Aims: The aim of this study was to find & compare the pyloric Canal Length (CL), Pyloric muscle thickness (MT) by using the High Resolution Ultrasonography (HRUS) in Preoperative & postoperative period (after Ramstedt Pyloromyotomy) for Infantile Hypertrophic Pyloric Stenosis (IHPS).

Methods: From January 2018 to June 2019, we have performed HRUS for 40 patients of clinically diagnosed cases of IHPS. & Ultrasonography machine: Phillips HD 7 machine & Alpinion E-CUBE with 3-12MHz linear probe, 3.5-5 MHz curvilinear probe and 5-7.5 MHz sector probe were used. The sonographic criteria for positive IHPS are Pyloric muscle thickness (MT) > 3 mm, pyloric Canal length (CL) >14 mm. Postoperative MT & CL at 2 month, 4 month & 6 month were determined and results were analysed with the preoperative pyloric parameters. Statistical analysis used: Mean and standard deviation of values were obtained by using Microsoft excel and statistical significance was analysed by regression study of grouped variables showing p – value by Microsoft excel.

Results: Pyloric parameters (MT & CL) gradually attain normal values over months and 80 % of patients showed resolution of pyloric MT & CL values by 6 months. MT assessment shows statistical significance at six months scan (p-value <0.05).

Conclusions: Serial postoperative HRUS in IHPS cases show gradual (mostly by 6 months) resolution of pyloric parameters (MT & CL) to normal. MT appears to be a consistent parameter for serial assessment.

Keywords: High-resolution ultrasound pylorus, infantile hypertrophic pyloric stenosis, postoperative pyloric morphology, ramstedt pyloromyotomy

INTRODUCTION

Infantile hypertrophic pyloric stenosis (IHPS) is one of the most common causes of gastric outlet obstruction in infants, presenting mostly between 2 and 6 weeks of life. The condition is characterized by hypertrophy of pyloric antral wall muscle and mucosa and failure of pyloric canal to relax resulting in gastric outlet obstruction. The incidence is 1–4/1000 live births, although regional and community variation may occur. A recent history of projectile and nonbilious vomiting which may be intermittent or with every feeding is the classical complaint. Clinical and biochemical findings such as dehydration, weight loss, visible gastric peristalsis with the features of dehydration, and hypokalemic hypochloremic metabolic alkalosis are common. High-resolution ultrasound (HRUS) is the modality of choice when there is the clinical suspicion of IHPS. HRUS is noninvasive, does not have radiation hazards, and so has got definite advantage in children. HRUS also allows a dynamic study with the direct observation of pyloric canal morphology. Ramstedt pyloromyotomy, introduced in 1911, still remains the
operative procedure of choice for the management of IHPS. This study aims to establish the role of HRUS as a first line of investigation in patients clinically presenting with IHPS and compare their pyloric parameters such as muscle thickness (MT) and canal length (CL) in the preoperative period and postoperative sequential follow-up after 2 months, 4 months, and 6 months.

**Materials and Methods**

This study was conducted with the joint collaboration of the Department of Pediatric surgery and the Department of Radiology, NRS Medical College and Hospital, Kolkata, India. Informed consent from the parents and Hospital Ethical committee clearance was duly taken. All neonates and infants presenting with nonbilious vomiting with or without visible gastric peristalsis, with biochemical parameters supporting IHPS were our study population. This is an hospital-based prospective type of observational study performed between the period of January 2018 and June 2019. The number of patients were 40 (male 36 [90%] and female 4 [10%]). Age ranges were: <4 weeks – 4 cases (10%), 4–8 weeks – 26 cases (65%), and >8 weeks – 10 cases (25%). Biochemical parameters found were hyponatremia – 20 cases (50%), hypokalemia – 28 cases (70%), hypochloremia – 26 cases (75%), and altered bicarbonate – S20 cases (50%).

**Exclusion criteria**

Pyloric parameters (CL and MT) were not evaluated in: (1) redo pyloromyotomy cases, (2) patients with bilious vomiting with the suspicion of other gastrointestinal pathology, and (3) association of systemic causes of vomiting.

We have used 500 mA X-ray machine with flouroscopic facility and ultrasonography machine: Phillips HD 7 machine and Alpinion E-CUBE with 3–12 MHz linear probe, 3.5–5 MHz curvilinear probe, and 5–7.5 MHz sector probe.

The baby is placed in the supine position with requirement of sedation in a few cases. Examination is started in the epigastric region and the transducer knob toward the head of the infant to obtain a sagittal scan, starting in the midline and gradually toward the right hypochondrium until the pylorus can be identified between the distended stomach on the left side and duodenum and gall bladder on the right side. In difficult cases such as excessive gas in the stomach, scan is hindered and a gravity-dependent maneuvers by positioning the infant in oblique positions by raising their left side up which displaces gas away from pylorus and gastric fluid toward pylorus, facilitates pyloric identification better. Sometimes, bottle feeding is proved to be helpful. After locating pylorus, transducer is rotated to obtain the longitudinal and transverse scans for measurement. Statistical analysis of the measurement of pyloric morphometry of preoperative and postoperative scans was done using the Microsoft excel data analysis with regression statistics showing $P$ values ($P < 0.05$ was considered significant with 95% confidence limits).

Sonographic pictures of normal pylorus are: (a) Mucosa–echogenic, (b) muscularis mucosa: hypoechoic, (c) submucosa: echogenic, (d) muscularis externa – hypoechoic, (e) and serosa – echoic. The sonographic criteria for positive IHPS are pyloric MT >3 mm, pyloric CL >14 mm with increased vascularity of pyloric muscle and mucosa, whereas MT <3 mm, CL <14 mm, and minimal vascularity of pyloric muscle and mucosa indicate negative for IHPS. Pyloric MT between 2 and 3 mm and CL between 12 and 14 mm are considered borderline cases. Sonographic signs of pyloric stenosis are: (a) target sign peripheral ring of hypertrophied and hypoechoic muscle surrounding central echogenic mucosa, resembling a doughnut; (b) Antral nipple sign: redundant pyloric mucosa protrudes into the gastric antrum; (c) collapsed mucosa, echogenic submucosa, thickened and elongated muscularis externa, compressed lumina with elongation of pyloric canal and increased vascularity of pyloric muscle and mucosa [Figures 1 and 2].

**Results and Analysis**

Postoperative HRUS evaluation after 2 months, 4 months, and 6 months of Ramstedt operation is shown in Table 1. It shows that the majority of cases (80%) regained normal pyloric MT and CL after the 6 months of operation [Table 2]. The test of significance done by using the Microsoft excel regression data analysis shows $P$ value, as shown in Table 3. Preoperative and postoperative HRUS pictures of MT and CL are shown in Figures 3-5.

![Figure 1: Abnormal pylorus (in infantile hypertrophic pyloric stenosis)-longitudinal image](image-url)
HRUS with curvilinear probe has become the imaging modality of choice for the evaluation of IHPS. It is the noninvasive technique requiring approximately 10 min.

It can be repeated and has no side effects. Eltomey et al. studied the cases of IHPS at postoperative day 3, after 1 week and 1 month and divided postpyloromyotomy changes in two major categories: (a) static images of pyloric muscle morphology and measurements and (b) dynamic real-time B-mode images of pyloric muscle behavior. They found that pylorus retains...
Table 3: Analysis of significance (P<0.05 - significant)

| MT (pyloric muscle thickness) | P (between preoperative and 4-month postoperative pyloric parameters) | P (between preoperative and 6-month postoperative pyloric parameters) |
|-----------------------------|-------------------------------------------------|-------------------------------------------------|
| CL (pyloric canal length)    | 0.056 (not significant)                         | 0.018 (significant)                             |
|                             | 0.175 (not significant)                         | 0.454 (not significant)                         |

MT: Muscle thickness, CL: Canal length

The limitations of our study are the lack of patients with failed pyloromyotomy and hence are excluded from this study. However, Huang et al. recommends follow-up sonography for the minority of cases unsuccessful after pyloromyotomy.\(^8\)

**Conclusions**

Serial postoperative HRUS in cases of IHPS shows gradual attainment (mostly by 6 months) of normalcy of pyloric parameters such as MT and CL after a successful pyloromyotomy. Serial evaluation of pyloric MT is more significant and predictive of attainment of normal parameters, as compared to the preoperative cases of IHPS.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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