The Diaphragm

Mary S. Maish, MD, MPH

KEYWORDS

• Diaphragm • Solitary fibrous tumor • Phrenic nerve
• Diaphragmatic hernia • Eventration

Although the diaphragm is not so grandiose, without it life as it is currently known would not be possible. This then begs the question, when did the diaphragm first develop and for what purpose? As it turns out this is a matter of semantics. As far back as 300 million years ago, vertebrate species had a primitive diaphragm that served only to separate an upper feeding compartment from a lower digestive tract.[1] In dinosaurs and other reptile and amphibious species, the lungs were always caudal to the diaphragm. Not until warm-blooded mammals evolved did the lungs herniate through the diaphragm into the thoracic cavity and became a critical component of respiratory function.[2] This transition is thought to have occurred about 100 million years ago in rodent type mammals. The diaphragm is now a critical organ for proper respiration and is present in some form in more than 5000 mammalian species. The diaphragm may be subtle in its presence but is indispensible in its function.

EMBRYOLOGY

The development of the diaphragm begins in the seventh week of gestation and is complete by the tenth week. It is derived from four embryologic precursors: the septum transversum, the right and left pleuroperitoneal membranes, and the dorsal mesentery of the esophagus (**Fig. 1**). The septum transversum is an anterior structure that becomes the central tendon and fuses with three dorsal structures to form the primitive diaphragm. The dorsal mesentery, containing the primitive aorta, inferior vena cava, and esophagus, becomes the posteromedial portion of the diaphragm. Myoblasts migrate into this structure, forming the crura bilaterally. The right and left pleuroperitoneal membranes grow medially and anteriorly to fuse with the central tendon. The final phase of diaphragmatic development is the formation of the neuromuscular component. The muscle fibers migrate from the third, fourth, and fifth cervical myotomes of the body wall. The phrenic nerves arising from the third, fourth, and fifth cervical nerves migrate distally, completing the final phase of diaphragmatic development.[3]

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Department of Surgery, UCLA David Geffen School of Medicine, 10833 Le Conte Avenue, Room 64-124 CHS, Box 957313, Los Angeles, CA 90095-7313, USA
E-mail address: mmaish@mednet.ucla.edu

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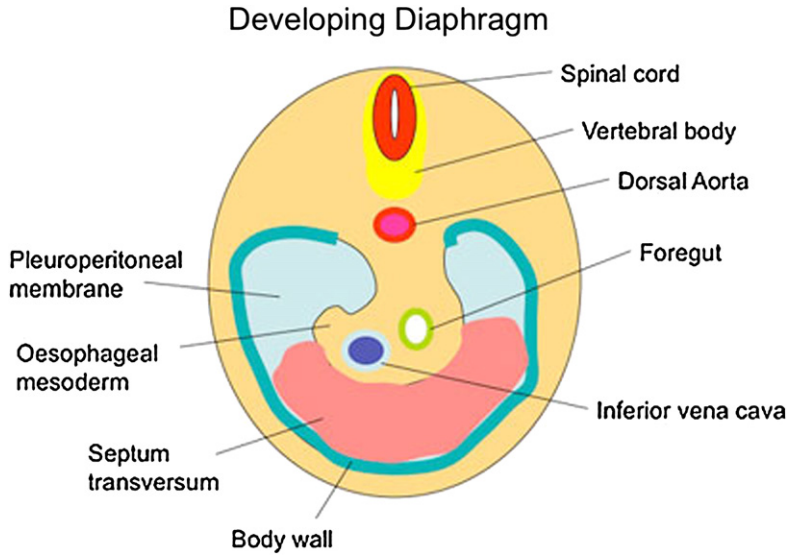

Fig. 1. Diagram of the developing diaphragm at 7 weeks. (Respiratory Dev © Dr Mark Hill 2008 Slide 30; Available at: http://embryology.med.unsw.edu.au. Accessed June 1, 2010; with permission.)

The importance of understanding embryologic development for a surgeon lies in gaining an understanding of the common variants and uncommon congenital defects that are encountered in surgical practice. Fortunately, the diaphragm is a very consistent organ and has no normal variations. However, several common abnormalities result from faulty embryologic development, including congenital diaphragmatic hernias and eventration, which will be addressed later.

ANATOMY

The Greek derivation of the words *dia* (in between) and *phragma* (fence) aptly describes this organ. The diaphragm is a musculofibrous dome-shaped membrane that separates the thoracic from the abdominal cavity. It has a muscular portion peripherally, and a fibrous portion centrally (**Fig. 2**). It has three major muscle groups: sternal, costal, and lumbar and a large fibrinous central tendon composed of three leaflets: right, left, and middle. Major structures pass through three openings: the caval opening (T8), the esophageal hiatus (T10), and the aortic hiatus (T12). In addition to the aorta, the aortic hiatus also allows passage for the thoracic duct and the azygos vein. The muscle origins are from the sternum anteriorly, the lower six ribs laterally, and the arcuate ligaments posteriorly. The crura are posterior muscle bundles that arise from the lumbar vertebrae: the right from L1–3 and the left from L1–2.[4]

BLOOD SUPPLY

The major arterial blood supply to the diaphragm comes from the left and right phrenic arteries (see **Fig. 2**). These paired arteries arise directly from the abdominal aorta near the aortic hiatus. They bifurcate posteriorly and give off a large anterior branch, which courses along the anterior and superior portions of the muscle, merging with the