



23.2. DIAPHRAGM ABDOMINALIS

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23.2.1. Learning objective Diaphragm Abdominalis

The Diaphragm Abdominalis has a much broader function than 'just' breathing. It has an energizing effect on various digestive / metabolic organs. In addition, this diaphragm is important for the static, both in standing and in movement.

This Diaphragm also plays a social role, through its role in speaking, singing and expressing many emotions, such as sobbing, screaming and laughing.

23.2.2. Macro-anatomy Diaphragm Abdominalis

- • Dome-shaped muscle, consists of three muscular parts and a tendon part. Separates the Thorax from the Abdomen.
- • Location and shape depend on:
 - breathing.
 - position of body.
 - filling state of the organs.
 - typology.
- • Localisation:
 - Right dome: 4th intercostal space.
 - Left dome: 5th intercostal space.
- • When inspired, the Diaphragm sinks 1 to 2 intercostal spaces, pars Sternalis and the visceral mass act as a fixed point.

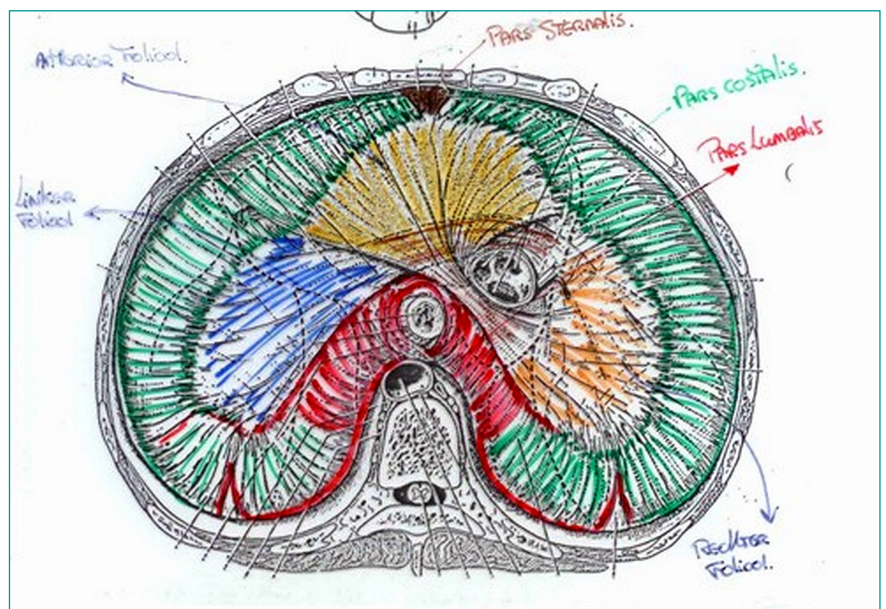
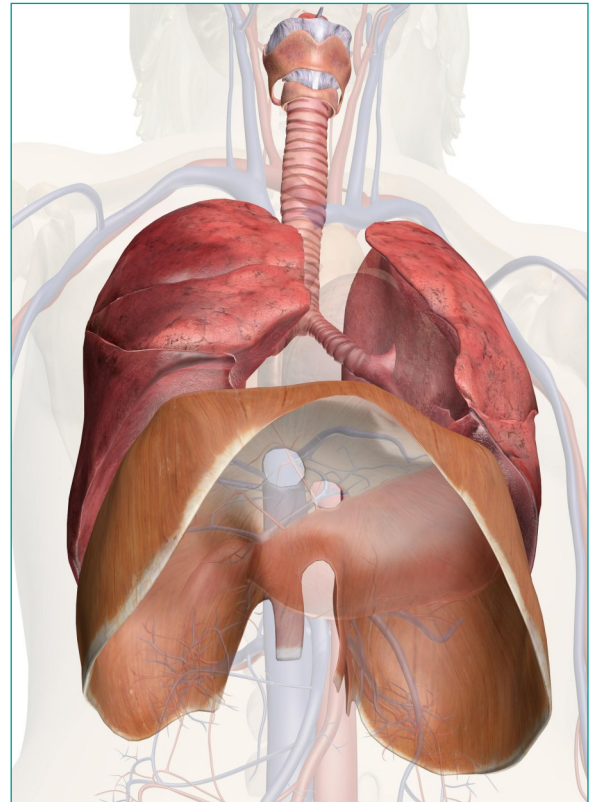
Horizontal part:

Pars Sternalis

- • Sutures to processus Xyphoideus and Centrum Tendineum.
- • Two vertical bundles, separated by an avascular opening: hiatus Phreno-Xyphoideus (fissura of Marfan).

Pars Costalis

- • Rises on the inside of Costae-VII - XII, alternating with the origins of the M. Transversus.
- • Costae-VII, VIII, IX: chondral attachment.
- • Costae-X, XI, XII: costal, osseous attachment, with 2 fibrous bridges or arcades of Senac, which unites Costa XII to Costa-XI and Costa-XI to Costa-X.
- • Pars Costalis is separated from Pars Sternalis by an opening: trigonum Sterno-costalis (fissura of Larrey).



Vertical part:

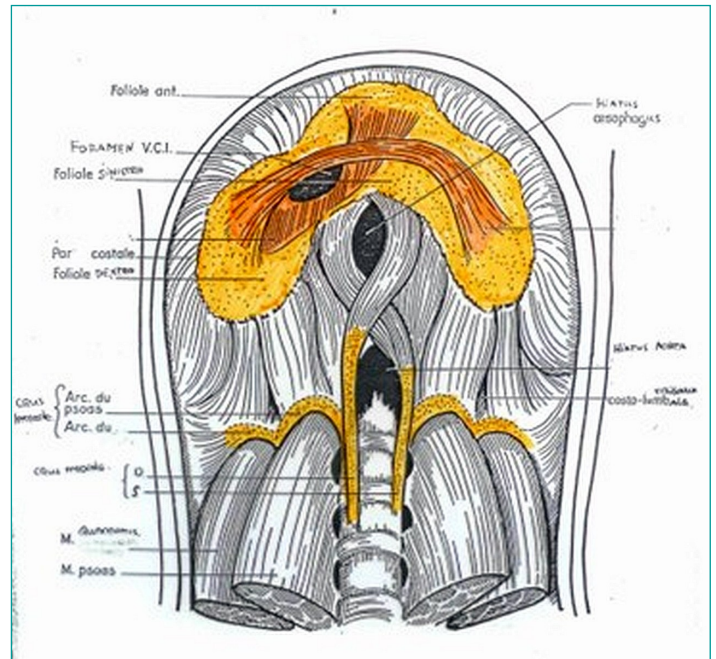
Pars Lumbalis

Crus Medialis:

- Insertions on the anterior side of the lumbar vertebrae and the intervertebral disc.
- Crus medial sinistrum:
 - Anterior side L₁ - L₂.
 - Insertion M. van Treitz.
- Crus medial dextrum:
 - Anterior side L₁ - L₂ - L₃.

The crura rise to cranial, connect with each other and form a fibrous structure for the Aorta and the Ductus Thoracicus. (at T₁₂). This creates the Hiatus Aorticus.

Then they start to intersect and form the muscular hiatus Oesophagus, a contractile opening.

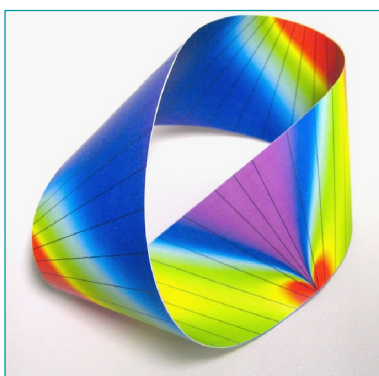


Crus Lateralis:

Forms the arcade of the Diaphragm.

- Lig. Arcuatum medialis (psoasarcade or arcus Lumbo-Costalis medialis) progresses from lateral side corpus L₁ to processus Transversus of L₂: passing through M. Psoas Major.
- Lig. Arcuatum lateralis (quadratus arcade or arcus Lumbo-Costalis lateralis) proceeds from processus Transversus L₁ to the top of Costa-XII; passing through M. Quadratus Lumborum.

Between pars Lumbalis and pars Costalis lies the trigonum Lumbo-Costale in which lymphatic trunci proceed. (connection Pleura with renal fasciae Renalis)

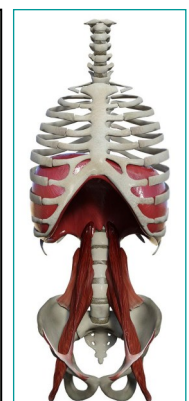


Intermezzo Crus Diaphragmalis:

The Crus Medialis, through its course, forms a lemniscate, or rather a Möbius Ring. A symbol of 'eternity', but in this functional sense a symbol of 'the law of conservation of energy'. The course is such that all the energy required for the contraction of pars Lumbalis & Costalis actually flows back to the Diaphragm Abdominalis. In other words, the muscle-tendon plate hardly consumes any energy when contracting. It is also logical that there is no such thing as 'muscle pain of the Diaphragm'.

From an osteopathic perspective, all structures are interesting, but we will briefly highlight the Crus Lateralis. It forms arcades (arches) under which important muscles run: the M. Psoas Major and the M. Quadratus Lumborum. Both are very active in almost every human activity. Both muscles are also closely 'connected' to both Ren and the Colon. At the lateral side of this we find the arcades of Senac.

The relationship between functional structures, such as Diaphragm Abdominalis, Musculi & Viscera, is abundantly clear. Lack of freedom (Mobility) of one affects the other. In the case of the Diaphragm Abdominalis, this is both functional (breathing, digestion) and static (posture) and dynamic (movement). We will discuss the influence of the Diaphragm Abdominalis on the statics later.



Osteopathy in the Visceral Field

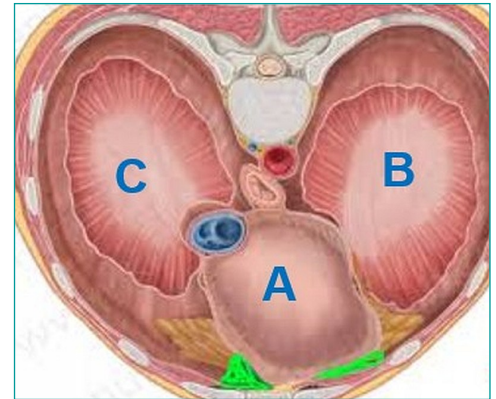
Part 4: from Endocrinology via Diaphragmata up to BBRS.

23. Diaphragmata. 2. Diaphragm Abdominalis.



Centrum Tendineum Diafragma Abdominalis

The peripheral muscle fibers come together in the centrum Tendineum. It is cloverleaf shaped with three folioli (leaves) and the stem is formed by the vertebral column.

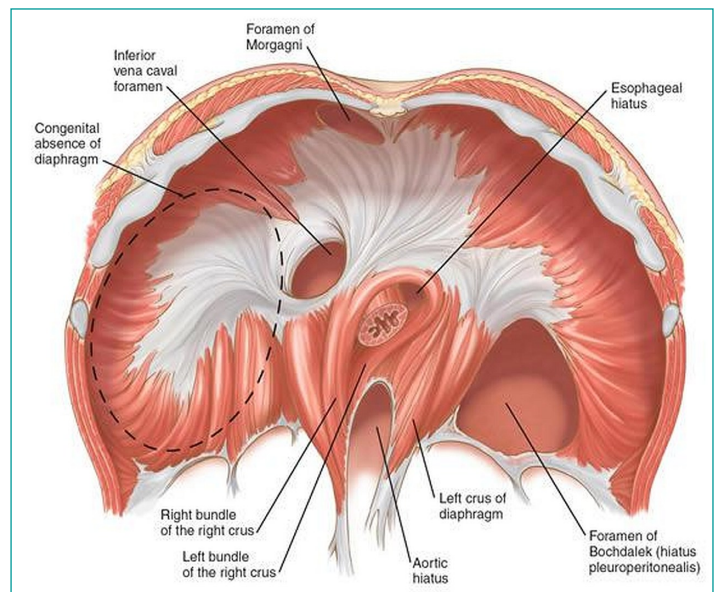
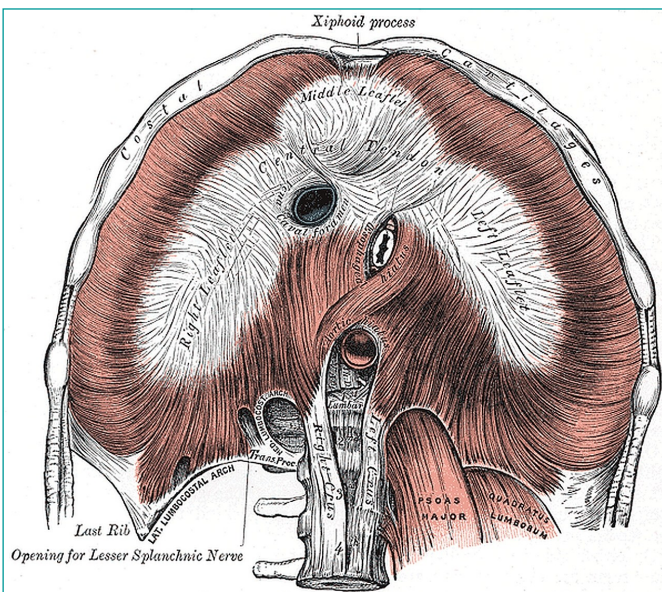


- a. Anterior Foliolum: receives bundles from pars Sternalis and the anterior pars Costalis.
- b. Right Foliolum: receives bundles of posterior pars Costalis and pars Lumbalis.
- c. Left Foliolum: is smaller and receives the same bundles.

The composition of the centrum Tendineum is formed by two types of fibers:

- Superior semi-circular band, connects the anterior foliolum and the right foliolum on top of the centrum Tendineum.
- Inferior semi-circular band, connects the right foliolum to the left foliolum.

These two bands form the fibrous foramen Vena Cava Inferior.

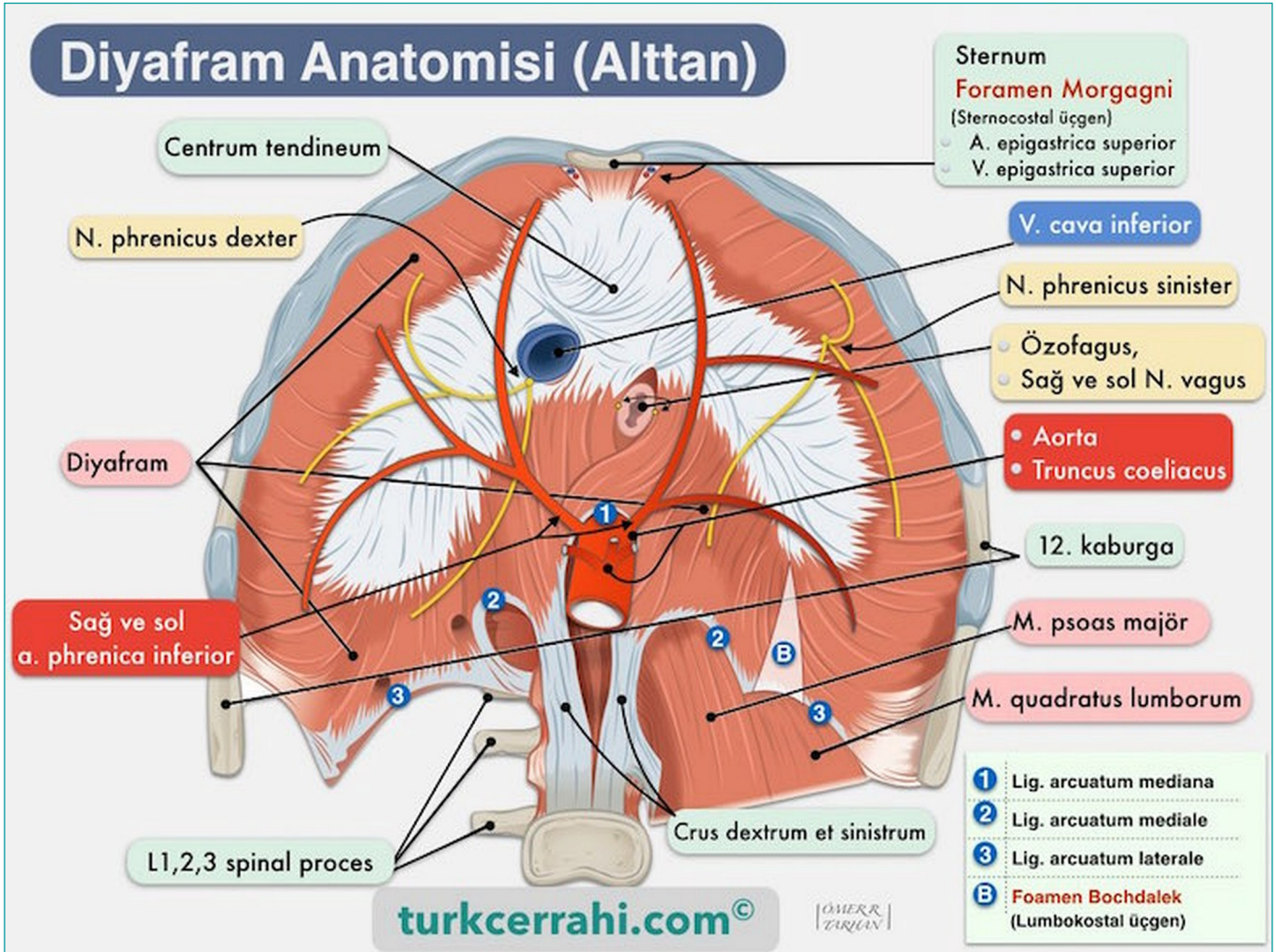


Intermezzo Lemniscate & energy:

Again, pay attention to the course of the fibers. The superior semi-circular band forms a lemniscate with the inferior semi-circular band. Thus, on the one hand, the three folioli are connected to each other, but on the other hand, the course is such that the energy of the contraction of muscular parts (pars Costalis & Lumbalis) flows back into the Abdominalis Diaphragm itself. In addition, the fibrous opening for the VCI guarantees that it will not be squeezed or shut.



Apertures Diaphragm Abdominalis



Hiatus Aorticus:

- • between the two medial crura.
- • is slightly oriented to the left.
- • is fibrous and not extendable.
- • is located at T₁₂.
- • passage Aorta and ductus Thoracicus, which rises behind the Aorta.

Hiatus Oesophagus:

- • formed by the intersection of the medial bundles of the crura.
- • is slightly to the left of the median line.
- • is muscular and stretchable.
- • is located at T₁₀.
- • passage of Oesophagus, connected by the Mm. of Rouget and Juvara (see Part 1, Section 4.2. Macro-Anatomy Oesophagus & Section 5.10. Osteopathy Gaster).
- • also grants passage to the two Nn. Vagi. (left anterior, right posterior).

Osteopathy in the Visceral Field

Part 4: from Endocrinology via Diaphragmata up to BBRs.

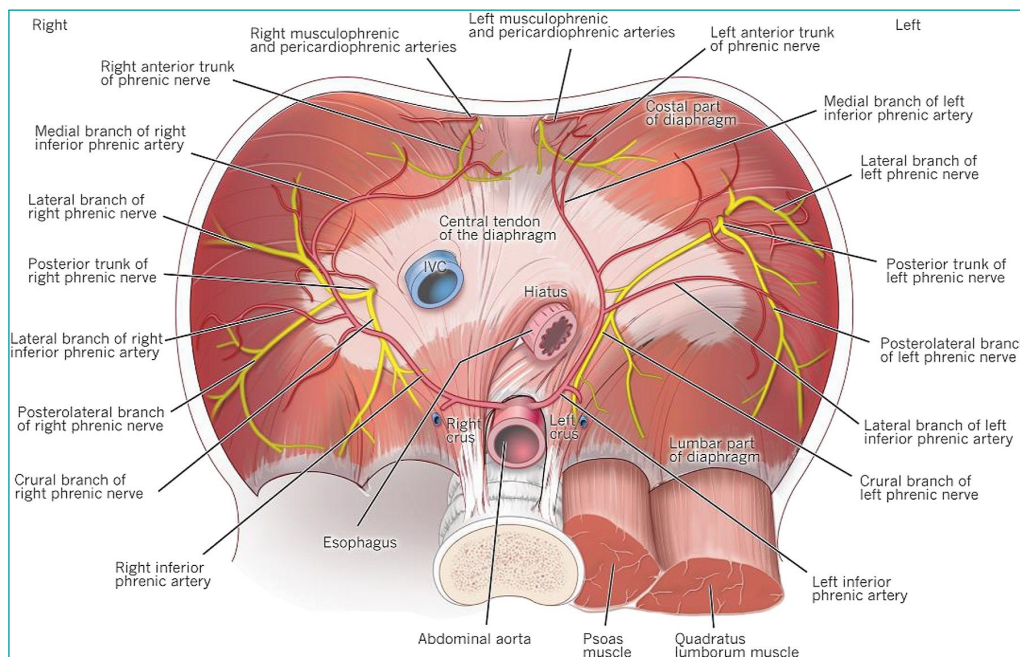
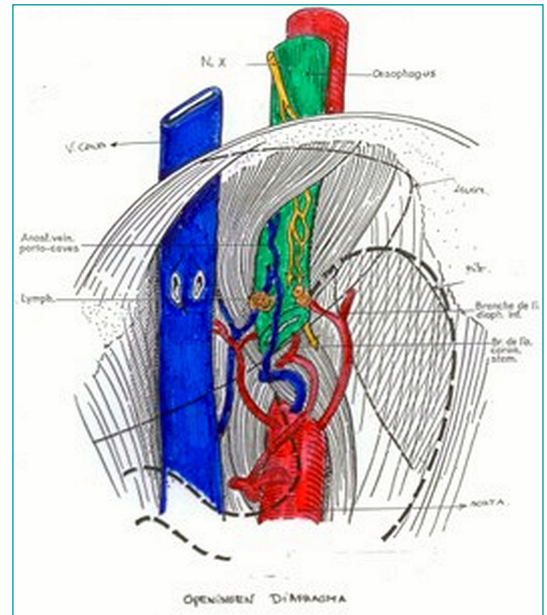
23. Diaphragmata. 2. Diaphragm Abdominalis.

Foramen Vena Cava:

- in Centrum Tendineum, slightly right-orientated.
- formed by two semi-circular straps.
- is fibrous and not stretchable.
- is located at T₉.
- passage to Vena Cava Inferior, connected to foramen by fibrous strands.
- also allows passage to the right N. Phrenicus.

Additional openings:

- Fissura of Marfan: in pars Sternalis.
- Fissura of Larrey fissure: trigonum Sterno Costalis.
- Trigonum Lumbo-Costalis: pars Lumbalis & pars Costalis.
- Various small openings for, among other things:
 - Nn. Splachnici major, minor, inferior.



From an osteopathic perspective, but also from a functional point of view, the openings in the Diaphragm are important. They provide passage to a number of essential transport systems: Aorta, Vena Cava Inferior, Ductus Thoracicus, N. Vagus (2x), Sympathetic chain, Nn. Phrenici, Nn. Splachnici.

Free passage of these transport systems is of great importance:

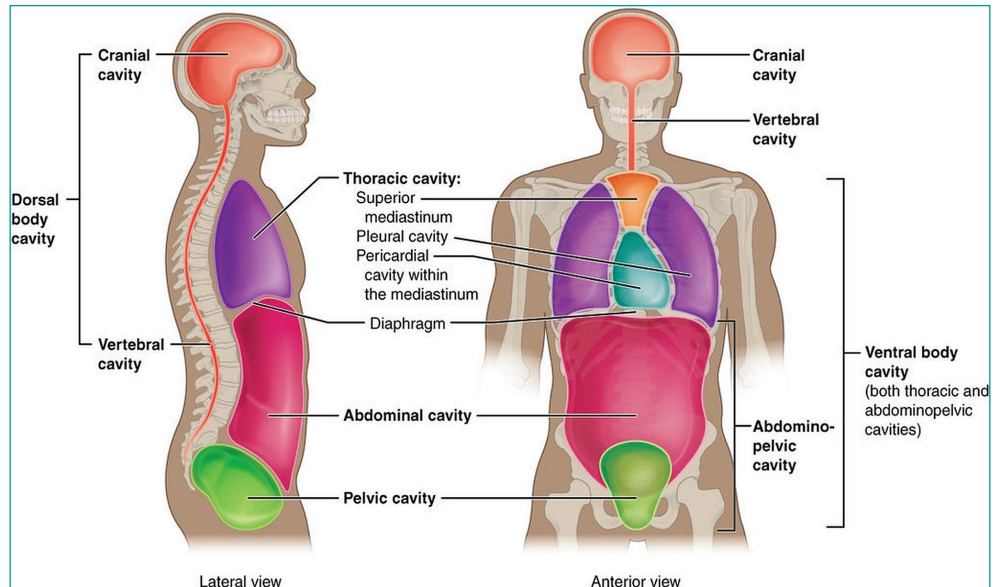
- *The Aorta and the V. Cava Inferior speak for themselves in this case.*
- *Ductus Thoracicus transports the fatty acids from the Intestinum to the Cor.*
- *The Nn. Vagi take care of the abdominal organs, both efferent and afferent.*
- *The sympathetic nerves for the fight, flight, fright response.*

For the free passage, the visceral sliding surfaces are important (Hepar, Gaster, Cor, Pulmones) and the ligamentous connections linked to them.

23.2.3. Surrounding Diaphragm Abdominalis

The Diaphragm Abdominalis is in itself a very thin dividing wall, both above (cranial) and below (caudal) we find various organs and their connections with the Diaphragm Abdominalis.

All connections are peritoneal continuations, either as Peritoneum itself, ligamenta, fascia, or otherwise. This means that the physiological function of the Peritoneum also applies here. (see Part 2, Section 13.8.).



From an osteopathic perspective, the organs form gliding surfaces, which are therapeutically essential for proper function of the Diaphragm Abdominalis. Therapeutically also known as:

- **Espace Portal:** the sliding surface between Hepar and Cor with the Diaphragm as a thin partition. But in between peritoneal sliding surfaces:
 - ◊ between Hepar and Diaphragm: bilayer Peritoneum (visceralis Hepar & Parietalis Diaphragmatica) with fluid (oil) in between.
 - ◊ between the Epicardium and the pericardial junction with the Diaphragm, equally with oil.
- **Espace Gastrique:** between Gaster and Cor, with the Diaphragm in between, with the following gliding surfaces:
 - ◊ between Gaster and Diaphragm: double Layer Peritoneum (Visceralis & Parietalis) and Liquid (Oil).
 - ◊ between the Epicardium and the pericardial junction with the Diaphragm, equally with oil.
- **Espace Pulmones Dextra et Sinistra:** sliding surfaces on the more lateral side:
 - ◊ Between Hepar and Diaphragm (see above) and between Pleura visceralis & Pleura parietalis.
 - ◊ Between Lien and Diaphragm and between Pleura visceralis & the Pleura parietalis.

These gliding surfaces are the 'to be or not to be' for the optimal functioning of the Diaphragm and thus free breathing. This is in addition to the Tension-Tonus ratios of the Thorax and the Abdomen.

In practical terms, these sliding surfaces are a good starting point for patients with respiratory problems, such as respiratory distress, dyspnoea d'effort, shortness of breath or however we use the medical terminology. Especially given the problems surrounding Covid-19, the so-called 'long Covid', often seems to be located around these sliding surfaces. This is a secondary phenomenon: that is, the problems of the sliding surfaces were already there, but the Covid-19 virus is particularly prevalent in this area, in particular Membrana Broncho-Pericardiaca of Hayeck.

All the more a point of attention for osteopathic intervention:

- ⇒ First of all, to clear the sliding surfaces in all possible mobility problems.
- ⇒ Then the correct breathing exercises, appropriate for the patient, for example Qi Gong.
- ⇒ Periodic inspection of these sliding surfaces.
- ⇒ Intervention where necessary.

23.2.5. Micro-Anatomy Diaphragm Abdominalis

The three-dimensional microstructure of the Diaphragm in rats has been studied to know the morphological basis, through which peritoneal fluids pass through the Diaphragm to penetrate the pleural cavity.

The peritoneal and pleural surfaces of the Diaphragm are covered with mesothelial cells and dotted with numerous microvilli. There are many circular gaps between mesothelial cells on the peritoneal side of the Diaphragm.

The subperitoneal connective tissue contains voluminous, irregularly shaped lymphatic vessels.

The results indicate that peritoneal fluid can flow directly through stomata and indirectly through the intercellular gaps between endothelial and mesothelial cells into the lymphatic vessels and then drain into the subpleural lymphatic vessels. The probable mechanisms by which a hydrothorax may occur during continuous ambulatory peritoneal dialysis were discussed.

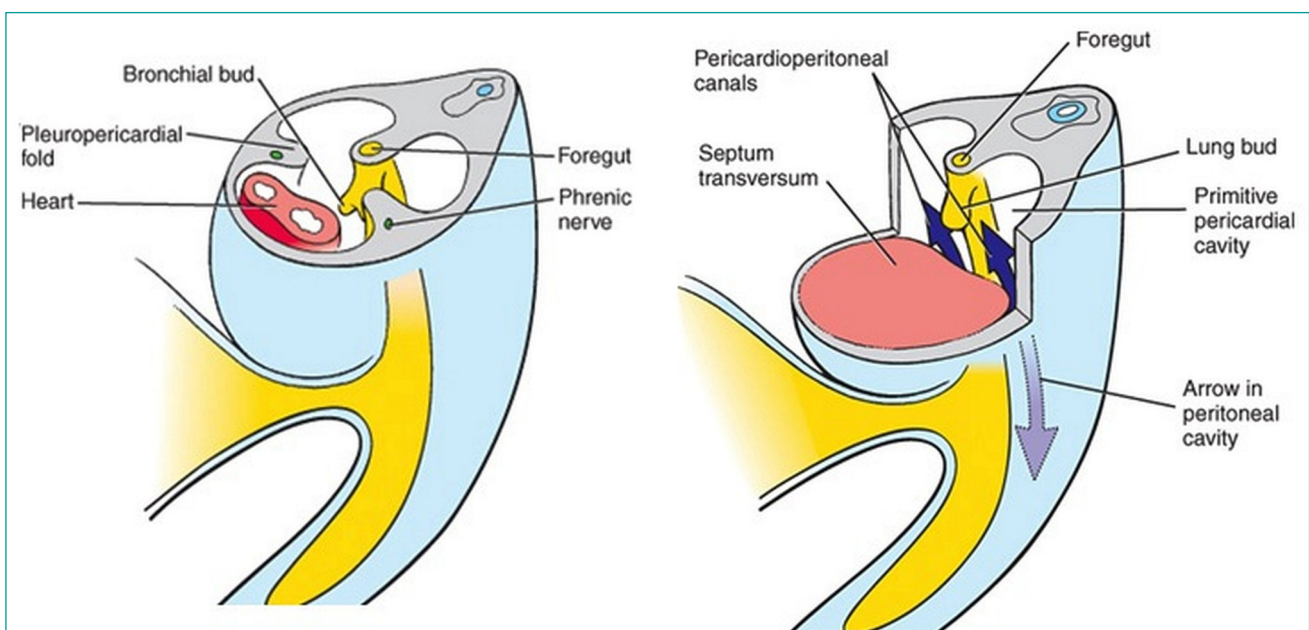
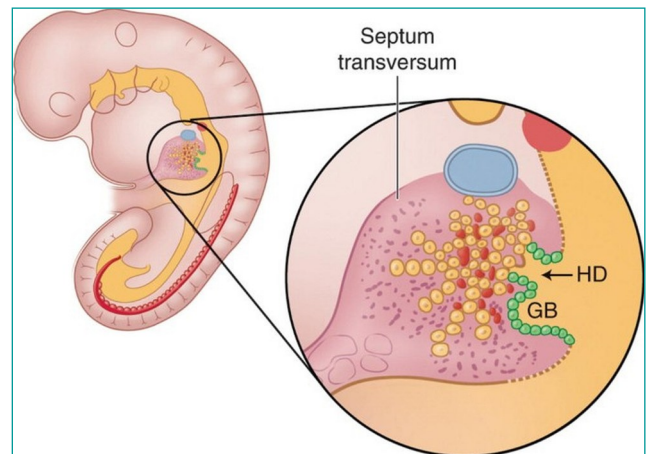
23.2.6. Brief Embryology Diaphragm Abdominalis

The Diaphragm develops from multiple embryonic origins. The muscle and its associated connective tissue and central tendon develop from three sources:

- ◇ ◇ the Septum Transversum,
- ◇ ◇ the pleuro-peritoneal folds, and
- ◇ ◇ the somites.

The Septum Transversum is the first structure present in the developing Diaphragm and serves as the first barrier between the thoracic and abdominal cavity.

In all vertebrates, the Septum Transversum is a thin, mesodermal layer of tissue, which separates the heart from the liver. In many reptiles and all birds and mammals, septa separates the heart and lungs from the liver and the rest of the abdominal contents.



Osteopathy in the Visceral Field

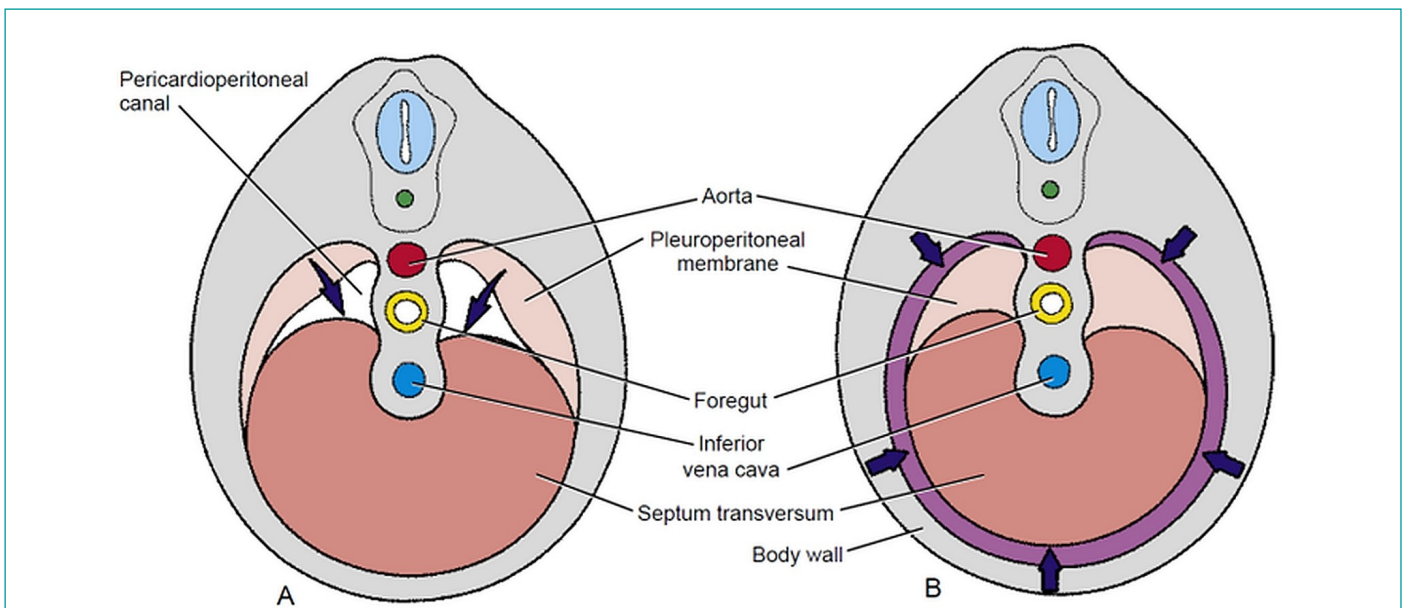
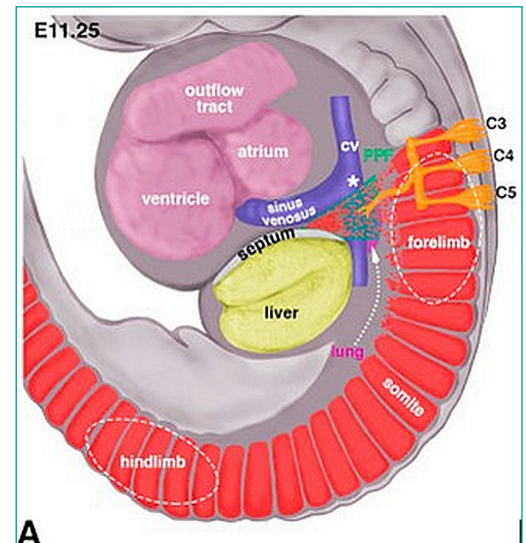
Part 4: from Endocrinology via Diaphragmata up to BBRs.

23. Diaphragmata. 2. Diaphragm Abdominalis.

The precursors of the muscles and the N. Phrenic nerve-axons migrate from the somites and neural tube, respectively, to the developing Diaphragm. The target of their migration is the pleuro-peritoneal folds. When the nerves and muscle precursors reach the folds, the folds are at the level of cervical somites.

Gradually, however, the folds and the developing diaphragm with its nerves and muscles descend caudally, eventually to lie on the thoracic / lumbar boundary. The Hepatocyte Growth Factor (HGF) is important for the development of the myogenic precursors of the developing diaphragm, probably also for the development of the N. Phrenicus.

The morphogenesis of the muscle connective tissue and the central tendon plane of the Diaphragm and their relationship to the Transverse Septum and the pleuro-peritoneal folds are barely understood. Based on histological analysis of autopsies by developing mouse embryos, it has been proposed that the Transverse Septum, initially present on the cranial plane of the liver (area Nuda), remains in place and gives rise to the central tendon plane of the Diaphragm.

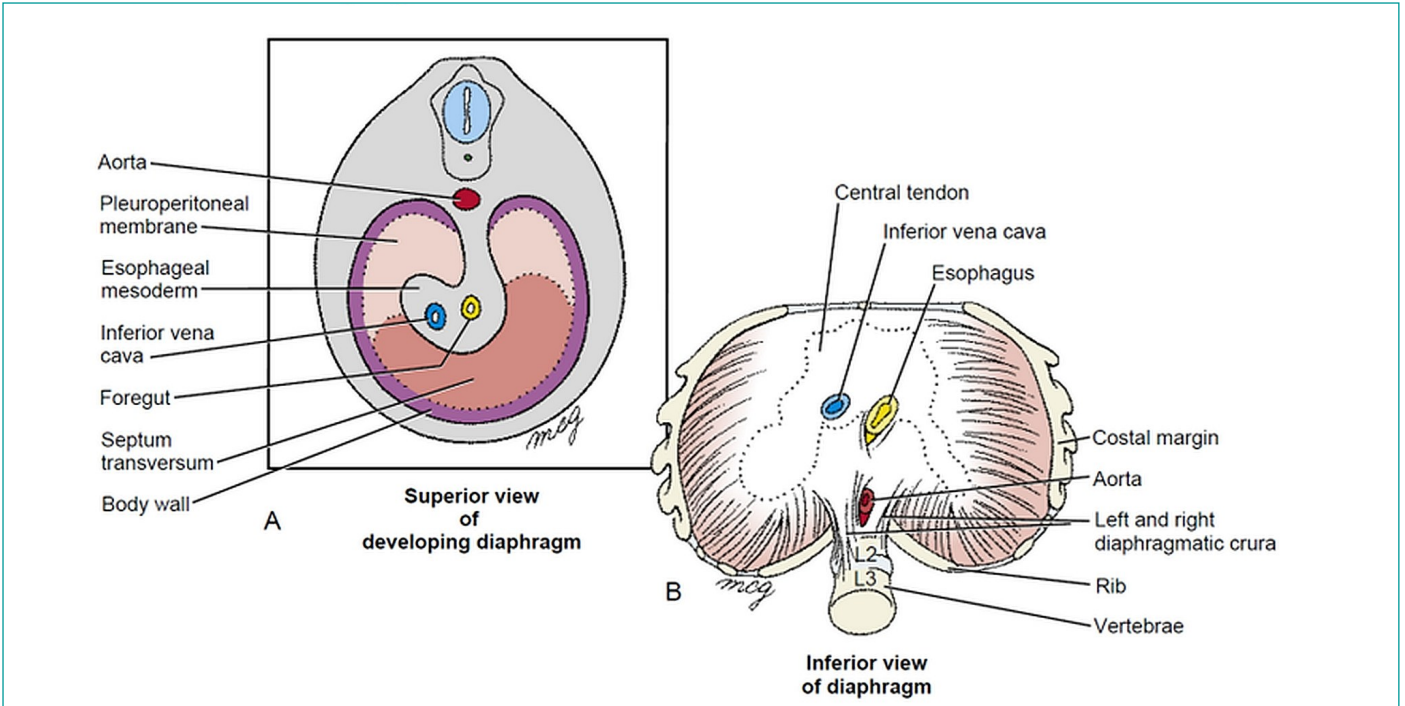


Closure of the pericardio-peritoneal channels (A, B). Between the 5th and 7th weeks, a pair of horizontal pleuro-peritoneal membranes grow from the posterior body wall to meet the Septum Transversum (arrows, A), closing the pericardio-peritoneal channels. These membranes form the posterior pillars of the Diaphragm and completely seal the pleural cavities from the peritoneal cavity. Arrows in B indicate invasion of the developing Diaphragm by muscle fibers of the adjacent body wall.

Source: Larsen, W.J., PhD, Human Embryology, Chapter 11, Development Respiratory System and body Cavities, figure 11.12. Churchill Livingstone, New York, 1993.

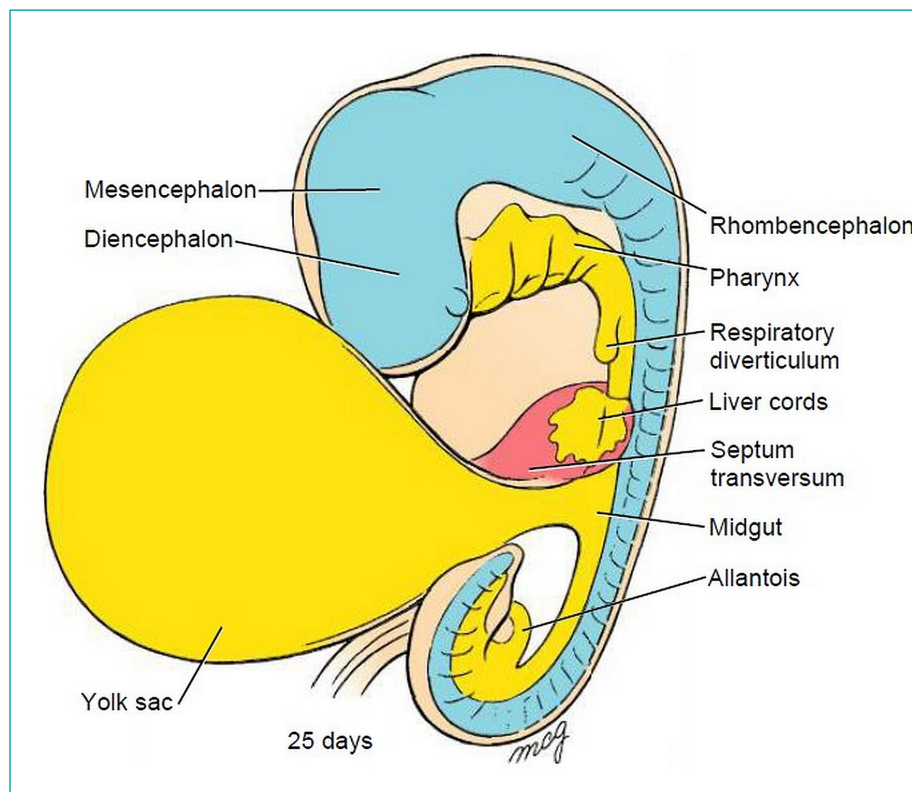
Sources:

- Dietrich S, Abou-Rebyeh F, Brohmann H, Bladt F, Sonnenberg-Riethmacher E, Yamaai T, Lumsden A, Brand-Saberi B, Birchmeier C. The role of SF/HGF and c-Met in the development of skeletal muscle. *Development*; 126:1621–9. PubMed, Google Scholar, 1999.
- Iritani I. Experimental study on embryogenesis of congenital diaphragmatic hernia. *Anatomy Embryology Berlin*. 1984;169:133–9. PubMed, Google Scholar, 1984.



Formation of the Diaphragm. The final Diaphragm is a composite structure, including elements of the Septum Transversum, pleuro-peritoneal membranes and Oesophagus mesenchyme, as well as a ridge of the body wall mesoderm. A. Superior sight. B. Inferior sight.

Sopurce: Larsen, W.J., PhD, Human Embryology, Chapter 11, Development Respiratory System and body Cavities, figure 11.13.and figure 11.1 (below). Churchill Livingstone, New York, 1993.



23.2.7. VLAN Diaphragm Abdominalis

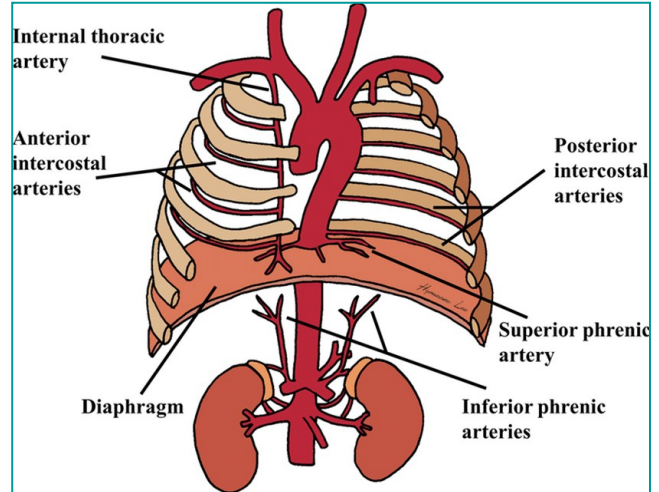
Vascularization

Arteries

Very richly vascularized mainly from the Aorta and A. Thoracica interna and A. Subclavia.

Veins

Follows the arteries and drains into the V. Cava Superior and Inferior.



Lymph

Two networks above and below the Diaphragm, connected by anastomoses (risk of infection).

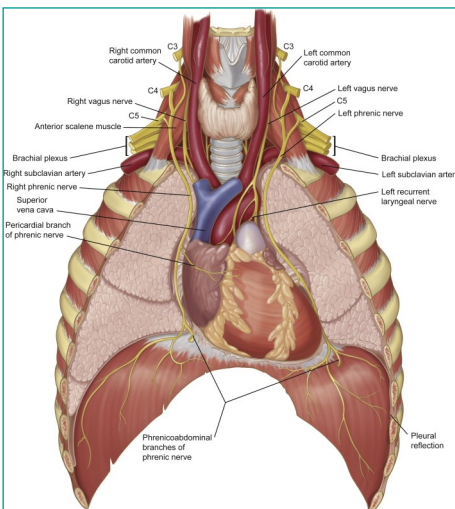
Innervation

Locomotive: two N. Phrenicae.

N. Phrenicus originating from the Cervical plexus (C₄), traverses the supraclavicularis region, then the mediastinum anterior. unfolds left and right in three branches.

Sensory: the last six intercostal nerves.

Vasomotor: Plexus Coeliacus.



The Diaphragm

MNEMONIC FOR INNERVATION

Diaphragm

MNEMONIC
"C3, 4, 5 keeps the diaphragm alive"

C3 C4 C5

The phrenic nerve is the motor and sensory nerve of the diaphragm. This nerve is derived from the cervical plexus - root values C3, C4, & C5.

REV Med

The Diaphragm

ASSOCIATED NEUROVASCULATURE

REV Med

Inferior view of Diaphragm

ATTACHMENTS

ANTERIORLY Xiphoid process	POSTERIORLY Lumbar vertebrae & arcuate ligaments	LATERALLY Costocartilages of ribs 7-10, and 11 & 12
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REV Med

The Diaphragm

3 MAJOR & 3 MINOR OPENINGS

REV Med

23.2.8. Brief Physiology Diaphragm Abdominalis

Respiration

At inspiration, the Diaphragm increases the three diameters of the Thorax by contraction:

- vertical: Diaphragm dome drops.
- transversal: ribs raised by fulcrum viscera.
- Sagittal: Sternum to anterior.

The result is directed towards the Pubis.

Individual differences depending on:

- gender: male - diaphragmatic.
female - high-costal.
- age: baby - abdominal.
child - high-costal.
- posture: sit - diaphragm rises (P-abdomen).
side lying - hemidiaphragm along support side increases.

Inspiration: Contract Diaphragm (23,000 /day).

Secondary aid: - Mm. Pectoralis.
- Mm. Sterno-Cleido
-Mastoideus.

Tertiary aid: - Mm. Scaleni.
- Mm. Seratus anterior and posterior.
- Mm. Rhomboidei.
- Mm. Levator scapulae.

P-abdomen rises, P-thorax falls.

V. Cava Inferior (VCI) vertical on inspiration.
Elbow shape at expiration.

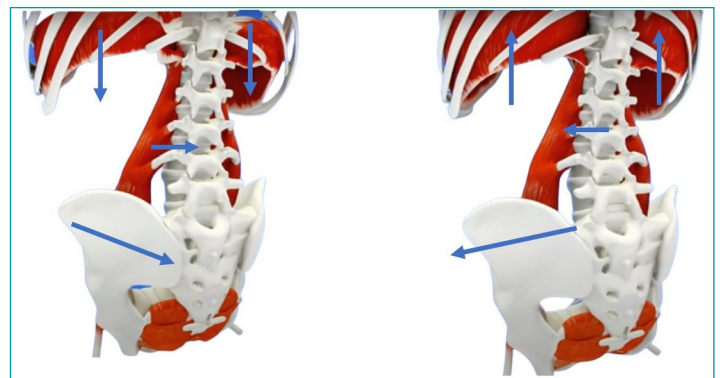
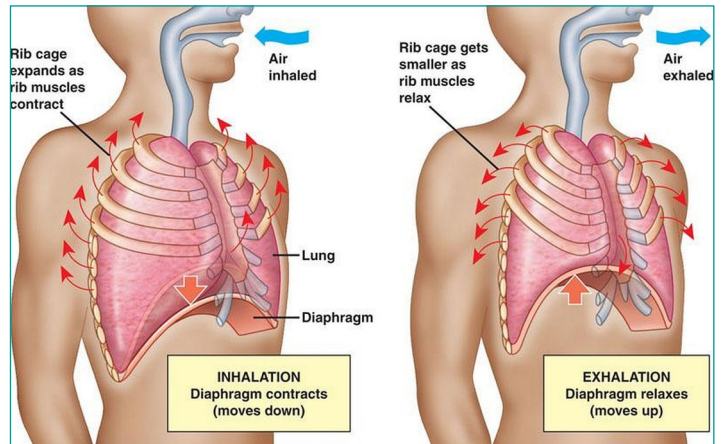
Expiration: mainly passive (E-pot → E-kin).

Auxiliary: - Mm. Transversus abdominis.
- Mm. Obliquus externus and internus.
- Mm. Intercostalis.
- Mm. Quadratus lumborum.

Digestion

Contraction and relaxation facilitates:

- the transit in the Oesophagus.
- the mixing of the stomach contents.
- the peristalsis of the intestines.
- Pump-piston mechanism flow Hepar.
- Pump-piston mechanism Pancreas (via Mesocolon Transversum).



*Inspiratie: retroversie Pelvis,
M. Psoas excentrisch.*

*Expiratie: anteversie Pelvis,
M. Psoas concentrisch.*

