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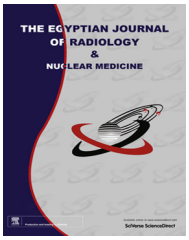

ORIGINAL ARTICLE

Postoperative ultrasonography changes of the pylorus in infants with hypertrophic pyloric stenosis

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KEYWORDS

Infantile;
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Abstract Infantile hypertrophic pyloric stenosis (IHPS) is a common condition affecting infants. Ramstedt pyloromyotomy procedure remains the standard of surgical treatment of IHPS till today. Postoperative ultrasonography of the pylorus is indicated in patients with persistent vomiting after pyloromyotomy to assess pyloric morphology, gastric emptying and excludes other associated conditions or complications that may present with this clinical picture.

Aim of the work: To assess the short term morphological and dynamic changes of the pyloric muscle following pyloromyotomy in patients with HPS.

Subjects and methods: Forty infants who were admitted to the pediatric surgery unit at Tanta university hospitals had a preoperative ultrasound (US) examination for assessment of the pylorus for HPS. Follow up postoperative US was performed on the 3rd day, after 1 week and 1 month by the same radiologist.

Results: All the patients showed pyloric measurements that exceeded the agreed upon criteria for diagnosis of HPS. On the postoperative scans the pyloric muscle measurements were recorded and compared to preoperative ones.

Conclusion: Postoperative US of the pylorus, with emphasis on the pyloric behavior, is a key tool in assessment of the postoperative changes of the pylorus for patient with surgically treated HPS.

1. Introduction

Infantile hypertrophic pyloric stenosis (HPS) is condition affecting approximately two to five per 1000 infants and is the most common condition requiring surgical repair in this age. In HPS the antropyloric portion of the stomach becomes abnormally thickened causing obstruction of the gastric outlet (1,2).

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Typically infants with HPS are clinically normal at birth then in the first few weeks of the postnatal life they develop nonbilious projectile vomiting as a result of the gastric outlet obstruction which may lead to weight loss and death if left untreated (1).

Ramstedt pyloromyotomy procedure remains the standard of surgical treatment of HPS till today. In a very few cases presenting with persistent vomiting caused by an incomplete Ramstedt pyloromyotomy, reoperation is necessary (3,4).

Preoperative ultrasonography of the pylorus is a well established non invasive tool in the diagnosis of HPS allowing direct observation of the pyloric canal morphology and behavior without the hazards of radiation exposure. Ultrasonography clearly shows the morphology of the canal and allows for its measurement (1).

Postoperative ultrasonography of the pylorus is indicated in infants with persistent vomiting after pyloromyotomy in conjunction with upper GI contrast studies to assess pyloric morphology, gastric emptying and excludes other associated conditions or complications that may present with this clinical picture (3–5). Hence, our aim was at assessing the short term morphological and dynamic changes of the pyloric muscle following pyloromyotomy in infants with HPS.

2. Subjects and methods

After approval of the Ethics committee at our institution 40 infants who were admitted to the pediatric surgery unit at Tanta university hospitals between January 2012 and June 2013 with the diagnosis of HPS were included in the study. They were 34 males and 6 females. All infants presented clinically with repeated projectile vomiting and failure of weight gain and/or weight loss. The age of the patients at the time of presentation ranged between 22 and 60 days with a mean of 43 days. Informed consents were taken from the infants parents to enroll them in this study. Routine preoperative clinical assessment of infants was performed with emphasis on detection of a pyloric mass or olive. An initial preoperative ultrasound of the pylorus was performed and the diagnosis of HPS was established based on the widely accepted criteria of a single muscle thickness of more than 3 mm and an elongation of the canal more than 12 mm (1). All infants underwent surgical repair by Ramstedt procedure through a circumumbilical incision approach (Bianchi modification), which facilitated postoperative US assessment as the scar site was away from the scan approach site. All infants recovered smoothly with no complications and were discharged on the 3rd postoperative day. Postoperative ultrasound examinations were performed on the second or at most third postoperative day before patient discharged from the hospital, one week postoperative and one month postoperative. Postoperative ultrasound examinations were all performed by the same radiologist performing the preoperative examination. Scanning was performed using the linear transducer on a Toshiba SSA-590A (Nemio MX, Toshiba Medical Systems, Japan), which has a 6–11 MHz frequency range. Pyloric muscle shape, measurements and behavior on real time B-mode ultrasonography were observed and recorded.

The scanning technique of the pylorus was performed by placing the transducer in the epigastric region with the knob of the transducer towards the head of the infant to obtain a sagittal scan, starting in the midline and slowly moving the transducer laterally towards the right hypochondrium until the pylorus could be identified. In infants with excessive gas in the stomach, which would hinder the scan, they were placed in an oblique position by raising their left side up which displaced the gases away from the pylorus and gastric fluid towards it facilitating better identification of the pylorus. Once the pylorus location was established, rotation of the transducer was done to obtain proper transverse and longitudinal scans in which measurements were taken on. In the postoperative patients the single muscle thickness of the pylorus was measured opposite to the pyloromyotomy site, i.e. at a 180° to the pyloromyotomy incision. The diameter of the pyloric canal was measured across the pylorus not including the pyloromyotomy

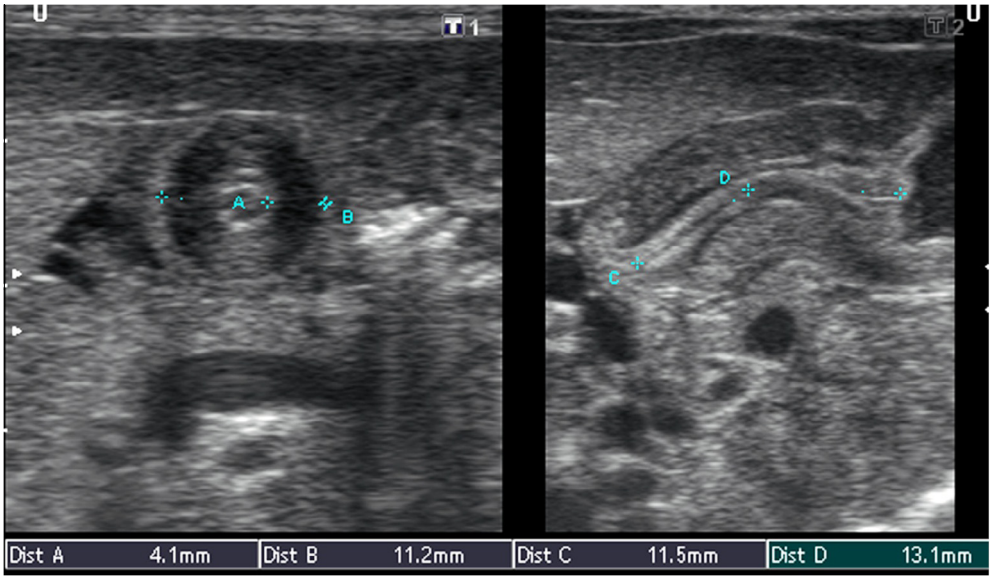

Fig. 1 Preoperative US of a patient with HPS (transverse and longitudinal images of the pylorus) showing its typical appearance of pyloric muscle thickening, elongation of its canal and mucosal bulge into the stomach.

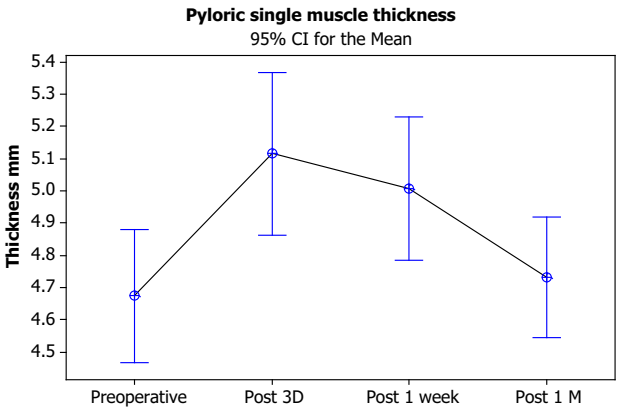

Fig. 2 Line chart showing the mean single muscle thickness measurements in the pre- and postoperative follow up.

site, i.e. at 90° pyloromyotomy incision, both measurements were taken in the transverse scan. The pyloric canal length was measured in the longitudinal scan. Statistical analysis of the pre- and postoperative measurements of the pyloric muscle was done using paired *T*-test for means, a p value of <0.05 was considered statistically significant with a 95% confidence interval. Analysis was performed using the Minitab 16 statistical analysis software (Minitab Inc. USA).

3. Results

Pyloric muscle measurements preoperatively were 4.6 ± 0.6 mm for single muscle thickness, 19.6 ± 3 mm for pyloric canal length and 14.3 ± 1.8 mm for pyloric canal diameter (Fig. 1).

Postpyloromyotomy pyloric muscle changes can be divided into 2 major categories, pyloric muscle morphology and measurements on static images and pyloric muscle behavior on dynamic real time B-mode images.

The pylorus retained its donut shape in transverse scans with distortion of its contour at the pyloromyotomy site. On the 3rd day postoperative scan the pyloromyotomy site appeared as a hyperechoic linear or wedge shaped area within the muscle associated with focal thinning of the muscle. The hyperechoic mucosa of the pyloric canal was also seen eccentrically located within the pyloric muscle and it was still seen bulging into the stomach on longitudinal scans. On the following scans, performed after 1 week and 1 month, these features became more evident with the pylorus resembling the shape of a flat car tire and the characteristic pyloric mucosa bulge into the stomach was lost.

There was an initial increase in the postoperative single muscle thickness compared to preoperative measurements on the 3rd day (5.1 ± 0.7 mm) and after 1 week (5 ± 0.6 mm) which started to decrease after one month (4.7 ± 0.6 mm) however not reaching the preoperative measurements (Figs. 2 and 3). The changes in the muscle thickness were statistically significant ($p < 0.05$) between the pre- and postoperative measurements.

The pyloric canal showed a decreasing trend in its length along the course of the postoperative period, measuring 18.3 ± 2.4 mm on the 3rd day, 16.6 ± 2 mm after 1 week and 13.9 ± 2 mm after one month. The change in the canal length was statistically significant ($p < 0.05$) for all measurements (Figs. 4 and 5).

The diameter of the pyloric canal showed a trend similar to that of the single pyloric muscle measurements, showing an initial increase in diameter followed by a decrease. It measured

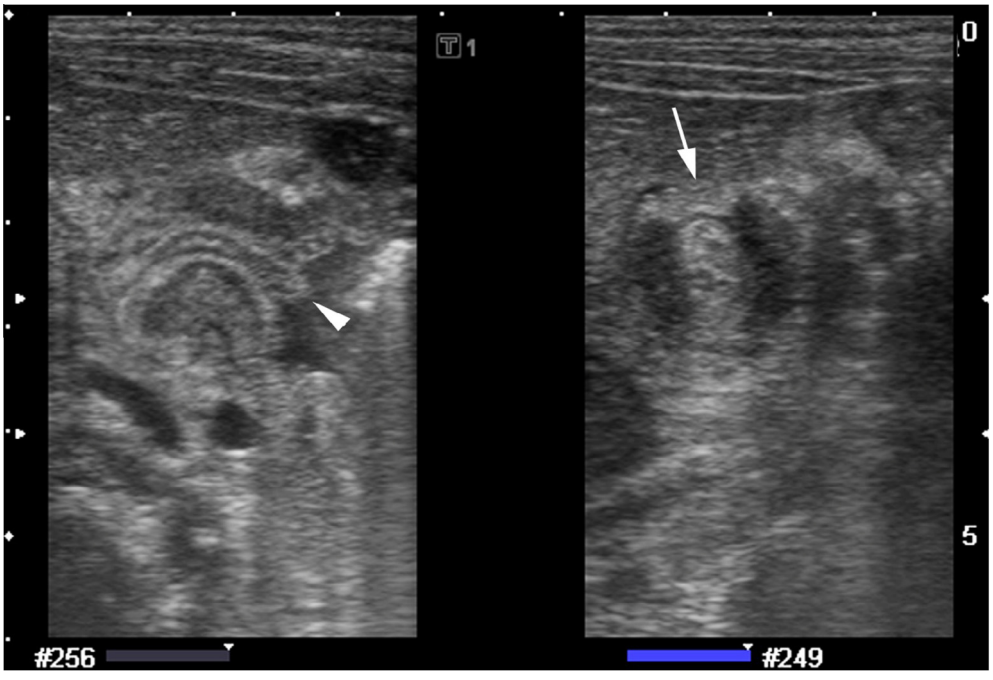

Fig. 3 Longitudinal and transverse ultrasound of the pylorus on the 3rd postoperative day showing the echogenic wedge shaped gap in the muscle at the site of pyloromyotomy (arrow) in the transverse scan. The hypertrophic pyloric mucosal bulge into the stomach is still seen in the longitudinal scan (arrowhead).

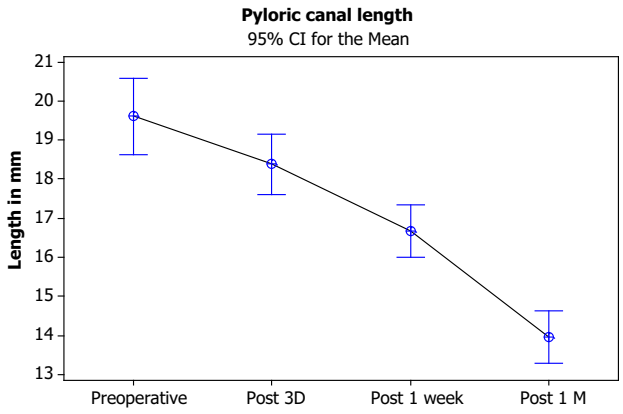

Fig. 4 Line chart of the mean pyloric canal length measurements in the pre- and postoperative follow up.

14.8 ± 2.1 mm on the 3rd day, 14.5 ± 1.8 mm after 1 week and 13.3 ± 1.6 mm after 1 month.

The change in canal diameter measurements was statistically significant ($p < 0.05$) between the pre- and postoperative measurements for all measurements except for that of the preoperative and 3rd day postoperative measurements where there was no statistically significant change ($p = 0.077$) (Fig. 6).

Regarding the pyloric muscle behavior on real time B-mode imaging, the most evident feature seen in first postoperative scan on the 3rd day, was the gapping of the pyloric canal mucosa and the propagation of the gastric peristalsis with free flow of gastric contents through it (Fig. 7).

4. Discussion

Owing to the high success rate of Ramstedt pyloromyotomy little was known about the postoperative changes of the pylorus, except for the autopsy reports after the rare deaths that happened to children who had this procedure or children having redo operations due to recurrence of their symptoms from an inadequately performed procedure (4–6). The time that is required for normalization of the pyloric muscle measurements is estimated to be between 12 weeks and 8 months (7–8). With the advent of the use of ultrasound in diagnosis of HPS, it became the tool of choice in following up the patients as well (9).

In this study it was found that despite the relief of vomiting and improvement of clinical symptoms in the patients postoperatively although the postoperative pyloric muscle measurements remained within the range that is considered diagnostic for HPS. The pyloric muscle even showed increase of its thickness in the early postoperative period, these findings are in agreement with those reported by Yoshizawa et al. (10) and confirmed by Muramori et al. (8). The increase in muscle thickness is thought to be due to elastic recoil of the muscle after its splitting during the pyloromyotomy procedure and/or associated edema of the pylorus (6–10). Pyloric canal length showed a steady decrease in its measurements over the serial postoperative scans with the greatest degree of change when compared to the other 2 parameters measured,

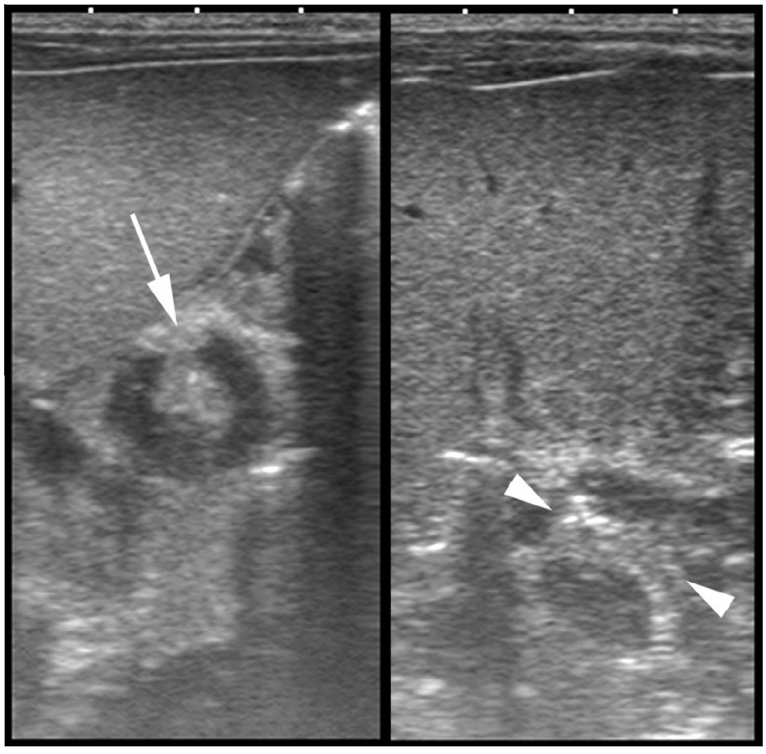

Fig. 5 Postoperative ultrasound of the pylorus after 1 month (transverse and longitudinal images) showing the pyloric muscle thinning at the site of pyloromyotomy and the increased thickness of the muscle opposite to it, in this patient it measured 6.4 mm. The pyloric canal is seen eccentrically located within the muscle and pylorus resembles the shape of a flat tire in the transverse scan (arrow). The longitudinal scan shows shortening of the pyloric canal length (between arrowheads) measuring 14 mm in contrast to 19 mm in the preoperative scan.

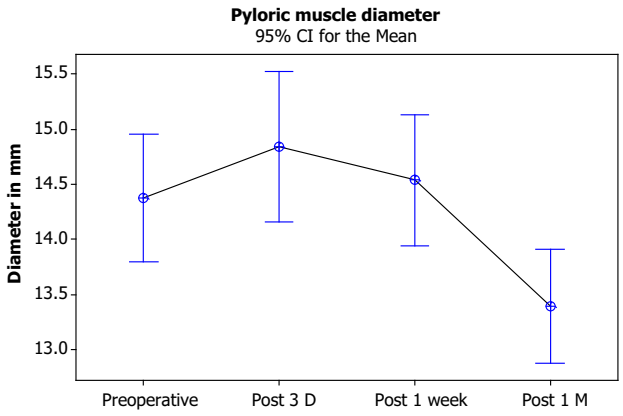

Fig. 6 Line chart showing the mean pyloric canal diameter measurements in the pre- and postoperative follow up.

Fig. 7 Longitudinal ultrasound of the pylorus on the 3rd postoperative day (same patient in Fig. 3) showing gapping of the pyloric canal with free passing of the echogenic gastric contents through it (arrow).

findings in this study are in agreement with those of Yoshizawa et al. (10) and Muramori et al. (8) who reported a similar trend however the latter author reported a difficulty in identifying the channel after a 4 month follow up period. Such observation suggests that the decrease in the canal length is a reliable measure in the assessment of postoperative changes of the pylorus. The diameter of the pyloric canal showed a trend similar to that of the single muscle thickness with an initial increase followed by decrease in its measurements; these findings are in agreement with those reported by Yoshizawa et al. (10) and Muramori et al. (8) and in disagreement with those of Huang et al. (2) who reported a decrease in pyloric diameter over a 3 day daily follow up scan. Several other measurements of the pylorus after Ramstedt pyloromyotomy were suggested including the alternative pyloric ratio by Huang et al. (2), which is ratio between the intermuscular distance to the pyloric diameter, and the pyloric muscle index by Okorie et al. (7), which involves a cumbersome calculation of the pyloric muscle volume to the patient's weight. The first was omitted due to a lack of acquiring an accurate measure for the intermuscular diameter in the postoperative scans as the resolving hypertrophic pyloric mucosa is echogenic and the passing gastric contents are echogenic as well with shadowing allowing for erroneous measurements.

In this study the pyloric morphology in postoperative infants showed a wedge scar in the muscle on transverse images in the early postoperative scans which gradually evolved to focal thinning of the muscle to give the pylorus a flat tire appearance, the findings are similar to those reported by Yoshizawa et al. and Vasileios et al. (10,11). There was loss of the characteristic mucosal bulge into stomach seen in the postoperative scans performed after one week.

In the setting of preoperative assessment of HPS Dias et al. (12) recommended the observation of the pyloric dynamic behavior on real time scanning. It was found that as early as the 3rd postoperative day on dynamic real time B-mode scanning, that gastric peristaltic waves propagated gastric contents smoothly through the pyloric canal, a finding lacking on the preoperative scans, these observations are similar to those reported by Huang et al. and Vasileios et al. (2,11). Ankermann et al. (3) who suggested that there will be lack of the free flow of gastric contents through the pylorus in the early postoperative period in patients with inadequate pyloromyotomy, a major limitation of this study is the lack of patients with failed pyloromyotomy to compare our findings with.

5. Conclusion

In conclusion based on the findings in this study, in the setting of assessment of the pylorus following pyloromyotomy, it is important to focus on its dynamic behavior on real time ultrasound before its measurements and morphology. If measurements are required, pyloric canal length is considered as the most reliable measure owing to its tendency to decrease over time postoperatively.

Conflict of interest

We have no conflict of interest to declare.

References

(1) Hernanz-Schulman M. Infantile hypertrophic pyloric stenosis. Radiology 2003;227(2):319–31.
(2) Huang YL, Lee HC, Yeung CY, Chen WT, Jiang CB, Sheu JC, et al. Sonogram before and after pyloromyotomy: the pyloric ratio in infantile hypertrophic pyloric stenosis. Pediatr Neonatol 2009;50(3):117–20.
(3) Ankermann T, Engler S, Partsch CJ. Repyloromyotomy for recurrent infantile hypertrophic pyloric stenosis after successful first pyloromyotomy. J Pediatr Surg 2002 Nov;37(11):E40.
(4) Hulka F, Harrison MW, Campbell TJ, Campbell JR. Complications of pyloromyotomy for infantile hypertrophic pyloric stenosis. Am J Surg 1997;173(5):450–2.
(5) Nasr A, Ein SH, Connolly B. Recurrent pyloric stenosis: to dilate or operate? A preliminary report. J Pediatr Surg 2008;43(2):e17–20.

(6) Wollstein M. Healing of hypertrophic pyloric stenosis after the Fredet-Rammstedt operation. Am J Dis Child 1922;23(6):511–7.
(7) Okorie NM, Dickson JA, Carver RA, Steiner GM. What happens to the pylorus after pyloromyotomy? Arch Dis Child 1988 Nov;63(11):1339–41.
(8) Muramori K, Nagasaki A, Kawanami T. Ultrasonographic serial measurements of the morphologic resolution of the pylorus after Ramstedt pyloromyotomy for infantile hypertrophic pyloric stenosis. J Ultrasound Med 2007;26(12):1681–7.
(9) Sauerbrei EE, Paloschi GG. The ultrasonic features of hypertrophic pyloric stenosis, with emphasis on the postoperative appearance. Radiology 1983;147(2):503–6.
(10) Yoshizawa J, Eto T, Higashimoto Y, Saitou T, Maie M. Ultrasonographic features of normalization of the pylorus after pyloromyotomy for hypertrophic pyloric stenosis. J Pediatr Surg 2001;36(4):582–6.
(11) Vasileios R, Naoum K, Dimitrios R. US evaluation of infantile hypertrophic pyloric stenosis before and after pyloromyotomy. Eurorad Radiological Case Database [serial on the Internet]. 2013: Available from: <http://www.eurorad.org/eurorad/case.php?id=11369>.
(12) Costa Dias S, Swinson S, Torrao H, Goncalves L, Kurochka S, Vaz CP, et al. Hypertrophic pyloric stenosis tips and tricks for ultrasound diagnosis. Insights Imaging 2012;3(3):247–50.