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Ultrasound in Emergency Medicine

FEASIBILITY OF EMERGENCY PHYSICIAN DIAGNOSIS OF HYPERTROPHIC PYLORIC STENOSIS USING POINT-OF-CARE ULTRASOUND: A MULTI-CENTER CASE SERIES

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□ **Abstract—Hypertrophic pyloric stenosis (HPS) is an acute abdominal emergency in infants that often presents to Emergency Departments. The clinical diagnosis of HPS relies on palpation of an olive-sized mass in the right upper quadrant of an infant with a history of projectile vomiting. However, studies have shown that clinicians cannot detect the olive in 11% to 51% of cases. Ultrasonography is the imaging modality of choice to diagnose HPS. HPS has a highly characteristic sonographic appearance that makes it readily identifiable on ultrasound. To our knowledge, there have been no reports documenting the ability of Emergency Physicians to diagnose HPS using point-of-care ultrasound. We present a multi-center case series (n = 8) of HPS diagnosed by Emergency Physician-performed ultrasound. We review the technique of incorporating point-of-care ultrasound into the physical examination of infants with suspected HPS and discuss the possible role of point-of-care ultrasound in the management of these patients.** © 2009 Published by Elsevier Inc.

□ **Keywords—emergency ultrasound; diagnosis; pyloric stenosis; pediatric**

INTRODUCTION

Hypertrophic pyloric stenosis (HPS) is an acute abdominal emergency in infants that often presents to Emergency Departments (EDs). However, most pediatric emergency visits, for conditions such as HPS, are to general hospital EDs that may lack pediatric expertise to definitively diagnose and treat HPS. Over 90% of pediatric patients requiring specialty care are transferred to tertiary care pediatric centers for definitive evaluation and management (1).

HPS is the most common cause of intestinal obstruction in infants. The incidence is approximately 2 to 5 per 1000 live births, with infants of affected parents at greater risk (2.5–20%) (2,3). The risk is four times higher in boys than girls (3). The pylorus hypertrophies after birth and causes progressive gastric outlet obstruction, with infants most commonly presenting between 2 and 6 weeks of age. The etiology of HPS is unknown.

Ultrasound is the imaging modality of choice to diagnose HPS (2,4,5). HPS has a highly characteristic sonographic appearance that makes it readily identifiable on ultrasound. With nearly one-third of general community EDs reporting full or limited access to point-of-care ultrasound, Emergency Physician access to point-of-care

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ultrasound in general community EDs in the United States is increasing (6). However, we could find no reports documenting the ability of Emergency Physicians to diagnose HPS using point-of-care ultrasound.

We present a multi-center case series of HPS diagnosed by Emergency Physician-performed ultrasound. We discuss the technique for incorporating point-of care ultrasound into the physical examination for infants with suspected HPS, and the sonographic criteria for the diagnosis of HPS.

METHODS

We report the demographic clinical and sonographic indicators of 8 infants with HPS identified by Emergency Physician-performed ultrasound from four separate hospital EDs in a case series format. Cases of HPS presented when the authors were on duty and when clinical suspicion prompted the performance of a point-of-care ultrasound examination. All four reporting centers are general hospitals with academic EDs and affiliated Emergency Medicine residency training programs. Three of the centers have Emergency Ultrasound fellowship training programs, and the remaining center contains a Pediatric Emergency Medicine fellowship training program.

The Emergency Physicians performing ultrasound in this case series had no formal training in pediatric-specific point-of-care ultrasound, but were all well versed in the principles and practice of emergency sonography. Of the 5 emergency physicians reporting cases in this series, all are credentialed to perform emergency ultrasound. Two emergency physicians had completed an Emergency Ultrasound fellowship, 2 were Emergency Physicians training as Emergency Ultrasound fellows, and 1 had completed a Pediatric Emergency Medicine fellowship with additional training in emergency ultrasound. This case series was determined to be exempt from review by all four reporting centers' Institutional Review Boards.

Ultrasound Technique

The point-of-care ultrasound examination for the diagnosis of HPS can be performed with the infant on an examining table or held in the parent's lap. The infant may be placed in the supine or in the right lateral decubitus position. For patient comfort, ultrasound gel may be warmed in a cup by microwave for several seconds. Using a high-frequency transducer, such as a 10-5-MHz linear array, in the longitudinal plane (Figure 1), the pylorus can be visualized in its short axis as a "donut" in the right upper quadrant between the gallbladder and stomach (5). Alternatively, scanning in the transverse plane (Figure 1), the pylorus can be found by systematically following the stomach caudally from the esophagus as it enters the abdominal cavity (4). The infant may be placed in the supine position or rolled in varying degrees to the right lateral decubitus position to best visualize the pylorus. If the stomach is not well visualized, the infant can be given a few sips of liquid during the ultrasound examination. Additionally, an over-distended stomach may displace the pylorus more posterior, thus obscuring it. Scanning the infant's right posterior side in the prone position has been reported as a successful alternative approach (7).

Furthermore, if an olive-sized mass is palpable or is suspected on physical examination, the transducer probe can be placed directly over the olive or the suspected area. Confirmation by ultrasonography may still be helpful in these instances, as annular pancreas and other forms of duodenal obstruction have, on occasion, been mistaken for the olive of HPS (8). If HPS is confirmed, the muscle wall thickness can be measured in either view, with the pyloric channel length measured in the long axis (Figure 2).

Figure 1. Longitudinal probe placement with infant in supine position (left). Transverse probe placement with infant in right oblique/decubitus position (right).

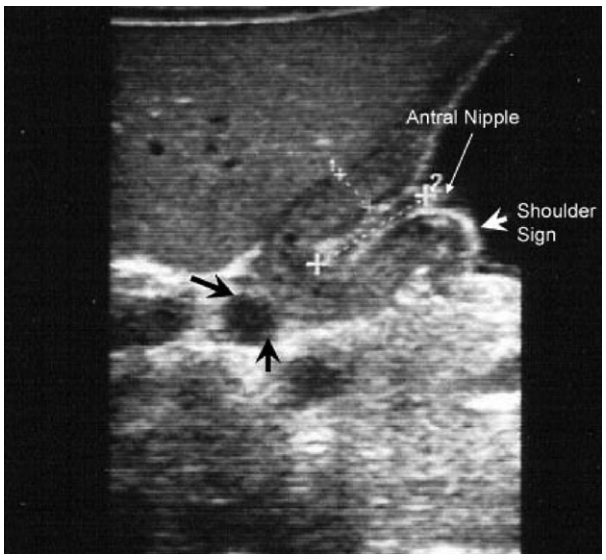

Figure 2. Measurement of muscle wall thickness (1) and pyloric channel length (2). Note that the hyperechoic "double-track" sign in the middle of the pylorus represents mucosa and is not measured as part of the muscle wall thickness. Black arrows point to duodenal bulb/cap.

Cases

Table 1 describes the demographics and clinical indicators of the 8 suspected cases of HPS that were diagnosed by Emergency Physician-performed ultrasound. HPS was visualized on ultrasound either immediately upon scanning or within a few minutes shortly afterward. All these cases were confirmed by subsequent Radiology Department ultrasound and at surgery.

DISCUSSION

The clinical diagnosis of HPS relies on palpation of an "olive"-sized mass in the right upper quadrant of an infant with a history of projectile vomiting. However, studies have shown that clinicians cannot detect an olive-sized mass in 11% to 51% of cases (9,10). Upper gastrointestinal (GI) series and ultrasound are used to diagnose HPS. However, ultrasound is preferred, as the pyloric muscle is visualized directly, unlike an upper GI series, which requires oral contrast to indirectly outline the pylorus (2,4,5). More importantly, with ultrasound there is no exposure to ionizing radiation.

Measurements of the muscle wall thickness and the pyloric channel length are the most commonly used sonographic criteria to diagnose HPS. Other authors have recommended measurement of the overall transverse diameter of the pylorus in short axis (11,12). However, given the dynamic peristaltic activity of pyloric muscle, there is some variation in the radiology literature about the lower limit of abnormal measurement values for HPS (2). A value of $>$ 3 mm for muscle wall thickness is considered abnormal. However, some radiologists use muscle wall thickness values $>$ 3.5 or 4.0 mm to make the diagnosis of HPS. A muscle wall thickness $<$ 2.0 mm is generally considered normal. Thus, a measurement $<$ 2.0 mm and visualization of gastric fluid passing into the duodenum effectively rules out HPS. A value between 2 and 3 mm is indeterminate for HPS and may denote pylorospasm, which may be caused by gastritis or milk protein allergy. A pyloric channel length measurement of 15 mm and greater is considered abnormal and consistent with HPS. Other radiologists recommend a pyloric channel length measurement cutoff value of 18 mm or greater. In cases where pylorospasm is a possibility, some radiologists recommend repeating the measurements within 5 to 10 min, or visualizing the pylorus for 3 min duration (13). In pre-term and low birth-weight infants, the pyloric ratio—measurements of the pyloric muscle wall thickness divided by the pyloric diameter—of 0.27 or greater has been suggested as a cutoff for the diagnosis of HPS (14).

Even in some tertiary pediatric centers, Radiology Department ultrasound may not be available after hours.

Table 1. Clinical Characteristics and Data of Hypertrophic Pyloric Stenosis Cases

Age	Sex	Family History	Projectile Vomiting	Increasing Vomiting	Weight Loss	$HCO_3 > 28$ meg/dL	Palpable Olive	Muscle Wall Thickness	Channel Length
21 days	M	No	Yes	Yes	No	No	Yes	3.7 mm	18.3 mm
28 days	F	No	Yes	Yes	Yes	No	No	4.0 mm	18.0 mm
38 days	M	No	Yes	Yes	No	No	No	4.0 mm	17.0 mm
51 days	M	Unknown	Yes	Yes	No	No	No	4.8 mm	18.0 mm
23 days	M	Yes	Yes	Yes	No	No	No	4.3 mm	16.0 mm
49 days	M	No	Yes	Yes	Yes	No	Yes	4.2 mm	17.5 mm
33 days	M	No	Yes	Yes	No	No	No	4.1 mm	17.8 mm
25 days	M	Unknown	Yes	Yes	No	No	No	4.5 mm	17.1 mm

Note: Presence of younger age ($<$ 35 days), family history, projectile vomiting, increasing vomiting, weight loss and elevated HCO_3 were predictors for HPS in the Bayesian Decision Network by Alvarez et al. (15). Ultrasound images of Case 1 are shown in Figure 3.

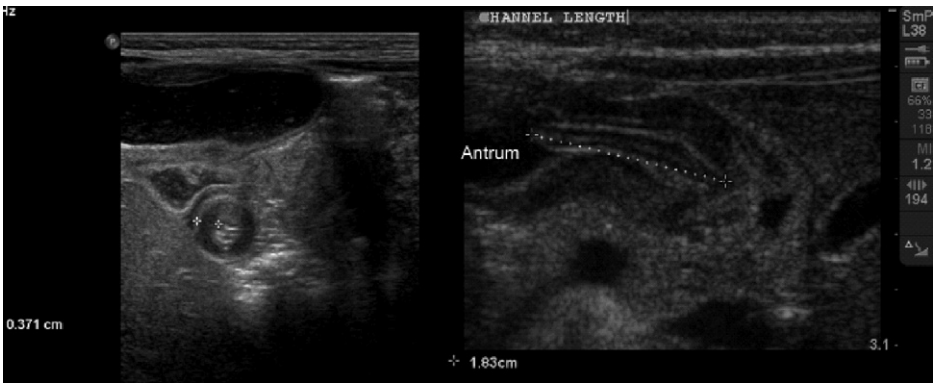

Figure 3. Short-axis view of donut and long-axis view of channel length of hypertrophic pyloric stenosis from Case 1. Calipers measuring muscle wall thickness and channel length.

Thus, strategies to reduce the need for imaging studies have been derived, such as a recent Bayesian decision network for diagnosing pyloric stenosis that remains unvalidated (15). Clinical examination and laboratory variables selected as significant by this Bayesian decision network are also presented in Table 1. With access to point-of-care ultrasound in EDs becoming more readily available, the need to reduce or limit the use of ultrasound imaging may be unnecessary (6). However, there is no urgency in making the immediate diagnosis of HPS, as these children can be treated with intravenous fluid hydration and admitted for definitive imaging the next day. Still, the ability to exclude HPS at the point-of-care as a diagnosis and thus prevent admission could also be valuable and cost-saving.

LIMITATIONS

This report is a non-consecutive case series. Thus we were unable to determine test performance characteristics for point-of-care ultrasound. No systematic observations regarding the accuracy of Emergency Physician-performed ultrasound in diagnosing HPS at the point of care can or should be inferred from this report.

CONCLUSIONS

In summary, our preliminary experience demonstrates the feasibility of incorporating point-of-care ultrasound with the clinical examination to diagnose HPS. Incorporating point-of-care ultrasound findings with clinical examination data, future investigation may determine if this will lead to higher diagnostic accuracy at the point of care. A prospective multi-center study will help determine the accuracy and test performance characteristics of Emergency Physician-performed ultrasound and clinical examination for the diagnosis of HPS. Figure 3.

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