Original Article

Diaphragmatic Crural Splitting and Median Arch Formation Variations

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Abstract

Objective: This study was designed to note down variations in the way of attachment of the crura of thoraco abdominal diaphragm and the way they form the median arch in view of their role as a barrier in gastro esophageal reflux and in designing esophageal hiatus. **The Study Methodology:** It was carried out in the anatomy department of Punjab medical college Faisalabad during years from 2006 to 2010. A total number of 45 human cadavers were dissected for this study. The observed variations were recorded and analysed. **Results and Conclusion:** The crura at their vertebral attachment seen divided into slips both on right and left sides in 64.4% of the cases. In the remaining 35.6% of the cases they did not show this division on either side. Two slips were noted in 48.9% of cases on right side and in 60% of cases on the left side. The medial most slips of both sides joined each other to form median arch in 88.9 % of cases. In 22.2 % of cases the arch formed at level between 1st and 2nd lumbar vertebra. Identification of these anatomical variations would be helpful in understanding the bases and treatment of gastroesophageal reflux disease and hiatal hernia etc. **Key Words**: diaphragmatic crura, gastroesophageal reflux, lower esophageal sphincter, esophagogastric junction.

INTRODUCTION

The diaphragm is a musculofibrous septum between thoracic and abdominal cavities. Its muscular fibres originate from the circumference of the thoracic out let and converge to insert into the central tendon. The muscular fibres are grouped as sternal, costal and lumbar. The sternal fibers arise by two fleshy slips from the posterior surface of the xiphoid process; the costal from the deep surfaces of the lower six ribs and their costal cartilages on either side; and the lumbar from aponeurotic arches named the lumbocostal arches and from the lumbar vertebrae by two pillars or crura. At their origin the crura are tendinous and blend with the anterior longitudinal ligament of the vertebral column. The right crus larger and longer than the left, arises from the anterior surface of the bodies and the intervertebral fibro cartilages of the upper three lumbar vertebrae while the left crus arises from the corresponding parts of the upper two only. The medial tendinous margins of the crura pass forward and medial ward, and meet in the midline to form an arch across the front of the aorta; this arch is often poorly defined [1]. The mammalian diaphragm has traditionally been studied as a respiratory muscle. However there is growing evidence that suggests that it should be more correctly be characterized as two separate muscles, the crural diaphragm and the costal diaphragm[2]. Troyer et al [3] showed that while the costal diaphragm expands the lower rib cage, the crural diaphragm does not change the dimensions of the rib cage appreciably. The crural diaphragm, it seems, has a minor respiratory role, but is greatly involved in gastroesophageal functions, such as swallowing, vomiting, and contributing to gastroesophageal reflux barrier.

The esophago gastric junction (EGJ) is therefore guarded by two sphincters, a smooth muscle lower esophageal sphincter (LES) and a skeletal muscle crural diaphragm. In cat and human the lower esophagel sphincter and crural diaphragm are anatomically superimposed[4]. These two sphincters relax simultaneously under certain physiological conditions i.e., swallowing, belching, vomiting, transient LES relaxation, and esophageal distension[5]. Gastrointestinal physiologists are becoming increasingly aware of the value of crural diaphragm in helping to stop gastric contents from refluxing into the esophagus. Gastro esophageal reflux occurs when the anti reflux barrier is ineffective[6]. In addition, transient crural muscle relaxations herald the onset of

spontaneous acid reflux episodes[7]. It has also been implicated as a possible contributing factor in sudden infant death syndrome[8]. The earlier studies relating to gastro esophageal reflux disease tended to concentrate on the lower esophageal sphincter. More recently attention is focussing on the extrinsic crural muscle. The study of Mittal showed that after crural myotomy, the lower esophageal sphincter cannot fully compensate for the loss of crural muscle[9]. The crural and costal parts of the diaphragm not only are distinct anatomically and functionally, but also have separate origins and nerve supply. During human development of costal diaphragm, myoblasts originating in the body wall probably derived from third fourth and fifth cervical segments, invade the pleuroperitoneal membranes[10]. In contrast, the crura develop in the mesentery of the esophagus[11]. The diaphragm receives its motor innervations via the phrenic nerve, with separate branches innervating the crural and costal regions[12]. The right crus of the diaphragm is also involved in the formation of esophageal hiatus. Since the esophageal hiatus is the only opening in the diaphragm that is vulnerable to visceral herniation, detailed study of the anatomy of crural diaphragm is important in understanding the mechanism and for grading and subsequent treatment of hiatal hernia.

MATERIAL AND METHODS

The study was carried out in the anatomy department of Punjab Medical College Faisalabad, during the years 2006--2010. A total of 45 human cadavers being dissected in the department of anatomy, irrespective of age and sex were selected for this study. After removal of the abdominal viscera the attachments of the diaphragmatic crura were noted.

DATA ANALYSIS

The collected information was entered into SPSS statistical version 10 and analyzed.

Table-I

Slips of crura

crura of diaphragm			Frequency	Percent	Valid Percent	Cumulative Percent
right crura	Valid	yes		64.4	64.4	64.4
		no	16	35.6	35.6	100.0
		Total	45	100.0	100.0	
left crura	Valid	yes	29	64.4	64.4	64.4
		no	16	35.6	35.6	100.0
		Total	45	100.0	100.0	

Figure-I

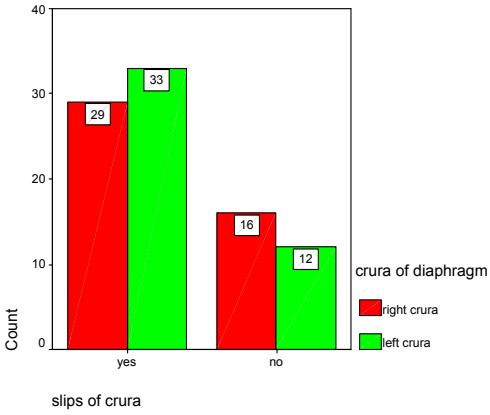


Table-II

Number of slips

crura of diaphragm			Frequency	Percent	Valid Percent	Cumulative Percent
right crura	Valid	0	16	35.6	35.6	35.6
		2	22	48.9	48.9	84.4
		3	7	15.6	15.6	100.0
		Total	45	100.0	100.0	
left crura	Valid	0	16	35.6	35.6	35.6
		1	1	2.2	2.2	37.8
		2	27	60.0	60.0	97.8
		4	1	2.2	2.2	100.0
		Total	45	100.0	100.0	

Figure-II

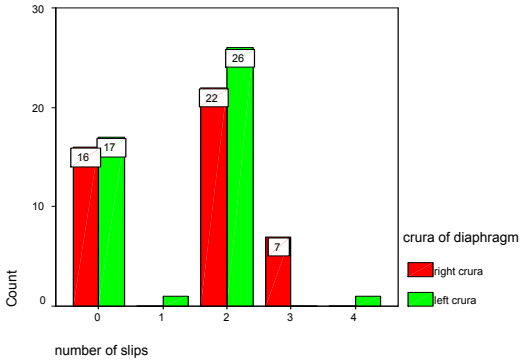


Table-III

Formation of arch

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	40	88.9	88.9	88.9
	no	5	11.1	11.1	100.0
	Total	45	100.0	100.0	

Figure-III

Formation of Arch

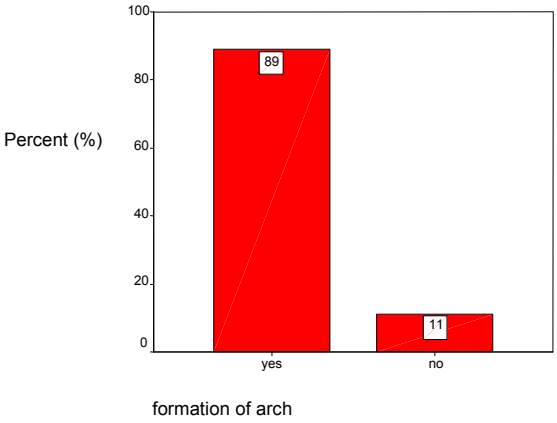


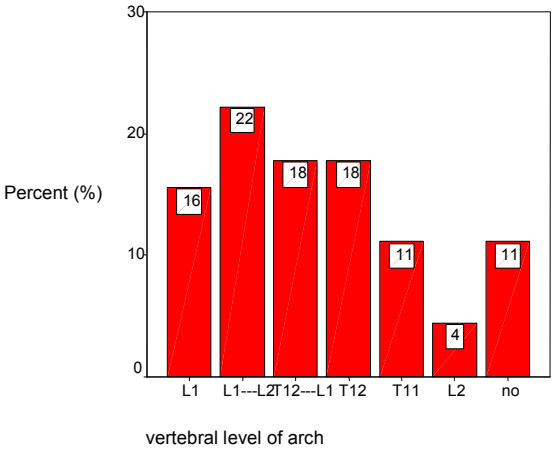
Table-IV

Vertebral level of arch

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	L1	7	15.6	15.6	15.6
	L1---L2	10	22.2	22.2	37.8
	T12---L1	8	17.8	17.8	55.6
	T12	8	17.8	17.8	73.3
	T11	5	11.1	11.1	84.4
	L2	2	4.4	4.4	88.9
	no	5	11.1	11.1	100.0
	Total	45	100.0	100.0	

Figure-IV

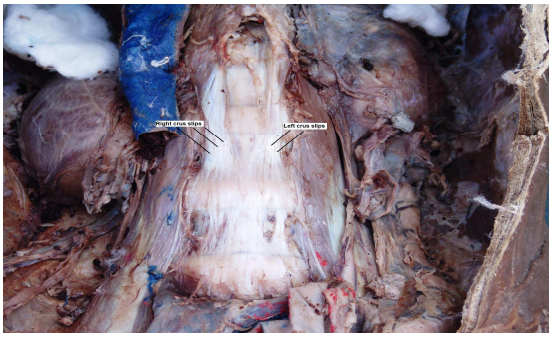
Vertebral level of arch



RESULTS

The crura at their vertebral attachment seen divided into slips in 64.4% cases on both sides. (Table I, Fig I and Fig V). Two slips were noted in 48.9% of the cases on right side and in 60% of cases on the left side. Three slips were noted in 15.6% of the cases on the right side while four slips were noted in 2.2% of the cases on left side. In 35.6% cases crura did not show division into slips on either side (Table II, Fig II). The medial most slips of both sides joined each other in front of the aorta to form a well defined arch in 88.9 % cases, while in 11.1% of the cases the arch formation was poorly defined (Table III, Fig III). The arch formed at level T12 and between T12 and L1 vertebrae in 17.8% of the cases each. In 22.2 % cases, arch formed at level between L1 and L2 vertebra. It formed at T11 in 11.1% of the cases and at L1 in15.1% of the cases (Table IV, Fig IV).

Figure-V



DISCUSSION AND ANALYSIS

The crura of the diaphragm got attention in an earlier study [14] and in that it was reported that 40% crura on right side and 37 % crura on the left side showed division into slips our study differs in that 64.4% of the crura show splitting on right and left side both. In majority of the cases two slips were noted; 48.9% on right side and in 60% on the left side. However in some of them three (15.6%) and in a few of them four slips (2.2%) were also noted. The arch formation by the medial slips has been reported to be either poorly defined or well defined in only 3% of the cases [1,14] whereas according to our findings there was a well defined arch in 88.9% cases although there was considerable variation in the level at which the arch was formed. In majority of the cases it formed at vertebral level between L1 and L2 (22.2%). However,

it formed at T11 (11.1%), at T12 (17.8%), between T12-L1 (17.8%) and at L1 (15.1%) also.

CONCLUSION

Since crural diaphragm has been noticed to be greatly involved in gastroesophageal functioning the above noted anatomical variations may help in understanding the role in physiological aspects of swallowing, belching, vomiting etc. and in treatment of both gastroesophageal reflux disease and hiatal hernia.

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CORRIGENDUM

With reference to article entitled **" Post-traumatic Stress Disorder after Myocardial Infarction"** published in Annals of Punjab Medical College Vol-5, No-2, 2011 page 101 & 105, the name & designation of second author (Humayun Sukrat) should be read as under:

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