ADITUM

Journal of Clinical Research and Clinical Case Reports

Open Access Case Report

A Few Words about Diaphragm

Siniša Franjić
Independent Researcher

Article Info

Received: April 28, 2021
Accepted: May 10, 2021
Published: May 12, 2021

***Corresponding author:** Siniša Franjić, Independent Researcher.

Citation: Siniša Franjić. "A Few Words about Diaphragm". Clinical Research and Clinical Case Reports, 1(2); DOI: http;//doi.org/04.2021/1.1009.

Abstract

The diaphragm separates the thoracic cavity from the abdominal cavity and performs an important function in breathing: the diaphragm shrinking, the volume of the thoracic cavity increases, creating a negative pressure that draws air into the lungs. The aorta, vein, esophagus, nerves and lymphatic vessels pass through the diaphragm. Precisely because of its position and the many systems affected by the diaphragm, it is extremely important how it works.

Key Words: diaphragm; breathing; body cavities; pain

Introduction:

The diaphragm separates the thoracic and abdominal cavities [1]. It is composed of a peripheral muscular portion which inserts into a central aponeurosisathe central tendon.

The muscular part has three component origins:

• A vertebral part: this comprises the crura and arcuate ligaments.

The right crus arises from the front of the L1–3 vertebral bodies and intervening discs. Some fibres from the right crus pass around the lower oesophagus.

The left crus originates from L1 and L2 only.

The medial arcuate ligament is made up of thickened fascia which overlies psoas major and is attached medially to the body of L1 and laterally to the transverse process of L1. The lateral arcuate ligament is made up of fascia which overlies quadratus lumborum from the transverse process of L1 medially to the 12th rib laterally.

The median arcuate ligament is a fibrous arch which connects left and right crura.

• A costal part: attached to the inner aspects of the lower six ribs.

• A sternal part: consists of two small slips arising from the deep surface of the xiphoid process.

Openings

Structures traverse the diaphragm at different levels to pass from thoracic to abdominal cavities and vice versa [1]. These levels are as follows:

- T8, the opening for the inferior vena cava: transmits the inferior vena cava and right phrenic nerve.
- T10, the oesophageal opening: transmits the oesophagus, vagi and branches of the left gastric artery and vein.
- T12, the aortic opening: transmits the aorta, thoracic duct and azygos vein.

The left phrenic nerve passes into the diaphragm as a solitary structure.

Body Cavities

The interior of the human body consists of several cavities that house the internal organs, or viscera [2]. The thoracic cavity is separated into the pericardial cavity, which contains the heart, and the two adjacent pleural cavities that contain the left and right lungs. The inferior surface of these cavities is a sheet of muscle called the diaphragm. The abdominopelvic cavity lies beneath the diaphragm and contains the organs of the digestive, urinary, and reproductive systems. The brain and spinal cord of the central nervous system are housed in the cranial and vertebral cavities, respectively.

The walls of the ventral body cavities (i.e., thoracic and abdominopelvic cavities) are lined with serous membranes that connect with and envelop the visceral organs. During embryonic development two layers of serosa develop; that is, an inner visceral layer that adheres to the organs and an outer parietal layer that is continuous with the cavity lining. As the visceral organs develop, they grow into the body cavities and therefore become covered by both the visceral serosa and parietal serosa. A thin layer of serous fluid occupies the space between the two layers of serosa. Sheets of the parietal serosa extend between the body cavity and organs to create what is known as mesentery (supporting organs of the digestive tract) or ligaments (supporting organs of the urinary and reproductive systems). The basic arrangement of serous tissues is similar for all of the ventral body cavities, but specific names are used to refer to the serous tissues in each of these cavities: 1) pericardium for the pericardial cavity; 2) pleura for the pleural cavities; 3) peritoneum for the abdominopelvic cavity.

Viewed in sections, the human body is not a solid object, like a rock, in which all of the parts are fused together [3]. Many vital organs are suspended in internal chambers called body cavities. These cavities have two essential functions: (1) they protect delicate organs, such as the brain and spinal cord, from accidental shocks and cushion them from the jolting that occurs when we walk, jump, or run; and (2) they permit significant changes in the size and shape of internal organs. For example, because they are inside body cavities, the lungs, heart, stomach, intestines, urinary bladder, and many other organs can expand and contract without distorting surrounding tissues or disrupting the activities of nearby organs.

The ventral body cavity, or coelom, appears early in embryonic development. It contains organs of the respiratory, cardiovascular, digestive, urinary, and reproductive systems. As these internal organs develop, their relative positions change, and the ventral body cavity is gradually subdivided. The diaphragm, which is a flat muscular sheet, divides the ventral body cavity into a superior thoracic cavity, bounded by the chest wall, and an inferior abdominopelvic cavity, enclosed by the abdominal wall and by the bones and muscles of the pelvis.

Many of the organs in these cavities change size and shape as they perform their functions. For example, the lungs inflate and deflate as you breathe, and your stomach swells during each meal and shrinks between meals. These organs are surrounded by moist internal spaces that permit expansion and limited movement while preventing friction. The internal organs within the thoracic and abdominopelvic cavities are called viscera. A delicate layer called a serous membrane lines the walls of these internal cavities and covers the surfaces of the enclosed viscera. Serous membranes are moistened by a watery fluid that coats the opposing surfaces and reduces friction. The portion of a serous membrane that covers a visceral organ is called the visceral layer; the opposing layer that lines the inner surface of the body wall or chamber is called the parietal layer.

When the mouth and nose are open, the air pressure in the lungs equals the atmospheric pressure [4]. The pressure of the space between the visceral and parietal pleura is slightly less than the atmospheric pressure. Inspiration contracts the diaphragm and increases the diameter of the thoracic cavity, decreasing the pressure between the lung and the parietal pleura. The lowered pressure of the pleural space draws air into the lungs. On expiration, relaxation of the diaphragm increases the pressure in the pleural space and expels air from the lungs. Expansion and contraction of the À exible ribs and chest aid inspiration and expiration.

Breathing

Ventilation, commonly known as breathing, occurs as the dimensions of the thoracic cavity are altered which changes air pressure within the lungs [5]. Essentially, to breathe in (inspiration), the size of the chest cavity is increased by the intercostal muscles between the ribs moving the ribcage up and out at the same time as the diaphragm, a muscular sheet between the thoracic and abdominal cavities, contracts and flattens. As these movements increase the chest volume in all three dimensions, the pressure is reduced so air is drawn in, aided by the pressure of the atmosphere outside. Breathing out (expiration) occurs when the intercostal muscles and diaphragm relax and the lungs deflate to their original dimensions and thus requires no muscular effort when breathing quietly.

Pulmonary ventilation consists of the process of inspiration (or inhalation), where air enters the lungs, and expiration (or exhalation), where air leaves the lungs [6]. During inspiration, the diaphragm and external intercostal muscles contract, causing the rib cage to expand and move outward, and expanding the thoracic cavity and lung volume. This creates a lower pressure within the lung than that of the atmosphere, causing air to be drawn into the lungs. During expiration, the diaphragm and intercostals relax, causing the thorax and lungs to recoil. The air pressure within the lungs increases to above the pressure of the atmosphere, causing air to be forced out of the lungs. However, during forced exhalation, the internal intercostals and abdominal muscles may be involved in forcing air out of the lungs.

Respiratory volume describes the amount of air in a given space within the lungs, or which can be moved by the lung, and is dependent on a variety of factors. Tidal volume refers to the amount of air that enters the lungs during quiet breathing, whereas inspiratory reserve volume is the amount of air that enters the lungs when a person inhales past the tidal volume. Expiratory reserve volume is the extra amount of air that can leave with forceful expiration, following tidal expiration. Residual volume is the amount of air that is left in the lungs after expelling the expiratory reserve volume. Respiratory capacity is the

combination of two or more volumes. Anatomical dead space refers to the air within the respiratory structures that never participates in gas exchange, because it does not reach functional alveoli. Respiratory rate is the number of breaths taken per minute, which may change during certain diseases or conditions.

Thorax

During inspiration the movements of the chest wall and diaphragm result in an increase in all diameters of the thorax [7]. This, in turn, brings about an increase in the negative intrapleural pressure and an expansion of the lung tissue. Conversely, in expiration the relaxation of the respiratory muscles and the elastic recoil of the lung reduce the thoracic capacity and force air out of the lungs.

In quiet inspiration the first rib remains relatively fixed, but contraction of the external and internal intercostals elevates and, at the same time, everts the succeeding ribs. In the case of the 2nd–7th ribs this principally increases the anteroposterior diameter of the thorax (by the forward thrust of the sternum), like a pump handle. The corresponding movement of the lower ribs raises the costal margin and leads mainly to an increase in the transverse diameter of the thorax, like a bucket handle. The depth of the thorax is increased by the contraction of the diaphragm which draws down its central tendon. Normal quiet expiration, brought about by elastic recoil of the elevated ribs, is aided by the tone of the abdominal musculature which, acting through the contained viscera, forces the diaphragm upwards.

In deep and in forced inspiration additional muscles attached to the chest wall are called into play (e.g. scalenus anterior, sternocleidomastoid, serratus anterior and pectoralis major) to increase further the capacity of the thorax.

Thoracic Muscles

A primary function of the deep muscles of the thorax is to provide the movements necessary for ventilation, or breathing [8]. Breathing has two phases—inspiration, or inhaling, and expiration, or exhaling—caused by cyclical changes in the volume of the thoracic cavity.

The thoracic muscles are very short: Most run only from one rib to the next. They form three layers in the wall of the thorax. The external intercostal muscles form the most superficial layer. They lift the rib cage, which increases its anterior-posterior and lateral dimensions. Thus, the external intercostals function during inspiration. The internal intercostals form the intermediate muscle layer. They may aid forced expiration by depressing the rib cage. The third and deepest muscle layer of the thoracic wall attaches to the internal surfaces of the ribs. It has three discontinuous parts (from posterior to anterior): the subcostals, innermost intercostals, and transversus thoracis. These are small, and their function is unclear, so they are not listed in this table.

The diaphragm, the most important muscle of respiration, forms a complete partition between the thoracic and abdominopelvic cavities. In the relaxed state, the diaphragm is dome-shaped. When it contracts, it moves inferiorly and flattens, increasing the volume of the thoracic cavity. Thus, the diaphragm is a powerful muscle of inspiration. It contracts rhythmically during respiration, but one can also contract it voluntarily to push down on the abdominal viscera and increase the pressure in the abdominopelvic cavity. This pressure helps to evacuate the contents of the pelvic organs (feces, urine, or a baby). It also helps in lifting heavy weights: When one takes a deep breath to fix the diaphragm, the abdomen becomes a firm pillar that will not buckle under the weight being lifted. The muscles of the anterior abdominal wall also help to increase the intraabdominal pressure.

When breathing is forced and heavy, as during exercise, additional muscles become active in ventilation. For example, in forced inspiration, the scalene and sternocleidomastoid muscles of the neck help lift the ribs. Forced expiration is aided by abdominal wall muscles that pull inferiorly on the ribs and push the diaphragm superiorly by compressing the abdominal organs.

Pain

Pain from the diaphragm radiates to two different areas because of the difference in the sensory nerve supply of the diaphragm [9]. Pain resulting from irritation of the diaphragmatic pleura or the diaphragmatic peritoneum is referred to the shoulder region, the area of skin supplied by the C3–C5 segments of the spinal cord. These segments also contribute anterior rami to the phrenic nerves. Irritation of peripheral regions of the diaphragm, innervated by the inferior intercostal nerves, is more localized, being referred to the skin over the costal margins of the anterolateral abdominal wall.

Rupture of the diaphragm and herniation of viscera can result from a sudden large increase in either the intrathoracic or intra-abdominal pressure. The common cause of this injury is severe trauma to the thorax or abdomen during a motor vehicle accident. Most diaphragmatic ruptures are on the left side (95%) because the substantial mass of the liver, intimately associated with the diaphragm on the right side, provides a physical barrier.

A nonmuscular area of variable size called the lumbocostal triangle usually occurs between the costal and lumbar parts of the diaphragm. This part of the diaphragm is normally formed only by fusion of the superior and inferior fascias of the diaphragm. When a traumatic diaphragmatic hernia occurs, the stomach, small intestine and mesentery, transverse colon, and spleen may herniate through this area into the thorax.

Aging

The incidence of gastrointestinal disorders increases with age [10]. Periodontitis, which is common in elderly people, leads to the loss of teeth and the need for false teeth.

The esophagus, which rarely causes any difficulties in younger people, is more prone to disorders in the elderly. The portion of the esophagus normally found inferior to the diaphragm can protrude into the thoracic cavity, causing an esophageal hiatal hernia. In some cases, the lower esophageal sphincter opens inappropriately and allows chyme to regurgitate into the esophagus, causing heartburn. Or in some older persons, chest pain may occur when this sphincter fails to open and a bolus cannot enter the stomach. Eventually, the esophagus may develop

a diverticulum that allows food to collect abnormally.

Peristalsis generally slows within the alimentary canal as the muscular wall loses tone. Peptic ulcers increase in frequency with age. The failure of older people to consume sufficient dietary fiber can result in diverticulosis and constipation. Constipation and hemorrhoids are frequent complaints among the elderly, as is fecal incontinence.

The liver shrinks with age and receives a smaller blood supply than in younger years. Notably, it needs more time to metabolize drugs and alcohol. With age, gallbladder difficulties occur; there is an increased incidence of gallstones and cancer of the gallbladder. In fact, cancer of the various organs of the gastrointestinal tract is seen more often among the elderly. For example, most cases of pancreatic cancer occur in people over the age of 60.

Conclusion

The diaphragm can cause pain. In many people, the breathing pattern is disrupted, and this can have a numerous negative consequences. Except tension in the neck and shoulders, headaches, digestive problems and difficulty breathing, a often problem created by the diaphragm is pain in the middle part of the back that travels across the ribs to the sternum.

References:

1. Faiz, O.; Moffat, D. (2002.): „Anatomy at a Glance", Blackwell Science Ltd, Oxford, UK, pp. 9.
2. Schillo, K. (2019.): „Human Anatomy and Physiology - Form, Function, and Homeostasis", Cognella, Inc., San Diego, USA, pp. 14. - 15.
3. Bledsoe, B. E.; Martini, F. H.; Bartholomew, E. F.; Ober, W. C.; Garrison, C. W. (2014.): „Anatomy & Physiology for Emergency Care - Pearson New International Edition, Second Edition", Pearson Education Limited, Harlow, UK, pp. 26. - 27.
4. Goodman, A. A. (2004.) Understanding the Human Body - An Introduction to Anatomy and Physiology", The Teaching Company, Chantilly, USA, pp. 33.
5. Atkinson, M. E. (2013.) Anatomy for Dental Students, Fourth Edition", Oxford University Press, Oxford, UK, pp. 41.
6. Heyden, R. J. (adv) (2013.) Anatomy & Physiology", OpenStax College, Rice University, Huston, USA, pp. 1015. - 1016.
7. Ellis, H. (2006) Clinical Anatomy - A Revision and Applied Anatomy, 11th Edition", Blackwell Publishing Ltd, Malden, USA, pp. 18.
8. Marieb, E. N, Wilhelm, P. B.; Mallatt, J. (2017.): „Human Anatomy, Eight Edition, Global Edition", Pearson Education Limited, Harlow, UK, pp. 327.
9. Moore, K. L Agur, A. M. R.; Dalley II, A. F. (2015.): „Essential Clinical Anatomy, Fifth Edition", Wolters Kluwer, Philadelphia, USA, pp. 182.
10. Mader, S. S. (2004) Understanding Human Anatomy and Physiology, Fifth Edition", McGraw-Hill, New York, USA, pp. 312.