The Integral Role of the Diaphragm in Osteopathy: A Comprehensive Examination of Its Functions and Implications in Diagnosis and Treatment

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Doctor of Philosophy in Osteopathic Clinical Sciences

Lima, Perú
May 25, 2024

Summary

Osteopathy views the human being as an integral entity. Within this integrality, the diaphragm plays a crucial role. It is not only the most important muscle for respiration but also the key structure separating the thoracic cavity from the abdominal cavity, facilitating communication between the thoracoabdominal viscera through various connecting ligaments. The diaphragm serves as a central hub where muscular chains intersect, acting as anatomical circuits through which the body's organizing forces propagate. It is also one of the diaphragms within the craniosacral system and maintains a significant relationship with the pericardium, as the pericardium attaches to the diaphragm's central tendon, influencing cardiovascular function and overall bodily harmony.

To fully appreciate the diaphragm's importance in osteopathic diagnosis and treatment, this review outlines its relationships with different osteopathic approaches (visceral and craniosacral), its connection with the pericardium, and its role within the body's muscular chains, highlighting the health repercussions arising from its dysfunctions.

Keywords: Diaphragm, visceral joints, muscular chains, myofascial lines, pericardium, craniosacral movement, osteopathic dysfunction, visceral relationships.

Content

Introduction

The thoracoabdominal diaphragm is one of the most significant transverse diaphragms, playing a crucial role in numerous vital functions. This review aims to explore how its dysfunction can lead to structural, craniosacral, and/or visceral lesions through lesion chains from an osteopathic perspective.

1. Problem Statement

The thoracoabdominal diaphragm is one of the most significant transverse diaphragms, playing a crucial role in numerous vital functions. Additionally, it maintains a significant relationship with the pericardium, as the pericardium attaches to the diaphragm's central tendon, influencing cardiovascular function and overall bodily harmony. This review aims to explore how its dysfunction can lead to structural, craniosacral, and/or visceral lesions through lesion chains from an osteopathic perspective.

2. **Justification**

The diaphragm is an essential muscle for life, playing a critical role in respiration and many other fundamental activities for humans. It contributes to increasing abdominal pressure, facilitating urination, defecation, childbirth, and enhancing thoracic pressure to aid the cough reflex. Osteopathy places significant and definitive importance on the diaphragm due to its anatomical and functional connections with adjacent structures. Therefore, it is crucial to review its embryological origin, anatomy, physiology, and biomechanics to gain a better understanding, comprehend the potential for dysfunction, and explore possible treatments.

3. **Objectives**

3.1 General Objective

To gather comprehensive information on the embryology, anatomy, physiology, biomechanics, and management of diaphragm dysfunctions for an integrative approach from an osteopathic perspective.

3.2 Specific Objectives

- To review the embryology, anatomy, and visceral joints with neighboring structures of the diaphragm to achieve detailed anatomical knowledge of this muscle, including its critical relationship with the pericardium.

- To examine the physiology and muscular biomechanics of the diaphragm to understand its functioning and its connections to vital bodily activities.

- To explore different theories regarding muscular chains and fascial pathways to comprehend their functionality and relationship with the body's organizing forces.

- To globally describe the dysfunctions of the thoracoabdominal diaphragm from an osteopathic viewpoint.

- To outline various techniques indicated for the treatment of diaphragm dysfunctions according to specific osteopathic principles.

4. **Theoretical Framework**

The theoretical framework compiles information on the embryology, anatomy, physiology, biomechanics, and management of certain diaphragm dysfunctions from an osteopathic perspective. Beginning with the definition of osteopathy by its founder, Dr. Andrew Taylor Still, it outlines the embryonic development that underpins anatomical relationships, provides an anatomical description of the diaphragm, details its movements, and presents the most commonly used osteopathic manipulation techniques.

Osteopathy, as defined by Dr. Andrew Taylor Still, is “a science that consists of verifiable, exact, and comprehensive knowledge of the structure and function of the human mechanism, including anatomy, physiology, and psychology. It encompasses elements of knowledge in physics and chemistry and has made discoveries of organic laws and corrective sources within the body itself, ... in harmony with its own mechanical principles, molecular activities, and metabolic processes, that can rectify displacements, disorganizations, disorders, and consequent diseases, to restore normal balance in form and function in health and strength.”

John E. Upledger further elaborates on osteopathy, describing it as “a complete system of medical care with a philosophy that combines the needs of the patient with the current practice of medicine, surgery, and obstetrics. It emphasizes the interrelationship between structure and function and has an appreciation of the body’s ability to heal itself.”

The diaphragm is a fundamental muscle for life, dividing the trunk into the abdominal and thoracic cavities. It works in conjunction with other muscles in the respiratory process, with the diaphragm being the principal respiratory muscle, creating negative pressure for air to enter the lungs. During inspiration, the diaphragm descends, pulling down the structures contained within the thoracic cavity, and during expiration, it relaxes and ascends, pulling up the abdominal structures.

Anatomically and functionally, the diaphragm is connected to processes occurring in the thorax and abdomen. It is part of the anterior, posterior, lateral, and spiral fascial lines described by Thomas Myers, as well as the straight and crossed muscular chains described by Leopold Busquet, which transmit the movement of body structures.

4.1 Embryological Origin

At the end of the third week, the intra-embryonic mesoderm differentiates into paraxial, intermediate, and lateral portions. The lateral portions divide into two layers: the somatic layer and the splanchnic layer of the mesoderm.

By the fourth week, the embryo's body folds in a cephalocaudal and lateral direction, closing the communication between the intraembryonic and extraembryonic coelom. The somatic mesoderm divides into a parietal layer, which will later form the serous membranes, and a visceral layer, which will form the serous membrane layer of the abdominal organs, lungs, and heart.

The main structure that divides the intra-embryonic coelomic cavity is the septum transversum, which occupies the space between the thoracic cavity and the yolk sac pedicle, leaving the space known as the pericardio-peritoneal canal. This does not completely separate the thoracic cavity from the abdominal cavity but leaves a wide communication, the pericardio-peritoneal canals, on each side of the foregut. During embryological development, the future pericardial, pleural, and peritoneal cavities are found to be interconnected.

Later in development, the pleural cavities form crescent-shaped structures known as pleuroperitoneal folds. These folds project towards the caudal end of the pericardio-peritoneal canal, ultimately closing the coelomic cavity and separating the thoracic cavity from the peritoneal cavity. The pericardio-peritoneal folds extend medially and ventrally, fusing with the septum transversum and the esophageal mesentery. As they incorporate into the body wall, they acquire a border of myoblasts, which form the diaphragm's muscular part.

The diaphragm derives from several structures:
1. The septum transversum, forming the tendinous part
2. The pleuroperitoneal membranes
3. The muscular components of the lateral and dorsal body walls
4. The esophageal mesentery, which develops into the crura of the diaphragm

Initially, the septum transversum is positioned against the cervical somites, and it is within this structure that the third, fourth, and fifth cervical spinal nerves develop. The phrenic nerves, which pass through the pleuro-pericardial folds, also develop within this septum. In adults, these phrenic nerves reach the diaphragm by traveling through the fibrous structures of the pericardium.

The descent of the diaphragm results from the rapid growth of the embryo's dorsal vertebral column. By the beginning of the third month, some dorsal bands of the diaphragm originate at the level of the first lumbar vertebra. The phrenic nerves distribute across the diaphragm, providing it with both sensory and motor innervation. The diaphragm's most peripheral portion, derived from the mesenchyme of the thoracic wall, receives sensory innervation from the lower thoracic intercostal nerves.

A common neonatal malformation is a diaphragmatic hernia, which occurs with an incidence of one in two thousand births. This condition arises when the pleuroperitoneal membranes fail to close the pericardio-peritoneal canal.

4.2 Anatomy of the Diaphragm

The diaphragm is a dome-shaped, musculo-fibrous sheet that separates the thoracic and abdominal cavities. Its superior surface is convex, facing the thoracic cavity, while the inferior surface is concave, facing the abdominal cavity.

The diaphragm can be divided into two portions:
1. A vertical portion fixed to the spine.

2. A horizontal portion comprising the right and left diaphragmatic domes, which are positioned towards the thoracic cage.

Histologically, the diaphragm consists of numerous intercrossed digastric muscles, formed by two parts:
1. A central aponeurotic part known as the phrenic center.
2. A peripheral part composed of muscle tissue.

4.2 Anatomy of the Diaphragm

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4.2.1 Insertions

The diaphragm consists of muscle fibers that radially insert into the lower boundary of the thorax and converge at the phrenic center. Based on their arrangement, these muscle fibers can be distributed into three portions: sternal, costal, and lumbar.

- Sternal fibers originate from two fascicles that arise from the back of the xiphoid process, separated by Larrey's notch.
- Costal fibers consist of six digitations and three arches of Senat. The digitations are chondrocostal, inserting from the seventh to the twelfth ribs and their corresponding cartilages. These fibers originate from the internal surfaces of the cartilages and adjacent areas of the lower six ribs on each side, blending with the fibers of the transverse abdominis. The Senat arches insert into three arcs extending between the tenth and eleventh ribs, the eleventh and twelfth ribs, and the twelfth rib and the first lumbar transverse process.
- Lumbar portion originates from two aponeurotic arches called the medial and lateral arcuate ligaments, and the lumbar vertebrae via two crura.

4.2.2 Quadratus Lumborum and Psoas Arches

The lateral arcuate ligament, also known as the quadratus lumborum arch, crosses over the top of the quadratus lumborum muscle, attaching medially to the transverse process of L1 and laterally to the inferior margin of the twelfth rib. Spasm of the quadratus lumborum muscle can cause pain during lateral flexion, shortening of the ipsilateral leg by up to 1 cm, and lesions of the lower ribs in expiration. Clinically, rib lesions in expiration present as sunken ribs, which are not painful but cause significant energy loss for the body and need correction.

The medial arcuate ligament, also known as the psoas arch, attaches to the external surface of the bodies of L1 and L2 and laterally to the anterior part of the L1 transverse process. It is separated from the crura by the interstice of the sympathetic cord. The psoas aponeurosis establishes a connection between the diaphragm muscle, the thoracolumbar junction, and the hip joint. Psoas muscle spasm is significant in lumbar region pathologies, as the psoas muscle is a factor in fixing disc protrusion due to its insertion on the lateral surfaces of the vertebral bodies from T12 to L4 and the deep portion of the costal processes from L1 to L5.

4.2.3 Crura of the Diaphragm

The diaphragm has two crura that blend with the anterior longitudinal ligament of the spine. The right crus is longer and extends to the body of the L3 vertebra, while the left crus reaches the body of the L2 vertebra. The crura converge at the midline, forming an arch that crosses the anterior surface of the aorta, known as the median arcuate ligament.

The superior surface of the diaphragm is covered by the parietal pleura, and the visceral pleura covers the lungs. Each diaphragmatic dome is associated with the base of the corresponding lung, and the pericardium is intimately attached to the diaphragm, with the heart resting on the central tendon via the pericardium. The inferior surface of the diaphragm is covered by parietal peritoneum, relating to the right side of the liver, the right kidney, and the right adrenal gland. On the left, it relates to the left side of the liver, the stomach fundus, the left kidney, and the spleen.

4.2.4 Relations

The superior surface of the diaphragm is related to the serous membranes of the pleura at the base of the lungs on each side and centrally to the pericardium over the phrenic center via the pericardiophrenic ligament. Inferiorly, most of the diaphragm is covered by peritoneum, and on the right side, it molds to the convex surface of the right liver lobe, connected via the hepatophrenic ligament, and to the right kidney and adrenal gland. On the left, it relates to the left liver lobe, the stomach fundus via the gastrophrenic ligament, the spleen via the phrenosplenic ligament, the colon via the phrenocolic ligament, and the left kidney and adrenal gland.

4.2.5 Phrenic Center

The horizontal portion of the diaphragm is shaped like a cloverleaf with three leaves: anterior, right, and left. The anterior leaf is the most developed, and the right leaf is wider than the left. The phrenic center is formed by two types of fibers called fundamental and associative, organized into two semicircular bands. The phrenic center lies immediately below the pericardium, with the heart resting on its surface.

4.2.6 Diaphragmatic Openings

The diaphragm is perforated in several places, forming three main openings: aortic, esophageal, and caval, along with several smaller openings.

- The aortic opening is the most caudal and posterior, located slightly to the left at the level of L2. It is bounded by the diaphragmatic crura. The aorta and thoracic duct pass through this opening, and occasionally the azygos and hemiazygos veins. The aortic opening is fibrous and

inextensible, preventing alterations in arterial flow. The aorta's position against the lumbar spine, near the line of gravity, protects it from torsional movements.
- The esophageal opening is located in the muscular part of the diaphragm at the level of T12, formed by the separation of fibers of the right crus. The esophagus, sympathetic gastric nerves, vagus nerves, and some lymphatic vessels pass through it. The fascia of the lower diaphragm continues upward in a conical shape, inserting into the esophageal wall 2 cm above the gastroesophageal junction, forming the phrenoesophageal ligament. This ligament limits the upward displacement of the esophagus. The esophageal opening is muscular and contractile, assisting the stomach's cardia in preventing gastroesophageal reflux. This sphincter relaxes after swallowing.
- The caval opening is located in the phrenic center at the level of T8 and T9. The inferior vena cava and the right phrenic nerve's abdominal branch pass through it. The caval opening is contractile, acting as a diaphragm that allows blood to ascend during inspiration by pressure changes, increasing its diameter. During expiration, it relaxes, partially closing to prevent blood from descending.

The accessory openings allow the passage of the sympathetic trunk, the greater splanchnic nerve, the azygos vein, the hemiazygos vein, the lumbocostal triangle (establishing communication between the subperitoneal and subpleural regions), and the sternocostal triangle (the space between the xiphoid process and costal margin through which thoracic vessels pass).

Vascularly, the abdominal branch of the internal mammary artery passes through Larrey's notch. The ascending lumbar vein passes beneath the psoas arch, and the lumbar arteries pass under the arches of the crura.

4.2.7 Innervation

The motor action of the diaphragm is provided by the phrenic nerves, while sensory innervation comes from the lower six or seven intercostal nerves, which innervate the periphery of the muscle.

4.3 Physiology and Biomechanics of the Diaphragm

The exchange of oxygen and carbon dioxide is crucial for life, requiring coordinated and efficient movement among the skeleton, respiratory muscles, and circulatory system.

Respiratory muscles, including the diaphragm, intercostal muscles, accessory muscles, and abdominal muscles, generate negative pressure to facilitate inspiration. During inspiration, the peripheral portion of the diaphragm contracts, moving downward and creating a vacuum in the thoracic cavity. This action straightens the diaphragm's curvature, expands the thoracic cage, increases the vertical diameter, displaces abdominal contents caudally, and increases lung volume with a decrease in pleural pressure. During normal expiration, the thoracic diameters decrease as the inspiratory muscles, including the diaphragm, cease their function, allowing the lungs to expel air.

Viewed from the side, the diaphragm descends further posteriorly than anteriorly, with its highest point at the phrenic center.

During forced inspiration, the diaphragm descends approximately 6 to 10 cm, while during forced expiration, it can reach the height of the fourth costal cartilage. When the diaphragm's muscle fibers contract, the phrenic center descends, increasing the thorax's vertical diameter. This movement is limited by the mediastinal elements and abdominal viscera, creating tension in the pericardium through the pericardiophrenic ligament.

At this point, the phrenic center becomes a fixed point, and the muscle fibers, acting from the periphery, elevate the lower ribs, expanding the lower thorax's transverse diameter. Simultaneously, the sternum lifts the upper ribs, increasing the anteroposterior diameter. Thus, the thoracic volume increases in three dimensions:

1. Vertical diameter by the descent of the phrenic center
2. Transverse diameter by the elevation of the lower ribs
3. Anteroposterior diameter by the elevation of the upper ribs via the sternum

The diaphragm plays a significant role in controlling intra-abdominal pressure, resisting the upward movement of abdominal contents during abdominal muscle contraction. It creates a pneumatic cushion in the lumbar region, reducing injury risk. Additionally, it aids venous and lymphatic drainage through pressure changes between the thoracic and abdominal cavities.

The abdominal visceral masses form a solid block of organs, including solid viscera (liver, spleen, and pancreas) and hollow viscera (stomach, intestines, and colon), which can fill with gases and mechanically impact the diaphragm. The right dome is protected from excessive pressure by the liver, which separates the diaphragm from areas of high pressure in the abdominal viscera.

The right dome must overcome the liver's resistance, which is greater than the resistance faced by the left dome from the stomach during descent. This makes the right crus more robust, with stronger and more fibrous fibers compared to the left dome.

The diaphragm is active in all activities requiring effort, such as sneezing, laughing, crying, vomiting, coughing, urinating, defecating, and childbirth. These actions involve deep inspiration with glottis closure, coupled with a powerful contraction of the trunk muscles.

4.4 Diaphragm and Muscle Chains

According to Leopold Busquet, "muscle chains are circuits of continuity in direction and planes through which the body's organizing forces propagate." There are two types of muscle chains. Straight chains help with the body's static posture, depending on the extension and flexion of the trunk. During flexion, the action of the rectus abdominis muscles causes the pubis to ascend and the sternum to move towards the navel. Simultaneously, the anteroposterior fibers of the perineum pull the coccyx towards the pubis, and the transverse fibers bring the ischium closer together, leading to the opening of the iliac crests.

Anatomically, the convergence point of these forces is the navel and the perineum. The viscera are surrounded by the abdominal wall in front, the perineal wall below, and the diaphragmatic wall above, each represented by fibrous centers: umbilical, perineal, and phrenic.

Extension at the lumbar spine is achieved through the contraction of spinal muscles, causing physiological lordosis. At the thoracic spine, the diaphragm is key for maintaining the body's static posture. It works with the spinal muscles to straighten the thoracic spine, with the diaphragm tending to create lordosis in the first three lumbar vertebrae, while the spinal muscles tend to create kyphosis, resulting in stabilization.

The flexion chain connects with the extension chain at the muscle chain that includes the sternocleidomastoid and the pectoralis minor, continuing towards the back.

Crossed chains ensure rotational movement, allowing the body to move in three dimensions. These chains are oriented towards movement; during rotation, the shoulder moves towards the opposite hip. The anterior crossed chain produces anterior torsion, while the posterior crossed chain produces posterior torsion. The crossed chain consists of muscle fibers connecting the left half of the trunk with the right half, with boundaries at the shoulder and the opposite hip.

The straight chains of extension and flexion and the crossed chains converge at the front at the navel and at the back at the L3 spinous process.

The diaphragm is crucial in the flexion chain due to its anterior fascicles connecting with the rectus abdominis muscles, in the extension chain through its posterior crura, and in the crossed chains through its lateral fascicles. Given the diaphragm's close relationship with both the parietal and visceral planes, dysfunction in one can affect the other.

"Restore freedom of movement to any structure, and it will fully perform its functions."

4.5 Diaphragm and Myofascial Meridians

According to Thomas Myers, myofascial lines are tension pathways that connect muscles with fascia, providing tension and movement to the myofascial network around the bones. These lines help maintain postural compensation in response to stability imbalances.

Several types of myofascial lines exist in the body:

- Superficial Back Line: Located on the posterior side of the body, it supports the body in extension.
- Superficial Front Line: Found on the anterior side of the body, it maintains body flexion and stabilizes balance along with the superficial back line (extension).
- Lateral Line: Situated on the lateral aspect of the body, it balances the anterior and posterior regions, bilaterally equalizing the right and left sides. It also anchors the lower limbs to the trunk and participates in lateral flexion and trunk rotation.

- Spiral Line: This line crosses over at the shoulder area posteriorly and at the navel area anteriorly, linking the body from the base of the skull to the feet. It compensates for and maintains torsions, rotations, and lateral shifts of the body.
- Arm Lines: These lines function to move the arms closer to or farther from the trunk.
- Functional Lines: Beginning from the arms, they run through the thorax to the pelvis and the opposite lower limb. Their primary role is to counterbalance or propel their counterpart on the opposite side, especially in sports activities like throwing a baseball, with minimal involvement in maintaining upright posture.
- Deep Front Line: Positioned between the lateral lines, superficial front line, superficial back line, and spiral line, it is known as the myofascial heart of the body.

The deep front line elevates the medial arch of the foot, stabilizes each segment of the lower limbs, supports the lumbar spine from the front, stabilizes the thorax, and facilitates relaxation and expansion during breathing, while also maintaining the balance of the neck and head. This line passes between the diaphragm and the psoas muscle as it extends from the lower limbs to the occipital region, traversing the thoracic viscera. Therefore, an injury along the deep front line could impact intrathoracic organs and the diaphragm muscle.

Diaphragmatic breathing and hip adduction are exclusive functions of the deep front line. In its superior pathway, the deep front line follows the diaphragm's fibers, surrounding the pericardium, mediastinal structures (parietal pleura, esophagus, and pulmonary vessels), and reaching the occipital region. Manipulation of intrathoracic viscera can be performed indirectly through the axillary region.

4.6 Diaphragm and Craniosacral Movement

The craniosacral system is a physiological system with its own rhythmic activity, linked to the central nervous system, autonomic nervous system, neuromusculoskeletal system, and endocrine system. This system comprises the meninges, the bony structures to which the meninges attach (including the sacrum), cerebrospinal fluid (CSF), and the structures involved in CSF production and reabsorption.

According to Dr. John E. Upledger, there are transverse diaphragms that can influence craniosacral movement. These diaphragms represent a shift from longitudinal to transverse muscle fibers and function to separate structures and protect organs. The body's transverse diaphragms include the craniosacral, thoracoabdominal, and pelvic diaphragms.

The cervico-thoracic diaphragm allows the passage of cervical vessels, and its dysfunction affects craniosacral movement due to its connection with the vertebrae and the base of the skull. The thoraco-abdominal diaphragm is crucial because it separates the thoracic cavity from the abdominal cavity and is related to many organs. When the diaphragm contracts, intrathoracic pressure decreases, causing the tendinous center and the pericardium (via the pericardiophrenic ligament) to be pulled downward. The pericardium's connection through the fascia to the carotid sheath and the base of the skull means that diaphragm dysfunction can reduce craniosacral movement. This reduction can lead to fatigue, muscle pain, toxin buildup, depression, and general discomfort.

The pelvic diaphragm supports pelvic viscera, elevates the pelvic floor, resists increases in intra-abdominal pressure, and maintains vaginal tone. Dysfunction in this diaphragm, due to its connection to the sacrum, can cause flexion in the craniosacral system.

Craniosacral movement relies on the motion of the brain and spinal cord, the fluctuation of CSF, the movement of intracranial and intraspinal membranes, and the synchronized mobility of the occiput with the sacrum through the dura mater. Since the diaphragm attaches to the dorsal vertebrae, restricted movement of the diaphragm can limit the movement of intraspinal membranes, disrupting the harmony of craniosacral movement.

4.7 Diaphragm and Pericardium: Dr. David Servan-Schreiber and Monserrat Gascon's Perspective

Monserrat Gascon emphasizes the significant relationship between the pericardium and the diaphragm from an osteopathic perspective. The pericardium, attached to the diaphragm's central tendon via the pericardiophrenic ligament, mediates the interaction between the diaphragm and other bodily structures. This connection implies that movements and tensions in the diaphragm directly impact the pericardium and vice versa.

Gascon highlights the holistic importance of this relationship, noting that restrictions or dysfunctions in the diaphragm can lead to disturbances in the pericardium. These disturbances can subsequently affect cardiovascular health, breathing, and overall bodily harmony. By considering the pericardium and diaphragm together, osteopathic and therapeutic practices can ensure a more comprehensive approach to health and wellness. This integrative view underscores the need to address both structures to maintain optimal physiological function and balance.

David Servan-Schreiber, MD, PhD in his book The Instinct to Heal shares the following.

"Fear causes the pericardium to react. When it contracts, it pulls on the stellate ganglion, which in turn sends sympathetic information to the cardiorespiratory center in the brainstem. From there, the stimulus continues to the thalamus and reaches the amygdala and cerebral cortex."

4.8 Visceral Diaphragm: Jean Pierre Barral´s Perspective

Understanding the connections between organs and the diaphragm is essential for comprehending dysfunctions.

Pulmonary Level: The pulmonary dome attaches to the cervicodorsal junction through the cervicothoracic fibrous septum. The pulmonary ligament extends from the hilum towards the diaphragm, and medially it is connected to the esophagus.

Pericardial Level: The pericardium is secured by the superior sternopericardial ligament above and in front, the vertebropericardial ligament above and behind, the right and left phrenopericardial ligaments below and behind, the inferior sternopericardial ligament below and in front, and the anterior phrenopericardial ligament below.

Esophageal Level: In its thoracic portion, the esophagus is associated with the trachea, left main bronchus, pleura, pericardium, vertebral column, aponeurosis, paravertebral muscles, left diaphragmatic crus, aorta, and the lower part of the left lung.

Abdominal Level: The abdominal cavity has a superior base (diaphragm), an inferior base (perineum), a posterior part (muscles and spine), and an anterior part (muscular structures). It contains intraperitoneal, retroperitoneal, and pelvic viscera.

- Intraperitoneal Visceral: Surrounded by peritoneum, which is not distensible but deformable, these organs are held together by intracavitary pressure and separated by intraperitoneal fluid.
- Retroperitoneal Viscera: Located behind the parietal peritoneum and in front of the muscular and bony structures, they are held in place by intracavitary pressure and intraperitoneal turgor.
- Pelvic Viscera: Situated below the peritoneal viscera in the pelvis.

Diaphragmatic movement is crucial to prevent adhesions between abdominal viscera. Jean-Pierre Barral emphasizes the importance of visceral movement and how restrictions in the diaphragm can affect the mobility of internal organs, leading to various dysfunctions. The abdominal viscera connect to the diaphragm through several structures:

Hepatic Level
- Coronary Ligament: Connects the posterior liver surface to the diaphragm, becoming the left and right triangular ligaments at its lateral insertions.
- Falciform Ligament: Connects the superior and anterior liver surface to the diaphragm.
- Inferior Vena Cava: Adheres to the phrenic opening and is connected to the liver via the suprahepatic veins.
- Lesser Omentum: Extends from the coronary ligament, linking the liver with the esophagus, stomach, and first part of the duodenum.

Gastric Level: The stomach's inferior surface relates to the diaphragm and indirectly to the pleura, lungs, and ribs. It also has direct connections with the liver, adrenal capsule, pancreas body and tail, transverse colon, and thoracolumbar spine (T10-L1). The greater omentum, attached to the diaphragm via the phrenicocolic ligament, connects the stomach with the transverse colon. The phrenicogastric ligament, a supporting structure for the stomach, links its posterior surface to the diaphragm.

Renal Level: The posterior surface of the kidneys rests against the diaphragm, with direct connections to the psoas and quadratus lumborum muscles. The right kidney's anterior surface is connected to the right colic angle of the second part of the duodenum and the liver's inferior surface via the hepatorenal ligament. The left kidney relates to the pancreas tail, spleen, stomach, transverse colon, splenic flexure, and small intestine.

Splenic Level: The spleen is related to the diaphragm externally, behind and above; internally, it is connected to the stomach, and below, to the kidney, left adrenal gland, and transverse mesocolon. The phrenocolic ligament serves as the suspensory ligament of the spleen.

4.9 Functional Alterations of the Diaphragm

Proper visceral function depends on physiological mobility, vascularization, and autonomic innervation. The diaphragm is a crucial pivot point in diagnosing and treating visceral osteopathy, as it transmits thoracic fixations to the abdomen. French osteopaths Jean-Pierre Barral and Pierre Mercier identified two types of organ movements:

1. Visceral Mobility: Movement of the organs in response to external forces. These forces, such as the voluntary movement of the diaphragm and the involuntary beating of the heart, push and pull the organs.
2. Visceral Motility: The inherent, individual movement of each organ, occurring along specific axes and amplitudes, typically at a frequency of 6-8 cycles per minute. This two-phase movement involves "expir," where the organ moves towards the median axis of the body, and "inspir," where it moves away, reflecting developmental and embryological migration patterns. Visceral motility is perceptible to the touch but requires specific training to detect.

Viscera are enveloped by serous membranes lubricated by serous fluid, allowing organs to glide over each other during trunk movements, costal respiration, and the Primary Respiratory Movement. When an organ's movement is restricted due to abnormal muscle tone, adhesions, or displacements, it affects other organs, muscle membranes, fascias, and bony structures.

Disruption in diaphragmatic mobility decreases visceral mobility, leading to poor circulation, secretion buildup, and transit disturbances. Dysfunction of organs in contact with the diaphragm impacts its function, and vice versa.

Osteopathic pathologies may arise from dysfunctions in physiological movements, including:

- Musculoskeletal Dysfunctions: Visceral connections to bone, vertebral, muscular, and lumbopelvic structures mean that dysfunctions can affect visceral mobility.
- Visceral Fixations: Adhesions form due to inflammation between serous layers or post-surgical procedures.
- Ligamentous Fixations: Occur post-ptosis.
- Poor circulation can lead to inadequate irrigation and lymphatic drainage, resulting in organ congestion.
- Vertebral blockages or fascial tension at an organ's nerve plexus can cause viscero- or angiospasms.
- Bone structure dysfunctions can lead to diaphragmatic dysfunctions, such as:
  - High lumbar vertebrae dysfunctions can cause diaphragmatic spasm.
  - Lower thoracic vertebrae and rib dysfunctions can lead to diaphragmatic spasm.
  - Blockages or dysfunctions necessitate the body’s adaptive capacity through muscle chains, requiring significant energy expenditure, resulting in muscle fatigue and imbalance.

The body's interconnected fascial system means tension anywhere can cause fascial tension, leading to dysfunctions and pain triggered by reflex pathways and muscular tension. Visceral fascia (pleura, pericardium, peritoneum) involvement in musculoskeletal movement alterations, and vice versa, are significant.

Given the diaphragm's multiple direct and indirect relationships with thoracoabdominal viscera, diaphragm spasms can:
- Impact thoracic structures, including the lungs, pericardium, esophagus, vena cava, aorta, trachea, left main bronchus, first rib, thoracic vertebrae, and vagus nerves.
- Affect abdominal organs like the liver, stomach, duodenum, transverse colon, kidneys, adrenal glands, spleen, pancreas, and lumbar spine.

Diaphragmatic descent can cause pericardial traction, resulting in heart descent, liver ptosis, stomach and intestinal displacement, and all abdominal viscera, disturbing pelvic-lumbar statics, causing hiatal hernia, lumbalgia, cystitis, colitis, and sigmoiditis.

Diaphragm immobilization due to liver hypertrophy can lead to vertebral injury at T4-T5, craniosacral movement alterations, and first rib inspiration injury.

Thoracoabdominal visceral dysfunctions can lead to diaphragmatic dysfunction. Diaphragm dysfunctions can affect craniosacral movement and vice versa through lumbar vertebral attachments, impacting dural movement and affecting the sacrum, skull base, and entire cranial membranous complex.

4.10 Diaphragm Mobility Tests

4.10.1 Patient Position: Supine

Therapist Position: Standing at patient´s knee height, placing hands on both sides of the rib cage, in a lateral rotational movement to the right and left.

Objective: To assess how much tension is around and, in the diaphragm itself, when sliding it to the right and left.

During the assessment, the following can be observed:

- Compare range of motion between right and left.
- Perceive the easiness and flow of the movement.
- Perform the assessment only once or twice, doing it more than that becomes a treatment.

4.10.2 Patient Position: Supine

Therapist Position: At the head of the patient, placing hands on the lower part of the thorax with thumbs positioned below the costal margin facing the navel. The patient is asked to take deep breaths in and out.

Objective: To verify the physiological movement of the diaphragm muscle, which ascends during inspiration and descends during expiration.

During the assessment, the following can be observed:
- Normal Diaphragm:Fingers move up synchronously during inspiration and down during expiration.
- Diaphragm in Inspiration: Fingers ascend during inspiration but do not descend during expiration.
- Diaphragm in Expiration: Fingers do not ascend during inspiration but descend during expiration.

4.11 Diaphragm Techniques

This section reviews various techniques for diaphragm normalization.

4.11.1 Supine Diaphragm Normalization:

Patient Position: Supine, with the head slightly elevated and legs flexed.

Therapist Position: At the head of the patient, grasping the lower thoracic cage with separated fingers. During the inspiration phase, apply upward and oblique traction, maintaining this during expiration. After several respiratory cycles, when the ribs no longer elevate, instruct the patient to pull in their abdomen at the end of expiration while the therapist performs the final elastification.

Unilateral Variant: Used when one hemidiaphragm is affected. Perform the same as the supine normalization but focus on mobilizing the affected hemidiaphragm first in the direction of the lesion and then in the direction of correction.

4.11.2 Supine Diaphragm Recoil Technique:

Patient Position: Supine

Therapist Position: At patient´s knee height place both thumbs in the lower border of the thoracic cage at the line projecting from the nipple. Follow the patient´s breathing and during expiration deepen both thumbs in a gentle but firm fashion, while keeping them in such depth during the face of inhalation, continue deepening both thumbs gently in every exhalation for at least 3 times as well as keeping the depth of the thumbs despite the fact of the pushing out of the abdomen wall when patient in inhaling. At the fourth exhalation, at the very end ask the patient to completely exhale and at the end of the exhalation phase, recoil both thumbs rapidly out of the lower border of the thoracic cage.

4.11.3 Seated Diaphragm Normalization:

Patient Position: Seated and leaning slightly forward.

Therapist Position: Standing behind the patient, supporting the patient's thorax. Both hands grasp the costal arch caudally, with fingertips palpating the diaphragm's insertions. Maintain bimanual pressure on the diaphragm while moving the thorax to the right and left, producing a muscle relaxation effect.

5. Conclusions and Recommendations

The diaphragm is the most critical muscle for respiration, separating the thoracic and abdominal cavities. It has numerous visceral connections that allow for dynamic interactions with internal organs and is part of the myofascial lines that maintain body posture. As one of the key diaphragms in craniosacral and visceral osteopathy, any mobility disorders in the diaphragm can affect the thoracoabdominal viscera and craniosacral movement.

Diaphragmatic dysfunction can lead to issues in the vertebrae where it attaches and in directly related muscles such as the psoas and quadratus lumborum, as well as indirectly affecting other spinal and abdominal muscles. Treatment of the diaphragm is an essential component of craniosacral and visceral osteopathy protocols. Addressing diaphragmatic issues can help restore normal function and improve overall bodily harmony and health.

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Bibliography

1. Busquet, Michele, and Leopold Busquet. 2010. Las cadenas fisiológicas, Tomo VII. Editorial Paidotribo. Pages 176-177.
2. Busquet, Leopold. 2004. Cadenas musculares, Tomo I. 7th edition. Editorial Paidotribo. Pages 15-91.
3. Busquet, Leopold. 2010. Las cadenas musculares, Tomo II. 7th edition. Editorial Paidotribo. Pages 84-91.
4. Curtil, Philippe, and Andrea Métra. 2004. Tratado práctico de Osteopatía visceral. Editorial Paidotribo. Page 24.
5. Essig-Beatty, D. 2008. "The Life and Times of Andrew Taylor Still, Founder of Osteopathic Medicine." International Journal of Osteopathic Medicine Vol. 11, Pages 69-70.
6. Gilberto, Gutierrez. 2004. Principios de anatomía, fisiología e higiene: Educación para la salud. Editorial Limusa S.A. Pages 235-236.
7. Hamonet, C. 2003. "Andrew Taylor Still and the Birth of Osteopathy." Joint Bone Spine Vol. 70, Pages 80-84.
8. Johannes, W. Rohen, and Elke Ütsen-Precoll. 2008. Embriología funcional: Una perspectiva desde la biología del desarrollo. 3rd edition. Editorial Médica Panamericana. Pages 84-87.
9. Latarjet, and Ruiz Liard. 2004. Anatomía humana. 4th edition. Editorial Médica Panamericana. Pages 900-906.
10. Leopold Busquet. 2004. Cadenas musculares, Tomo I. 7th edition. Editorial Paidotribo. Pages 15-91.
11. Manuel de fisioterapia. Neurología, pediatría y fisioterapia respiratoria, Módulo II. Editorial Mad. S.L. 2004. Pages 432-434.
12. Medina, Ortega. 1997. Tratado de Osteopatía integral. Editorial Escuela de Osteopatía Medina. Pages 34, 126-132, 133, 145-147.
13. Miguel Palastanga, Derek Ield, and Roger Soames. 2000. Anatomía y movimiento humano. Estructura y funcionamiento. 3rd edition. Editorial Paidotribo. Pages 434-436.
14. Myers, Thomas W. 2010. Vías anatómicas. 2nd edition. Editorial Elsevier Masson. Pages 1-5, 73-75, 96-97, 114-115, 130-131, 149-150, 170-173, 178-180, 197-198.
15. Parsons, J. 2006. Osteopathy Models for Diagnosis, Treatment and Practice. Elsevier Limited. Pages 4-5.

16. Philippe Curtil, Andrea Métra. 2004. Tratado práctico de Osteopatía visceral. Editorial Paidotribo. Page 24.
17. Ricard, François. 2003. Tratamiento osteopático de las lumbalgias y lumbociáticas por hernias discales. Editorial Médica Panamericana. Page 100.
18. Ricard, François. 2005. Tratamiento osteopático de las algias del raquis torácico. Editorial Médica Panamericana. Pages 29-32, 82-85, 157.
19. Ricard, Jean, and Luc Sallé. 2009. Tratado de osteopatía. 3rd edition. Editorial Médica Panamericana. Page 122.
20. Sadler, T. W. 2006. Langman: Embriología Médica. 5th edition. Editorial Médica Panamericana. Pages 159-163.
21. The effect of osteopathic manipulative techniques on diaphragm movement and respiratory function in asymptomatic subjects. Wendy S. 2009. A research project submitted in partial fulfilment of the requirements for the degree of Master of Osteopathy, Unitec Institute of Technology.
22. Upledger, John, and Jon D. Vredecoogd. 2007. Terapia cráneo sacra I. 2nd edition. Editorial Paidotribo. Pages 73-89.
23. Williams, P., and R. Warwick. 2005. Gray Anatomia. Salvat Editores, Vol. I. Pages 606-608.
24. Ylinen, Jari. 2009. Estiramientos terapéuticos. Elsevier Masson. Pages 226-227.
25. David Servan-Schreiber. 2005. The Instinct to Heal, Rodale Books.