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Evaluation of ultrasonographic parameters in the diagnosis of pyloric stenosis relative to patient age and size

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Abstract

Introduction: Pyloric thickness of 3 mm or higher and length of 15 mm or higher by ultrasonography (US) is widely accepted as diagnostic criteria for pyloric stensosis (PS). However, infants presenting at earlier ages are held to this same criteria, which may not be applicable.

Methods: Retrospective review was conducted on patients evaluated with pyloric US to rule out PS from May 2010 through December 2010. Pearson correlation was used to detect an association between weight and age with pyloric thickness and length. Sensitivity and specificty for US parameters were determined.

Results: Three hundred four patients underwent 318 ultrasounds, of which 67 had PS. Of those with PS, age and weight had a positive correlation with thickness ($P < .007$), and age positively correlated with length ($P < .001$). In patients with and without PS, there was a negative correlation for both age and weight with thickness ($P < .02$). Those who did not have PS held a stronger negative correlation between age and thickness ($P = .002$). Overall, US had a 100% sensitivity and specificity for PS. Thickness of 3 mm or higher was 100% sensitive and 99% specific, and pyloric length of 15 mm or higher was 100% sensitive and 97% specific.

Conclusions: Although significant associations between age and weight with pyloric thickness and length may exist, our data indicate that this does not have an impact on the diagnostic criteria for PS.

Pyloric stenosis (PS) affects 2 to 5 in 1000 live births and is the most common intraabdominal condition requiring surgery in the first few months of life [1,2]. Ultrasonography (US) has become a critical adjunct in confirming the diagnosis of PS [3]. Pyloric muscle thickness of equal to or greater than 3 to 4 mm and a pyloric muscle length equal to or greater than 15 to 18 mm are the accepted criteria for ultrasonographic evidence of PS [1,4,5]. Although PS most commonly presents between 4 and 6 weeks of age, PS can present in younger infants, even rarely in the neonatal period [6-8]. In addition, several recent studies have suggested that the pyloric muscle thickness and length directly correlate with age and weight, yet how that impacts the accepted criteria is not known [8,9]. This raises the question whether the currently accepted criteria for US are still applicable or need to be modified based on age and weight. We therefore investigated the relationship between patient age and weight and the size of the pylorus as determined by muscle thickness and length on US in patients with and without PS.

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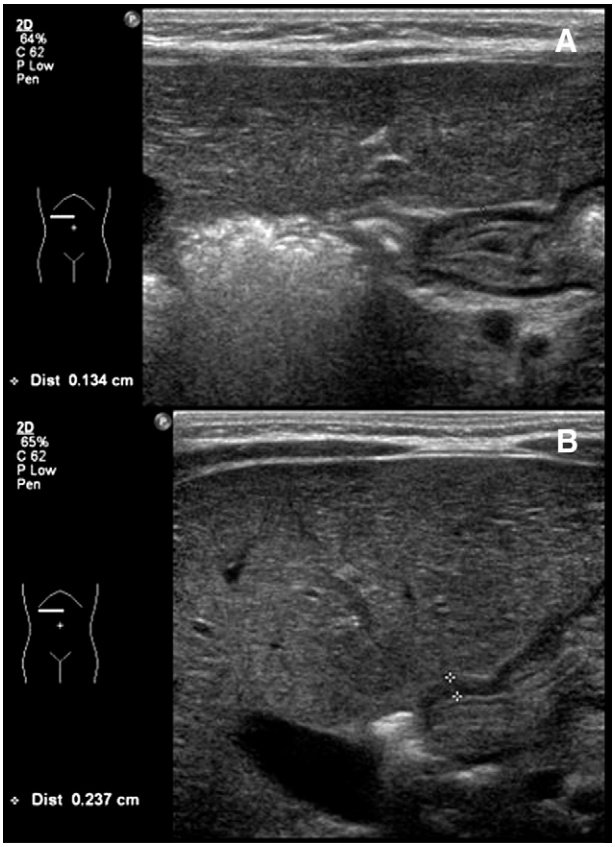

Fig. 1 Representative ultrasound images depicting the pylorus in relaxation (A) and the contracted pylorus (B).

1. Methods

After obtaining institutional review board approval, a retrospective review was conducted of every infant evaluated with US to rule out pyloric stenosis from May 2010 through December 2010. Patient demographics and US parameters were recorded. Pearson correlation was used to evaluate the relationship between pyloric muscle thickness and length and the child's age and weight. The presence of PS was confirmed by whether the infant underwent a pyloromyotomy, had resolution of vomiting, or was found to have another etiology for vomiting such as gastroesophageal reflux.

All US examinations in this study were performed by pediatric sonographers with supervision by a pediatric radiologist. All of the sonographers performing the studies had earned registration with the American Registry of Diagnostic Medical Sonographers. All pyloric US examinations were performed with a linear 12-MHz transducer.

Diagnostic criteria for PS included muscle thickness equal to or greater than 3 mm, length equal to or greater than 15 mm, and/or limited flow of fluid through the pyloric channel. When contractions were noted, measurements were taken during both contraction and relaxation (Fig. 1). Sensitivity and specificity of US were determined for overall diagnosis and each individual diagnostic parameter. Those with PS were compared with those without PS using 2-tailed t tests for continuous variables χ^2 with Yates correction where appropriate for categorical variables. Data are expressed as the mean ± SD, and $P \leq .05$ was considered significant. All ages were corrected for prematurity.

2. Results

Over the study period, 304 patients 6 months or younger underwent 318 abdominal USs. Mean age was 50 ± 30 days, and 61% were male. Overall, 67 patients had PS. Sixty-three patients underwent a pyloromyotomy with a preoperative diagnosis of PS based on the initial US findings; the intraoperative findings confirmed the presence of PS in all 63 cases. Four other patients underwent repeat US a mean 2.5 days later (range, 1-5 days), which were positive—2 of

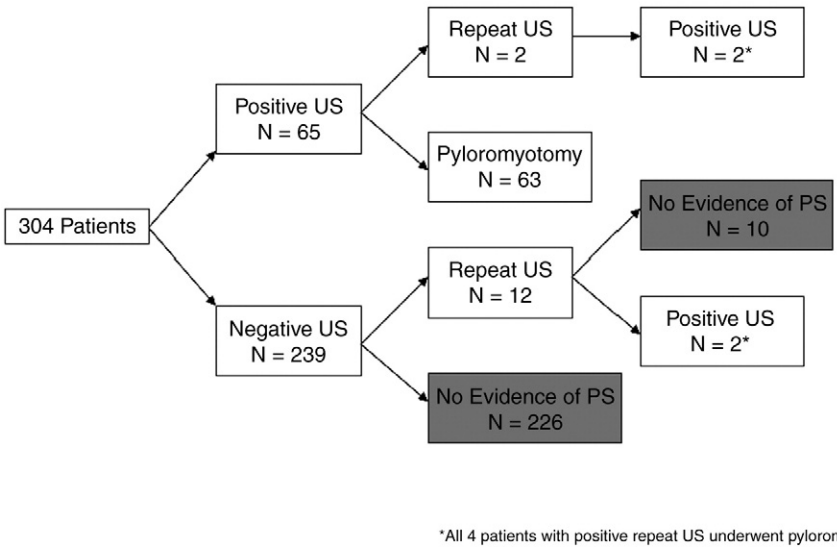

Fig. 2 Distribution of patients.

which were positive on the initial external studies but were repeated to confirm the diagnosis. All 4 of these patients underwent pyloromyotomy and had confirmed PS. Ten other patients had a repeat US at a mean 6.5 ± 8.2 days from the initial US, all of which were still negative (Fig. 2). All patients with a negative US had resolution of their symptoms or were found to have another etiology other than PS as the source of vomiting. The indication for repeat US in all 14 patients was ongoing emesis.

Overall, ultrasound (using both length and thickness criteria) was 100% sensitive and specific. Pyloric muscle thickness of 3 mm or higher alone was 100% sensitive and 99% specific, and a length 15 mm or higher was 100% sensitive and 97% specific. The lack of flow across the pylorus, when reported, was 92% sensitive and 100% specific. Flow of fluid through the pylorus was not commented on in 35% of the reports.

Three patients with PS had a pyloric muscle thickness of less than 3 mm: 2 (who were considered false negatives) underwent repeat US 1 and 5 days later and had thicknesses of 3.3 and 4.9 mm. Their ages were 15 and 33 days. The third patient (a 29-day-old) had a thickness of 2.9 mm and a pyloric length of 21 mm, which was interpreted as positive for PS. Two patients without PS had pyloric muscle thickness greater than 3 mm; however, these were measurements obtained during contraction and were 2.2 and 1.8 mm during relaxation. Only one of these patients underwent repeat ultrasound 2 days later, which was negative. Both had resolution of their emesis.

Pyloric muscle length was less than 15 mm in 2 patients with confirmed PS. One of these patients had a muscle thickness of 3 mm and a length of 14 mm without any flow across the pylorus observed during the examination while the stomach was distended and that US was interpreted as

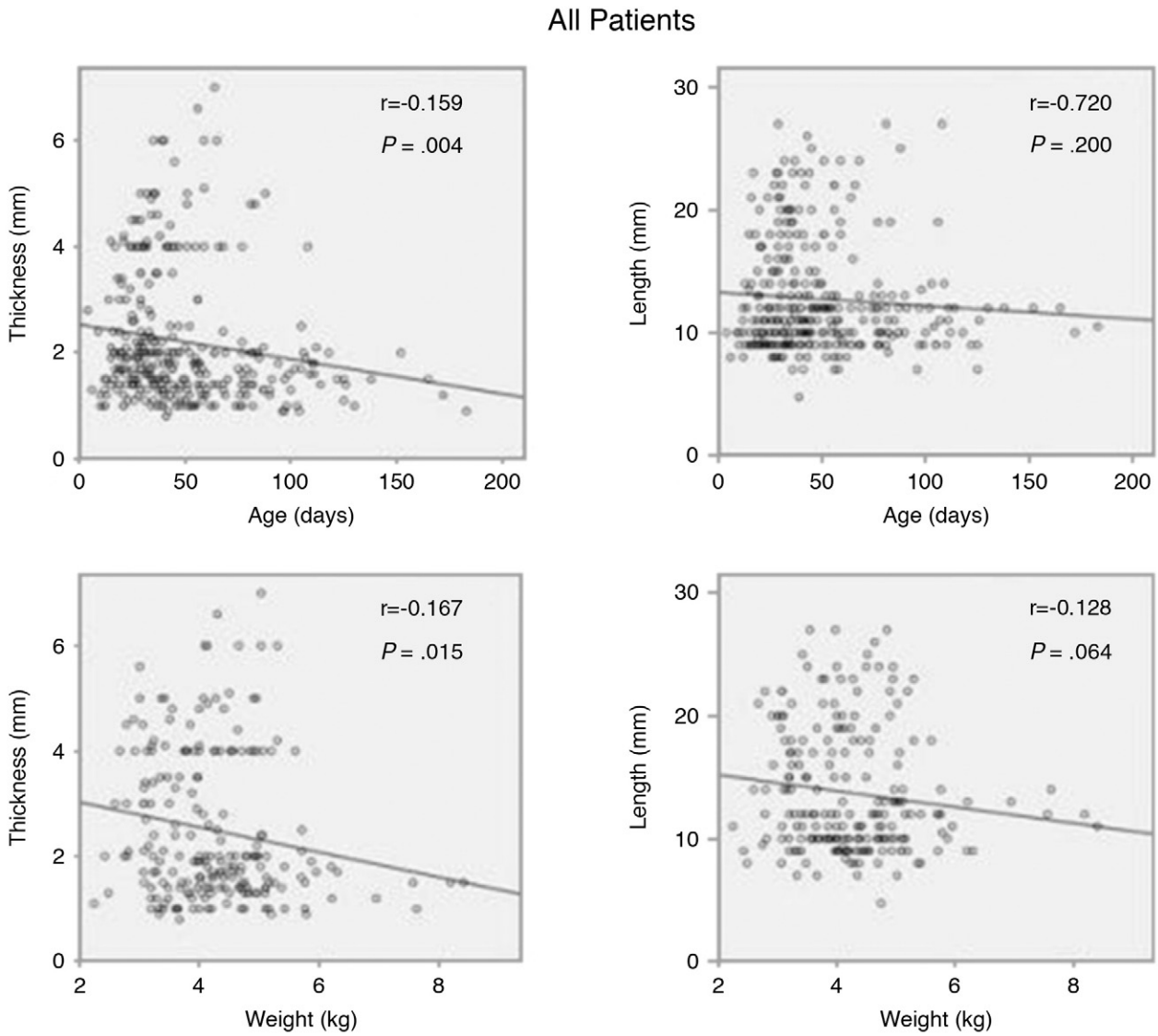

Fig. 3 Scatter plot with Pearson correlation for all infants undergoing pyloric ultrasound correlating pyloric thickness and length to age and weight.

positive. The other patient underwent a repeat US 5 days later, which was positive for PS by all 3 criteria. Muscle length was greater than 15 mm in 8 patients without PS. All of these patients had a pyloric muscle thickness less than 3 mm.

There was a negative correlation between age and pyloric muscle thickness ($R = -0.159$; $P = .004$) as well as weight and pyloric muscle thickness ($R = -0.167$; $P = .02$) for all patients (Fig. 3). In the patients who underwent myotomy, there was a positive correlation between age and both muscle thickness ($R = 0.353$; $P = .003$) and length ($R = 0.409$; $P < .001$); weight correlated positively with pyloric muscle thickness ($R = 0.318$; $P = .007$; Fig. 4). Patients who did not have PS had a negative correlation between age and pyloric muscle thickness only ($R = -0.199$; $P = .002$; Fig. 5).

Comparisons were made to identify other factors that were predictive of PS. Multiple other characteristics in addition to US were significant predictors of the presence of PS including age, sex, and weight. These are outlined in Table.

3. Discussion

In 1977, the use of US in the diagnosis of PS was reported in a case series of 5 patients [10]. This report used a pyloric diameter of greater than 1.8 cm as diagnostic for PS. As US technology improved, the muscle thickness and length were able to be determined more accurately and would become the focus of US criteria moving away from the total pyloric diameter. A prospective study of 200 patients in 1986 established the diagnostic criteria of 3-mm pyloric muscle thickness and a pyloric length greater than 18 mm [11]. In addition, the ability to perform real-time US allowed the ultrasonographer to assess for flow across the pyloric

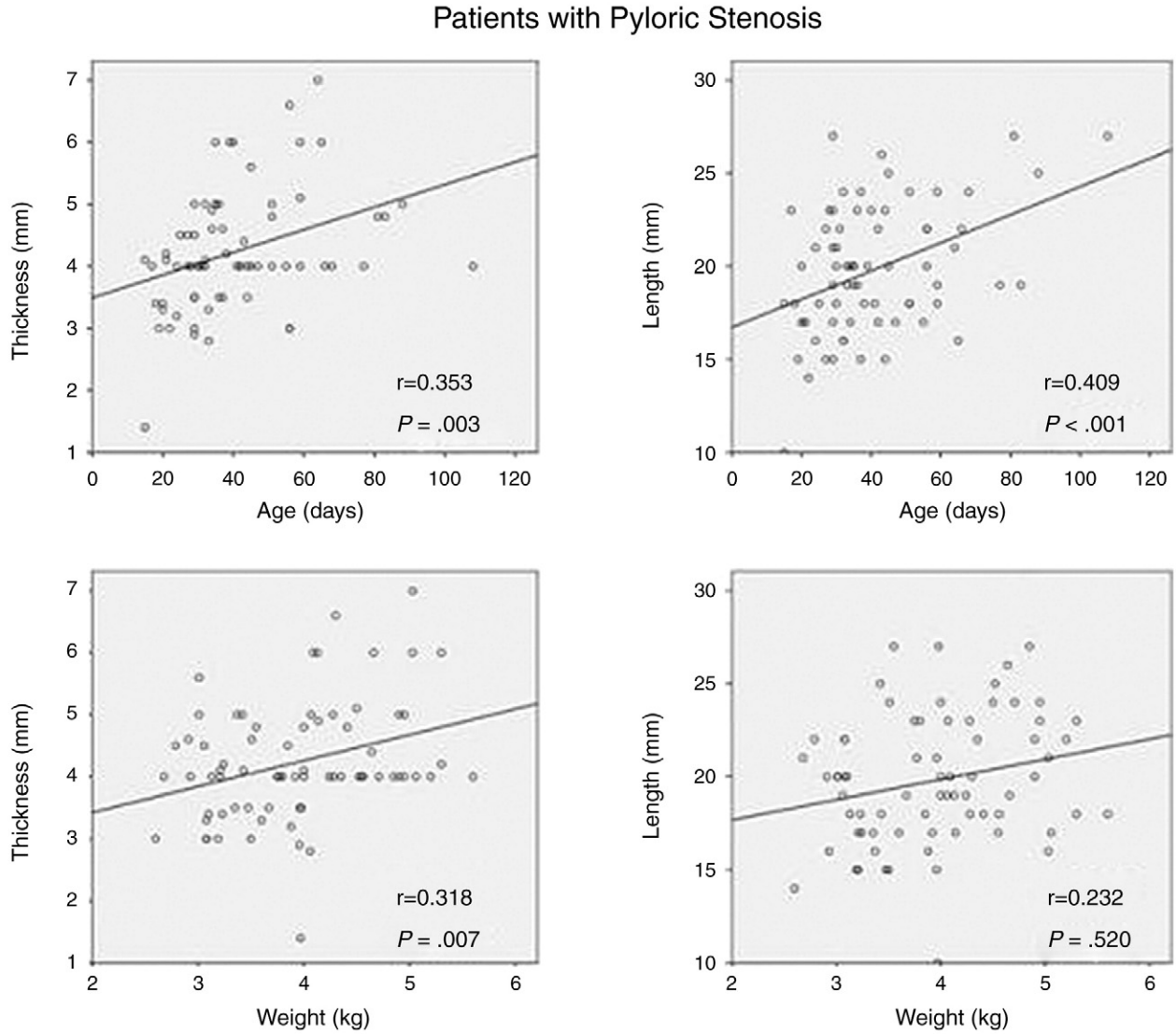

Fig. 4 Scatter plot with Pearson correlation for all infants with pyloric stenosis undergoing pyloric ultrasound correlating pyloric thickness and length to age and weight.

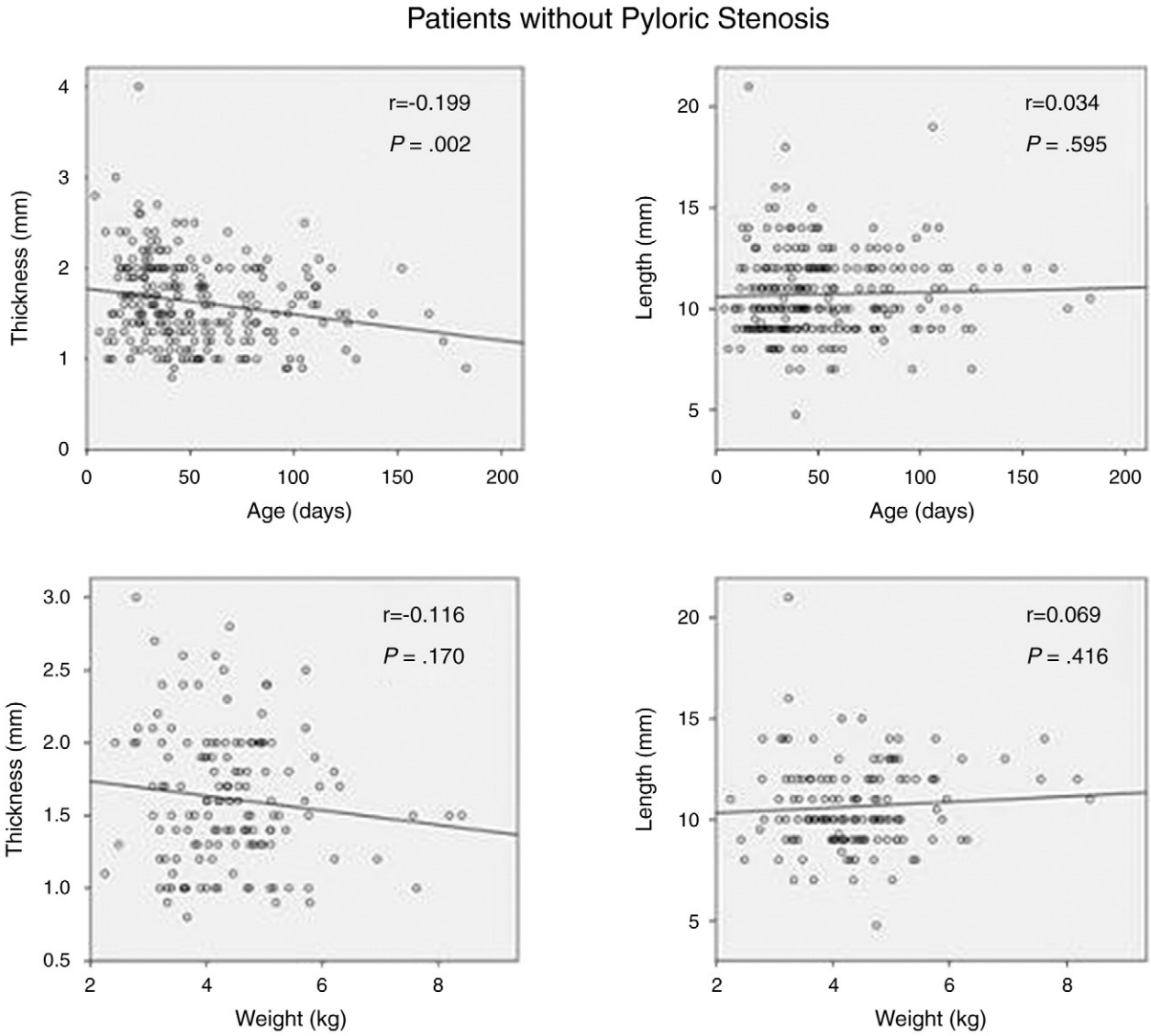

Fig. 5 Scatter plot with Pearson correlation for all infants who did not have pyloric stenosis undergoing pyloric ultrasound correlating pyloric thickness and length to age and weight.

channel, which was initially considered an important component to the US-based criteria and led to its more widespread use—although the significance of this finding is probably not as important as originally thought. Several subsequent reports would support the role of US reporting sensitivities of 98% to 100% and specificities of 99% to 100% [5,12].

More than 2 decades later, these same criteria are still applied across the entire spectrum of infants being evaluated for PS regardless of age or weight. In fact, because more recent studies have correlated US measurements to age and weight, the applicability of decades-old criteria needs to be readdressed [8,9]. However, these reports demonstrating correlations between age and weight with US measurements have not looked at those infants who had negative ultrasounds and, therefore, have not been able to adequately assess the sensitivity and specificity of US in the diagnosis of PS to determine if new criteria based on age and weight are necessary.

In our series of 318 ultrasounds, we found that there was a correlation between age and weight and the US measurements of the pylorus. In the presence of PS this correlation was positive—larger and older infants had a larger pylorus. However, this finding did not affect the cutoff for pyloric muscle thickness or length as diagnostic criteria for PS. In fact, US was 100% sensitive and specific in making the diagnosis of PS using the aforementioned criteria. This is consistent with what has been previously published and reaffirms the diagnostic utility of these established criteria in diagnosing PS.

Although US criteria mainly focus on thickness and length, assessment of flow across the pylorus has historically been described as a potential advantage to real-time US [2]. When either criteria for thickness or length are met, sensitivity and specificity are both 100%. This indicates

Table Comparison of patients with confirmed PS to patients without PS

Parameter	PS patients (n = 67)	Non-PS patients (n = 247)	*P*
Mean (±SD) age at US (d)	41.7 ± 18.6	51.8 ± 32.6	.001
Mean (±SD) weight (kg)	4.0 ± 0.7	4.4 ± 1.1	<.001
Male sex (%)	76	57	.004
Prematurity (%)	9	16	.2
Mean (±SD) pyloric thickness (mm)	4.3 ± 0.9	1.7 ± 1.0	<.001
Mean (±SD) pyloric length (mm)	20.1 ± 3.2	10.7 ± 2.1	<.001
Flow through the pylorus on US (%) [a]	7	100	<.001
Upper gastrointestinal series (%)	4	15	.02
Positive upper gastrointestinal series (%) [b]	67	0	.004
Repeat US (%)	6	4	.74

[a] Was not commented on in all studies: n = 45 for patients with PS; n = 188 for non-PS patients.

[b] Sensitivity of upper gastrointestinal series was 67%; specificity was 100%.

that flow across the channel is not an important component of ultrasound evaluation. The true value in real-time US is the ability to ensure that there is relaxation of the pyloric muscle when obtaining the measurements.

Twelve patients underwent repeat US of which 2 were positive for PS. We have previously published data supporting the role of repeat US in selected cases [13]. One could argue that these 2 cases exemplify why the US criteria need to be readjusted. However, our data support that by decreasing the size criteria, even in small infants, there would be an increase in false positives, of which we had none, and more infants would undergo unnecessary operations. For this reason, we favor the use of repeat US in the infant who does not initially meet US criteria for PS but continues to have symptoms.

Interestingly, we observed a negative correlation between age and weight and the pyloric measurements in those infants who did not have PS, which suggests that, in the normal pylorus, there is a decrease in size over time. This may provide some insight into the pathophysiology of PS where the normal pylorus undergoes an ontogenetic change that leads to a decrease in the pyloric muscle thickness and length. Pathologic disruption of this preprogrammed morphological change may lead to ongoing pyloric growth and subsequent hypertrophy. Certainly, the current data set is not adequate to draw any definitive conclusions regarding the pathophysiology of PS.

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