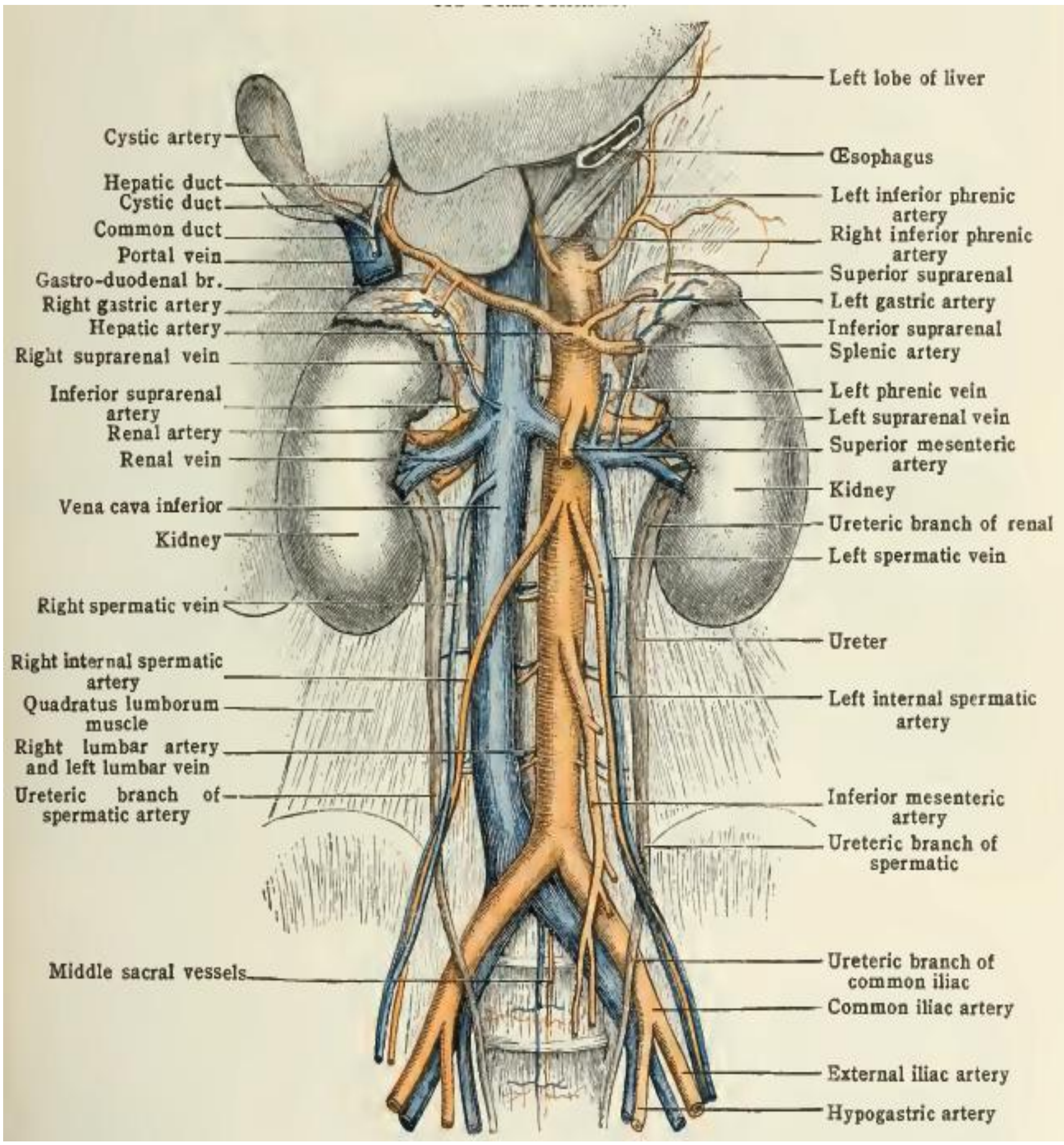


[803]

[802] Meyers, M. A. (2006b). The renointestinal relationships: normal and pathologic anatomy. In: Meyers, M. A. (Ed.). (2006). *Dynamic radiology of the abdomen normal and pathologic anatomy (5th ed.)* Springer: doi: 10.1007/0-387-21804-1, p.494

[803] Meyers, 2006b, p.495

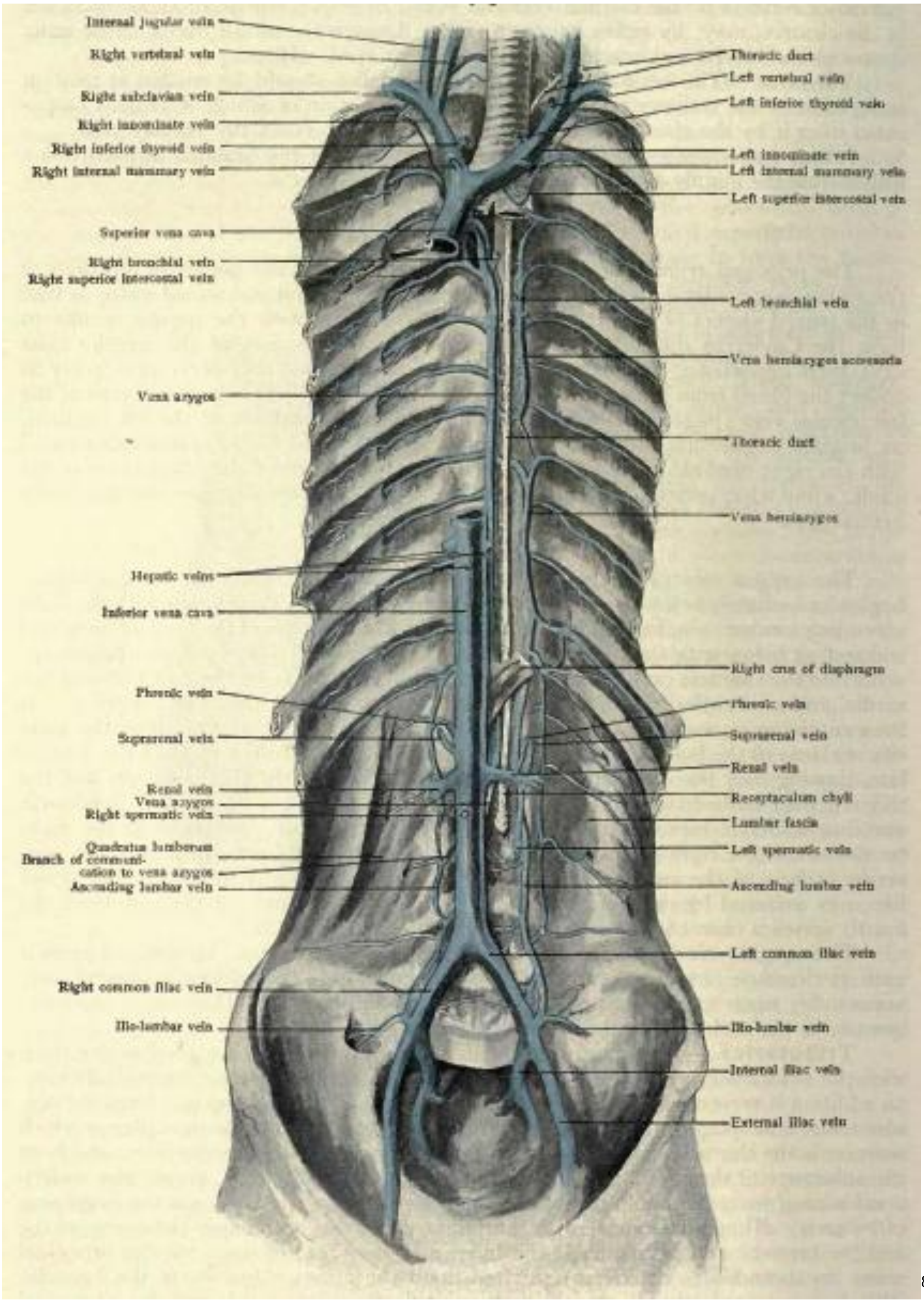
Appendix D – Neurovasculature and Lymphatics



[804]

Figure D1: Great abdominal vessels

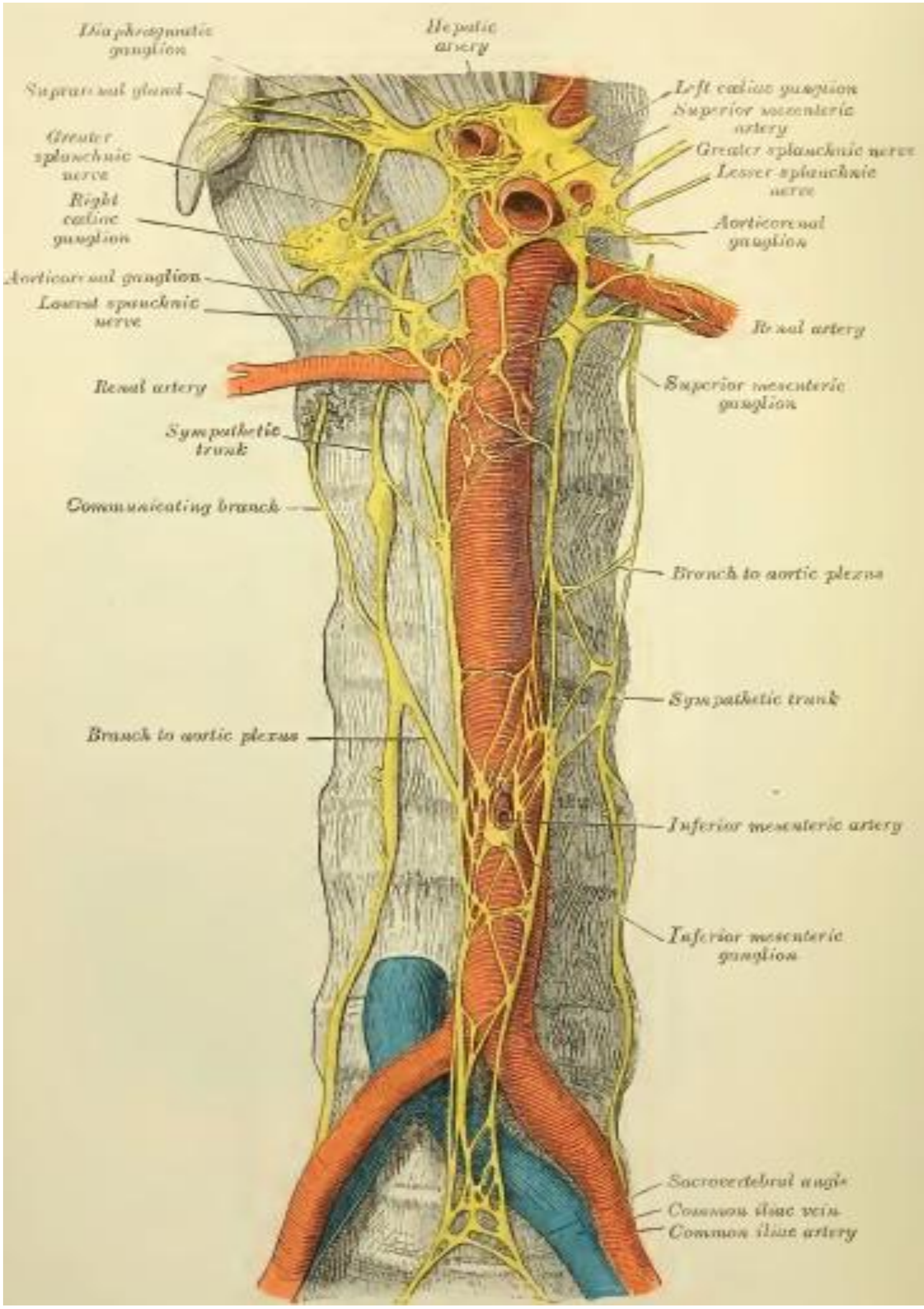
[804] Jackson, 1914, p.591



805

Figure D2: The inferior caval system

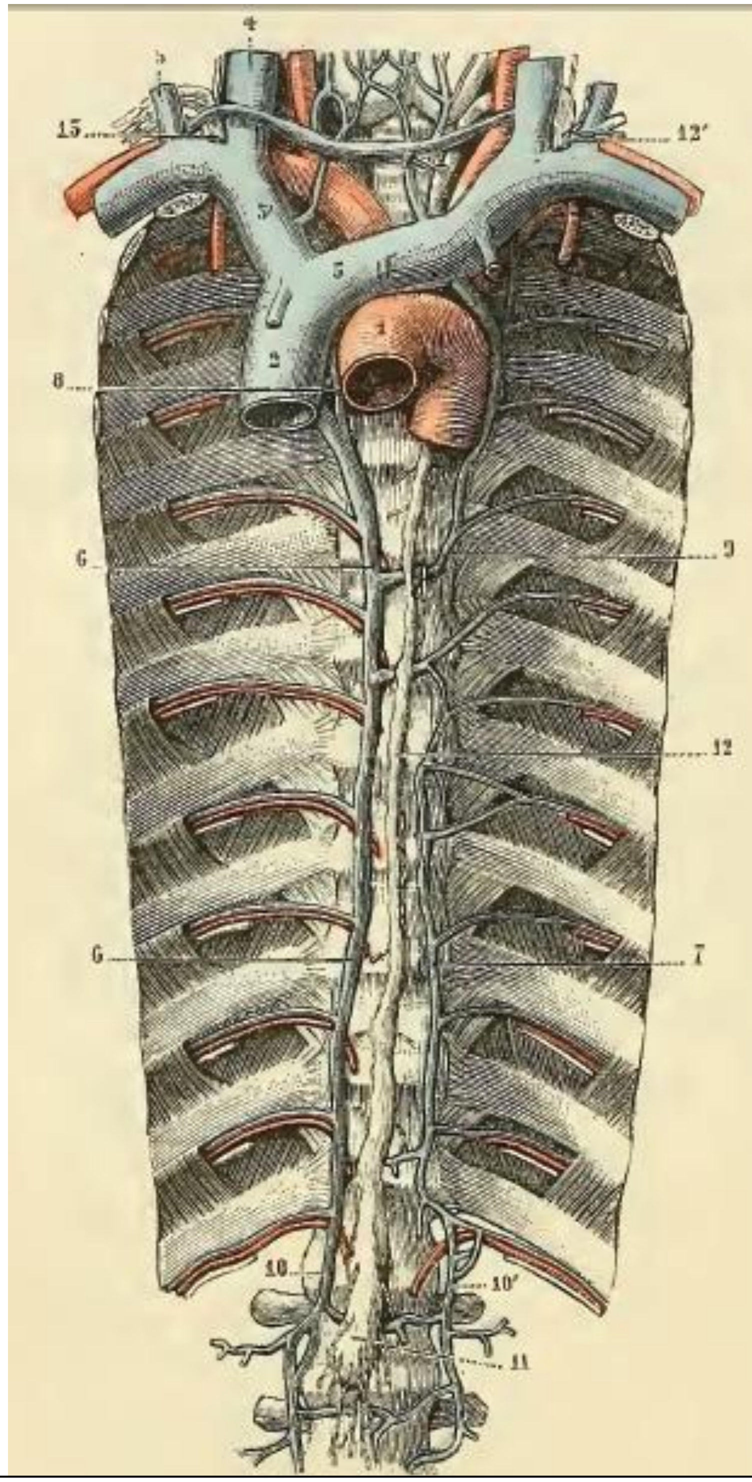
805 Piersol, 1913, p.894



[806]

Figure D3: Abdominal portion of the sympathetic trunk with the celiac and hypogastric plexuses

[806] Gray, H. (1913). A*natomy Descriptive and Applied (18th Ed.).* (Howden, R. Ed.). Philadelphia: Lea & Febiger. Downloaded from www.archive.org, p.1000

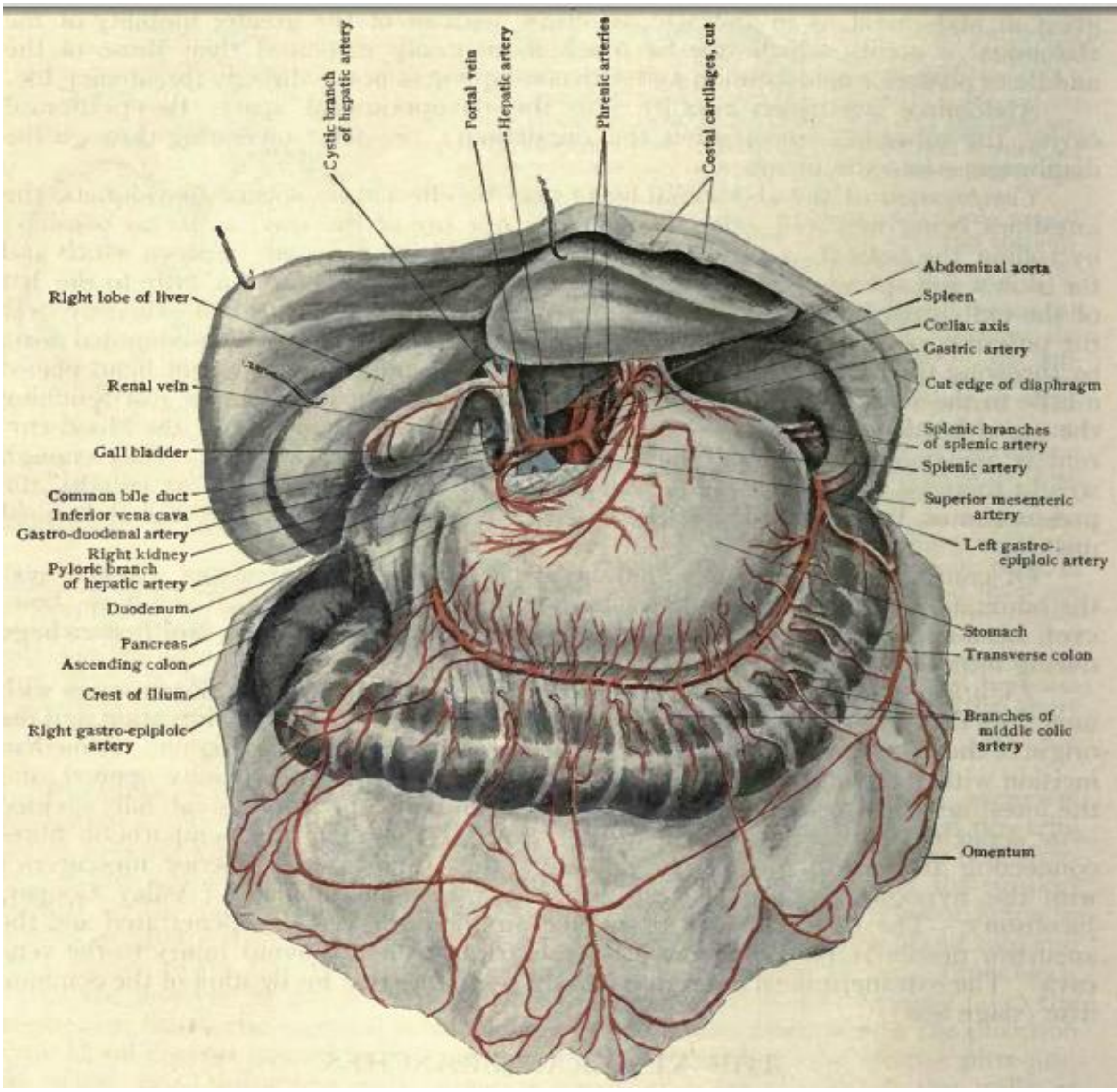


807

Figure D4: The Thoracic duct

12 – Thoracic duct, 12' – Entrance of thoracic duct into left subclavian vein

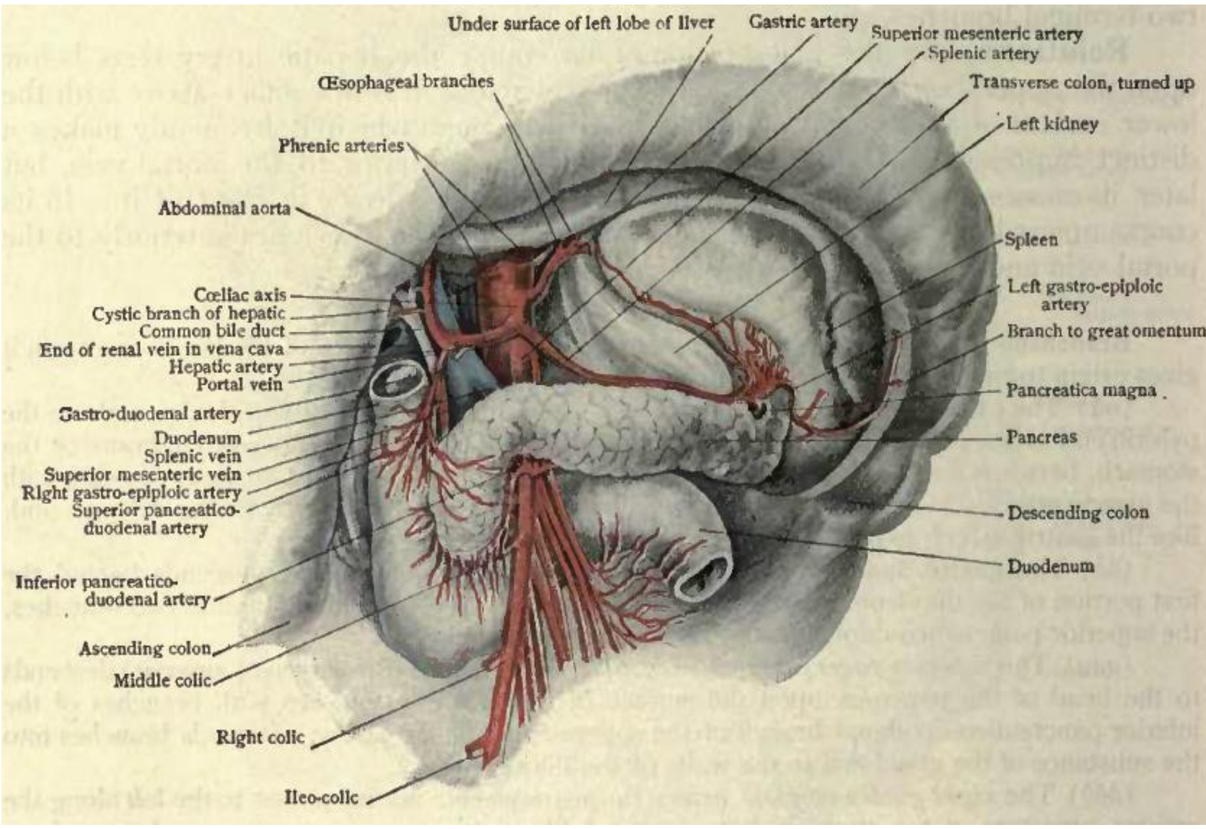
807 Testut, L. (1900). *Traité d'anatomie humaine tome deuxième (4e Éd.).* Paris: Octave Doin. Downloaded from www.archive.org, p.346



[808]

Figure D5: The celiac trunk with branches

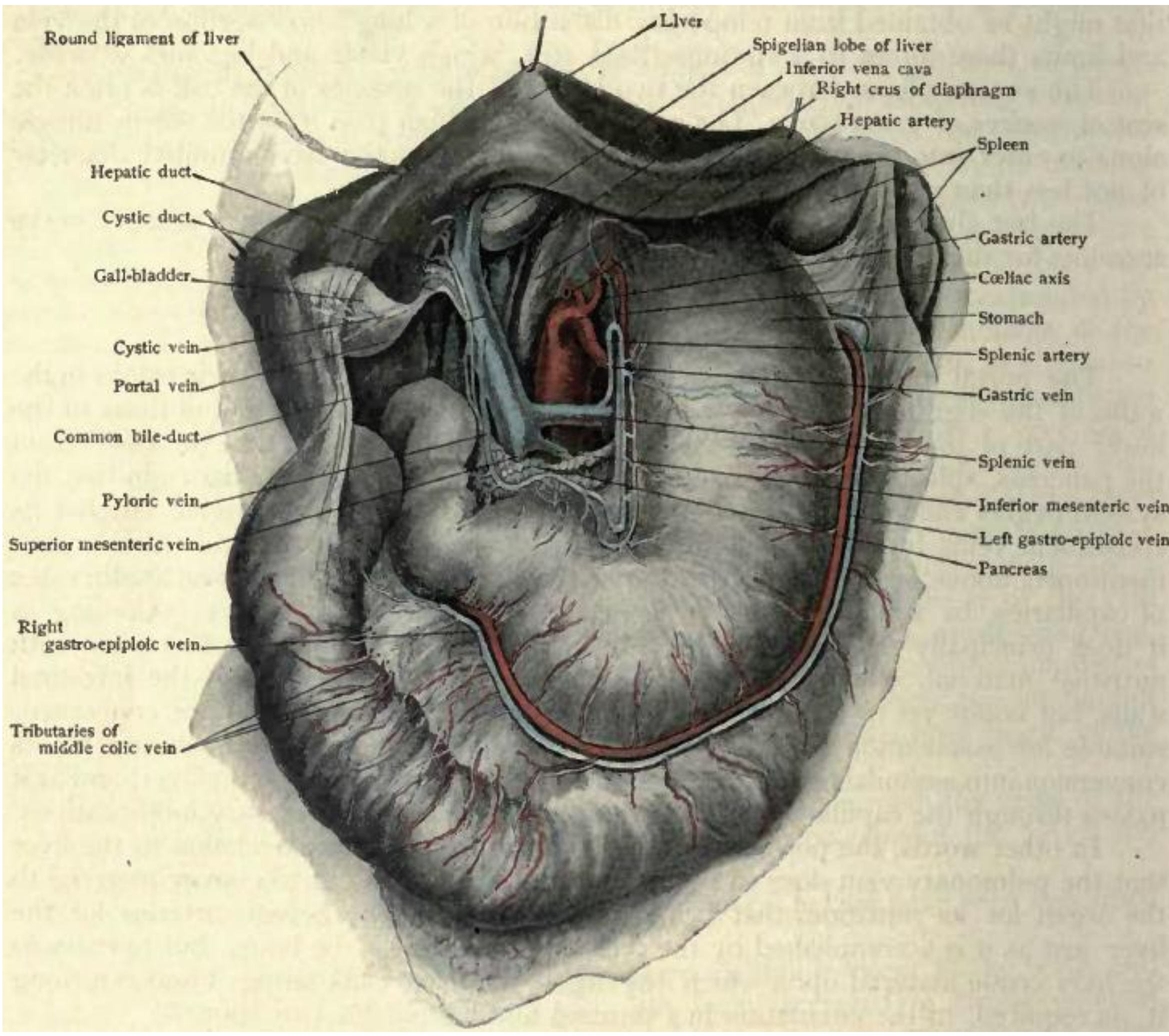
[808] Piersol, 1913, p.798



[809]

Figure D6: The celiac trunk exposed by removal of the stomach and displacing the transverse colon superiorly

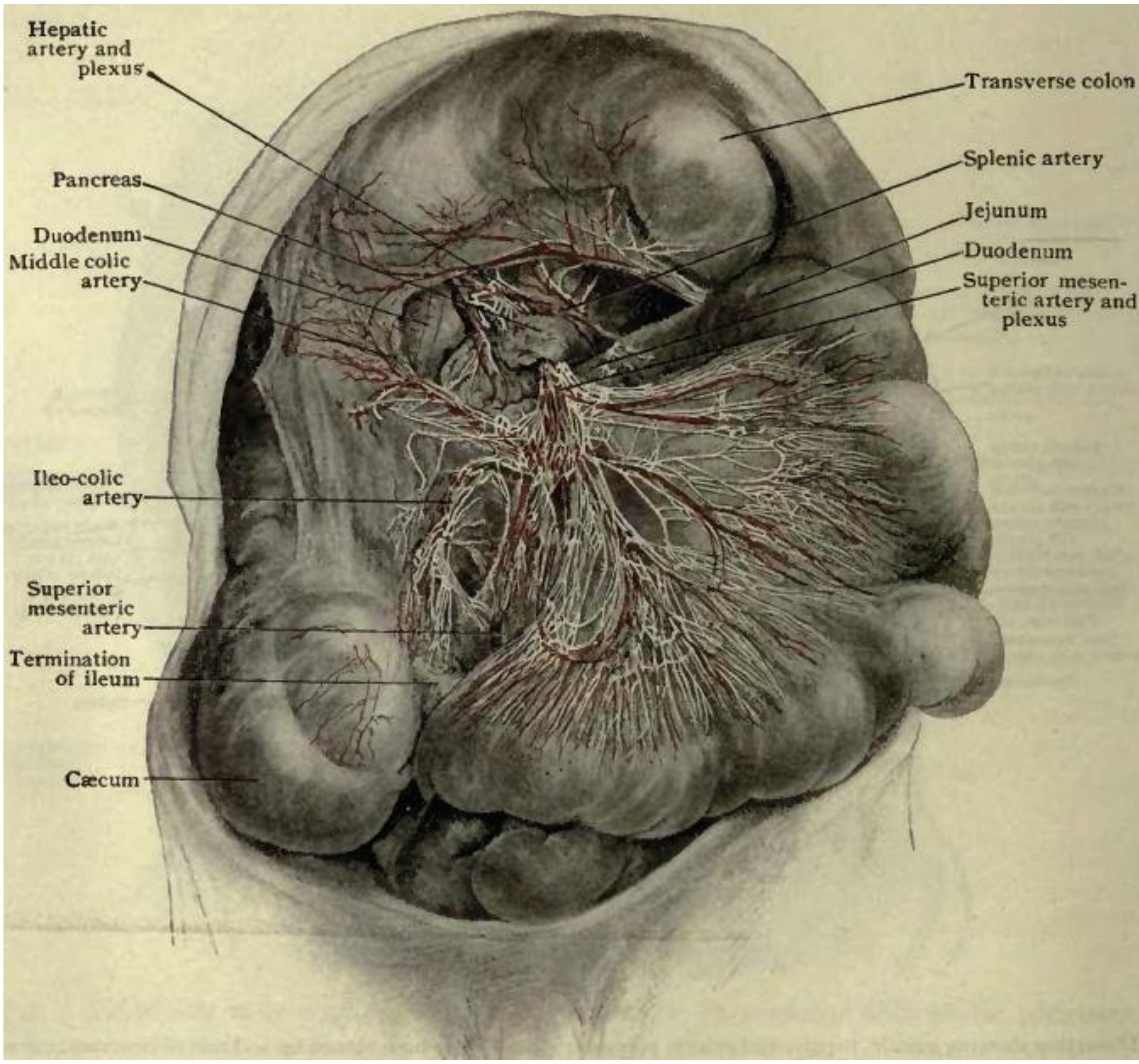
[809] Piersol, 1913, p.800



[810]

Figure D7: The portal vein exposed by displacing the liver superiorly

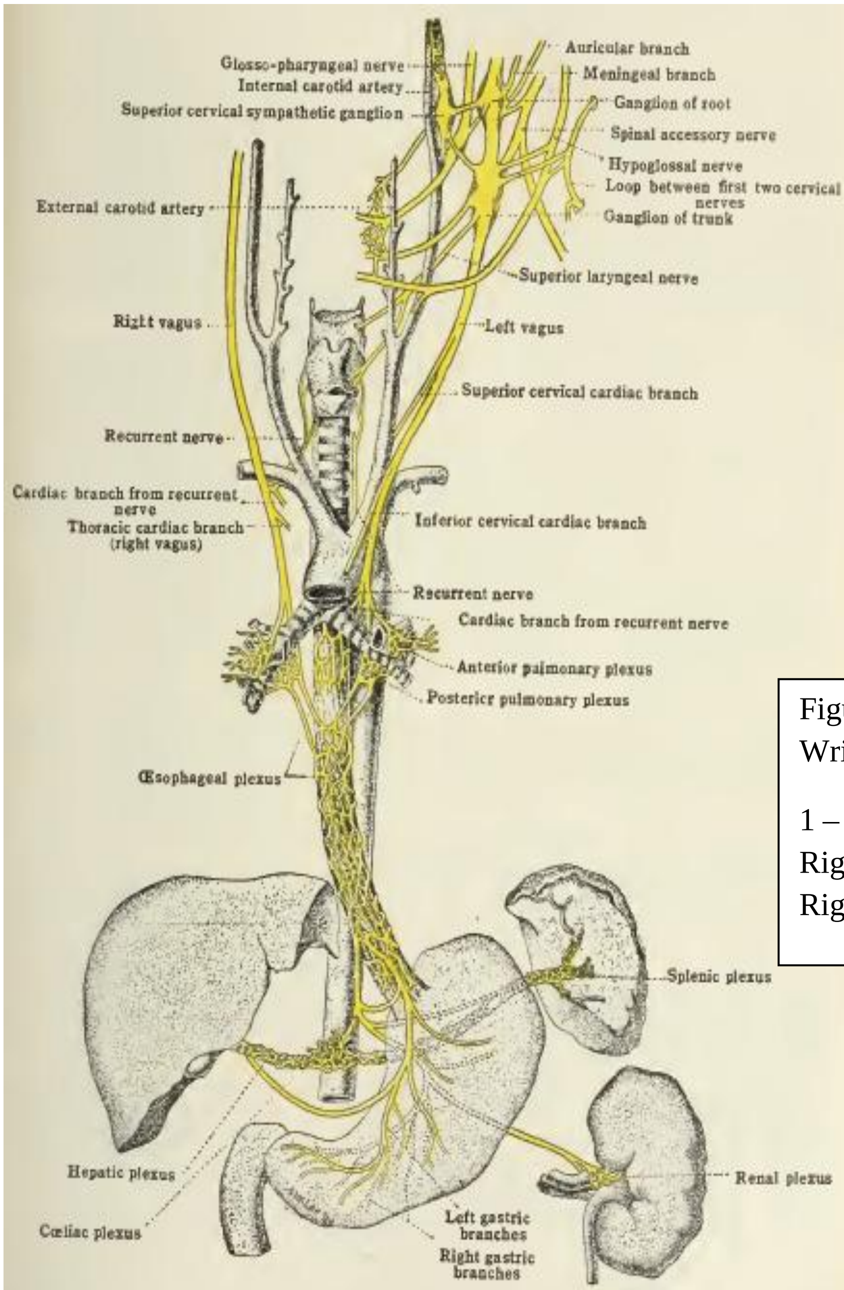
[810] Piersol, 1913, p.920



[811]

Figure D8:Dissection of hepatic and superior mesenteric plexuses

[811] Piersol, 1913, p.1372



812

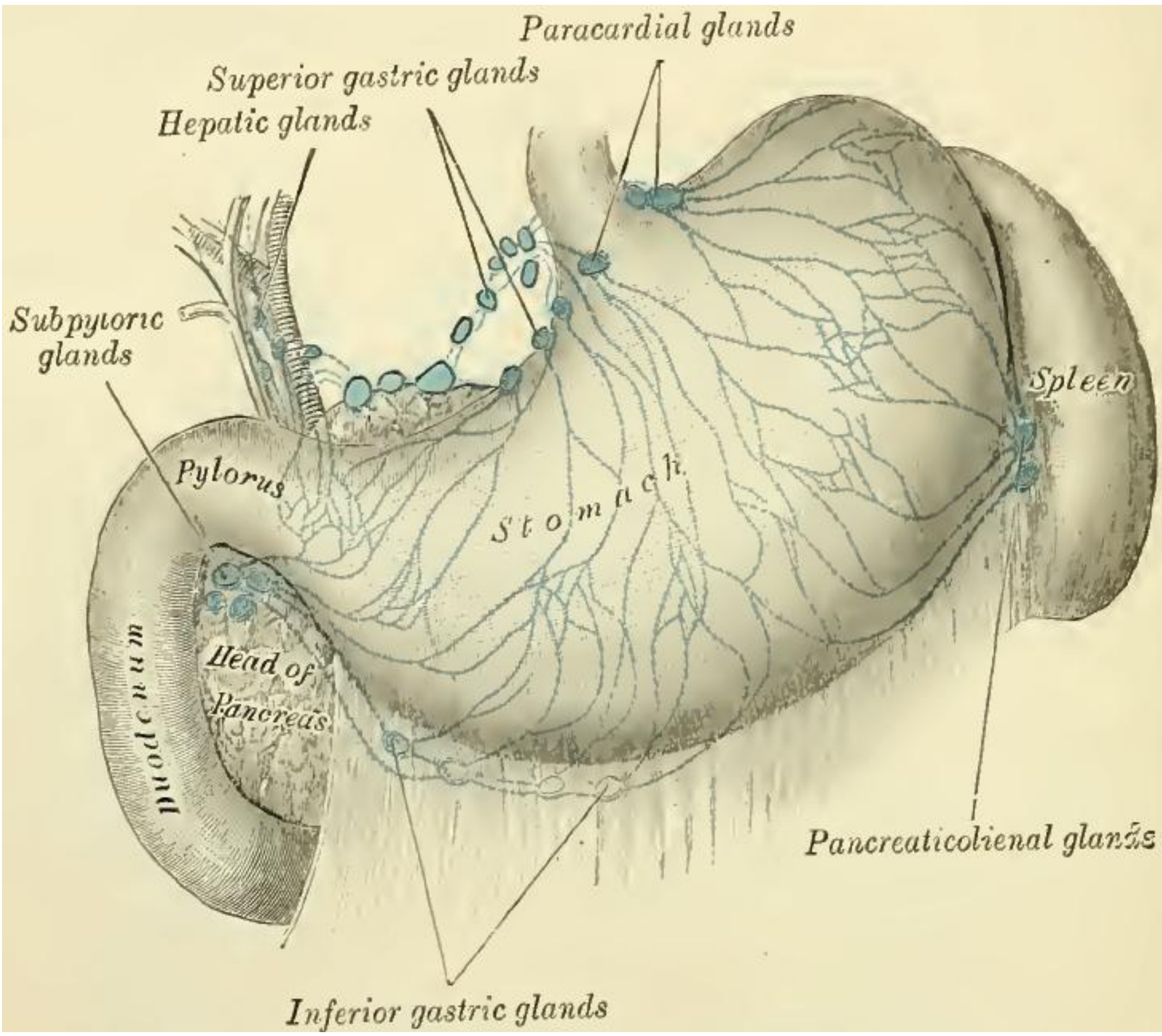
Figure D10: 'Anse mémorable de Wrisberg'

1 – Right celiac ganglion, 2 – Right greater splanchnic nerve, 3 – Right vagus nerve

813

Figure D9: Schematic of the distribution of the vagus nerves

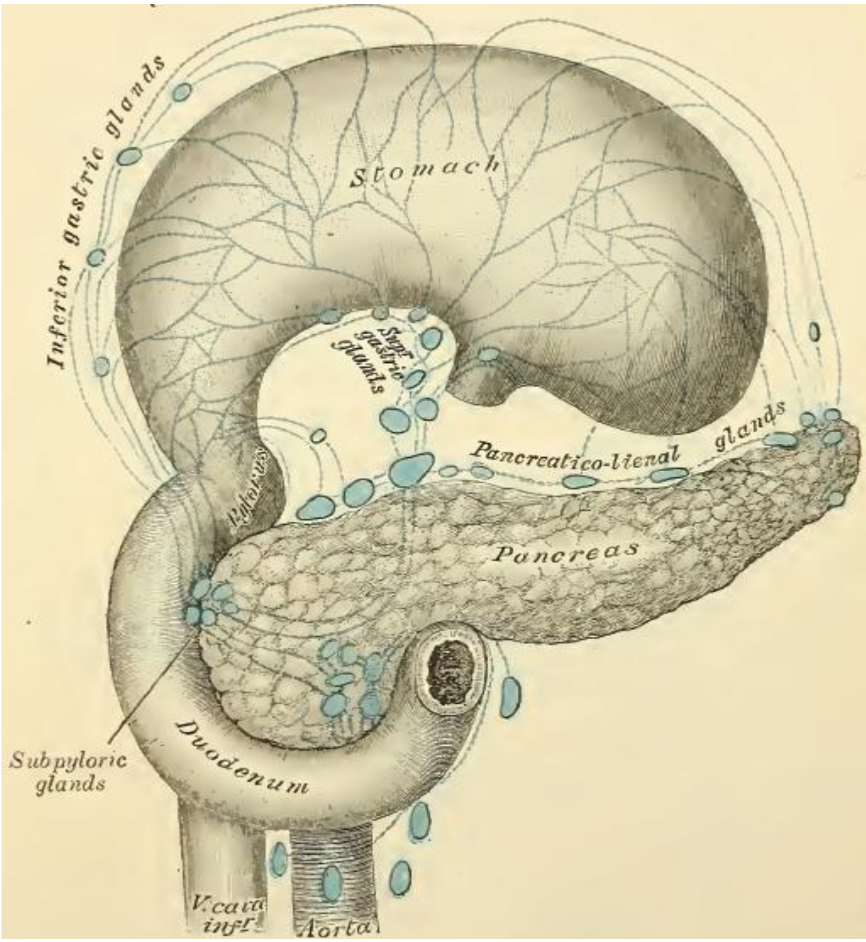
812 Jackson, 1914, p.955
813 Testut, 1899. p.263



[814]

Figure D11: Semi-schematic view of the lymphatics of the upper abdomen

[814] Gray, 1913, p.788



[815]

Figure D12: Semi-schematic view of the lymphatics of the upper abdomen with the stomach displaced superiorly

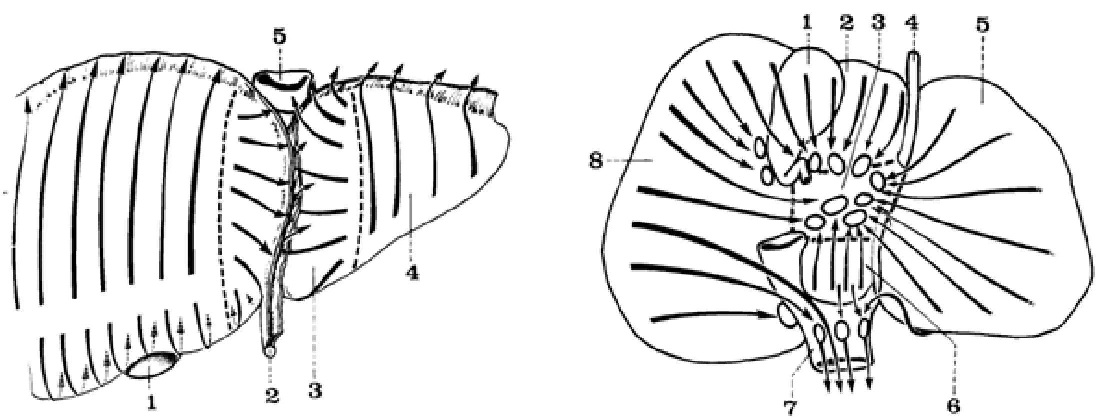
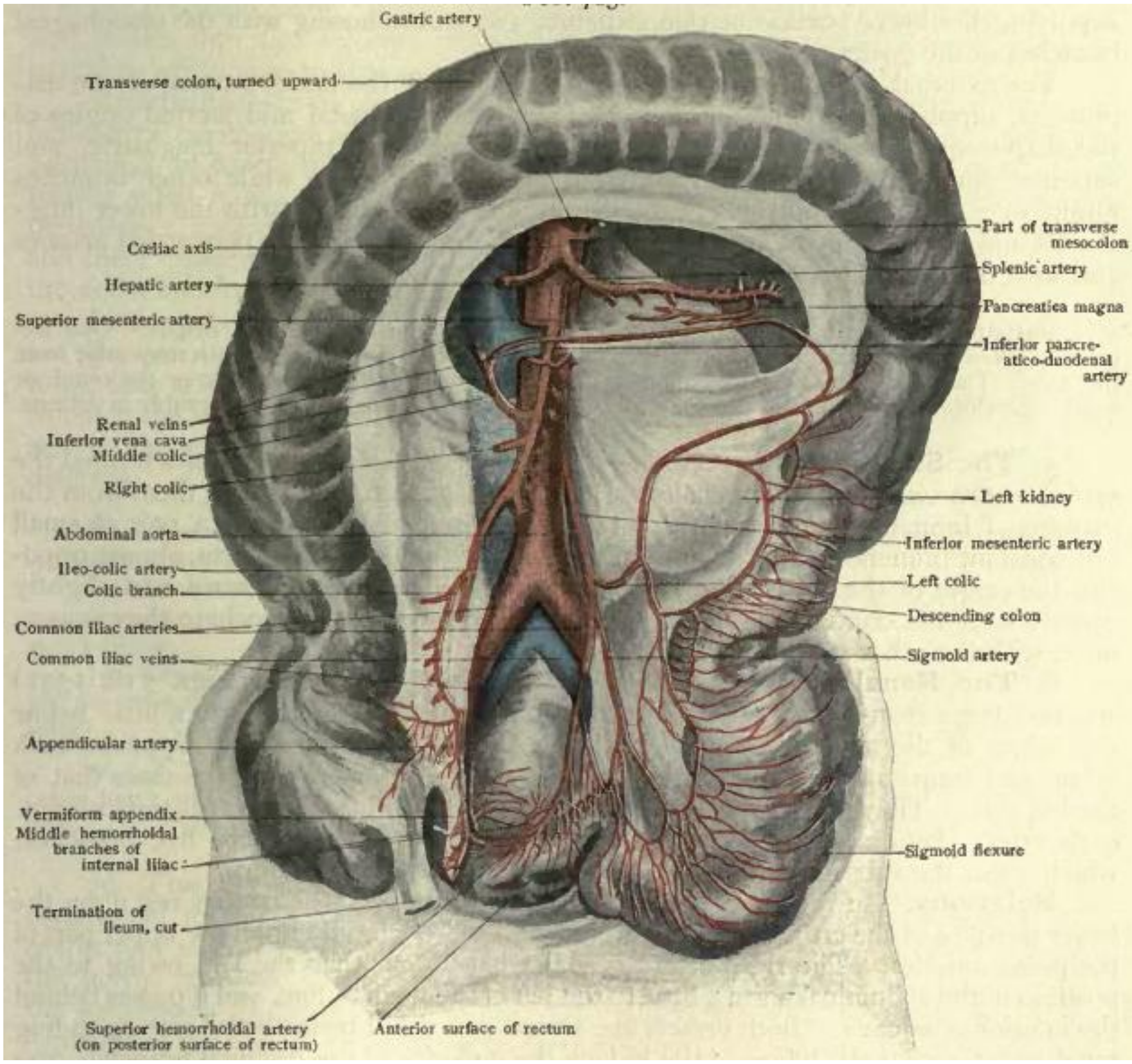

[816]

Figure D13: Semi-schematic view of the lymphatics of the liver. The anterior surface is displayed on the left with the inferior surface displayed on the right

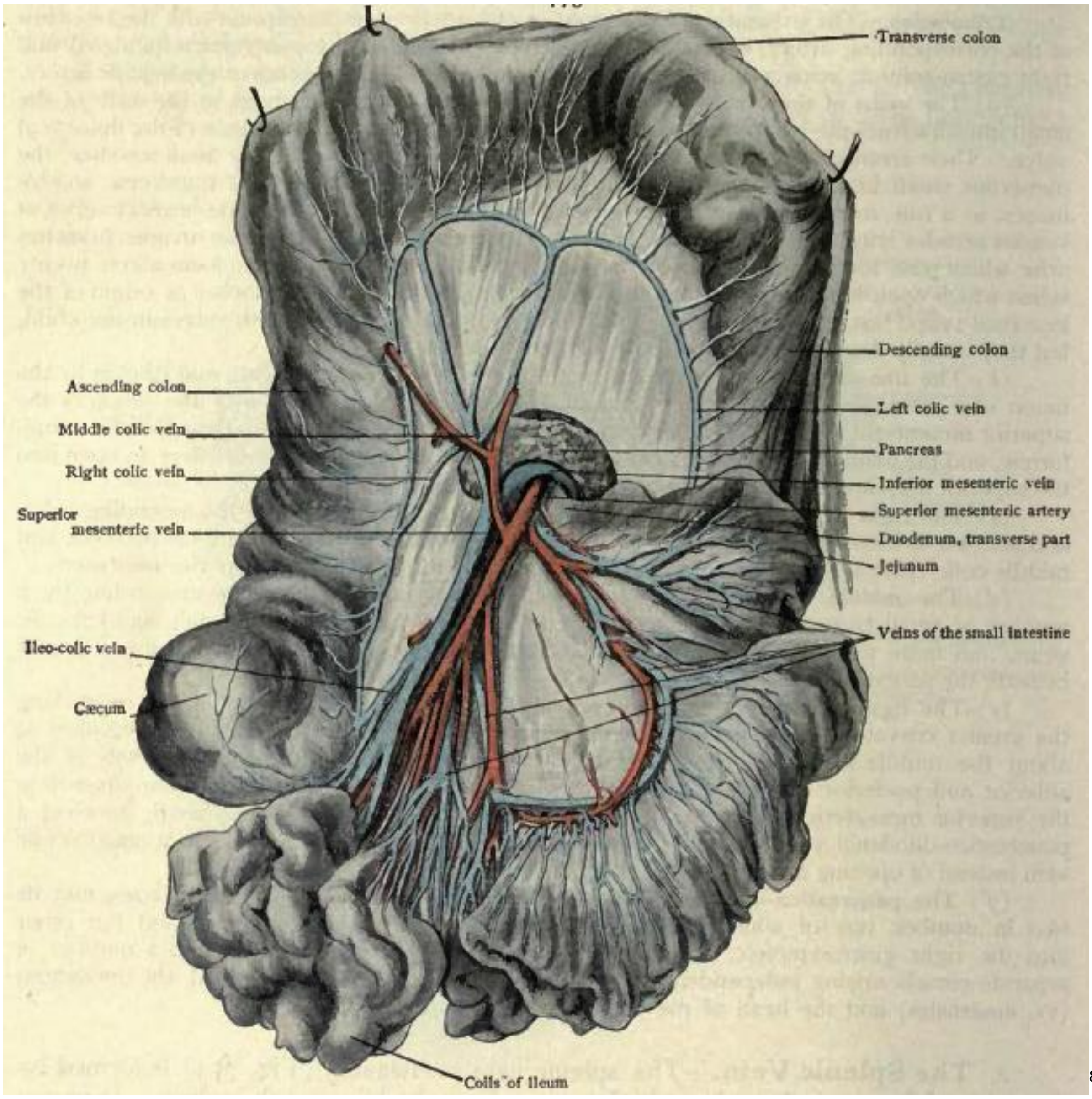
[815] Gray, 1913, p.789
[816] Bouchet & Cuilleret, 2001, p.1977



[817]

D14: The superior and inferior mesenteric arteries after the removal of the small intestine

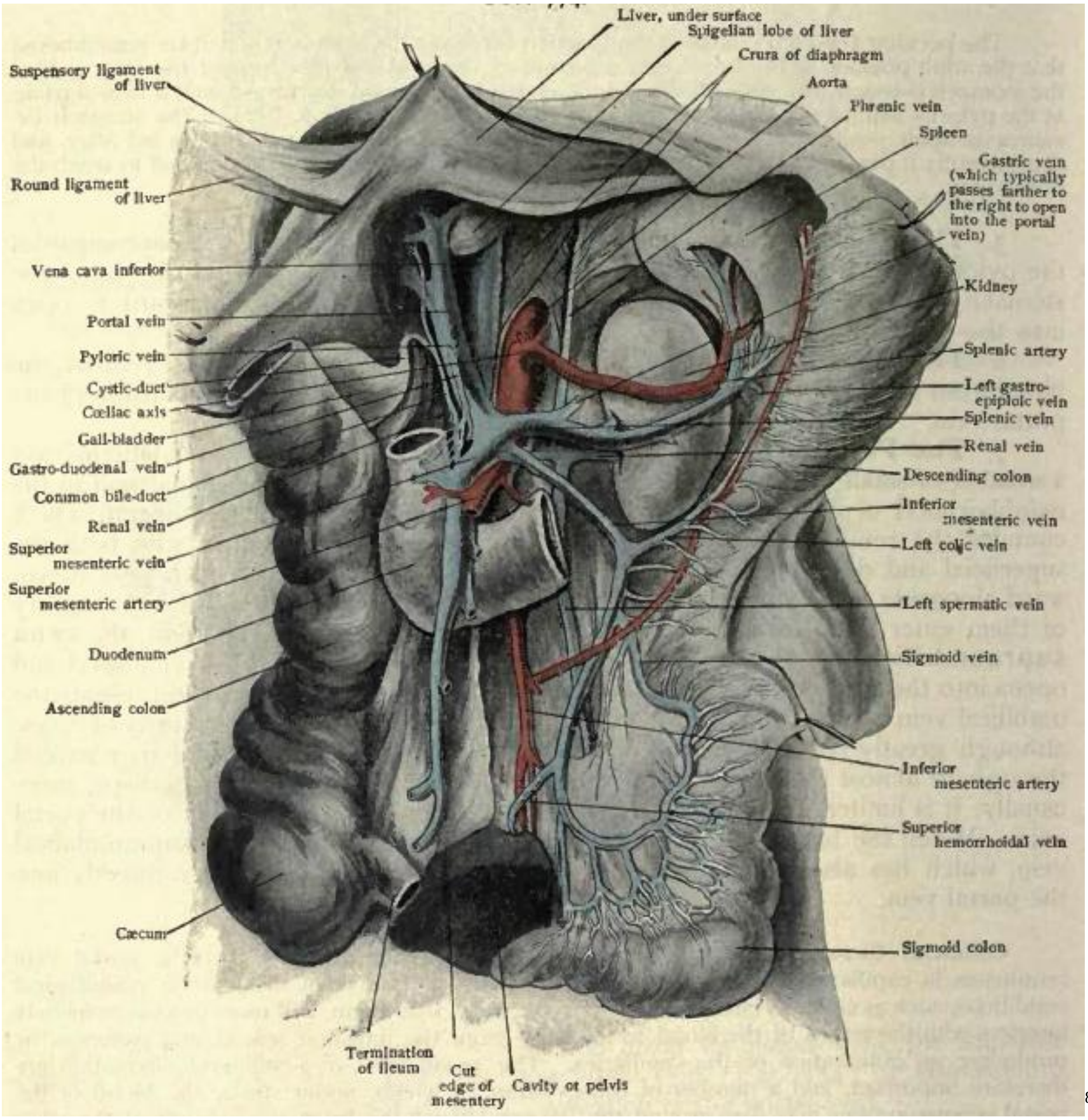
[817] Piersol, 1913, p.803



[818]

Figure D15: Superior mesenteric vein with tributaries after displacing the transverse colon superiorly

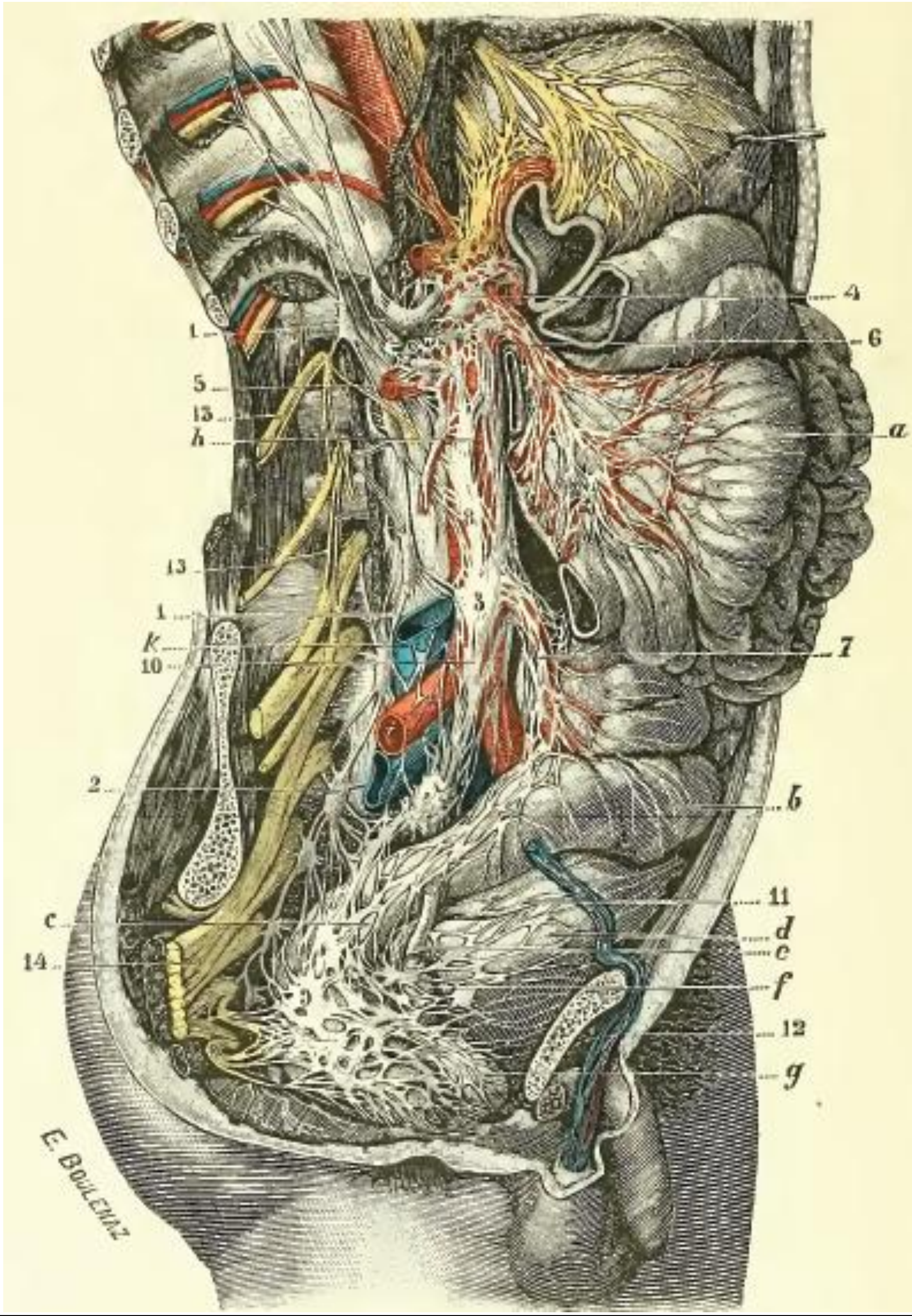
[818] Piersol, 1913, p.922



[819]

Figure D16: Inferior mesenteric and splenic veins; tributaries of portal vein. The stomach and transverse colon have been removed and the liver displaced superiorly

[819] Piersol, 1913, p.924

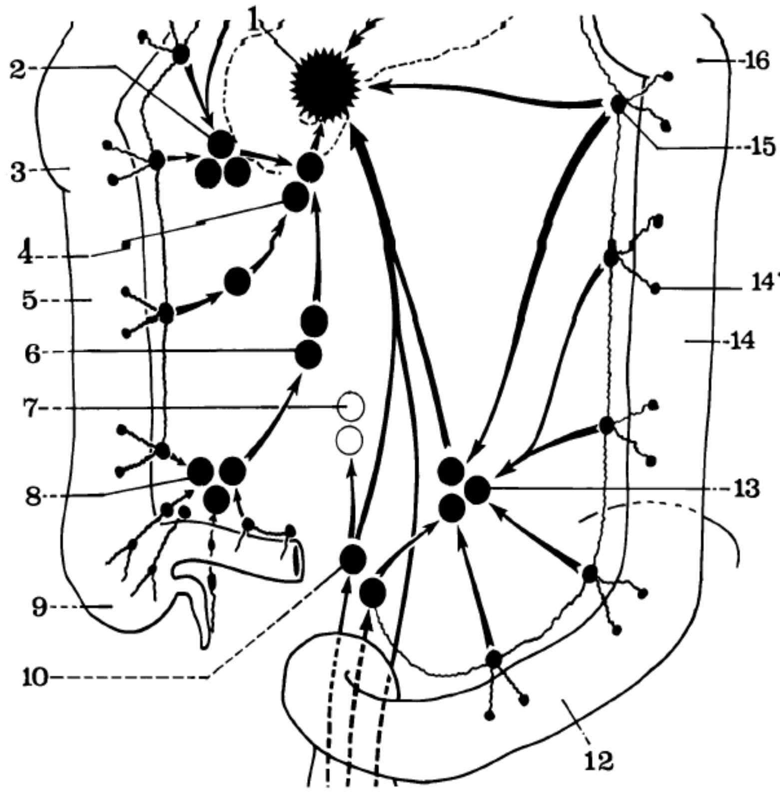


[820]

Figure D17: Abdominal sympathetic system

1 – Lumbar sympathetic trunk and ganglia, 2 – Sacral sympathetic trunk and ganglia, 3 – Celiac ganglion, 4 – Celiac plexus, 5 – Renal plexus, 6 – Superior mesenteric plexus, 7 – Inferior mesenteric plexus, 8 – Intermesenteric plexus, 9 – Hypogastric plexus, 10 – Anastomotic plexus, 11 – Deferential plexus, 12 – Spermatic plexus

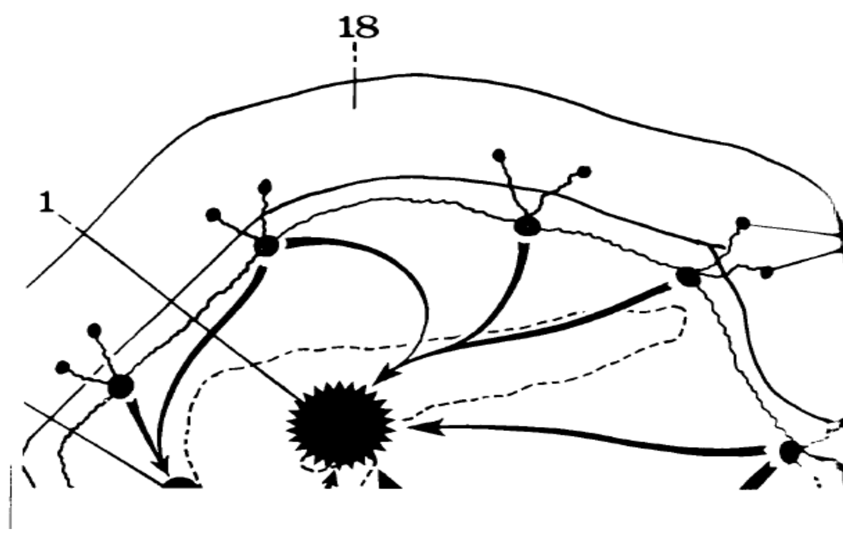
[820] Testut, 1899, p.270



821

Figure D18: Lymphatic drainage of the ascending and descending colons

1 – Central retro-pancreatic group, 2 – Intermediate group, 4, 6 – Principal groups, 7 – Lumbo-aortic ganglia, 8 – Ileocaecal ganglia, 10 – Superior haemorrhoidal, 13 – Intermediate sigmoid group, 14' – Epicolic group, 15 – Paracolic group



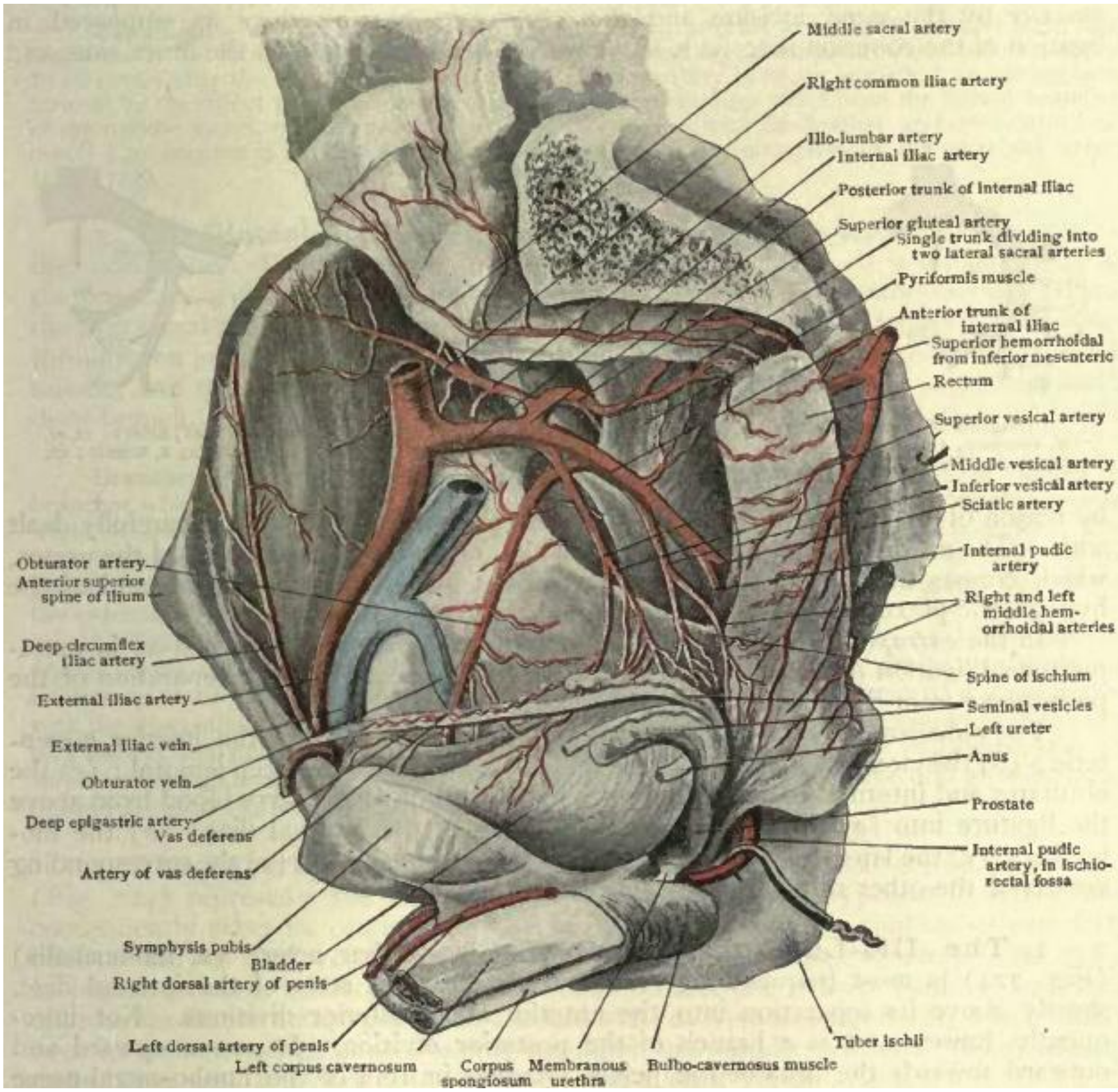
822

Figure D19: Lymphatic drainage of the transverse colon

1 - Central retro-pancreatic group

18 – Transverse colon

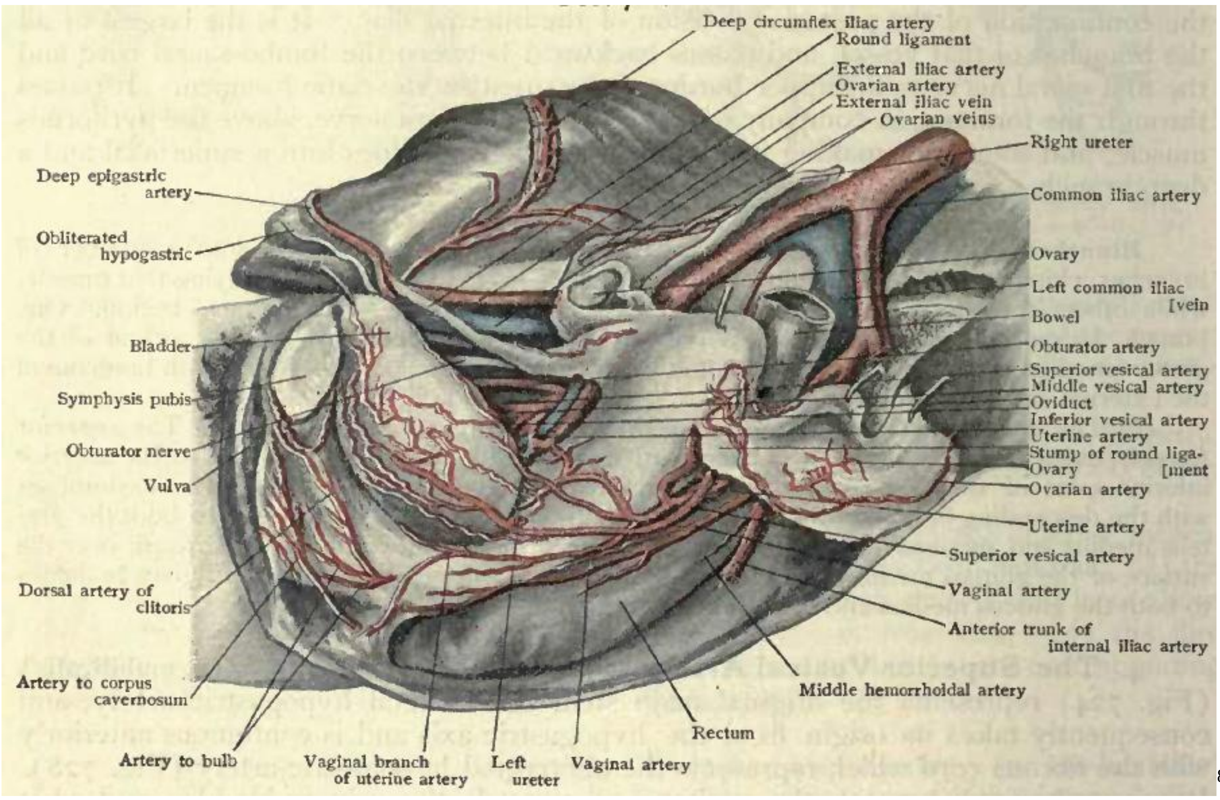
821 Bouchet & Cuilleret, 2001, p.2074
822 Bouchet & Cuilleret, 2001, p.2050



[823]

Figure D20: Dissection of male pelvis displaying the internal iliac artery and its branches

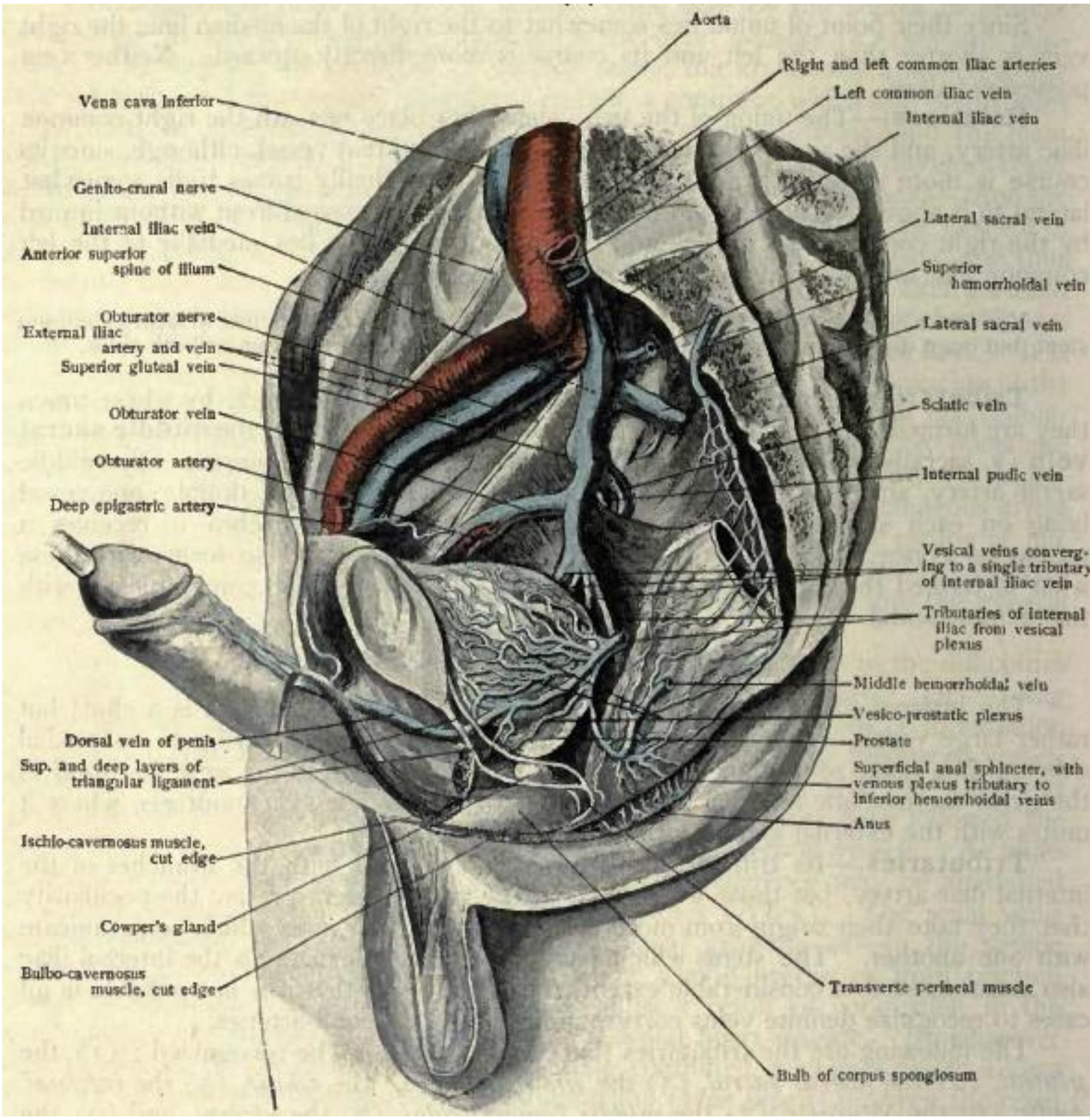
[823] Piersol, 1913, p.809



[824]

Figure D21: Dissection of the arteries of the female pelvis

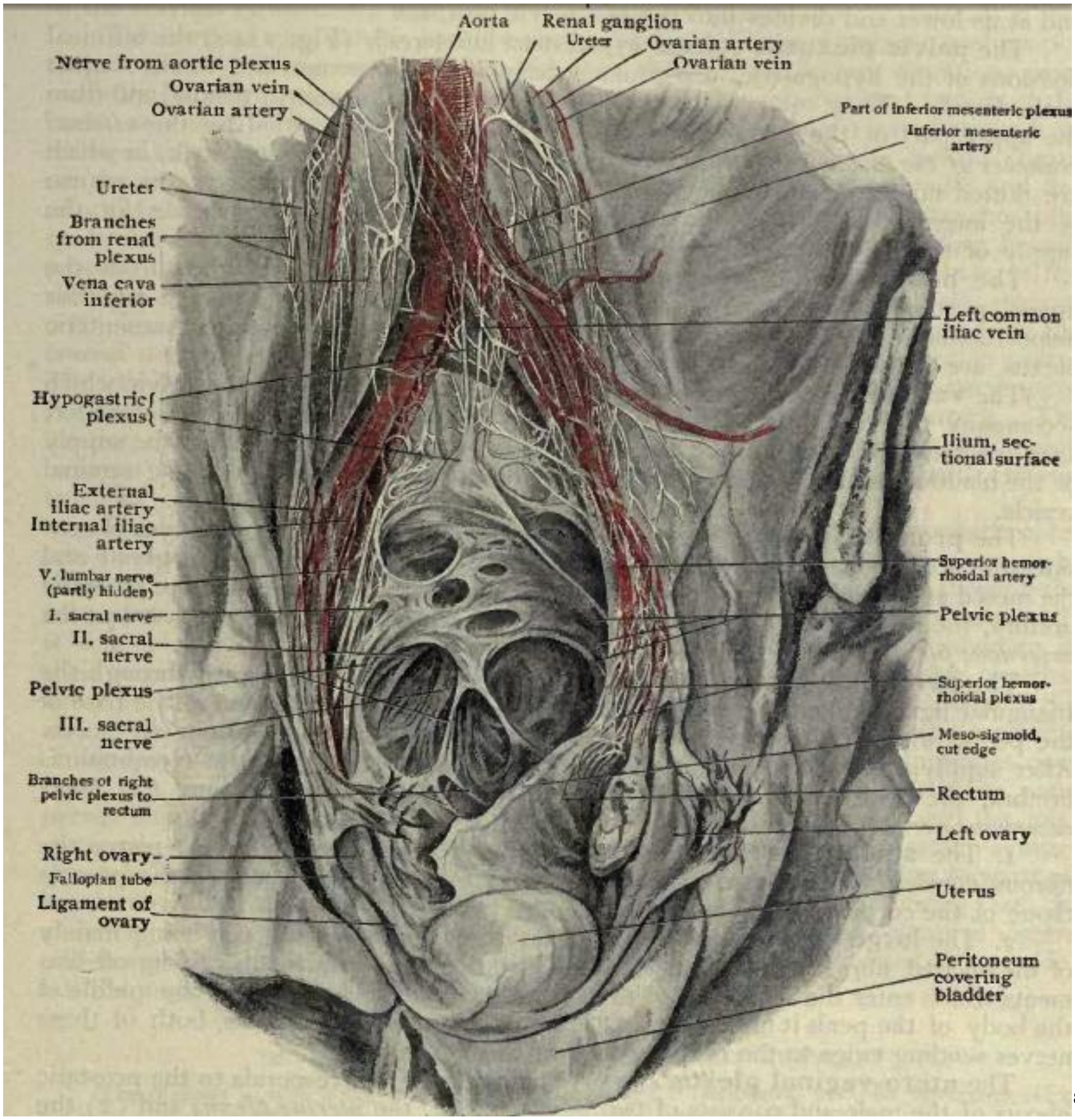
[824] Piersol, 1913, p.812



[825]

Figure D22: Dissection of male pelvis displaying the veins

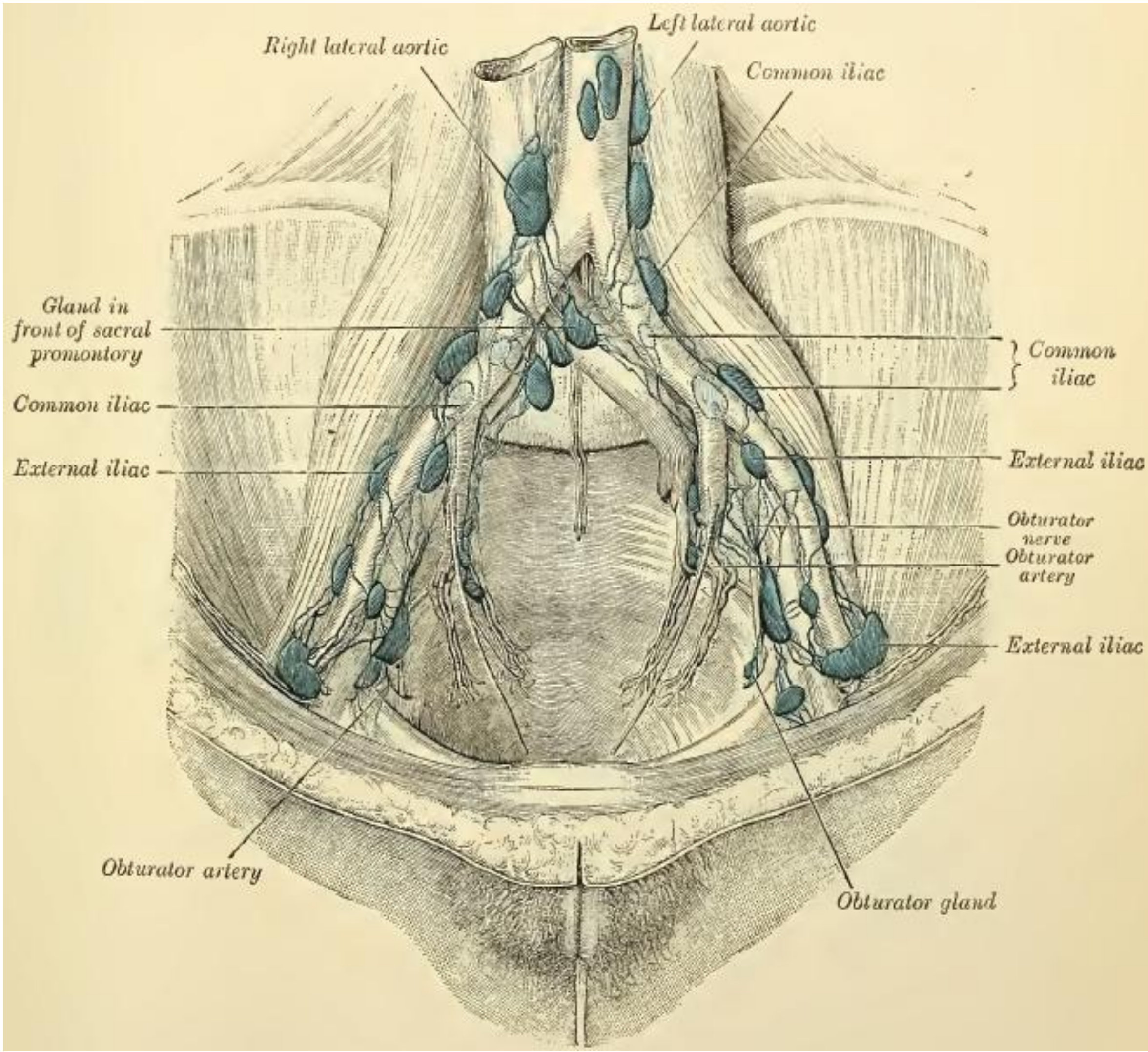
[825] Piersol, 1913, p.906



[826]

Figure D23: Dissection of hypogastric and pelvic plexuses

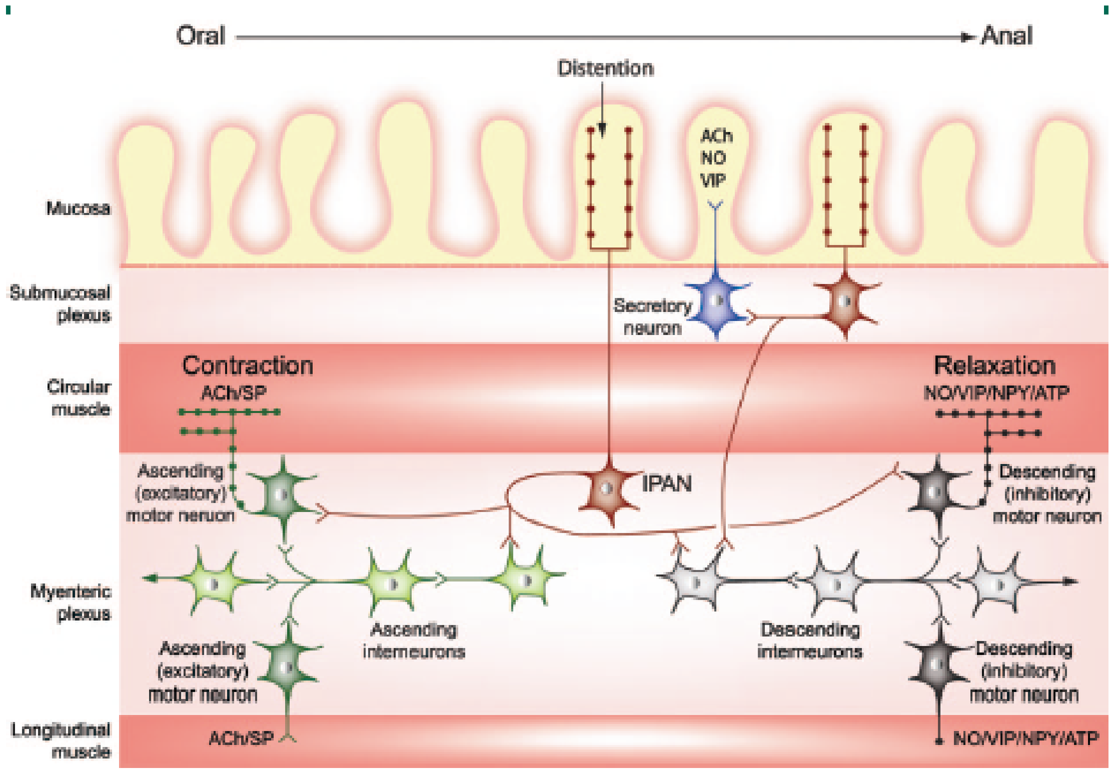
[826] Piersol,p1913, p.1373



[827]

Figure D24: The lymphatics of the pelvis

[827] Gray, 1913, p.785



Local distension of the intestinal wall, distortion of the mucosa, and chemical contents in the lumen activates intrinsic primary afferent neurons (IPANs) located in both the submucosal plexus and myenteric plexus. The IPANS project both in oral and anal directions to make synapses with interneurons, motor neurons, and other sensory neurons within the ENS. The peristaltic reflex includes an ascending excitatory reflex mediated by myenteric motor neurons that utilize acetylcholine (ACh) and substance P (SP) and elicit contraction of the circular or longitudinal smooth muscles located orally to the site of stimulation. The descending inhibitory reflex involves inhibitory motor neurons that utilize nitric oxide (NO), vasoactive intestinal polypeptide (VIP), neuropeptide Y (NPY), and adenosine triphosphate (ATP) in various combinations and elicit relaxation of the circular muscle and longitudinal muscle located anally to the site of stimulation. The peristaltic reflex is coordinated by the action of cholinergic interneurons that receive inputs from IPANs and project to either the excitatory or the inhibitory motoneurons. Secretomotor and vasodilator reflexes are mediated by neurons located in the submucosal plexus that release ACh, VIP, or NO.[828]

Figure D25: Schematic displaying some of the connections involved in local enteric reflexes

[828] Benarroch, E. E. (2007). Enteric nervous system functional organization and neurologic implications. *Neurology, 13, p.1953-7. p.1954*

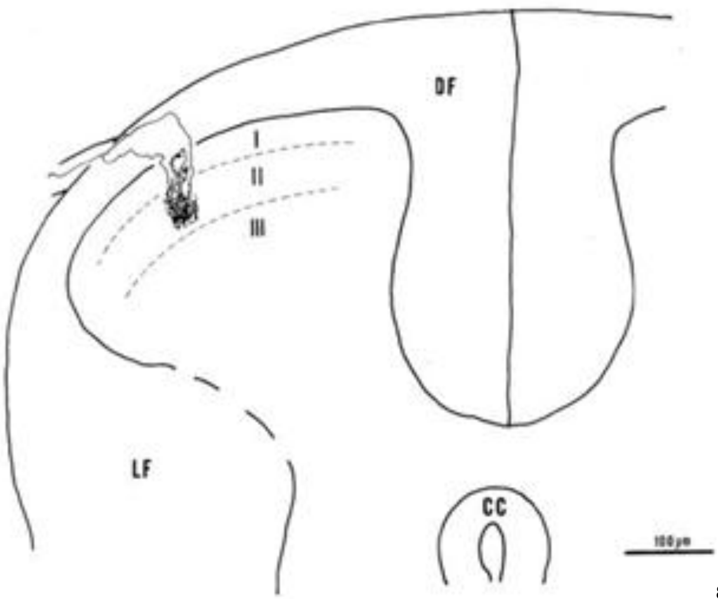


Figure D26: A transverse reconstruction of the termination of a somatic C-afferent fibre displaying its relatively focused central connections.

829

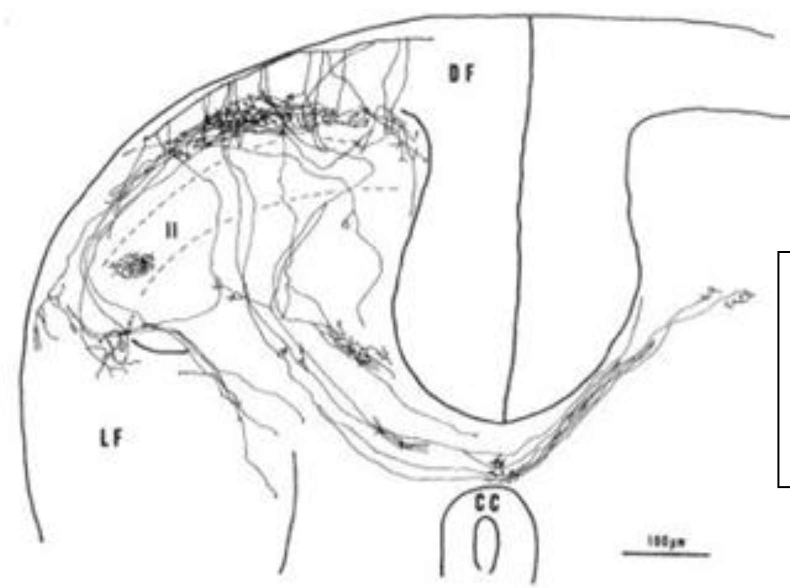


Figure D27: A transverse reconstruction of the termination of a visceral C-afferent fibre displaying its diffuse central connections.

830

[829] Sugiura, Y., Terui, N. & Hosoya, Y. (1989). Difference in distribution of central terminals between visceral and somatic unmyelinated (C) primary afferent fibers. *Journal of Neurophysiology, 62, p.834-840, p.837*
[830] Sugiura, Terui & Hosoya, 1989, p.839

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