ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2014/39–44/$2.00/©JCCA 2014

Duplicated right crus of the diaphragm: a cadaveric case report

Srinivasa Rao Sirasanagandla, MSc[1]
Dr. Satheesha B Nayak, MSc, PhD[1]
Dr. Kumar MR Bhat, MSc, PhD[2]
Dr. Sudarshan Surendran, MSc, PhD[1]
Dr. Deepthinath Regunathan, MSc, PhD[1]
Naveen Kumar, MSc[1]
Dr. Surekha D Shetty, MSc, BAMS[1]
Jyothsna Patil, MSc[1]

The lumbar part of the diaphragm arises from the lumbar vertebrae by right and left crura. The duplication of crura of the diaphragm is rarely reported in the past. During regular dissection classes to the medical students, we came across a case of duplicated right crus of the diaphragm. The right crus of the diaphragm was duplicated completely and presented two separate crura; medial right crus & lateral right crus. The medial right crus was attached to the anterolateral surfaces of the superior three lumbar vertebral bodies and intervertebral discs and merged with the anterior longitudinal ligament. The lateral right crus attached

La partie lombaire du diaphragme se divise en pilier droit et pilier gauche qui s'attachent directement aux vertèbres lombaires. La duplication des piliers du diaphragme est rarement signalée dans le passé. Pendant les cours réguliers de dissection avec les étudiants en médecine, nous avons constaté un cas de duplication du pilier droit du diaphragme. Le pilier droit du diaphragme a été dupliqué complètement et se présentait comme deux piliers distincts : pilier médial droit et pilier latéral droit. Le pilier médial droit était toujours attaché aux surfaces antérolatérales des trois corps vertébraux lombaires supérieures et aux disques intervertébraux, et se confondait avec le ligament longitudinal antérieur. Le pilier latéral droit était attaché seulement au disque intervertébral entre la troisième et la quatrième vertèbre lombaire. Ces deux

[1] Department of Anatomy, Melaka Manipal Medical College, Manipal University, Madhav Nagar, Manipal, Karnataka, India
[2] Department of Anatomy, Kasturba Medical College, Manipal University, Manipal, Karnataka, India
Corresponding author:
Dr. Satheesha B Nayak MSc, PhD
Professor and Head, Department of Anatomy
Melaka Manipal Medical College (Manipal Campus)
International Centre for Health Sciences
Manipal University
Madhav Nagar, Manipal
Udupi District
Karnataka State, INDIA.
576 104
Telephone: +91 820 2922519
+91 9844009059

only to the intervertebral disc between the third and fourth lumbar vertebrae. These two crura bordered a retrocrural space in the inferior posterior mediastinum. The greater and lesser splanchnic nerves entered the abdomen by passing through this space. No duplication was observed in the left crus. The muscle fibres of medial right crus contributed to the formation of the esophageal opening. Knowledge of variations in the diaphragmatic crural anatomy is useful in the diagnosis of disease processes in the retrocrural space and also might help while performing the surgical repair of gastroesophageal reflux disease.

(JCCA 2014;58(1):39-44)

KEY WORDS: diaphragm, crura, hiatus, lumbar, gastroesophageal reflux, retrocrural space

piliers étaient accolés à un espace inframédiastinal dans le médiastin postérieur inférieur. Les nerfs splanchniques (grands et petits) entraient dans le ventre en passant par cet espace. Aucune duplication du pilier gauche n'a été observée. Les fibres musculaires du pilier médial droit ont contribué à la formation de l'ouverture de l'œsophage. La connaissance des variations de l'anatomie du diaphragme crural est utile pour le diagnostic des processus pathologiques dans l'espace inframédiastinal et peut aussi être utile lors d'une réparation chirurgicale du reflux gastro-œsophagien pathologique.

(JCCA 2014;58(1):39-44)

MOTS CLÉS : diaphragme, piliers, hiatus, lombaire, reflux gastro-œsophagien, espace inframédiastinal

Introduction

The diaphragm is a musculoaponeurotic sheet forming a partition between the thoracic and abdominal cavities. The muscle fibres of the diaphragm arise from the circumference of the inferior thoracic aperture. Although it is a continuous structure, the muscle is considered to have three parts, sternal, costal and lumbar based on the region of their attachment. Its lumbar part arises from the lumbocostal arches (arcuate ligaments) and from the lumbar vertebrae by two pillars or crura. Near the vertebral attachment, the crura are tendinous in structure and merge with the anterior longitudinal ligament. The right crus is stronger, broader and longer than the left, and originates from the anterolateal surface of the first three lumbar vertebral bodies and intervertebral discs (IVDs). The left crus arises from similar surfaces of the upper two lumbar vertebrae and the intervening IVD. The medial margins of the two crura meet in the midline and form the ill-defined median arcuate ligament and form the boundaries of the aortic hiatus.[1] Although the diaphragm is studied as a respiratory muscle, currently it is considered to have two distinct functional parts; the costal diaphragm with major respiratory role and crural diaphragm with minor respiratory role.[2,3] The latter is said to contribute greatly to the gastroesophageal functions, such as swallowing, vomiting, and also acts as a gastroesophageal reflux barrier.[4] The esophageal hiatus is an elliptical opening in the muscular part of the diaphragm, situated at the level of the T10 vertebral body. Several studies have reported that the formation of the hiatus gets contribution from the muscle fibres of both right and left crura.[5] Studies have also confirmed the crucial role of the crural diaphragm in preventing the development of gastroesophageal reflux.[6] Any surgical or pathological process that affects the structural integrity of the wall of the esophageal hiatus will interfere with the mechanics of the gastroesophageal junction.[7] Consequently a good knowledge of the structural variations of the diaphragmatic crura becomes crucial to our understanding of gastrointestinal physiology. The small triangular region situated in the posterior mediastinum, inferiorly, bordered anteriorly by the two diaphragmatic crura, is referred to as the retrocrural space. As this space is subjected to pathologic processes, the anatomic variations of the crural diaphragm are clinically important for diagnostic procedures involving this anatomic compartment.[8] In this report, we present a rare case of a duplicated right diaphragmatic crus forming an accessory retrosternal space and discuss the clinical significance of this anatomical variant.

Case report

During regular dissection classes for medical students, we

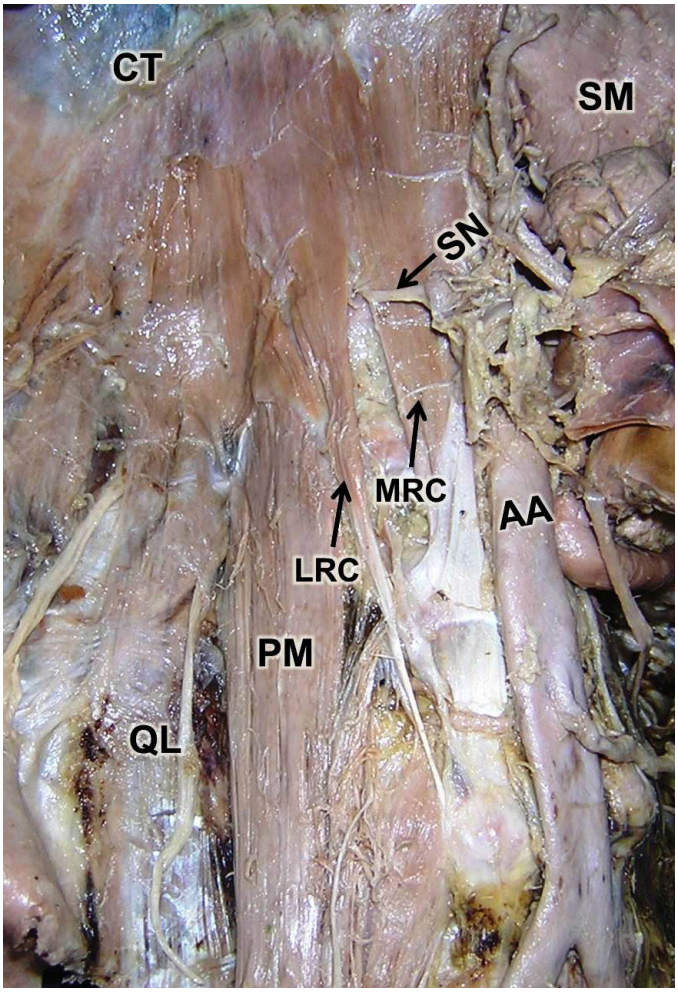

Figure 1:
Dissection of posterior abdominal wall showing the duplication of right crus of the diaphragm into medial right crus (MRC) and lateral right crus (LRC). Note the emergence of splanchnic nerve (SN) between the MRC and LRC. (SM: stomach, PM: psoas major, AA: abdominal aorta, QL: quadratus lumborum, DM: diaphragm, CT: central tendon)

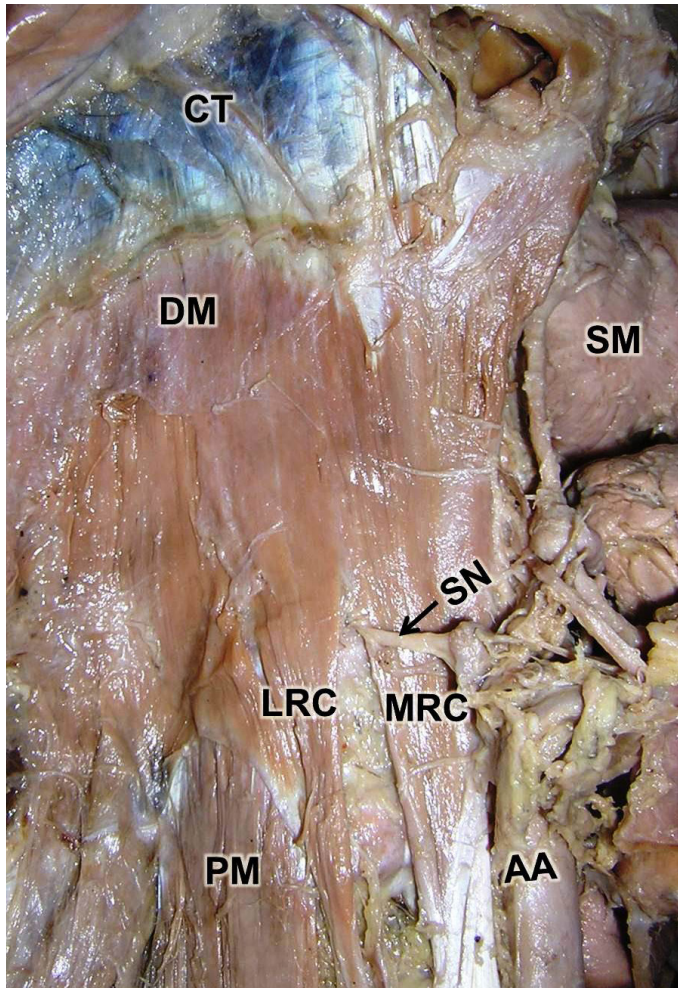

Figure 2:
Closer view showing the duplicated right crus of the diaphragm (DM). (SM: stomach, PM: psoas major, AA: abdominal aorta, SN: splanchnic nerve, MRC: medial right crus, LRC: lateral right crus, CT: central tendon)

identified duplicated right crus of the diaphragm in an approximately 55-years-old male cadaver of South Indian origin. The lumbar part of diaphragm had right and left crura. The right crus of the diaphragm was completely duplicated and presented two separate crura; medial right crus & lateral right crus (Figures 1 & 2). The medial right crus was attached to the anterolateral surface of the bodies and intervertebral discs of the upper three lumbar vertebrae and blended with the anterior longitudinal ligament. The lateral right was crus attached only to the intervertebral disc between the third and fourth lumbar vertebrae (Figure 1 & 2). The two crura are widely separated from each other. These two crura bordered an additional retrocrural space, which is situated in the lower part of the

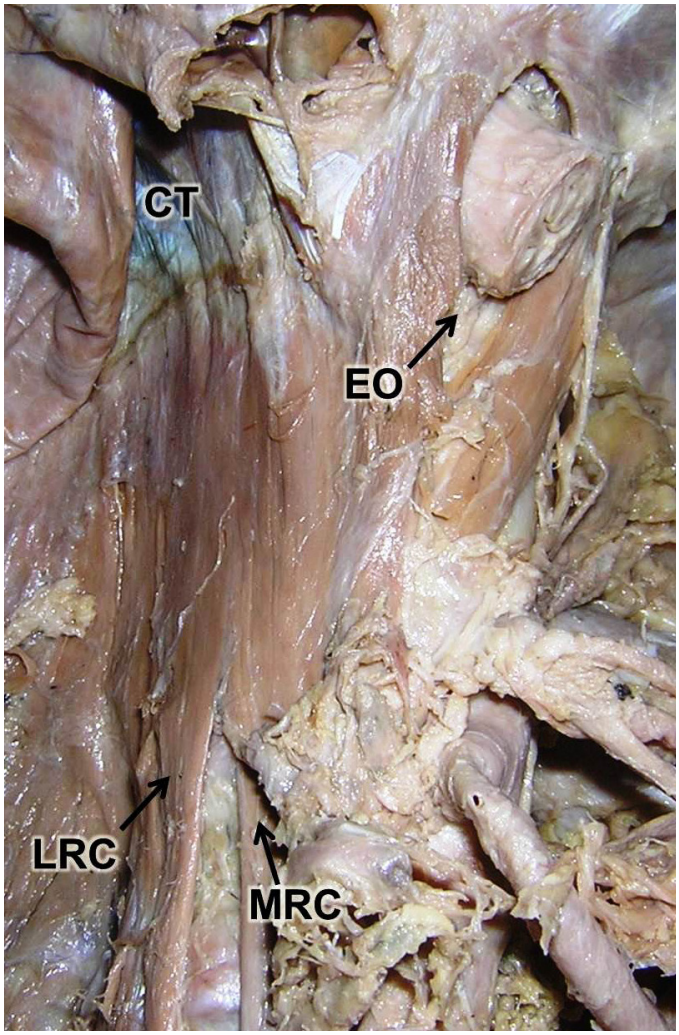

Figure 3:
Dissection of posterior abdominal wall showing the esophageal opening (EO) formed by the medial right crus of the diaphragm. (MRC: medial right crus, LRC: lateral right crus, CT: central tendon)

posterior mediastinum. The greater and lesser splanchnic nerves entered the abdomen by passing through this space (Figure 1 & 2). The esophageal hiatus was formed by the contribution from the medial right crus (Figure 3). No duplication was observed on the left side. The left crus arose from the anterolateral surface of the bodies and intervertebral discs of the upper two lumbar vertebrae.

Discussion

Development of diaphragm occurs between the 3rd to 8th weeks of intrauterine life. It mainly develops from the four components; septum transversum, pleuroperitoneal membranes, dorsal mesentery of the esophagus and muscular ingrowth from the lateral body walls.[9] Bochdalek hernia, Morgagni's hernia, and hiatal hernias and agenesis are the commonly reported congenital anomalies of the diaphragm. However, occurrence of accessory diaphragm and anomalies affecting the crura alone (duplication) are very rare. These rare anomalies are usually asymptomatic and are found incidentally during imaging. It has been demonstrated that the formation of accessory diaphragm is due to the improper timing in the interaction of the lung buds and septum transversum. The duplication of right crus might be a result of lack of proper timing in the interaction of the lung buds and dorsal mesentery of the esophagus as cura of the diaphragm mainly come from the dorsal mesentery.[10,11]

Most studies demonstrate that the vertebral attachments of the diaphragmatic crura usually extend from L1to L3 vertebrae on the right side, L1 to L2 on the left side.[1] However, the attachment of the right crus can extend down to the lower border of L4.[12] In a study by Ahmad et al, the left crus attachment had extended down to the lower border of L3.[13] In the present case the medial right crus attached to the bodies and intervertebral discs of the upper three lumbar vertebrae and blended with the anterior longitudinal ligament, but the additional right crus was attached only to the intervertebral disc between L3 and L4. Though the duplication of the right crus of the diaphragm has been reported, information about the frequency of its occurrence is scanty in the scientific literature.[14]

Loukas et al. have studied the various morphological patterns of circumferential muscle fibers forming the esophageal hiatus and classified them into six groups. The most common type of esophageal hiatus was formed by the muscular contributions arising solely from the right crus, the Type I (45%). Type II (20%) formed by the equal muscular contributions from the right and left crura. Type III (15%) formed by the right and left muscular contributions arose from the right crus with an additional band from the left crus. In, Type IV (10%) the right and left muscular contributions arose from the right crus along with two additional (anterior and posterior) bands coming from the left crus. In Type V (5%), the hiatus received

contributions arising solely from the left crus. In Type VI (5%), the right and left muscular contributions originated from the left crus with two additional bands, one from the right crus and one from the left crus.[3] Earlier, studies conducted on morphological patterns of muscle fibres forming the hiatus have showed that type 1 was the predominant.[3,15,16] Contrary to these studies, one study has shown that the type 1 was observed only in 10% of study subjects.[17] In the present study the muscular fibres of the hiatus received contribution from only the medial right crus, similar to type 1.

Muscular tumors namely leiomyosarcomas and rhabdomyosarcomas; lipomas and desmoids are the primary neoplasms that have been reported to occur in the diaphragmatic crura. The intrathoracic malignancies such as pleural mesothelioma and metastatic lung or esophageal malignancies may spread and cause subsequent invasion of diaphragmatic crura.[18,19] The knowledge of variations of the diaphragmatic crura is very useful during the diagnosis and treatment of the malignancies of the crura. It has been described that thickening of the crura can be used as an indicator for diaphragmatic injury in the setting of trauma.[20,21] The knowledge of anatomic variants of the crura may also be important while setting of trauma.

The retrocrural space is situated in the inferior part of the posterior mediastinum bordered by the right and left crura. The contents of this space may be subjected to the various pathologic processes, including lipoma, lymphangioma, vascular abnormalities like aortic aneurysm, hematoma, azygos and hemiazygos continuation of the inferior vena cava, and abscesses.[8] Knowledge of variations in the diaphragmatic crural anatomy may be important as it facilitates diagnosis of disease processes in retrocrural region.

Usually, the thoracic sympathetic trunk passes behind the medial arcuate ligament. Sometimes, it passes through the diaphragmatic crura to become the lumbar sympathetic trunk. The medial branches of the lower thoracic sympathetic ganglia; the greater and lesser splanchnic nerves, enter the abdomen by piercing the diaphragmatic crura and finally relay in the celiac ganglia and contribute in the formation of celiac plexus. In the present case, the right crus of the diaphragm was duplicated completely and the splanchnic nerves entered the abdominal cavity by passing through the space between the two right crura. Awareness of variant anatomy of splanchnic nerves in the retrocrural region is clinically important while performing imaging-guided techniques for percutaneous blockade of the celiac plexus.[8]

There is anecdotal evidence which indicates that chiropractic spinal manipulative therapies of the thoracolumbar spine may have a beneficial effect on conditions such as gastroesophageal reflux disease, irritable bowel and even duodenal ulcers[22,23] but the scientific evidence to support this contention is lacking. The greater and lesser splanchnic nerves which originate in the lower thoracic spinal cord, pass through the diaphragmatic crura and supply the stomach and small intestine and may play a role in this therapeutic effect. It is possible that spinal manipulative therapy of the thoracolumbar spine could help to alleviate entrapments of the greater and lesser splanchnic nerves as they pass through the muscular crura of the diaphragm and, in this way, promote normal gastrointestinal function. Conversely, abnormalities of the diaphragmatic crura, as described in the present paper, may have a detrimental effect on the splanchnic nerves which normally pass through them.

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