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The esophageal hiatus: what is the normal size?

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Abstract

Background A hiatal hernia is defined as the protrusion of intra-abdominal organs through a dilated esophageal hiatus. The esophageal hiatus and its function have been described extensively, but an exact anatomical determination of its normal size is lacking. It seems important to define the normal size, as crural closure is an important part of surgical treatment of gastroesophageal reflux disease (GERD) and hiatal or paraesophageal hernias. The aim of this study was to determine normal values for the size of the esophageal hiatus.

Methods In a prospective study 50 consecutive cadaver autopsies were performed between February and May 2008. The subjects had died from several diseases not related to GERD. Size of the esophageal hiatus was measured after opening the abdominal cavity before extirpation of any organs. Distance of the cardia and gastroesophageal junction and position of the angle of His were further measured. A formula was used to calculate the hiatal surface area (HSA). Results were analyzed regarding subject height, weight, body mass index (BMI), and chest circumference.

Results In all 50 cadavers (24 male/26 female) the autopsy was performed and all measurements were obtained. Mean age was 74 years (40–90 years), mean height was 1.68 m (1.39–1.83 m), mean weight was 71 kg (40–120 kg), and mean body mass index (BMI) was 25 kg/m^2 (14–40 kg/m^2). Mean chest circumference was 101 cm (75–178 range). Mean HSA was 5.84 cm^2 (3.62–9.56 cm^2). In all cadavers the gastroesophageal junction was intraabdominal, the mean distance to the angle of His was 3.6 cm (2.7–4.6 cm), the mean length of the right and left crura was similar at 3.6 cm (2.7–4.6 cm), and the opening segment had a mean length of 2.4 cm (1.7–4.0 cm).

Conclusion The mean HSA was determined in these normal subjects to be 5.84 cm^2. It was directly proportional to chest circumference and independent of height, weight, BMI, and gender.

Keywords Gastro-esophageal reflux disease · Hernia · G-I · Endoscopy · General · Esophageal

Hiatal or paraesophageal hernia (PEH) is defined as the protrusion of intraabdominal organs through a dilated esophageal hiatus. Hiatal hernias are classified according to the anatomic characteristics in relation to the gastroesophageal (GE) junction into: type I hiatal hernia, which is the common sliding hernia where there has been upward migration of the GE junction; type II hernia, which is uncommon and is a true PEH with the stomach herniated alongside the esophagus and the GE junction remaining in its normal anatomic position; and type III hernia, which is a mixed hernia with both a sliding and paraesophageal component. Both type II and III are also called "paraesophageal hernias" or "intrathoracic stomachs."

The esophageal hiatus and its function have been described extensively [1], and it is known that the crura augment the lower esophageal sphincter in a patient with an intact

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antireflux barrier. An exact anatomical determination of the normal size of the esophageal hiatus is lacking, and to date no normal values have been available to determine the normal size of a patient's esophageal hiatus.

Large studies have shown that the main failure of hiatal or paraesophageal hernia repair or antireflux procedures is the failure of crural closure or crural reinforcement [2–5]. It is widely accepted that for redo procedures or large paraesophageal hernias (PEH) the use of a prosthetic synthetic or biological mesh for reinforcement of the hiatus reduces the recurrence rate [6–10]. In a recently published study the concept of tailoring the hiatal closure to the size of the hiatal surface area (HSA) was introduced and preliminary results presented [10]. As a consequence, for better comparison of future studies, the HSA should be reported, as the critical point for failure is crura closure [5].

The aim of this study was to determine normal values for the size of the esophageal hiatus.

Methods

In a prospective study cadaver autopsies were performed between February and May 2008. Subjects who had died from diseases related to hiatal hernia, paraesophageal hernia, gastroesophageal reflux disease (GERD) or prior antireflux procedures or diaphragmatic surgery were excluded prior to the autopsy. The study population was determined as 50 consecutive cadaver autopsies to obtain parameters to determine the normal values for the esophageal hiatus. The cadaver autopsies were performed in all subjects in a standardized procedure, measuring the size of the esophageal hiatus after opening the abdominal cavity but before extirpation of any organs. After minimal hiatal dissection a divider was used to obtain the measurements for all parameters (Fig. 1). First, the length of the crura was measured in centimeters, beginning at the crural commissure up to the edge where the pars flaccid begins (R, Fig. 2). Then the circuit between the both crural edges was further measured (s).

The formula used for the hiatal surface area (HSA) was that reported by Pointner and Granderath [10]: from the two measured values (R and s), the angle of the crural commissure (alpha) was calculated using an arcsin function as: $\text{alpha1} = \arcsin(s/2)/R$. As a further result: $\text{alpha0} = 2 \times \text{alpha1}$. The radian measure is calculated with the formula: $B = \pi \times R \times \text{alpha0}/180$, and the formula is:

$$\text{HSA} = B \times R/2.$$

Distance of the cardia and gastroesophageal junction (GE) and position of the angle of His were further measured during the cadaver autopsies. Further data for subject height, weight, body mass index (BMI), and chest circumference were collected. Values are reported as means (range, minimum to maximum). Nearly all patients dying in the hospital are dissected for autopsy, and this cadaver study was performed in subjects who were already going to undergo autopsy. As no visible additional cuts were made and only measurements were taken, no additional approval was necessary to perform this study.

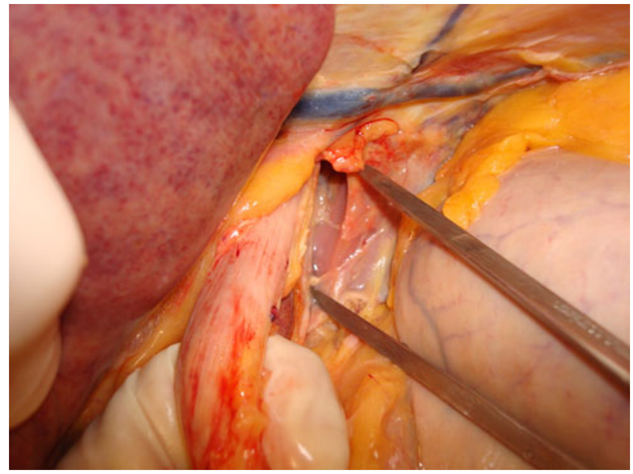

Fig. 1 Hiatal region after dissection and before measurement of the hiatal surface area (HSA)

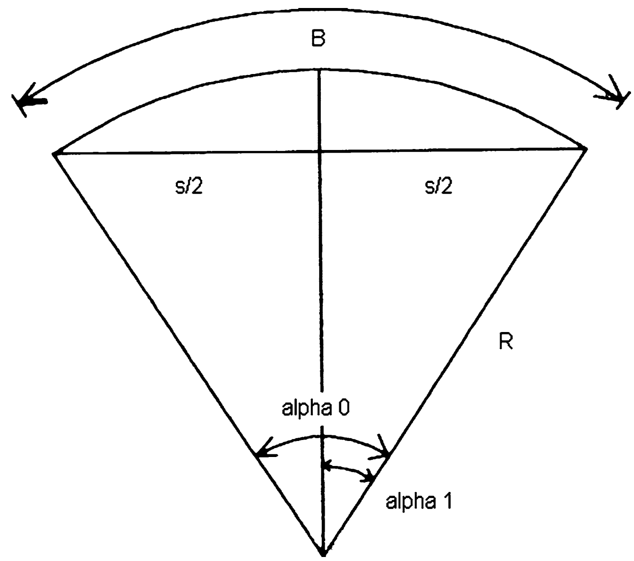

Fig. 2 Calculation of the hiatal surface area (HSA). With the measured two values (s and R), the angle of the crural commissure (alpha0) is calculated using the equation: $\text{alpha1} = \arcsin(s/2)/R$ and $\text{alpha0} = 2 \times \text{alpha1}$. The radian measure is calculated using the formula: $B = \pi \times R \times \text{alpha0}/180$, and the formula is: $\text{HSA} = B \times R/2$

Results

In all 50 cadavers (24 male, 26 female) the autopsy was performed and all measurements were obtained according

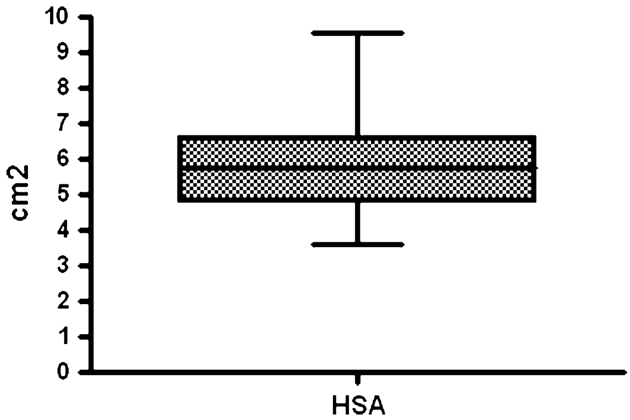

Fig. 3 Normal value of the hiatal surface area (HSA). Mean HSA was 5.84 cm^2

to the study protocol. The mean age was 74 years (range 40–90 years), mean height was 1.68 m (range 1.39–1.83 m), and mean weight was 71 kg (range 40–120 kg). Mean BMI was 25 kg/m^2 (range 14–40 kg/m^2). Mean chest circumference was 101 cm (range 75–178 cm). In all cadavers the GE junction was located intra-abdominally, the mean distance to the angle of His was 3.6 cm (range 2.7–4.6 cm), the mean length of the right and left crura was similar at 3.6 cm (range 2.7–4.6 cm), and the opening segment had a mean length of 2.4 cm (range 1.7–4.0 cm).

The mean HSA was 5.84 cm^2 (range 3.62–9.56 cm^2). The interquartile range for the HSA was from 4.8 cm^2 (25th percentile) to 6.6 cm^2 (75th percentile) (Fig. 3). The HSA was directly proportional to chest circumference (Pearson $r = 0.3235$, 95% confidence interval 0.04959–0.5522, $p = 0.0219$), while there was no correlation with height ($p = 0.5383$), weight ($p = 0.2561$), BMI ($p = 0.4101$) or gender ($p = 0.2886$).

Discussion

Hiatal closure and crural reinforcement tailored to the individual patient is seen as a critical part of surgical repair of GERD, and hiatal and paraesophageal hernias. Several concepts exist for the approach to hiatal closure in these patients. One approach is to perform sutures for the primary repair and to use mesh reinforcement for crural closure in redo procedures only. Another approach is the consequent use of prosthetic synthetic or biological mesh [7, 11]. While there are randomized studies showing a benefit of mesh placement, the potential danger of mesh erosion into the esophagus exists [12–14], as the hiatus is a very mobile area with interaction between the diaphragm with respiratory movements and the esophagus. Studies with the use of biological mesh show good results [8, 9], as well as a recent study using Vicryl mesh and BioGlue [15]. It is accepted that durable repair of large paraesophageal hernias cannot be achieved without mesh placement.

Except for a few studies, the focus has recently been on different meshes [7–9, 11, 16–19] and the potential threats to mesh fixation [14, 20, 21], and less on the anatomy of the hiatus. Tailoring hiatal closure to the hiatal surface area is one possibility to achieve study protocols which can be compared in the future. While the size of the HSA is not reported in recent studies, there were also no normal values existing for comparison to determine the need for further closure or reinforcement. The depth of the hiatal canal was not evaluated in our study as the focus was on HSA and the determination of a normal value useful for decision-making during surgery in patients with paraesophageal hernias. The depth of the canal might be of importance in the etiology or development of a hiatal hernia, but for the repair of the hernia the options are either to reduce the HSA and reinforce it or to bridge it.

The normal values from this cadaveric subjects reflect the correct thresholds used in the recent study for tailoring the crural closure technique [10]. As the minimal value in our study for the HSA was 3.6 cm^2, the concept of applying simple suture closure for patients with HSA less than 4 cm^2 is convincing. The further concept of crural closure should be revised in a clinical setting in further studies, eventually in combination with tailoring of the fundoplication to the appropriate location [22]. An accurate and reproducible manner to measure the size of the hiatal defect before closure exists. The normal values we describe for the parameters to calculate the HSA are now available with this study. Future studies have to create thresholds and guidelines for the size of the hiatus after crural closure. As the HSA is directly proportional to chest circumference, this parameter could be considered in further studies for the tailoring of the technique for crural closure and reinforcement. The anterior–posterior diameter (APD) after crural closure should be recorded [23] If future studies include these three important steps, comparability will be much better between different techniques with different meshes and mesh fixation, to find the technique with the least recurrence.

Disclosures The authors Andreas Shamiyeh, Kornel Szabo, Frank Alexander Granderath, Gerhard Syre, Wolfgang Wayand, and Jörg Zehetner have no conflicts of interest or financial ties to disclose.

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