

Sonographic Measurements of Subdiaphragmatic Length, Diameter, and Diameter to Length Ratio of Esophagus in Gastroesophageal Reflux Disease Diagnosis in Children

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Abstract: Gastroesophageal reflux disease (GERD) is a common condition among infants and young children. In this age-group, in particular, this condition needs to be diagnosed and treated as early as possible, because any delay may lead to unwanted consequences in terms of their growth and development. Although ultrasonography has been claimed as a sensitive and accurate diagnostic modality, it is time-consuming and difficult to perform in young children. This study aimed to evaluate correlation of some sonographic anatomical parameters of distal esophagus with results of classic sonography in diagnosis of GERD in infants and children. In this cross-sectional analytic-descriptive study, 282 infants and children were recruited. Based on the results of gray-scale conventional sonography, GERD was diagnosed in 185 cases. Length of the subdiaphragmatic esophagus, distal esophageal diameter and wall thickness, and diameter to length ratio were documented by ultrasound and compared between the groups with and without GERD. One hundred and thirty nine boys and 143 girls with a mean age of 16.78±20.99 (range: 1-144) months were enrolled in this study. The length of subdiaphragmatic esophagus was significantly lower in the cases with GERD, while the distal esophageal wall thickness and the diameter to length ratio were significantly higher in the same group. Among the studied sonographic variables, diameter to length ratio was the best indirect indicator of GERD with an optimal cut-off point of 0.45 (sensitivity: 61.1%, specificity: 57.7%). The length of subdiaphragmatic esophagus was predictive of GERD only in the age-group of 12-60 months with low sensitivity and specificity (<42%). This study showed that only the diameter to length ratio of the subdiaphragmatic esophagus might be used to predict GERD among children with limited efficiency.

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1. Introduction

Gastroesophageal reflux (GER) is defined as an involuntary passage of gastric contents backwards up into the esophagus, and is a common finding in infants and also seems to be physiological and benign process in neonates (Costa and Campobasso, 1999; Naik et al., 1985; Vandenplas et al., 2009). Gastroesophageal reflux disease (GERD) is the most common esophageal disorder in children and infants (Di Mario et al., 1995). The symptoms associated with GER or GERD can differ depending on the patient's age and health status. Symptoms of GERD include esophagitis, Barrett's esophagus, esophageal ulcer, upper GI bleeding and also some respiratory symptoms (Lagergren et al., 1999; Delavari et al., 2012).

The classic method of studying GERD is the upper gastrointestinal series with barium (Meschan and Ott, 1984). Recently gastrointestinal ultrasonography (GEUS) has been suggested as an available, noninvasive and sensitive method, providing morphological and functional information

(Gomes et al., 1993; Gomes and Menanteau, 1991). These ultrasonographic studies have mainly focused on the evaluation of the gastroesophageal junction and GERD was made by backward of gastric contents into the esophagus (Mittal, 2005; Mittal et al., 2005; Holloway, 2007; Zhu et al., 2004). Although the previous ultrasonographic techniques have been claimed as a sensitive and accurate diagnostic modality, it is time consuming and has difficulties in performance at young children. The aim of this study was to evaluate correlation of some sonographic anatomical parameters of distal esophagus with results of classic sonography in diagnosis of GERD in infants and children.

2. Material and Methods

In this cross-sectional analytic-descriptive study, 282 infants and children were recruited from Tabriz Children's Teaching Centre in a 15-month period from January 2011 to March 2012. Inclusion criteria were the patients aged between 1 month and 14 years with clinical signs and symptoms of GERD.

Exclusion criteria were the patients with the signs or symptoms of gastrointestinal atresia or occlusion, gastroenteritis and confirmed hypertrophied pyloric stenosis or a systemic disease (Aslanabadi et al., 2010; Taheri et al., 2010; Aslanabadi et al., 2011; Aslanabadi et al., 2011; Seyedhejazi et al., 2012; Azarfari et al., 2013; Seyedhejazi et al., 2013). The ultrasound equipment utilized was with 5 MHz convex transducer (Nemati et al., 2010). Ultrasonographic studies were performed after a liquid feed consumption to produce adequate gastric distension. Ultrasonography was performed with the patients in supine position. For visualization of abdominal esophagus in a longitudinal section, the transducer was placed in the midline below the xiphisternum and angled approximately upwards. Sonographic diagnosis of GER was based on the

visualization of the passage of gastric fluid into the abdominal esophagus and the esophageal clearance of refluxed material by peristalsis. Based on the results of mentioned conventional sonography, GERD was diagnosed in 185 cases. Length of the sub-diaphragmatic esophagus, distal esophageal diameter and wall thickness, and the diameter to length ratio were documented by ultrasound and compared between the groups with (n=185) and without (n=97) GERD.

Data were presented as mean \pm standard deviation (SD), or percentage. Statistical analysis was performed with SPSS for windows version 13.0 using independent-samples t-test and Chi-square test. Receiver operator characteristic (ROC) curve was used to examine the predictive values. A $P < 0.05$ was considered statistically significant.

Table 1. Sonographic parameters in patient and control groups

Age (month)	Sonographic diagnosis	Length (cm)	Diameter (mm)	Length to diameter ratio	Thickness
1-6	Control	12.09 \pm 2.26	5.59 \pm 0.58	0.48 \pm 0.10	1.64 \pm 0.29
	Patient	11.38 \pm 2.00	5.58 \pm 0.85	0.50 \pm 0.09	1.63 \pm 0.29
6-12	Control	14.74 \pm 5.05	6.05 \pm 0.56	0.45 \pm 0.13	1.68 \pm 0.31
	Patient	12.65 \pm 2.25	5.84 \pm 0.75	0.47 \pm 0.09	1.69 \pm 0.32
12-24	Control	16.80 \pm 3.77	6.10 \pm 0.73	0.38 \pm 0.07	1.56 \pm 0.44
	Patient	13.56 \pm 3.94	6.24 \pm 1.25	0.51 \pm 0.25	1.81 \pm 0.37
24-60	Control	17.02 \pm 3.60	6.84 \pm 0.96	0.42 \pm 0.12	1.69 \pm 0.31
	Patient	14.14 \pm 3.15	6.60 \pm 1.30	0.48 \pm 0.10	1.92 \pm 0.44
60-120	Control	18.89 \pm 6.54	7.26 \pm 1.17	0.41 \pm 0.11	1.95 \pm 0.47
	Patient	17.23 \pm 4.37	7.43 \pm 1.25	0.45 \pm 0.13	2.05 \pm 0.62
All	Control	15.70 \pm 4.72	6.83 \pm 0.98	0.43 \pm 0.11	1.70 \pm 0.35
	Patient	12.65 \pm 2.90	5.94 \pm 1.02	0.49 \pm 0.13	1.72 \pm 0.36

3. Results

The mean age of the patients with GERD (n=185) was 11.82 \pm 14.49 months, and of the control group (n=97) was 26.24 \pm 27.38 months ($P < 0.001$). In the patient group, there were 93 males and 92 females and in the control group the males were 46 and females were 51 ($P = 0.65$).

After age- and gender-matching, the mean length of the subdiaphragmatic esophagus in the patients group was significantly shorter than the non-GERD group ($P < 0.001$). Moreover, the mean wall thickness of esophagus in the GERD group was significantly greater than the healthy group ($P = 0.03$). Comparing different age groups, there were significant differences in terms of mean subdiaphragmatic esophageal length ($P < 0.001$), esophageal diameter ($P < 0.001$), and esophageal wall thickness ($P = 0.002$).

According to ROC analysis, the area under the curve for the mean diameter/length ratio was significantly great in value (AUC=0.63, $P < 0.001$).

Accordingly, the cut off point for esophageal diameter/length ratio was considered as 0.45 which resulted in sensitivity and specificity of 61.1% and 57.7%, respectively. Other ultrasonographic variables failed to result in statistically significant findings in the ROC analysis.

4. Discussion

Several methods are available for evaluation and diagnosis of GERD in children including esophageal pH monitoring, upper gastrointestinal contrast radiography, upper gastrointestinal endoscopy and ultrasonography studies (Ashorn et al., 2002; Salvatore et al., 2004; Koumanidou et al., 2004). Some studies suggested ultrasonography as the first imaging approach in children with suspected GERD (Jang et al., 2001; Westra et al., 1990; Fallahi et al., 2007; Farina et al., 2008). Sonographic studies are mainly based on the backflow of gastric contents to the esophagus. However, this technique is time-consuming and difficult to perform in infants and

young children. Therefore, in this study we aimed to evaluate correlation of some sonographic anatomical parameters of distal esophagus with results of classic sonography in diagnosis of GERD.

In this study we evaluated four sonographic parameters including length of subdiaphragmatic esophagus, diameter of distal esophagus, wall thickness of esophagus and diameter to length ratio. In our study, after age-and gender-matching, the mean length of the subdiaphragmatic esophagus in the patients was significantly shorter than controls. In agreement with our study, Halkiewicz et al. (2000) evaluated 128 infants and children and showed that patients with GERD had shorter subdiaphragmatic esophagus. Also some other studies confirmed the findings of our study (Koumanidou et al., 2004). However, in this study we showed that the cut off point for esophageal diameter length ratio was 0.45 which resulted in low sensitivity and specificity, but Koumanidou et al showed higher sensitivity (>0.90%) (Koumanidou et al., 2004). Our study showed that the length of subdiaphragmatic esophagus could not replace the classic method of sonography in GERD, and this was in contrast to few other studies (Koumanidou et al., 2004).

In conclusion, the results of our study show that the classic sonography method is more reliable and only the diameter to length ratio of the subdiaphragmatic esophagus could be used to predict GERD among children with limited efficiency.

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