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Διπλωματική Εργασία

«THE ROLE OF VISCERAL MANIPULATION IN REHABILITATION»

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Με πλήρη επίγνωση των συνεπειών του νόμου περί πνευματικών δικαιωμάτων, δηλώνω ενυπογράφως ότι είμαι αποκλειστικός συγγραφέας της παρούσας Μεταπτυχιακής Διπλωματικής Εργασίας, για την ολοκλήρωση της οποίας κάθε βοήθεια είναι πλήρως αναγνωρισμένη και αναφέρεται λεπτομερώς στην εργασία αυτή. Έχω αναφέρει πλήρως και με σαφείς αναφορές, όλες τις πηγές χρήσης δεδομένων, απόψεων, θέσεων και προτάσεων, ιδεών και λεκτικών αναφορών, είτε κατά κυριολεξία είτε βάσει επιστημονικής παράφρασης.

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Πίνακας περιεχομένων

Περίληψη

Στόχος: η οσφυαλγία, ο αυχενικός πόνος, η δυσμηνόρροια, η χρόνια δυσκοιλιότητα, το σύνδρομο ευερέθιστου εντέρου είναι καταστάσεις που μπορεί να εκδηλωθούν χωρίς συγκεκριμένη παθολογική αιτιολογία με σοβαρά και χρόνια συμπτώματα και αφορούν πολλούς ανθρώπους επιφέροντας μεγάλο οικονομικό βάρος στα συστήματα υγειονομικής περίθαλψης. Η αντιμετώπιση αυτών των καταστάσεων από τη σύγχρονη ιατρική και τους κλάδους αποκατάστασης αποτελεί πρόκληση λόγω των διαφορετικών και σύνθετων αιτιών αυτών των συνθηκών. Η σπλαγχνική κινητοποίηση (ΣΚ) είναι μια ρουτίνα ειδικών και ευγενών κινήσεων που εφαρμόζονται στους ιστούς των κοιλιακών, θωρακικών και πυελικών περιοχών που βρίσκονται τα όργανα, με πολλά υποσχόμενα αποτελέσματα σε διάφορες ιατρικές καταστάσεις. Σκοπός της παρούσας μελέτης είναι η διερεύνηση του γενικού ρόλου της ΣΚ, με ποιά είδη παθολογικών καταστάσεων σχετίζεται και η αποτελεσματικότητά της σε αυτές.

Αποτελέσματα: Υπάρχουν πολλές έρευνες σχετικά με το ρόλο και την αποτελεσματικότητα της ΣΚ σε διάφορες ιατρικές καταστάσεις. Σημαντικά θετικά αποτελέσματα αναφέρονται σε ασθενείς με οσφυαλγία μετά από σπλαχνική δια χειρός θεραπεία. Επιπλέον, υπάρχουν ισχυρές ενδείξεις ότι η εφαρμογή σπλαχνικής θεραπείας βελτιώνει τα συμπτώματα σε ασθενείς με γαστρεντερολογικά συμπτώματα, ιδιαίτερα ασθενείς με σύνδρομο ευερέθιστου εντέρου και δυσκοιλιότητα. Πολύ σημαντική πτυχή της ΣΚ που αποδεικνύεται πειραματικά είναι η αποτελεσματικότητα της στην λύση περιτοναϊκών συμφύσεων και η πρόληψη του μετεγχειρητικού ειλεού. Ωστόσο, τα σημερινά στοιχεία περιορίζονται από τον μικρό αριθμό ελεγχόμενων κλινικών δοκιμών που έχουν διεξαχθεί σε αυτόν τον τομέα και για συγκεκριμένες ασθένειες υπάρχουν μόνο αναφορές περιστατικών. Έτσι, προτείνεται περισσότερη επιστημονική έρευνα σχετικά με τους μηχανισμούς και την αποτελεσματικότητα του σπλαχνικού χειρισμού στην αποκατάσταση.

Πηγές δεδομένων: η βιβλιογραφική ανασκόπηση έγινε μετά από αναζήτηση ιατρικών και οστεοπαθητικών βάσεων δεδομένων (PubMed, Osteopathic Research Digital Repository, Physiotherapy Evidence Database (PEDro)

Λέξεις κλειδιά: : “visceral manipulation”, “visceral treatment”, “visceral osteopathy”

Abstract

Objective: Low back pain, cervical pain, dysmenorrhea, chronic constipation, irritable bowel syndrome are conditions that can manifest with no specific pathological etiology with severe and chronic symptoms, concerning a lot of people with major financial burden to the healthcare systems. Treatment of these conditions by modern medicine and rehabilitation disciplines is challenging due to different and complex causes of this kind of conditions. Visceral manipulation (VM) is a routine of specific and gentle movements applied to the tissues of abdominal, thoracic and pelvic regions that organs are lying in, with promising results on several medical conditions. The aim of this study is to explore the general role of VM, with which kind of medical conditions or pathologies is associated with and the effectiveness on them.

Results: There are a lot of researches about the role and the effectiveness of VM on several conditions. Significant positive effects are reported in patients with low back pain after visceral manual therapy. Additionally, there is strong evidence that application of visceral treatment ameliorates symptoms in patient with gastroenterological symptoms especially, patients with irritable bowel syndrome and constipation. Very important aspect of VM proven experimentally is it's efficacy on lysing peritoneal adhesions and prevention of postoperative ileus. However, the current evidence is limited by the small number of controlled clinical trials that have been conducted in this field and for particular diseases there are only case reports. Thus, it is suggested more scientific investigation on the mechanisms and the efficacy of visceral manipulation on rehabilitation.

Data sources: A literature review will be undertaken by searching medical and osteopathic databases (PubMed, Osteopathic Research Digital Repository, Physiotherapy Evidence Database (PEDro).

Key words: “visceral manipulation”, “visceral treatment”, “visceral osteopathy”

INTRODUCTION

Last years a lot of progress has been made on rehabilitating several different musculoskeletal, gastrointestinal and gynecological conditions. However, there are still a lot of medical conditions that are under thorough investigation by medical community. Conditions like low back pain, cervical pain, dysmenorrhea, chronic constipation, irritable bowel syndrome can manifest with no specific pathological etiology with severe and chronic symptoms. That seems to be a challenge on assessing these cases with the modern rehabilitation and medical techniques due to different and complex causes of this kind of conditions. Consequently a versatile ensemble of techniques is employed for investigating different treatment protocols. Visceral manipulation (VM) is a routine of specific and gentle movements applied to the tissues of abdominal, thoracic and pelvic regions that organs are lying in [20,22]. This study describes the characteristics of VM, to which kind of medical conditions or pathologies can be used and the effectiveness on them in order to be used as a tool to the modern rehabilitation disciplines.

1. HISTORY OF MANUAL THERAPY

Manual therapy seems to be used as a therapeutic practice since ancient years and its first appearance is estimated since the first medicine practice appeared. Ancient Thailand statues date back 4.000 years; show the use of manual medicine procedures [1]. As it is proved from the translation of inscriptions and papyri, as well as from the technique of mummification they used ancient Egyptians had excellent knowledge of anatomy and were familiar with manual medicine. Almost 2.500 years ago, Hippocrates the Greek doctor known as the father of modern medicine was known to use manual medicine procedures, particularly traction and leverage techniques, in the treatment of spinal deformity [2]. Although for a long time there was not any progress in this field, at 19th century a lot of interest was shown on developing the ideas of treatment manually. graduated Edinburgh University at 1784, became very famous in London developing numerous of manual medicine procedures. Using this kind of practice he was under a lot of criticism by his colleagues, like many other supporters of manual medicine [3]. after a lot years Andrew Taylor Still and Daniel David Palmer studied and developed the ideas of manual therapy. The majority of manual therapy techniques practiced today by multiple disciplines, including physiotherapy, are derived from Still’s ideas and osteopathic manipulative therapy (OMT) that he developed [4].

2. OSTEOPATHY

2.1. HISTORY OF OSTEOPATHY

Andrew Taylor Still, the developer of osteopathy was born in 1828 in Lee County, Virginia and worked as a physician and surgeon in the United States of America in the latter half of the nineteenth century. Coming from a religious family and he believed that god made all creations perfect, including the human body. Thus, he came with the idea that human body as a perfect creation is wise enough to be able to self-heal. As a young boy, he was suffering from severe headaches. One day that he was sitting on a rope swing that his father made for him and had a headache, he thought to take the rope and use it to hang his head in order to relieve himself. He slept like this all night and surprisingly he woke up the next day with no pain at all. This incident contributed to develop his later ideas that the function of the nervous system is closely related with body mechanics. He couldn't attend a regular school as his father was a minister-physician and moved to small communities and countryside and even further to the west, so Still was taking lessons at houses that worked as little schools. He gained a lot of medical experience travelling with his father and joining the army during the Civil war. He was reading a lot of medical and anatomical books as he believed that this is the key to manage illness more efficiently. After the loss of three of his children from spinal meningitis in 1864, he dedicated himself to study more about illness, and disease, trying to find more effective ways of treatment. By 1892 he established the first independent school of osteopathy in Kirksville.

1. Picture of Andrew Tailor Still holding the femur bone. Adapted from [10]

Two years after the establishment of the school the first students graduated and some years after State of Vermont were the first to recognize the profession of osteopathy. In a short time 13 osteopathic colleges opened in the US (ASO) and in 1897 Missouri introduced recognized the graduates of these colleges as independent physicians and surgeons. In order to achieve more recognition, a lot of changes made to occurred to the curriculum and osteopathy began to evolve from the 'philosophical osteopathy' of Still to a more science-based approach. Former students of the American schools and UK schools spread their osteopathic knowledge to the mainland of Europe and beyond. An important person in the development and spread of the osteopathy was John Martin Littlejohn, a Scotsman who moved to America to study medicine and joined Still to ASO. Littlejohn returned to England and in 1917 established the British School of Osteopathy (BSO) in London, which was the first official training center of osteopathy in Europe. Still died the same year and by that time there were already 5,000 osteopathic practitioners in the US and many others had spread across the world. From the early 20th century, the osteopathic healthcare had also reached countries including Japan, Israel, Russia, South Africa, Singapore and Brazil but with. Today, osteopathic practice is available all over the world in more than 50 countries [5-13].

2.2. DEFINITION OF OSTEOPATHY

According to the world health organization (WHO) "osteopathy is a primary contact and patient-centered healthcare discipline, that emphasizes the interrelationship of structure and function of the body, facilitates the body's innate ability to heal itself, and supports a whole-person approach to all aspects of health and healthy development, principally by the practice of manual treatment" [14].

European committee for standardization defines osteopathy as “a practice uses osteopathic, medical and scientific knowledge to apply the principles of osteopathy to patient diagnosis and treatment. The aim of osteopathy is to improve and support all aspects of health and healthy development. Osteopathic treatment may be preventive, curative, palliative or adjuvant. Osteopaths analyze and evaluate the structural and functional integrity of the body using critical reasoning of osteopathic principles to inform individual diagnosis and treatment of the patient.

These principles are:

- the human being is a dynamic functional unit, whose state of health is influenced by the body, mind and spirit; if one part is changed in the system, the balance of the whole pattern will be affected;
- the body possesses self-regulatory mechanisms and is naturally self-healing; the human being always tries to regain its own dynamic balance and establish homeostasis; and
- Structure and function are interrelated at all levels of the human being.

The osteopathic approach to healthcare is patient-centered and focused on the patient’s health rather than disease-centered. Scientific rigor and evidence-informed practice are an important part of patient treatment and case management. Osteopaths use manual contact to identify and evaluate movement in all structural and functional aspects of the patient, identifying alterations of function and movement that impede health and addressing these. The highly developed sense of touch and attention to complex systems as a unit is typical of an osteopathic approach. Osteopathy is an independent healthcare discipline. Osteopaths should also cooperate with practitioners of other disciplines. Osteopathy is based on principles drawn from human physiology, anatomy, embryology and other biomedical sciences. In consequence of the complexity of the human organism there are a number of different models that are used in osteopathy” [15].

At his autobiography Still describes: “Osteopathy is that science which consists of such exact, exhaustive and verifiable knowledge of the structure and function of the human mechanism, anatomical, physiological and psychological, including the chemistry and physics of its known elements, as has 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, disorganisations, derangements, and consequent disease, and regain its normal equilibrium of form and function in health and strength”[7].

2.3. PHILOSOPHY OF OSTEOPATHY

Osteopathy is a protocol of manual medicine that includes movements of the human body in order to facilitate rehabilitation and maintenance of homeostasis and normal function of the body, so that the body is capable to “heal itself” from any internal or external factors such. This manual approach can be applied in all kind of conditions that can impair individual's health such as stress, injury or illness [16]. Initially osteopathy considered to be a manual procedure that approaches patients mechanically and emphasizes the potential of the musculoskeletal system to affect all the functions and consequently the overall health of a person [17]. Over the time the original ideas of Still have been developed in some basic philosophies since they are derived by logical reasoning rather than by empirical findings through scientific experiments. The four basic concepts of osteopathy are:

The body consists of many parts which relate to each other in multiple ways. This can usually be obvious only when one part is disrupted by trauma or illness. Mechanical traumas to one area can affect another area; for example, an injury to the knee can affect gait and consequently change the distribution of the forces and increase the stress on the spine. The same can be observed in case of a disease or dysfunction of viscera affecting other tissues of the body for instance, a lung infection can lead to reduction of oxygen to blood circulation and this consequently cause reduction of perfusion to other parts of the body becoming vulnerable to disease or dysfunction. Similarly if the hepatic function is impaired for some reason, then toxins can be accumulated into circulation. Malfunction of internal organs may also affect neurological activity, which may then cause changes to musculoskeletal function. This philosophy also applies to a spiritual-mental level. Body and spirit are considered to be interdependent. Under emotional stress, physical symptoms and/or physical changes may occur such as headaches, gastroenterological symptoms and changes to blood pressure. Additionally, emotional or physical stress for some reasons makes the body to lose the ability to deal with further stress factors [17].

All body parts are unified. Anatomically, the whole body and all its systems are integrated by means of fascia. The continuity of the fascia all over the body unites all the systems and the cells, supports and maintains all the structures, render them capable to function and move in harmony. The concept of body's unity is also applied on a functional level. Every part of the body is responsible for regulating a certain function, such as temperature, ph. Although, each of these parts communicate and cooperate together in order to maintain the homeostasis of the whole body. The nervous system controls and regulates all these parts. Central nervous system is responsible for the musculoskeletal system and the autonomic nervous system controls the visceral function. Likewise, the endocrine system regulates the hormonal secretion and immune system is protecting the body. Even if those systems are described as separate units, it is well known that they all cooperate together in a harmony, known as neuroendocrine-immune system [18].

Compensation and adaptation play also a major role in the concept of unity. Alterations to one system cause adaptations to another, in order to preserve the harmonic function of the body. The purpose of compensation is to minimize the effect of any internal changes, since this could lead to reduction of body's efficiency and consequently its ability to survive. Human body is highly adaptable and capable to handle large amounts and combined stress factors [17].

Structure governs function:

This statement can be easily understood giving the fact that if something is structured in a certain way in order to accomplish a certain purpose, then changing the initial structure it would change the forthcoming purpose. For centuries, it is known that a pathological change in a structure causes alterations to the way that the structure functions. For instance, if there is an injury to ligament or to any soft tissue then instability might appear to the adjacent joint, affecting its normal function. Likewise, in a case of dysfunction of the liver, will influence all the functions of the liver, such as, detoxification, have an effect on every function that the liver is expected to perform, such as detoxification of the blood. It should be mentioned that the original concept was 'the rule of the artery is supreme' and that meant that when the body fluids disturbed, either directly, or indirectly via the autonomic nervous system reflexes controlling vasomotor tone and this affects all of the other tissues. Certain disease processes have consistent reflection in the somatic structure and by addressing the somatic structure it could beneficially affect the function of the local tissue/organ, and the general health of that individual.

This concept is one of the fundamental principles of osteopathic medicine. Therefore by studying in detail the anatomy and understanding the relation of one structure to another, it could be possible to assume which changes would appear if a structure is moved from its normal position and the consequences on the continuous structures. For example, a change on the position of a rib, will cause disruption of the attached intercostal muscles and this will have an effect on the structures passing within them, such as, on the fluid exchange of the artery, vein and lymphatic system, and on the nerve conduction of impulses, both peripheral and centrally to its spinal segment, and on its neurotrophic function, having deleterious consequences on both somatic and visceral structures supplied. Thus, this inappropriate position of the rib will lead to a compensatory pattern developing in other areas of the thorax or spine, and they will then create a similar disturbance [18].

<u>The body possesses self-regulatory mechanisms</u>

The body tries to maintain homeostasis constantly, and has mechanisms in order to manage the function of the body, such as, hormonal regulation (hypothalamic-pituitary axis excreting certain hormones to other glands) and nervous regulation (receptors to salt in the kidneys). All those mechanisms are constantly interacting with each other and work together in order to achieve a constant state of balance. But, in a case of dysfunction, the body will have to work more to preserve this balance. This extra work is termed as the allostatic load. If this extra load is big or sustained, then specific effects might occur such as general fatigue or sickness. Thus, if the dysfunction is removed, extra work would be reduced and returning to 'normal homeostasis' of the body. Consequently this would improve both locally and generally person’s health. Previously it was thought that this occurs due to the inherited life force. Now, it is known that body works as a tensegrous system so if extra stress is removed the body regains its ability for regulation [18].

<u>The body has the inherent capacity to health</u>

This could be seen as an extension of the previous concept. The body has a multiple level system of defence in order to be protected from external or internal dangers (the skin, mucus, defensive cells from immune system). So the body already has a lot of mechanisms to protect its-self from injuries or disease [18]. Based to the "Terrain Theory" of Antoine Bechamp and Claude Bernard pathogen factors are almost always present in the body so the body is constantly exposed to them [19]. Therefore body's inherent systems have a capacity to resist them. The pathogens affect a person only when the general health of the person is already impaired by internal or external factors such as injuries, psychological or social stress, bad nutrition, other pathology, etc. According to this theory, disease or illness manifests when the body is not capable to activate it's inherit defensive systems due to excessive demands from external or internal stressors. Hence, finding and resolving of those excessive demands, the body will be able activate again its defence system. Therefore, in order to prevent disease, health should be promoted and in order to promote health, the body structure must be as normal as it is possible [18].

Some years later the following concepts were added as supplements to the basic concepts:

When the normal adaptability is disrupted, or when environmental changes overcome the body's capacity for self-maintenance, disease may ensue

As it was already mentioned the human body has the ability to adapt to stress factors either the factors arising from the internal environment or from the external factors. However, if a lot of stressors co-exist or older issues exist that have not been resolved completely yet, such as injuries or emotional traumas, then the body loses its ability to cope with all the stressors and a disease may manifest. So even if an injury that haven't been healed properly occurred years ago and a new injury occurs, it can be the cause of reduction of the efficacy of the body to resolve the new one. Additionally, when smaller stress factors from different kind of sources co-exist can have the same impact with one major stress factor, showing that stress can be accumulative [9, 18].

The movement of the body fluids is essential to the maintenance of health

This concept is the most famous and usually referred as 'the rule of the artery is supreme'. To the fluids are included all the kind of fluids of the body: arterial, venous, lymphatic and cerebrospinal. Since through these fluid systems the body controls and mediates immunity, nutrition and detoxification, they are considered to play crucial role to the harmonic function of the body. Consequently, any change or malfunction to these fluids can, directly or indirectly, have a major impact on maintenance of health [9, 18].

Nerves play a crucial part in controlling the fluids of the body

All the blood vessels are innervated by the sympathetic neural system, thus the blood flow that passes through the vessels is strongly related to the sympathetic system [17]. Any changes to the autonomic nervous system could result in changes to the fluid system. Somatic nerve system controls the muscles as well as the posture of a person. Changes in muscle tone may also affect the flow of the fluids locally causing for example edema or swelling. The same applies when the muscles adapt to a global change of the posture that could result in to abnormal function of the fluid system. According to this theory any kind of stress either somatic or mental can have a global systemic impact to the body [18].

There are somatic components to disease that are not only manifestations of disease but also contribute to the maintenance of the diseased state

The concept of somatic component of the disease refers either to a direct damage of the body or to indirect manifestations of visceral pathologies [9]. For example in case of visceral disease the affected organ will transfer the information through neural pathways to a particular spinal segment, in order to manage the problem. At the same spinal segment visceral efferent drives synapse with motor efferent drives. This stimulation leads to changes to the muscle tone causing a local dysfunction. In osteopathy this phenomenon is known as viscero-somatic connection while a primary visceral component affects secondarily a somatic- bodily component leading to dysfunction. Similarly, the secondary dysfunction transfers information back to the spinal segment affecting the initial dysfunction creating a vicious cycle [18]. There are also other kinds of connections also such as somato-visceral, viscero-visceral, somato-somatic, somato-emotional and viscero-emotional [16].

3. VISCERAL MANIPULATION

3.1. VISCERAL MANIPULATION DEFINITION

The previous concepts highlight how important component is the normal function of the viscera.

One of the approaches of osteopathy is the visceral manipulation.

TRADITIONAL APPROACHES	CONTEMPORARY APPROACHES
Thrust (High Velocity/Low Amplitude) Approach	Balanced Ligamentous Tension and Ligamentous Articular Strain
Muscle Energy Approach	Representative Models
Myofascial Release Approach	Facilitated Positional Release
Osteopathy in the Cranial Field	Progressive Inhibition of Neuromuscular
Strain and Counterstrain Approach	Functional Technique
Soft Tissue/Articulatory Approach	Visceral Manipulation
Lymphatics Approach	Still Technique
	Chapman’s Approach
	Fulford Percussion

1. Osteopathy approaches. Adapted from [10]

Visceral manipulation is a routine of specific and gentle movements applied to the tissues of the abdominal, the thoracic and pelvic regions that the organs are lying. The aim of visceral therapy is to facilitate and restore the normal mobility, tone, and inherent motion of the internal organs as well as their associated tissues in order to function more optimally. Disruption of the normal mobility or inherent motion can occur due to adhesions and scars to the articulated tissues usually caused by infectious pathologies of surgeries. Also, altered motion can be observed due to over-laxity of the adjacent ligaments, such as kidney or uterus ptosis and as a secondary dysfunction of a somato-visceral or viscero-visceral connection [20-24].

3.2. HISTORY OF VISCERAL MANIPULATION

From a historical point of view, after Still's initial thoughts, the concept of visceral osteopathy was introduced by the French osteopath Jacques Weischenck in the 1980s [25]. Only after a few years in 1983 the publication by the French osteopaths Jean-Pierre Barral and Pierre Mercier [20], visceral manipulation became more popular and more practitioners started to show interest in this field. There appear to be over 14,000 registered therapists who have completed basic VM training. They are mostly represented in North America and Europe and come from professional fields such as physiotherapy and medicine. [26].

HISTORICAL CONTRIBUTORS Jean-Pierre Barral TO VISCERAL OSTEOPATHY
Jacques Weischenck
Jean-Pierre Barral
Pierre Mercier
Alain Croibier
Georges Finet and Christian Williame
Jerome Helsmoortel
Thomas Hirth
Peter Wührl
Caroline Stone

2. Historical contributors of visceral osteopathy manipulation in chronological order. Adapted from [27]

3.3. VISCERAL MANIPULATION PHILOSOPHY

Visceral osteopathy includes various types of manipulation applied either directly to the organs through the body wall, or indirectly through movements applied to particular segments of the body that are related physically or via reflexes to the organs. Any kind of dysfunction within the body may have a visceral factor. People without manifesting any kind of symptoms of visceral disease, may have visceral component. In cases of biomechanical/musculoskeletal tensions and restrictions, such as low back pain there might be present visceral factors. Thus manipulating organs and body tissues without symptoms can help many cases of musculoskeletal pain. The same concept applies if someone manifest some kinds of visceral symptoms, does not mean that the problem should be addressed only with visceral manipulation to the related organs. Instead, musculoskeletal factors to the related tissues there might be present and should be considered. All the internal organs should function properly, without any restrictions. Any restriction, fixation or adhesion to another structure, can lead to functional deterioration of the organ. Alteration to the organ's motion, can lead to major changes both to the organ itself and to the related structures since the motion is repeated many times daily in the body.

As it was previously referred, consideration of visceral movement dynamics has long been part of the osteopathic approach. Only in recent years , the study of visceral manipulation outside osteopathy starts becoming more relevant to orthodox medicine, and there are there are more and more research in order to investigate the normal physiological patterns of visceral movement. During gross movements, such as respiration, all the tissues of the body, as well as the internal organs will change their position, will bend or extent also will be stretched or compressed. The visceral motion is interdependent because of the serous membranes, the fascia, the ligaments and other living tissues which attach the organs with the rest of the body. Physiologic visceral motion can be divided into three categories: a. visceral mobility (movement of the viscera in response to voluntary movement, or due to gross movements), b. visceral motility (inherent motion of the viscera themselves) and c. peristalsis [20-22].

i. VISCERAL MOBILITY

Visceral mobility is the voluntary or not motion of the internal organs affected by different systems of the human body working in combination or separately through certain paths. In order to comprehend how these paths affect the motion and function of the viscera they are categorized into models:

- *Biomechanical model:* includes muscles, bones, fascia, ligaments and organ's attachment. For example, dura matter is one of the meninges of the brain surrounding the brain and is connected with skull. Then it runs along the spinal cord through the vertebrae ending to coccyx. Many internal organs, vessels and other structures are also connected with different regions such as cervix, mediastinum and pelvis. For educational reasons fascia is divided into different structures and has different names but in real it is one structure that runs continuously through the body. This confuses any understanding of how these fascial structures are functionally connected. Fascia interconnects all the body cavities, the mesenteries, the ligaments, the tendons and finally the muscles and the bones, providing support to all these structures and the same time allowing movement between them without friction.

  The *sliding surfaces* of an organ are serous membranes that secrete fluids in order to facilitate the movement of the organs against other organs or musculoskeletal structures, as well as protecting the membranes from friction. An organ can be strictly connected with a muscular wall (liver-diaphragm), with the bones (lung-thorax) or with another organ (bladder-uterus). These serous membranes have different names according to which organ they cover: meninges (central nervous system), pleura (lungs), peritoneum (abdominal cavity) and pericardium (heart).

  Some internal organs have *"ligaments"* or mesenteries supporting them. The ligaments of the viscera do not resemble with the ligaments of the musculoskeletal system. They are folds of peritoneum or peritoneum or other fascial tissue that connects the either the organs with each other or an organ with the wall of the body's cavity that is lying in. Their aim is to preserve the normal position of the organ mainly against gravity or due to gross mobility of the viscera such as respiration. Additionally, the direction of their attachment to the organ leads also the organ to move into certain directions. Finally they form through which nerves and vessels pass through.

Tensegrity describe the property of structures that are capable to hold together under tension forces. Muscles, ligaments and tendons are characterized with tensile properties, in contrast to bones that present compression properties [20-22].

- ❖ Neural model: includes the central nervous system, the autonomic system divided into sympathetic, parasympathetic and enteric nervous system. The visceral and somatic nervous systems synapse to particular segments of the spine allowing interaction between the two systems in order to function harmonically. However, sometimes a musculoskeletal injury can cause changes to neural system provoking efferent drives to an organ, affecting its mobility and consequently its function [20-22]. It is described extensively to paragraph "*There are somatic components to disease that are not only manifestations of disease but also contribute to the maintenance of the diseased state"* (page 11)

- ❖ Respiratory /circulation model: includes the circulation system, the lymphatic system and the respiratory system. There is continual fluid movement amongst compartments, carrying and exchanging molecules in order to achieve nutrition and immunity. This kind of flow is actively mediated chemically or osmotically. There are additional kinds of passive flow of the fluids: the first comes from the repetitively compression of the vessels by the contraction of muscles and the second arises from different pressures during respiration. The most represented examples are the contraction of the gastrocnemius working as pump and the function of diaphragm.

Transversely oriented membranes, as well as longitudinally-oriented ligamentous structures of the body are also responsible to distribute the different pressures. For example normally during coughing the pressure produced in the bladder is almost +100 cm H_2O and likewise during hard pushing defecation can raise the pressure intrarectal to+200 cm H_2O [22].

ii. PERISTALSIS

The organs consist of smooth muscles and some kind of cells that make them contract and create an active movement to the viscera. This motion is called peristalsis and this phenomenon is well known to appear to the bowel while transferring the products. However, this movement is observed almost to all organs, both solid and hollow, such as the bladder, stomach, bile duct, ureter, uterus, prostate and liver, where is resented as internal force of the organs and their ducts (sometimes due to neural action and sometimes due to muscle action). Additionally this kind of motion appears to structures that are related to the viscera such as the lymphatic vessels in the mesenteries. [20-22].

iii. VISCERAL MOTILITY

Apart from peristalsis, all the motion that has been described is passive and is created due to the movement of other structures. Although, another movement of the organs has been observed that is active and internal. This movement is called motility and it is thought to have embryologic origins. During the time that fetus is developing the mesenchymal cells are organized to a particular area in order to form an organ. As new cells are added the organ moves to reach its final destination. For instance the stomach elongates moves caudally and rotates clockwise. When development stops these inherent forces for motion still exist to the organ and expressed as a momentum of direction with very low amplitude that is very difficult to be felt. These motion patterns of the viscera were first described by Jean-Pierre Barral, developing the ideas of William Garner Sutherland [20-22]

4. ANATOMY OF THE INTERNAL ORGANS

4.1. Digestive system

4.1.1. Pharynx

The pharynx is a tube about 12 cm long at the base of the skull, which merges into the esophagus at the lower level of the cricoid cartilage. The posterior wall of the pharynx is flat and lies in the frontal plane without any gaps. The nasal cavities open into the pharynx in front and above, the oral cavity open into the lower end of the pharynx. There are three general areas: the nasal, oral and laryngeal parts of the pharynx (nasopharynx, oropharynx, laryngopharynx)

The pharyngeal wall has 3 layers: the mucous membrane, the muscularis and the adventitia which consists of connective tissue. The tunica muscularis is absent superiorly under the base of the skull and the wall there consists of a tough fibrous tissue membrane (pharyngobasilar fascia) by which the pharynx is attached to the base of the skull over a wide area.

The mucus membrane is loosely connected with the tunica muscularis. A tough, elastic, longitudinally directed membrane broadening downwards contributes to the reversible extensibility of the pharynx. The nasal portion of the pharynx has the same epithelium as the oral cavity. Mucous glands, the pharyngeal glands provide lubricating mucus. In the laryngeal portion at the transition to the esophagus, the mucosa of the anterior and posterior wall of the pharynx is separated from the skeleton of the larynx and the cervical spinal column by a venous plexus (upper narrowing of the esophagus).

The tunica muscularis consists of striated muscles, the elevators and the constrictors of the throat. The 3 constrictors pharynges ascend posteriorly and are inserted in a tough fibrous band, the pharyngeal raphe, which is attached to the pharyngeal tubercle at the base of the skull. The muscles overlap in such a manner that the lower part of the superior and middle constrictor muscles are always convert on the outside by the margin of the following muscle. Origins: the superior pharyngeal constrictor from pterygoid process and pterygomandibular raphe. The medial pharyngeal constrictor: from the greater and lesser horns of the hyoid bone. The inferior pharyngeal constrictor: from the outer surface of the thyroid and cricoid cartilage.

The elevators pharyngis are poorly developed. The palatopharyngeous in the posterior palatine originates from the pterygoid process and the aponeurosis of the palate and runs downwards into the dorsal wall of the pharynx where the fibers partly cross those of the opposite side. The stylopharyngeous which originates from the styloid process passes between the superior and middle constrictor muscles along their internal surface. It is inserted partly at the submucosa and partly at the cricoid cartilage. The salpingopharyngeous runs from the end of the cartilage of the auditory tube to the wall of the pharynx.

Adventital connective tissue: The muscle tube of the pharynx is covered by a thin fascia. It may be moved against the vertebral column because of connective tissue space, the retropharyngeal space. This extends laterally into the pharyngeal space. Both spaces are continuous with the mediastinum [28].

<table>
<tr><th>Arterial supply</th><th>Venous drainage</th><th colspan="2">Innervation</th></tr>
<tr><td>tonsillar artery (from fascial) to tonsil</td><td>external palatine vein to pharyngeal plexus</td><td>Motor</td><td>Sensory</td></tr>
<tr><td>Branches from</td><td rowspan="4">pharyngeal venous plexus to internal jugular vein</td><td>Pharyngeal plexus via vagus nerve from cranial root CN X -> all muscles of pharynx except of stylopharyngeous</td><td>CN IX via plexus</td></tr>
<tr><td>ascending pharyngeal</td><td rowspan="3">Branches from external and recurrent branches of vagus -> inferior constrictor</td><td>Maxillary nerve CN V_2</td></tr>
<tr><td>lingual</td><td rowspan="2">Tonsillar nerves from branches from glossopharyngeal CN X and vagus</td></tr>
<tr><td>ascending and descending palatine</td></tr>
</table>

3. Arterial supply, venous drainage and innervation of the pharynx. Adapted from [29]

4.1.2. Esophagus

The esophagus (gullet) conveys the bolus of food to the stomach. In the adult it measures about 25-30 cm. the distance from the front teeth to the transition of the esophagus into the cardia in the adult is about 40 cm.

Esophagus has 3 narrow places, the uppermost, the sphincter lies at the level of cricoid cartilage. Its function is to close the entrance to the esophagus and it is the narrowest part with a width of only 14 mm. during deglutition the constriction is relaxed for 0.5-1 sec. a thin-walled place in the posterior surface of the opening into the esophagus may become pushed out-a so- called pressure diverticulum or pharyngoesophangeal diverticulum. The middle narrowing, the aortic narrowing is due to the esophagus being crossed by the aortic arch. The esophagus descends behind the bifurcation or the trachea. Scar formation due to inflammation of the hilar lymph glands may pull esophageal wall towards the hilus- attraction diverticulum. The lower constriction of the esophagus, the diaphragmatic narrowing, lies in the esophageal hiatus of the diaphragm. It is connected with the complicated closure mechanisms of the lowest 2-5 cm of the esophagus, which relaxes during deglutition.

The layer of the esophageal wall resembles those of the remainder of the intestinal tract.

The mucosa has stratified non-keratinized, squamous epithelium. The small numbers of mucous glands, the esophageal glands, increase along the course of the esophagus. They are situated in the submucosa. The strong muscle tracts of the mucous membrane run spirally. These muscles pleat the mucosa in the undilated esophagus into longitudinal folds ("reversible folds"). The submucosa adapts to these changes.

The upper third of tunica muscularis consists of striated but anatomically innervated muscles, which are gradually replaced by smooth muscle in the middle and lower thirds of the esophagus. The muscle bundles are attached partly to the dorsal surface of the cricoid cartilage and are partly continuous with the inferior constrictor muscle of the pharynx.

The esophagus, like the trachea is under longitudinal tension, and this helps to stabilize it and to facilitate the passage of food during deglutition. The tension also assists closure of the lower portion of the esophagus. The latter is twisted on its longitudinal axis at the level of transition into the cardia, and the longitudinal tension produces "stretch closure" (twisting closure). The latter assists the "functional sphincter of the cardia". i.e. the sphincter effect of the intra-abdominal pressure on the abdominal part of the esophagus. The stretch effect is sustained by a connective tissue membrane which is suspended between the esophagus and the opening (hiatus) of the diaphragm. This is also the site where hernias (ruptures: paraesophageal hernias) into the chest cavity can form. A submucous venous pad also contributes to closure of the esophagus. Since this vessels connect the portal vein with the inferior vena cava they can become swollen, varicose, and may bleed if the portal vein is obstructed.

The connective tissue of the adventitia contains smooth muscle fibers, which may run in bundles to the left main bronchus and into the left mediastinal pleura.

- <u>Esophagus and the posterior mediastinum</u>

The esophagus begins as a continuation of the lower end of the pharynx at the level both of 6th cervical vertebra and of the cricoid cartilage; this is the upper constriction sphincter of the esophagus. It ends at the transition into the cardia of the stomach, just below the diaphragm at the level of the 10th -12th thoracic vertebra. The esophagus can be divided into three sections.

The uppermost section of the esophagus is the sort cervical portion (pars cervicalis). It lies behind the trachea, to which it is bound by connective tissue, and in front of the spinal column to the left of the mid-plan, in the connective tissue space between the middle and deep cervical fascia. The thyroid gland extends on both sides to the lateral borders of the esophagus. The recurrent laryngeal nerves ascend to the larynx in the groove between the esophagus and the trachea. The left recurrent nerve winds around the aortic arch, the right round the brachiocephalic trunk. The inferior thyroid artery, situated lateral o the esophagus, to which it gives off some branches, reaches the thyroid gland.

After entering the upper thoracic opening, the thoracic portion (pars thoracica) of the esophagus extends into the posterior mediastinum. It runs first between the tracheal bifurcation or the left principal bronchus and the descending aorta (middle constriction of the esophagus), from which it also receives branches. Then the esophagus moves away from the spine and continues downward in a swallow arch toward the right, behind the left atrium of the heart. Over a short stretch it approaches the right mediastinal pleura and then it passes through the esophageal hiatus of the diaphragm while the descending aorta is inserted between the esophagus anteriorly and the spinal column (closing with the esophagus). Where the esophagus passes through the diaphragm (lower sphincter part of the esophagus) it is accompanied ventrally and dorsally by the vagal trunks, which as a continuation of the pharyngeal plexus and give rise to the vagal nerves. The glossopharyngeal nerve supplies the superior and medial constrictor muscles of the pharynx. During inspiration the esophagus moves up to 7 cm away from the lower thoracic spine. The esophagus remains mobile longitudinally because it is fixed at the esophageal hiatus of the diaphragm by a circular elastic membrane the thoracic portion is exposed to traction by the lungs.

The abdominal portion (pars abdominals) is 1-3 cm long merges into the cardia of the stomach. The intra-abdominal pressure effectively acts like a “functional cardiac sphincter” on the abdominal portion of the esophagus [28].

4.1.3. Stomach

The fragments of food (boll) are chemically broken down in the stomach (ventriculis, gatser) by the gastric juice contains protein-digesting enzymes (pepsinogen), hydrochloric acid and mucus or mucin. The chime is discharged from the stomach intermittently.

The cardiac portion of the stomach is the continuation of the onfice of the esophagus. The cupola of the fundus of the stomach arises on the left of the cardia. The cardiac notch (forming the plica cardiac inside the stomach) lies between the fundus and the esophagus. The main part of the stomach is its body which is continuous with the fundus. It merges into the pyloric part which is dilated to form the antrum pyloricum and then ends as the pylorus, the opening of the stomach into the duodenum. The stomach has an anterior and a posterior surface. The upper (medial or inner) border, the lesser curvature is indented at its lower third: the angular notch (forming the plica angularis inside the stomach where it marks the borderline between the body and the pyloric region). The lower (outer) border of the stomach, the greater curvature has its most prominent bulge just opposite the angular notch. The basic shape of the stomach as just described is influenced by several factors, such as body posture, stomach contents, its muscle tonus and influence of nearby organs. The capacity of the stomach is about 1200100 ml. the mucosa shows a few longitudinal folds along the lesser curvature (“gastric pathway”) and there are others folds running in an oblique or transverse direction (“reverse folds”) which demarcate mucosal riches (“digestive chambers”) where larger pieces of food may be held for a while.

- Peritoneum

A serous membrane covering the peritoneum enables the organs in the peritoneal cavity to move freely against each other. There is usually about 50 ml of fluid the peritoneal cavity, which serves as a lubricant.

It consists of a visceral layer which covers the viscera and a parietal layer that lines the wall of the peritoneal cavity, visceral and parietal peritoneum.

The two layers are continuous and form the peritoneal sac which contains a capillary space. The connections between the visceral and parietal layers of the peritoneum, where organs are completely enveloped by the peritoneum (intraperitoneal position), are formed by thin peritoneal reduplications, i.e. tissue laminae which carry vessels and nerve to those particular organs.

These reduplications to the stomach are called ligaments. The gastrosplenic ligament passes from the greater curvature to the spleen; and its continuation to the wall of the trunk is called the phrenicosplenic ligament. From the lesser curvature to the liver extends the hepatogastric ligament which continues as hepatoduodenal ligament.

- Fine structure

The peritoneal epithelium (mesothelium because of its origin from the embryonic mesoderm) consists of flat simple cuboidal cells with a border of microvilli, assign of considerable absorptive activity. The subserous connective tissue is partly a loose, mobile layer, as in the mesenteries, and partly firm connection between the serosa and the adjacent organs, as in the parietal peritoneum above the liver. Only the parietal peritoneum has a sensory innervation [29]

Arterial supply	**Venous drainage**	**Innervation**	
Left gastric from celiac trunk	Right and left gastrics drain to portal vein	**Sympathetic**	**Parasympathetic**
Right gastric from common hepatic artery	Short gastrics and left gastroepiploic drain into splenic vein ->superior mesenteric vein-> portal vein	From T6-T9 spinal cord segments via great splanchnic nerve to celiac plexus	From anterior and posterior vagal trunks
Right gastroepiploic from (gastro-omental) from proper hepatic or	Right gastroepiploic drains to SMV		

gastroduodenal arteries			
Left gastroepiploic from splenic artery			
Short gastric arteries (4 to 5) from distal splenic artery			

4. Arterial supply, venous drainage and innervation of the stomach. Adapted from [29]

4.1.4. Small intestine

Digestion and absorption of food takes place in the small intestine (gut). Digestion is the enzymatic breakdown of nutrients into absorbable components i.e. of carbohydrates into monosaccharides, of proteins into amino acids and of fat into fatty acids and glycerol. The most important source of the enzymes responsible is the pancreas. to be digested fat must first be emulsified by bile. The chime is carried along through the intestine by mixing and transporting movements of the intestinal wall. The intestinal mucosa contains various types of epithelial cells specialized for different functions e.g. some for absorption and mucus formation and endocrine cells that stimulate pancreatic secretion and produce peristalsis of the gallbladder and the intestine. The connective tissue of the mucosa contains many lymph follicles.

The small intestine (gut) follows the stomach. Its length varies between 3 and 4 cm according to the degree of contraction of its longitudinal muscle layer. It consists of the duodenum, jejunum and ileum, which are not clearly determined from one another. The duodenum lies almost entirely in the retroperitoneal space on the posterior abdominal wall. In contrast the jejunum and ileum from a mobile intraperitoneal convolute (coils) of small intestine inside a space framed by the large intestine (the colon).

- <u>Duodenum</u>

The duodenum is C-shaped and winds around the head of the pancreas. It lies mainly to the right of the vertebral column. We distinguish the superior part at the level of 12^{th} thoracic- 1^{st} lumbar vertebra, the descending part at the level of the 3^{rd}-4^{th} lumbar vertebra and the horizontal and ascending part which climbs across the midline to duodenojejunal flexure at the level of 1^{st}-2^{nd} lumbar vertebra: the levels of the planes apply to the recumbent position during expiration. The beginning of the superior part is dilated – the duodenal bulb. It still lies intraperitoneally (hepatoduodenal ligament).

The bile duct and the pancreatic duct open into the middle of the duodenum. At the transition of the duodenum into the transition of the duodenum into the jejunum is the duodenojejunal flexure, where the small intestine turns into the peritoneal cavity. All this site riches may be present in the peritoneum: the superior and inferior duodenal recess, the retroduodenal and paraduodenal recess into which the intestinal loops may stray and from internal herniae.

❖ <u>Jejunum and Ileum</u>

The upper 2/5 of the intraperitoneal section of the small intestine are called jejunum and its lower 3/5 the ileum. They merge into each other without any definite border. If the abdominal cavity is opened the convoluted small intestine, which is movable at the mesentery, can be pushed aside.

The mesentery is fixed at its root, the radix mesenterii, to the posterior abdominal wall, along a line which extends from duodenojejunal flexure obliquely downward and to the right as far as the opening of the small intestine into the colon. The radix mesenterii is 15-18 cm long, but the total length of the mesenteric attachment to the small intestine may exceed 4m. With shortening of the intestine by contraction the mesentery becomes correspondingly folded [28]

	Arterial supply	**Venous drainage**	**Innervation**	
Duodenum	Gastroduodenal artery, branch of common hepatic -> superior anterior and posterior pancreatic duodenal arteries	Drain directly or indirectly to portal vein	**Sympathetic**	**Parasympathetic**
	SMA -> anterior and posterior pancreatic duodenal arteries		Via celiac and superior mesenteric plexus	Vagus via celiac and superior mesenteric plexus
	Important anastomosis between celiac trunk and SMA via duodenal arteries			
Jejunum Ileum	Superior mesenteric artery	SMV drains ileum and jejunum	Preganglionic fibres from T5-T9 spinal cord segments -> sympathetic trunk -> greater and lesser splanchnic nerves	Preganglionic fibres from posterior vagal trunk
	15-18 branches from SMA to jejunum and ileum	Posterior to neck of pancreas joins splenic vein to form portal vein	Synapse on postganglionic cells in celiac and superior mesenteric ganglia	Synapse on postganglionic cells in myenteric and submucosal plexus in intestinal wall

5. Arterial supply, venous drainage and innervation of duodenum, jejunum and ileum. Adapted from [29]

4.1.5. Large intestine

Digestion and absorption are completed in the small intestine and the large intestine (colon) contains the indigestible residues of the food stuffs which are being decomposed by bacteria (fermentation and putrefaction).The main task of the colon is the vital reabsorption of water and electrolytes which have entered the intestines with the digestive juices

The large intestine is 1.5-1.8 m long. It begins with the ileocecal (colic) valve. The appendix hangs from the cecum as a dilated intestinal pouch. The cecum is followed by the colon, which frames the convolutions of the small intestine. The ascending colon runs close to the anterior abdominal wall on the right side under the liver at the right is the colic flexure. As the transverse colon it runs in an arch along the anterior abdominal wall to the left upper corner of the abdominal cavity. At the left colic flexure, at the level of the lower pole of the spleen, it turns at right angles into the descending colon which, covered by the convolutions of the small intestine, passes downward and posteriorly along the left lateral abdominal wall. The attachment of the left flexure, the phrenicocolic ligament forms the floor of the splenic niche. The bend of the colon at the left flexure represents an obstacle for the passage of the intestinal contents and increased peristalsis is required to overcome it. The sigmoid colon lies in the left iliac fossa and enters the false pelvis in an S-shaped loop. The rectum starts in front of the 2nd-3rd sacral vertebra and ends at the anus.

The full colon effectively "floats" on the abdominal viscera and its position is higher than when empty Features of the large intestine. The external longitudinal muscles are compressed into three 1 cm wide longitudinal bands the teniae coli. The tenia libiera is seen anteriorly, the tenia mesocolica lies medial to the ascending and descending colon and on the transverse colon it is related to the origin of the mesocolon. The tenia omentalis lies posteriorly and medially at the transverse colon below the origin of the great omentum. The colon is sacculated (haustra) and has folds which protrude into the lumen the semilunar folds. There are small projecting appendages of fat from the subserosa of the colon the appendices epiploicae.

<u>Peritoneum:</u> The ascending end descending colon lie behind the peritoneum i.e. only in front are they covered by peritoneum. Their posterior wall is fixed to the posterior wall of the trunk. The cecum may be fixed to the posterior wall of the trunk or it may be mobile by means of a short mesocolon. The vermiform appendix and the transverse and sigmoid colon lie within the peritoneum and have a transverse and sigmoid mesocolon. The rectum is initially covered anteriorly by the peritoneum but later lies outside the peritoneum

<u>Mucosa:</u> There are no villi in the large intestine. The crypts are very deep (about 0 5 mm) and lie very close together. The epithelium of the crypts consists almost entirely and that of the surface for the most part, of goblet cells which produce lubricating mucus. The remaining epithelia have a ciliated border of microvilli, an expression of their great water-absorptive function. There are solitary lymphoid nodules.

Movements of the large intestine: The intestinal contents are moved along in the colon as they thicken by slow peristalsis and antiperistalsis. By means of a few transport movements the intestinal contents are moved into the distal part of the colon.

Cecum and the Ileocecal Valve (Colic Valve)

The cecum, the pouchlike, widest part of the large intestine, is 6-8 cm long. It lies on the right upper part of the ilium (right iliac fossa) near the anterior abdominal wall.

Ileocecal (colic) valve: The distal part of the ileum protrudes as a round or oval papilliform projection (the colic or ileocecal valve) into the cecum. It pushes aside and forces apart the circular muscle layer of the cecum which, in turn, surrounds the lower end of the ileum like a muscular clamp. The ileum, together with its mucosa, forms an upper and a lower lip, which end in a posterior and an anterior frenulum in which the circular muscle fibers of the cecum are again united. The ileocecal valve lies in front of the mesocolic band (tenia mesocolica), the muscle fibers of which are inserted partly in the muscular valve of the circular muscle fibers of the cecum and which can open the end of the ileum.

Some of them radiate into the longitudinal muscle layer of the lower ileum. Their contraction assists in dilating the end of the ileum which forms an ampulla immediately before the ileocecal valve. The ileocecal valve can actively change its shape like a sphincter.

Shortening of the longitudinal muscle layer of the invaginated end of the ileum and of the tenia results in shortening of the papilla and dilatation of its ostium. Contraction of the circular muscle layer of the ileum and cecum results in extension of the papilla and closure of the ostium. The sphincter opens periodically and allows the contents of the small intestine, i.e., of the ileum, to pass into the large intestine, the cecum, and hinders reflux. Furthermore, if the cecum is tightly filled, a mechanical valvular mechanism can come into operation to prevent reflux, as the lips of the valve become tightly pressed against each other. Contraction of the arched circular muscle fibers produces elevation and shortening of the cecum and so helps to empty the funnel-shaped outlet of the appendix.

Peritoneum: While the ileum lies intraperitoneally the cecum is often fused with the posterior abdominal wall: fixed cecum (cecum fixum). However, quite often there is a "mesocecum" which permits the cecum to become mobile, cecum mobile.

The vermiform appendix has a mesoappendix and this can account, at least in part, for the considerable variability of its position. Above and below the opening of the ileum into the cecum there is a peritoneal fold the ileocecal fold directed toward the appendix, behind which there are two peritoneal pockets, the superior and inferior ileocecal recesses. Frequently on the right side behind the cecum or the ascending colon there is a further peritoneal space, the retrocecal recess. The cecum already contains semilunar folds.

Rectum

The rectum is 15-20 cm long and is S- shaped. It follows at first the convexity of the sacral bone, the sacral flexure and then tums backward at the level of the coccyx and passes through the floor of the pelvis, the perineal flexure. Finally, it becomes the anal canal and ends at the anus. It also has a projection to the left formed by the Kohlrausch fold. The sacral flexure lies behind the peritoneum and is covered anteriorly by the peritoneum. The perineal flexure runs extraperitoneally. Haustra (sacculations) and teniae (bands) are absent from the rectum, and the longitudinal muscle layer is continuous. In the upper third of the rectum is a portion of considerable extensibility, the rectal ampulla. If it is filled the feeling of the need to defecate occurs. Below the ampulle three constant transverse folds project like wings into the lumen of the intestine: 2 smaller ones on the left and between them a larger one on the right. Kohlrausch's fold at a distance of 5-6 cm from the anus. Through contraction of the circular muscle fibers the folds approximate to each other: and on contraction of the longitudinal muscle fibers they move apart from one another ("rectoanal pylorus").

Anal canal: In its lower 2/3rds it is lined by a thin, lightly keratinized skin containing sensory innervation, which merges into the external skin. The latter reaches into the end of the anal canal. It has cornifying, pigmented epidermis, heirs with sebaceous glands and sweat glands. The mucosa of the colon reaches the upper 1/3 of the anal canal. In this zone 6-10 roll-shaped longitudinal folds, the anal columns arch into the lumen. They are thrown up by knots of vessels and are covered by several layers of non- keratinized squamous epithelium. At their lower ends the anal columns are joined together by transverse folds. The grooves between the longitudinal folds end in shallow pockets at their anal ends. They are covered with a single layer of columnar epithelium. The region of the anal column, which is about 1 cm long, is called the hemorrhoidal zone. Branches of the superior rectal artery descend in the anal columns. They lie beneath the mucosa and form the bases of internal hemorrhoids (piles). The arteries are connected by nodular arteriovenous anastomoses with the anorectal venous plexus. The columns form e cavernous body which contributes to closure of the anus.

Closure of the anus: The anal canal is actively closed by smooth muscle fibers (the continuation of the circular muscle layer of the intestine) the internal sphincter muscle of the anus and by striated muscle fibers the external sphincter muscle of the anus. The internal sphincter of the anus is about 2 cm high and its hard lower edge can be palpated in the patient. The longitudinal muscle layer of the intestine radiates partly into the internal sphincter muscle and partly into the perianal skin which it draws into the anus. Above the external and the internal sphincter muscles lies the puborectal muscle. This is the most important muscle of the sphincter it closes the anus and forms part of the levator ani muscles. It pulls the perineal flexure forward in a loop (closure) II the muscle relaxes the anus moves backward (opening). Damage to the puborectal muscle has a more serious effect on rectal incontinence than a lesion of any of the other sphincter muscles. Part of the pubococcygeal muscle also takes part in anal closure. The muscles are under permanent tension except during the act of defecation.

Defecation: Defecation is preceded by transport of feces into the rectum. The increasing tension of the rectal wall acts as a stimulus to defecation. The involuntary sphincter muscles are relaxed the reflex action and the other intestinal muscles contract. The external sphincter and the levator ani muscles are relaxed voluntarily and pressure is applied by the abdominal muscles [28].

4.1.6. Liver

The liver and the pancreas are the large intestinal glands. The liver acts as an exocrine gland in respect of production of bile. The bile acids emulsify fat m the intestine. The bile pigments are end products of the hemoglobin catabolism. Bile accumulates m the gallbladder and is discharged into the duodenum as needed. The most important action of the liver is its role as the largest organ involved in carbohydrate, protein and fat metabolism. These functions consume about 12% of the total oxygen content of the blood. The temperature of the blood in the liver veins reaches about 40 °C. Compression or contusions can produce dangerous tears in the soft hepatic tissue. The liver is held together by a dense connective tissue capsule, Glisson's capsule.

The lower edge of the liver runs laterally along the costal arch. From the point where the medioclavicular line crosses the line of the 8th rib the liver margin runs obliquely through the upper abdominal region (the epigastrium) to the left. The greater part of the liver lies below the right dome of the diaphragm. We distinguish the convex diaphragmatic surface which, in the upright position, has a horizontal surface end a curved anterolateral surface that points downward from the visceral surface. The latter ascends from the sharp lower edge obliquely backward and abuts posteriorly with a blunt edge on the diaphragmatic surface. Most of the liver is covered by the peritoneum, but posteriorly it is joined to the tendinous center of the diaphragm (the area nuda or bare area).

Diaphragmatic surface: The reflect folds between the visceral peritoneum of the liver and the parietal peritoneum form band-like structures on the diaphragm. The hepatic falciform ligament divides the anterior surface of the liver superficially into right and left lobes of the liver. It is attached to the inner surface of the abdominal wall and its lower margin takes up the ligamentum teres hepatis end extends toward the umbilicus. The falciform ligament forms the hepatic coronary ligament on the superior surface of the liver beneath the diaphragm. This peritoneal reflection which connects the liver and the diaphragm delimits the bare area, which is not covered by peritoneum. There the liver is in direct contact with the diaphragm. The fold, here called the triangular ligament, surrounds a triangular part of the bare area on both sides. The left triangular ligament runs in a connective tissue cord, the fibrous appendix. The right triangular ligament forms a blunt angle whose posterior fold forms the hepatorenal ligament. The inferior vena cava runs to the diaphragm behind the peritoneum within the bare area.

Visceral surface: The porta hepatis, the entrance into the liver, forms e cross-connection between the sagittal grooves which together are shaped like an H. The left sagittal groove accommodates the remnants of fetal vessels: anteriorly the ligamentum teres hepatis, a remnant of the umbilical vein, posteriorly the venous ligament of the liver, a remnant of the venous duct. The right sagittal groove contains the gall bladder anteriorly, and posteriorly the inferior vena cava. The quadrate lobe bulges out in front of the porta hepatis, the caudate lobe behind it. The lower surface of the left hepatic lobe bears the imprint of the stomach, that of the right lobe of the superior duodenal flexure, kidney, adrenal gland and of the right colic flexure. The hepatoduodenal ligament opens over the porta hepatis like a tent and affords space for the vessels passing through the porta to divide into two main branches.

Bile Ducts and Gallbladder

The bile reaches the duodenum via the large bile ducts. The nearby gaff bladder collects and concentrates the bile. The large bile duct has the diameter of a pencil. Proximal to the origin of the cystic duct to the gall bladder it is called the common hepatic duct and distal to it the choledochal duct. In the porta hepatis, the left and right hepatic ducts form the common hepatic duct which is 4-6 cm long. The cystic duct from the gall bladder which is 3-4 cm long opens into it at an acute angle. The choledochal duct is 6-8 cm long. It passes behind the bulb of the duodenum to the posterior, medial side of the descending duodenum where, in 77% of cases, it penetrates the duodenal wall to open into the major duodenal papilla with the pancreatic duct. In over 50% of cases, the ducts form a common hepatopancreatic ampulla. Radiological studies have shown that it is more common for the ducts to open separately. Before its entry into the ampulla, each duct has a sphincter muscle. The ampulla may itself be closed by its own sphincter muscle, the sphincter ampullae (Oddi). The mucosa of the ampulla has folds which restrict the reflux of bile and pancreatic secretion into the ducts. The thin wall of the bile ducts is made up of tall epithelial cells, a prominent elastic network, and a thin muscle layer Mucus ducts open into the bile ducts.

The gallbladder (vesica fellea) is a pear-shaped, thin-walled bag. Some 8-12 cm long x 4-5 cm wide, which holds up to 30-50 ml fluid. The gallbladder lies in a fossa in the liver to which it is attached by connective tissue. The fundus of the gallbladder extends beyond the lower margin of the liver. Its neck points upward and backward and lies above the duodenal bulb. The lower surface of the gallbladder is covered by peritoneum. The lumen of the neck of the gallbladder and of its connections with the cystic duct is incompletely sub-divided by spiral diaphragmatic folds of mucosa, known as the spiral fold (Heister's valve) [28].

4.1.7. Pancreas

The pancreas is the most important intestinal gland. The composition of pancreatic juice depends on the food ingested. Like gastric secretion pancreatic secretion is activated by a nervous stimulation, then by the stimulus provided by the filling of the stomach and finally by the action of a hormone released from the duodenum. During the third phase partly digested proteins cause liberation of hormones from the mucous membrane of the duodenum which reaches the pancreas via the blood stream

The pancreas is shaped like a horizontal wedge with its thin end on the left. It is 14-18 cm long, weighs 65-75 g and lies behind the peritoneum at the level of the 2nd lumbar vertebra. The head, the thickest part, fits into the duodenal loop to the right of the spine. Posteriorly and below its uncinate process hangs downward and embraces the superior mesenteric artery and vein, which are situated in the pancreatic notch. The horizontal body bulges with the omental tuber into the omental bursa towards the lesser omentum. It then bends around the spine toward the hilus of the spleen, which it reaches by its tail in the phrenico-splenic ligament. The pancreas is covered by connective tissue and is divided into lobules. It is only loosely connected to the posterior wall of the trunk and it moves with respiration. The transverse mesocolon runs over the head of the pancreas along the anterior head of the pancreas. Thus, the anterior surface of the gland is divided into an upper part which lies in the posterior wall of the omental bursa, and an inferior part which faces the free abdominal cavity.

Its excretory duct, the pancreatic duct, is 2 mm in diameter and runs right through the length of the gland. It receives short, vertical tributaries from the lobules. In about 77% of cases (in anatomical preparations) the pancreatic duct ends together with the common bile duct on the major duodenal papilla, in the remainder (more common according to radiological studies) it ends nearby. If present, the accessory pancreatic duct ends above the bile duct. It is absent in 3% and present as a side branch in 33%, but it can also be the main duct in 5-6% of cases.

Position: The pancreas and the duodenum are situated in the middle of the upper abdomen. Along the upper margin of the pancreas runs the splenic artery. The splenic vein runs parallel to it a little lower down. It joins the inferior mesenteric vein behind the body of the pancreas and together they pass behind the head of the pancreas with the superior mesenteric vein into the portal vein. The superior mesenteric artery takes its origin from the aorta, runs behind the head of the pancreas and downward for several centimeters, then through the pancreatic notch on the uncinate process, over the upper border of the horizontal part of the duodenum and into the root of the mesentery. The head of the pancreas lies in front of the inferior vena cava and the aorta and reaches upward to the celiac artery.

The root of the transverse mesocolon is fixed to the anterior edge of the pancreas and divides the abdominal cavity into the upper and lower abdomen.

<u>Greater and Lesser Omentum</u>

The blood and lymph vessels of the upper abdominal organs are mostly situated in the greater and lesser omentum. The lesser omentum (which develops from the ventral mesogastrium) is a peritoneal fold that is stretched between the lesser curvature of the stomach, the upper duodenum and the porta hepatis. The delicate hepatogastric ligament and the tough hepatoduodenal ligament can be distinguished. The greater omentum is a flap-like, fat-rich double peritoneal fold which develops from the dorsal mesogastrium. It hangs downward from the greater curvature of the stomach and the transverse colon [28].

4.1.8. Blood Vessels of the Upper Abdominal Organs

<u>Arteries:</u> The celiac trunk (axis) usually supplies the entire stomach, liver, spleen and part of the duodenum and pancreas. Its origin from the aorta lies in the aortic hiatus of the diaphragm. The origin is covered by the ganglia (celiac plexus) of the autonomic nervous plexus. The trunk divides into the common hepatic artery, the left gastric artery and the splenic artery (Haller's tnpod). The common hepatic artery divides into the gastroduodenal artery and the hepatic artery. The gastroduodenal artery descends behind the duodenal bulb It gives off the right gastroepiploic artery to the greater curvature of the stomach, which forms an anastomosis with the left gastric

epiploic artery from the splenic artery (arterial arch of the greater curvature). It ends in the superior pancreaticoduodenal arteries which supply the duodenum and the head of the pancreas. They are connected with the superior mesenteric artery via an anterior and posterior arterial loop. The right gastric artery, a branch of the hepatic artery, runs back toward the lesser curvature of the stomach. The hepatic artery passes inside the hepatoduodenal ligament, medial to the common bile duct to the porta hepatis where it divides into two branches. The cystic artery usually arises from the right branch and supplies the anterior and posterior surfaces of the gallbladder. The left gastric artery runs within a peritoneal pouch (the gastropancreatic fold) to the cardia. After giving off esophageal branches, it runs along the lesser curvature of the stomach and anastomoses with the right gastric artery (arterial arch of the lesser curvature). The splenic artery which generally follows a tortuous course, runs along the upper margin of the body and tail of the pancreas, and finally passes in the phrenicosplenic ligament to the spleen. It gives off pancreatic branches to the pancreas, and within the gastrosplenic ligament, the left gastroepiploic artery to the greater curvature of the stomach (arterial arch of the greater curvature), as well as the short gastric arteries to the fundus of the stomach

Veins: Venous blood from the upper abdominal organs drains via the portal vein into the liver

4.1.9. Blood Vessels of the Lower Abdominal Viscera

Of the lower abdominal viscera the jejunum, the ileum and the colon are wholly, and the duodenum and pancreas are partly, supplied by the superior and inferior mesenteric arteries. The border between the supply areas of these two arteries lies in the left half of the transverse colon and coincides approximately with the border between the areas under the influence of the vagus and the sacral parasympathetic nerves.

Superior mesenteric artery: It arises from the aorta immediately below the celiac trunk, runs downward behind the head of the pancreas and enters the mesentery between the lower margin of the pancreas and the upper margin of the Inferior part of the duodenum, about 3 cm below the duodenojejunal flexure. In rare cases traction of the vessel's trunk can produce closure of the duodenum. The artery is enveloped by a dense nervous network, the superior mesenteric plexus. On the left side 10-16 jejunal and ileal arteries arise from the superior mesenteric artery. Each divides into two branches which are connected with the neighboring arteries (arcades of the 1st order). Further rows of transverse cross-connections follow (arcades of the 2nd—4th orders), producing an ever narrower vascular meshwork. The formation of arcades is more marked in the lower part of the small intestine than in its upper part. The parallel blood vessels which run from the outer arcades to the intestine are end arteries and their blockage will result in a local lesion of the intestine.

The inferior pancreaticoduodenal arteries are the first to arise behind the head of the pancreas from the right side of the mesenteric artery. They are connected with the arch formed by the superior duodenal arteries. They then give off 3 arteries to the large intestine. Following on the supply area of the ileal arteries is that of the ileocolic artery, the terminal branch of the superior mesenteric artery. This artery gives off branches to the cecum and to the lower part of the ascending colon, and the appendicular artery to the appendix. Next is the right colic artery with branches reaching the right colic flexure, and finally the middle colic artery, which supplies about 1/3 of the transverse colon. It anastomoses with the adjacent branches of the left colic artery, which arises from the inferior mesenteric artery. The arcades of the arteries of the large intestine form a row of wide mashes. As a rule they are not connected with the arteries of the retroperitoneal space.

The veins from the area, supplied by the superior mesenteric artery, drain into the portal vein

<u>The Inferior mesenteric artery</u>: arises ventrally at a rather low level (3rd—4th lumbar vertebra) from the aorta, tums to the left and runs across the psoas muscle and the linea terminalis into the lesser pelvis. Its first part often lies below the horizontal part of the duodenum. This artery is covered by a dense network of autonomic nerve fibers. The left colic artery arises either directly from the inferior mesenteric artery or, together with the sigmoid artery, from the short common stem of the inferior mesenteric artery. The left colic artery divides into an ascending branch which continues the supply to the intestine from the middle colic artery (a branch of the superior mesenteric artery), and into a descending branch. This supply area is often followed by the sigmoid artery or arteries which reach the sigmoid colon in the pelvic mesocolon.

<u>Arteries of the rectum:</u> The last branch of the inferior mesenteric artery is the superior rectal artery. It runs across the internal iliac artery into the lesser pelvis behind the rectum and supplies the latter down to the internal sphincter muscle of the anus. This artery may be divided into two branches. Branches of the superior rectal artery are joined above the pelvic floor on either side by the branches of the middle rectal artery, which comes from the internal iliac artery. Below the pelvic floor which is pierced by the branches of the superior rectal artery, these are joined on each side by branches of the inferior rectal artery from the internal pudendal artery. However, the anastomoses of the middle and lower rectal arteries with the superior rectal artery are inadequate as a substitute for the superior rectal artery. As the superior rectal artery has only a single communication with the sigmoid artery the sigmoidea ima artery the former vessel must not be ligated below this junction

The vena from the area supplied by the inferior mesenteric artery drain into the portal vein as do the veins from the upper parts of the rectum. The veins from the middle and lower parts of the rectum dram via the internal iliac veins into the inferior vena cava.

<u>Portal Vein</u>

Venous blood from the unpaired abdominal viscera (the gastrointestinal tract gallbladder pancreas and the spleen) which are supplied by the three unpaired abdominal arteries (the celiac trunk and superior and inferior mesenteric arteries) reaches the liver via the portal vein and runs through the hepatic veins to the inferior vena cava. Nutrients absorbed from the intestine thus reach the central metabolic organ by the shortest route.

The portal vein is formed from 3 root veins, the splenic inferior mesenteric and superior mesenteric veins

The splenic vein like the splenic artery runs along the upper margin of the pancreas. In its course it receives the short gastric veins, the left gastroepiploic vein and the pancreatic and duodenal veins. Behind the body of the pancreas it unites with the inferior mesenteric vein and behind the head of the pancreas it drains together with the superior mesenteric vein into the portal vein.

The inferior mesenteric vein contains blood from the descending and sigmoid colon and from the upper rectum (superior rectal vein). Its course differs from that of the inferior mesenteric artery. Both vessels run together until the departure of the left colic artery. From there the vein follows that particular branch and then runs in a peritoneal recess the superior duodenojejunal fold, across the duodenojejunal flexure behind the pancreas

The superior mesenteric vein carries blood from the small intestine the cecum and the ascending and transverse colon accompanied by the superior mesenteric artery behind the head of the pancreas and it receives the duodenal pancreaticoduodenal and right gastroepiploic veins during its course

The following veins end directly in the trunk of the portal vein the right and left gastric veins from the lesser curvature of the stomach the cystic vein from the gallbladder the prepyloric vein from the anterior surface of the pylorus and lastly the paraumbilical veins which accompany the ligamentum teres in the falciform ligament of the liver. They form anastomoses between the subcutaneous veins of the abdominal wall and the portal vein and open into the left main branch of the portal vein

Portocaval anastomosis: The drainage area of the portal vein borders on that of the superior and inferior vena cava at the following sites esophagus (blood from the esophageal veins flows through the azygos vein and the hemiazygos vein to the superior vena cava 013) rectum (blood from the middle and lower rectal veins drains through the internal iliac vein to the inferior vena cava abdominal wall connected with the superior vena cava by the thoracoepigastric veins and the inferior vena cava via the superficial epigastric veins. It is in those regions that portocaval anastomoses occur i.e. connections between the areas drained by the portal vein and the superior vena cava or the inferior vena cava. Additional portocaval anastomosis may be present between the mesenteric veins and the retroperitoneal veins [28].

4.2.Urinary system

The kidneys produce urine by eliminating water and various harmful metabolic products most of which arise in other organs. Thus the internal environment of the tissues is regulated the equilibrium of minerals and water is maintained and the hydrogen ion concentration (pH) of the body IS kept constant. The process of elimination takes place in 2 phases at first an ultrafiltrate of blood plasma, the primary urine, is produced. This contains substances dissolved in blood in the same concentration as in the blood except for proteins. Following this various materials particularly glucose and water are reabsorbed from the primary urine, the daily output of which is about 150 liters. During this process the amount of urine is reduced to 1% of its original volume to produce the greatly concentrated secondary urine. The urine then leaves the body via the urinary tract organs, i.e. the renal pelvis ureters urinary bladder and the urethra. In addition the kidneys have endocrine effects on blood pressure and hemopoiesis.

Anatomy: The kidneys are bean-shaped and their longitudinal axes correspond approximately to that of the body. They converge upward toward the back .The kidneys are situated in a connective tissue space behind the peritoneal cavity in the lumbar region on either side of the spine. Their upper poles extend about as far as the upper margin of the 12th thoracic vertebra and in the adult their lower poles reach down to the 3rd lumbar vertebra. The hilum lies at the level of the first lumbar vertebra. The 12th rib crosses the kidney obliquely at the border between its upper and middle thirds. Together with the 12th rib part of the lumbar portion of the diaphragm and the costodiaphragmatic recess of the pleura lie across the upper third of the kidney. In 65% of cases the right kidney lies about half a segment lower than the left. In deep inspiration and in the upright position the kidneys descend by about 3 cm. Rotation and dipping movements are also possible. The kidneys are kept in position by a fascial sheath and a fatty capsule. The suprarenal (adrenal) gland which is embedded in the fat capsule sits upon the upper pole of each kidney like a cap. The inferior vena cava and the descending part of the duodenum lie near the hilum of the right kidney. The anterior surface of the right kidney touches the liver and the right colic flexure. The abdominal aorta runs near the hilum of the left kidney. The anterior surface of the left kidney touches the stomach pancreas and left colic flexure and with its lateral border it touches the spleen. Posteriorly both kidneys border on the diaphragm above medially on the psoas major muscle laterally on the quadratus lumborum muscle and the transverse abdominal muscle. The kidney is crossed posteriorly by the subcostal iliohypogastric and ilioinguinal nerves parallel to the course of the 12th rib [28].

4.2.1. Kidneys

The kidney (ren or nephros) in the adult weighs 120-300 g, is 10-12vm long, 5-6 cm broad and about 4 cm thick. The convex lateral margin has a more pronounced curve at the poles, which appear, therefore, to be rolled in medially. On the medial margin lies the renal hilum (porta renalis) through which the blood vessels nerves and the renal pelvis enter and leave

Renal capsule: The kidney is enveloped by a tough capsule of collagenous fibers which is connected to the kidney by areolar tissue. It can easily be stripped off right up to the hilum. The capsule at the hilum is connected to the connective tissue of the vessels which enter into a central recess the renal sinus

Body of the Kidney: After removal of the vessels, nerves, pelvis and fat from the renal sinus, the body of the kidney appears as a thick-walled slightly flattened pouch. Its entrance is narrowed to a slit by an anterior and posterior lip of the body. The anterior and posterior walls of the body of the kidney are formed of several parts the renal lobes (renculi) each of which forms a pyramid, renal papilla pyramids stand out from the inner superior surface of the renal pouch. The subdivision of the kidney into renal lobes does not correspond with its division into vascular segments, as each renal lobe is supplied by several branches of the renal artery and each branch supplies more than one lobe.

There are usually five vascular segments to the kidney a superior, antero- superior, antero-inferior, inferior and posterior segment.

The kidney is fixed in position by the renal fascial envelope, a fibrous tissue sheath and a fatty capsule (capsula adiposa). The fascial envelope consists of anterior and posterior layers of the subperitoneal fascia which join laterally. Most of the anterior layer (leaf) is covered by peritoneum. The fascial envelope of the kidney is open medially and at the lower end where the vessels and nerves from the prevertebral space enter the renal hilus. Both laminae of the fascia extend to the diaphragm. The fatty capsule consists of depot fat and it therefore shrinks on any form of malnutrition, thereby increasing the motility of the kidney.

Blood Vessels of the Kidney

The renal artery and vein in the hilus enter the loose, fatty connective tissue that lies between the renal parenchyma and the renal pelvis, except for the papillae. The artery divides into the following branches: the interlobar arteries enter the medulla between the pyramids. They divide and run as arcuate arteries like arteries between the cortex and the medulla both of which they supply [28].

4.2.2. Ureter

The ureter is shaped like a slightly flattened tube 4-7 mm diameter. Its length varies, being about 30 cm in the male and about 1 cm shorter in the female. The slitlike lumen of the ureter has a stellate appearance because its mucosa is folded longitudinally. The two ureters penetrate the wall of the urinary bladder at its fundus, 4-5 cm apart from each other, obliquely from behind and above toward the middle. They run for 2 cm in the bladder wall and end in a slit, the ostium ureths.

Position of the ureters: The abdominal portion of the ureter passes almost vertically downward along the fascia of the psoas muscle and is covered by the peritoneum. The ureter crosses underneath the testicular or ovarian blood vessels. At the entrance into the lesser pelvis it crosses over the point where the common iliac vessels divide. The left ureter passes beneath the pelvic colon.

The pelvic portion: The ureter crosses beneath the ductus deferens in the male and beneath the uterine artery in the female. It is palpable through the anterior wall of the vagina (of importance in ureteric calculi). Physiological constrictions of the ureter are found where it leaves the renal pelvis, where it crosses the iliac vessels and where it enters the bladder (danger of impaction of ureteric calculi). In the newborn and in babies the ureter is often tortuous.

Nerves and vessels: The blood vessels and lymphatics of the ureter arise from those in its neighborhood [28].

4.2.3. Renal Pelvis

The renal pelvis AC1 (pyelon) loosely lines the renal pouch. Only in the area of the papillae is it firmly attached to the parenchyma of the kidney. A calix is formed around each papilla as it protrudes into the renal pelvis. The calices have a stalk of varying length. The stalks are surrounded by loose connective and fatty tissue which fills the space between the kidney and that part of the renal pelvis which is not adherent to the parenchyma. Vessels and nerves run through this space [28].

4.2.4. Urinary Bladder

The urinary bladder (vesica urinaria) in the adult lies in the lesser pelvis beneath the peritoneum, in the subperitoneal connective tissue space behind the pubic bones. In the newborn the bladder lies higher than the pubic bones. The body (corpus) of the bladder tapers upward toward the front into its vertex, the apex of the bladder; the fundus (base) of the bladder lies posteriorly. The median umbilical ligament ascends from the vertex to the umbilicus; it is the remnant of the embryonic urachus; the lateral umbilical ligaments: the remnants of the obliterated umbilical arteries ascend from the body of the bladder to the umbilicus. Both ureters enter the bladder at its base and the urethra leaves it from there. The vertex and the upper wall of an empty bladder collapse giving it a cuplike appearance. When the bladder is full the vertex and the upper wall are elevated and form a flat oval cushion, which may extend above the upper rim of the pubic symphysis. Only during contraction of the bladder muscles, when it is emptied by micturition, does it assume a globular shape. When the bladder contains about 350 ml or more of urine the urge to urinate is felt, but 700 ml or more of urine can be voluntarily retained. In a case of paralysis of the bladder its capacity may be much greater.

The peritoneum covers the bladder from the vertex to about the line where the ureters enter the bladder. It is movable over the bladder and forms a transverse reserve fold which straightens out when the bladder is filled. If filled to capacity the vertex of the bladder ascends between the abdominal wall and the peritoneum. In this position the bladder can be punctured through the abdominal wall without injuring the peritoneum. In front and laterally the bladder is surrounded by loose connective tissue, the paracystium which contains vessels and nerves. The ureter has sensory innervation.

Internal surface: The mucosa in life is soft and reddish, and two areas can be distinguished. At the base (fundus) between the orifices of the ureters and the exit of the urethra, lies the trigone of the bladder (trigonum vesicae). The transverse ureteral ridge, the interureteric fold, connects both openings of the ureters. The lower thicker angle of the triangle protrudes as the uvula vesicae from behind into the inner mouth of the urethra, which is narrowed by a surrounding ring, the internal ostium of the urethra. Venous plexuses here form a compressible pad for closure of the opening. The trigone of the bladder has no folds and is marked by blood vessels. The rest of the interior wall has folds which protrude into the lumen of the contracted bladder. If the urethra is narrowed, e. g, hypertrophy of the prostate with advancing years these folds project like trabeculae because of muscular hypertrophy due to overwork (trabeculated bladder)

Blood vessels: The superior vesical artery originates from the umbilical artery, the distal part of which becomes obliterated after birth and forms the lateral umbilical ligament. The veins form a prominent network under the bladder. The lymphatics run to lymph nodes alongside the umbilical artery and in the prevesical connective tissue [28].

5. The role of visceral therapy

In order to investigate the role of visceral manipulation in rehabilitation, more and more researches are conducted, either using only visceral manipulation or as a complementary method of treatment.

5.1. Musculoskeletal system

Low back pain (LBP) is one of the most common and challenging musculoskeletal conditions, affecting 70% – 85% of the adult population at some point in life [30]. About 40% of people have LBP at some point in their lives, with estimates as high as 80% among people in the developed world [31,32].Despite the fact that there is a large number of research investigating different kind of approaches for low back pain, only a few effects are observed by the recommended interventions [33]. Hence, the need to investigate new strategies such as visceral manipulation became popular the last decade.

Tamer S, et al showed that the addition of visceral manipulation to patients with no specific LBP, have positive effects on pain and improves the quality life and function of the patients [34]. A double-blinded, randomized, controlled, clinical trial preliminary study, showed improvement in the mobility and function of lumbar spine to patients with chronic LBP and visceral dysfunction after a combination of visceral manipulation and conventional physical therapy program [35]. In a randomized placebo controlled trial demonstrated that application of physical therapy in combination with visceral techniques to patients with LBP produce promising improvements in pain at 1 year [36].A single-blinded, randomized trial conducted on 15 asymptomatic subjects demonstrated significant improvement in pressure pain thresholds at the L1 paraspinal musculature and 1st dorsal interossei immediately after the visceral mobilization of the sigmoid colon intervention [37]. A systematic review on women during or after pregnancy with LBP suggests that, Osteopathic manual treatment (OMT), that includes visceral manipulation decreases pain and increases functional status [38]. A case report on a 33 year old male with LBP showed that visceral manipulation and dietary recommendations decreased the perception of LBP 80 %, improved the function, mental and physical condition [39]. Another randomized trial in patients with chronic low back pain demonstrated that osteopathic manipulative treatment with the addition of specific techniques to the diaphragm and the abdomen ameliorates the levels of pain and disability [40]. Tozzi et al, showed that specific application on the fascia of the kidney in patients with low back pain have a positive impact on pain perception and improves the mobility of the kidney to patients with LBP [41].

Cervical pain affects globally approximately 4.9% of the population and manifests more common in women than men [42].Neck pain may occur due to damage of the structures in the neck including: vascular, neural, airway, digestive, and musculoskeletal system or be referred from other areas of the body [43]. Whiplash is a common type of injury on the neck that is categorized into grades regarding to the severity of the damage and the symptoms [44]. There are various approaches such as, heat/ice treatment, ultrasound therapy, and immobilization with cervical collar, physical therapy and medication [45]. A study on patients with long-term whiplash injury showed significant improvement both on physical and mental aspect, leading to amelioration to disability and quality of life after osteopathic intervention including visceral techniques [46]. Another subtype of cervical pain is chronic nonspecific pain of neck that is not associated with a particular disease or modification of anatomical structures [47]. The diagnosis is challenging and thus application of efficient treatment becomes difficult [48]. A randomized, double-blind, placebo-controlled pilot study in patients with chronic nonspecific neck pain and functional dyspepsia showed that a single visceral manipulation session including techniques to the stomach and liver decreased the level of neck pain and increased the amplitude of the electromyographic signal of the upper trapezius muscle immediately and a week after treatment [49].

5.2. Gastrointestinal system

Talking about movement of internal organs the most expected and obvious effect of visceral manipulation is on diseases or conditions related to viscera. In a lot of different diseases patients present gastrointestinal symptoms either primarily due to the adjacent affected organs or secondarily as a consequence of disruption on the gastrointestinal balance.

One of the diseases that cause abdominal pain, abdominal distension, and bowel dysfunction for recurrent periods is irritable bowel syndrome (IBS) that affects 10-20% of the adult population worldwide [50]. Recent researches relate IBS to abnormalities in gut motility and sensitivity, activation of gut immunity, disturbances in brain–gut interactions, disruption of the epithelial barrier driven by the intestinal microbiota and psychological disorders. However, the underlying mechanism is not fully understood yet [51]. Because of that the conventional drug treatments available for IBS are mainly targeted at symptom reduction showing low efficacy [52]. Thus, a lot of complementary alternative medicine modalities are under investigation such as, relaxation sessions, hypnosis, acupuncture, yoga, cognitive-behavioral psychotherapy [53-57] and visceral manipulation.

Attali et al, showed that patients with IBS that treated with visceral osteopathy had significant improvements in gastrointestinal symptoms such as, diarrhea, abdominal distension and abdominal pain without change of constipation, as well as they had decreased rectal sensitivity. Additionally, the symptoms were reduced after one year in comparison to the placebo group [58]. A randomized sham-controlled study showed that manipulation to spinal segments including visceral manipulation to the abdominal organs, improved the severity and the quality of life to patients with IBS [59]. Another randomized controlled study, demonstrated that 68 % of the patients with IBS treated with osteopathic techniques, including visceral techniques noted definite overall improvement in symptoms and 5% of them was free of symptoms at the end of the study [60].

Another disease resembles a lot IBS and is included to inflammatory bowel disease (IBD) is Crohn's disease (CD). It manifests several different symptoms affecting mainly the gastrointestinal system, such as diarrhea or constipation, abdominal pain/swelling, ulcers, but also somatic symptoms for example, joint pain, ophthalmic inflammation and last but not least 25% of the patients present psychological symptoms [61]. Also it is characterized by recurring episodes that duration and intensity vary and followed by inactive periods [1], affecting the quality of the patient's life [62–64]. Likewise to IBS, treatment with drugs or surgical approaches aims to reduce the inflammation on the gut and work more symptomatically rather than therapeutically. In order to avoid the implications of a surgery, reduce the costs and try to be more effective, new strategies have been investigated [65,66].

A randomized controlled trial showed that the application of soft tissue techniques including visceral techniques in patients with Crohn’s disease improved the quality of their life regardless the phase of their disease (outbreak or remission) [67]. Another study on patients with CD in remission presenting IBS-like symptoms, showed significant reduce on the symptoms, improvement on quality life and reduced consumption of antispasmodics, after osteopathic manipulation techniques mostly to the spine and abdomen[68].

As it was already mentioned gastrointestinal symptoms can be present at diseases in which viscera are not involved directly, such as autism. A repeat-measures longitudinal study on children with autism addressed with visceral manipulation techniques, showed improvements on gastrointestinal symptoms, in particular on vomiting and appetite [69]. Similarly, a five-repot study on children with cerebral palsy treated with neural and visceral manipulation showed that there was improvement to quality of life to 4 out of the 5 subjects and all the participants presented increased number of bowel movements during the study [70]. Another case report study showed physical therapy approach including visceral manipulation after failed biofeedback therapy for constipation reduced subject’s rectal pain with defecation to 1–2/10, resolved the pain during urination, and stopped using water enema and those changes maintained after one year [71].

Colonic inertia is a subtype of constipation, characterized by severe functional constipation, with no obstruction to the outlet, delayed transit of the stools to the colon, absent or almost absent colonic motor activity and no response to pharmacologic application [72]. It is usually addressed with colectomy and ileorectal anastomosis that restores constipation but is still challenging for the quality of life of the patients [73]. A case report of a 41-year-old woman with low back pain and diagnosed with colonic inertia received osteopathic treatment including visceral manipulation, it was achieved temporary normalization of colon function for a full 2 weeks [74].

After abdominal surgeries several complications have been reported, such as ileus and adhesions [75, 76]. Postoperative ileus presents severe symptoms like nausea, vomiting, intolerance of oral intake, abdominal distention and delayed passage of feces [77]. Although there is no efficient treatment for ileus, lot of strategies are combined, such as laparoscopy, epidural anesthesia and drugs, in order to reduce its occurrence [78-79]. A rodent model study showed that visceral techniques after abdominal surgery improved the gastrointestinal function and significantly decreased the number of intraperitoneal cells leading to redaction of the risk of postoperative ileus [80]. Another study showed that osteopathy treatment with the addition of visceral manipulation to general surgical patients reduced the time to flatus and decreased postoperative hospital length of staying [81]. As it has already mentioned, adhesions is a side effect of major surgeries and they are present almost to 90-100% of cases following surgery [82]. There are various therapeutic approaches but none have been proven to prevent the formation of adhesions [83]. A study in a rat model showed that visceral mobilization improved the mobility of the viscera, the adhesions could be lysed easier with less force and after 7 days there was absence of cecueabdominal adhesions [84].

Gastroesophageal reflux disease (GERD) manifests mainly with regurgitation ,heartburn, bad breath, chest pain, but there are also atypical symptoms such as, cough, sibilances, wheezing, laryngitis, hoarding, sinusitis, asthma and dental erosion [85,86]. The mechanisms under GERD appears include relaxation of lower esophageal sphincter, disruption of the crural diaphragm, esophageal shortening [87]. The standard medical approach is PPIs and dietary, although it is shown that there is a correlation between long term use of PPIs and development of polyps, mucosa degeneration and osteoporosis. Growing strategies have been explored for GERD such as, psychotherapy, hypnotherapy and neuromodulators [88, 89]. A Randomized Controlled Trial on patients with GERD showed that application of visceral manipulation improved significantly the symptoms one week after the intervention, improved cervical mobility. Moreover it was observed that subjects with greater gastroesophageal reflux symptoms presented lower pressure point threshold in C4 spinous process [90].

Biliary dyskinesia is a functional gastrointestinal disorder and characterized with significant abdominal pain. It includes several conditions such as stones to the gallbladder, biliary dysmotility, sphincter of Oddi dysfunction, ampullary stenosis, and post cholecystectomy syndrome. The most common management is invasive, such as cholecystectomy, and is not always satisfactory resulting in controversy among gastroenterologists and surgeons [91]. A case report of a 51-year-old woman with intermittent postprandial right upper quadrant pain, that worsen after meals and radiated into her mid-to-low back and epigastrium showed that after 2 sessions of osteopathic approach including specific abdominal manipulation her pain was resolved completely [92].

5.3. Urogenital system

Female lower urinary tract symptoms (LUTS) present to women of all ages, but it is most common in older age [93]. LUTS are divided into three major groups: a. Urge urinary incontinence, b. Stress urinary incontinence c. Mixed incontinence [94, 95]. The treatment is usually surgical, pharmacological and conservative including pelvic floor muscle training (PFMT which is the recommended method [96]. A systematic review and meta-analysis in women with LUTS showed that osteopathic approach, including visceral techniques improved significant statistically and relevant clinically the symptoms in comparison to no treatment [97]. A randomized controlled trial on pediatric dysfunctional voiding showed that the additional osteopathic treatment including assessment and addressing the related organs significantly improved the symptoms in short-term in comparison to application of the conservative treatment only [98].

Dysmenorrhea is a condition describing painful menstruation periods in women and affects 50% of the women [100-101]. It is divided into two subtypes: A. Primary if there is no pathological cause and B. Secondary that dysmenorrhea occurs as a consequence of underlying pathology such as endometriosis [99]. The common management of dysmenorrhea is with analgesics and non-steroid anti-inflammatory drugs. Although pharmacological approach reliefs the symptoms, adverse side effects and low efficacy to some cases have been reported [102]. A randomized controlled trial in women with primary dysmenorrhea demonstrated decreased levels on intensity and duration of the pain as well as increased levels in quality of the life of the patients in comparison to women that did not receive any kind of intervention, after the application of 6 sessions of osteopathic manipulating techniques to the related organs [103]. A case report on a 29 year old woman with abnormal increased flow during menstruation, leucorrhoea, pain to the abdominal area and low back due to endometriosis received 8 osteopathic sessions including visceral techniques. The results showed significant decrease on the pain levels and major improvement on quality of the patient's life [104].

According to the latest international glossary on infertility and fertility care, "is a disease characterized by the failure to establish a clinical pregnancy after 12 months of regular, unprotected sexual intercourse or due to an impairment of a person's capacity to reproduce either as an individual or with his/her partner. Fertility interventions may be initiated in less than 1 year based on medical, sexual and reproductive history, age, physical findings and diagnostic testing. Infertility is a disease, which generates disability as an impairment of function" [105]. Infertility affects more than 186 million people in the word and is observed in majority to developing countries [106]. Besides age, lifestyle and environmental factors play crucial role in a successful conception. Many of the issues that cause a woman to have difficulty with conception can be traced to scar tissue, fascial restriction, and congested lymphatics [107,108]. A case series report on 10 challenging reproductive women showed that 6 of them achieved to conceive after osteopathic intervention including visceral manipulation [109].

CONCLUSION

This research shows that visceral manipulation can have an effect in addition to other therapies to several conditions and diseases. A lot of research has been conducting concerning low back pain with significant results. The same applies on diseases and conditions with gastrointestinal symptoms, especially to irritable bowel syndrome and constipation. Additionally, it seems to have some impact on urogenital conditions such as dysmenorrhea and infertility.

Visceral structures represent the entire contents of the cavities of the body, carry a significant mass within these, and are under the same laws of physics and types of trauma as the locomotor system [110]. It is estimated that the collective mass of the viscera represents an average of 12% of total body weight [111]. All the internal organs are connected to each other through a double-layered articulation system of serous membranes, such as the pleura, pericardium and peritonea. Normal functions such as inspiration, digestion and body movement requires the organs to be able to slide [19, 84, 112]. The visceral structures are attached to the somatic frame by a vast network of fascial attachments [113]. Liver and kidney move 3 cm with every respiration and they are attached to psoas and quadratus lumborum by the renal fascia. [112,114]. It is known that nociceptive stimuli give referring pain to the somatosensory system via the viscerosomatic reflex. Visceral nociceptors can be activated by lack of blood flow and inflammation, distention of hollow organs and traction on the mesentery [115]. There are different kinds of receptors on enteric neurons that are responsible for important functions of the gut. Mechanoreceptors control mucosal abrasion, tension receptors are responsible for stretching, chemoreceptors mediate different chemical stimuli in the lumen, such as pH, osmolality, and there are various receptors that control the fluid exchange in the gut [116].

However, the current evidence is limited by the small number of controlled clinical trials that have been conducted in this field and for particular diseases there are only case reports. Thus, it is suggested more scientific investigation on the mechanisms and the efficacy of visceral manipulation on rehabilitation.

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