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Diagnostic Accuracy of Laryngeal Ultrasound for Evaluating Vocal Fold Movement Impairment in Children

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ABSTRACT

Purpose: Vocal fold movement impairment (VFMI) secondary to recurrent laryngeal nerve (RLN) injury is a common source of morbidity after pediatric cervical, thoracic, and cardiac procedures. Flexible laryngoscopy (FL) is the gold standard to diagnose VFMI yet can be challenging to perform and/or risks possible clinical decompensation in some children and is an aerosolizing procedure. Laryngeal ultrasound (LUS) is a potential non-invasive alternative, but limited data exists in the pediatric surgical population regarding its efficacy. We aimed to investigate the diagnostic accuracy of LUS compared to FL in evaluating VFMI.
Methods: A prospective, single-center, single-blinded (rater) cohort study was undertaken on perioperative pediatric patients at risk for RLN injury. Patients underwent FL and LUS. Cohen's kappa was used to determine chance-corrected agreement.
Results: Between 2021 and 2023, 85 paired evaluations were performed with patients having a median (IQR) age of 10 (4, 42) months and weight of 7.5 (5.4, 13.4) kilograms. The prevalence of VFMI was 27.1%. Absolute agreement between evaluations was 98.8% (kappa 0.97, 95% CI: 0.91–1.00, P < 0.001). The sensitivity and specificity of LUS in detecting VFMI was 95.7% and 100%, yielding a positive predictive value (PPV) of 100% and negative predictive value (NPV) of 98.4% (95% CI: 90–100%). Diagnostic accuracy was 98.8% (95% CI: 93–100%).
Conclusion: LUS is a highly accurate modality in evaluating VFMI in children. While FL remains the gold standard for diagnosis, LUS offers a low-risk screening modality for children at risk for VFMI such that only those with an abnormal LUS or presence of clinical symptoms discordant with LUS findings should undergo FL.
Type of Study: Prospective, single-center, single blinded (rater), cohort study.
Level of Evidence: Level II.

1. Introduction

Vocal fold movement impairment (VFMI), defined as decreased or absent mobility of one or both vocal folds, can lead to substantial morbidity in children in the form of stridor, aspiration, feeding difficulties, dysphonia, and recurrent respiratory infections [1–3]. In children, VFMI can result from birth trauma, prolonged intubation, congenital disorders, acquired laryngeal anomalies, neurologic disorders, post-viral neuropathy, and neoplastic insult but is most commonly secondary to iatrogenic recurrent laryngeal nerve (RLN) injury [1–4]. Its prevalence is often under-recognized, and recent work has described VFMI to be present in as many as 1 in 4

Abbreviations: VFMI, vocal fold movement impairment; RLN, recurrent laryngeal nerve; FL, flexible laryngoscopy; LUS, laryngeal ultrasound; IRB, institutional review board; EAT, esophageal and airway treatment; PPV, positive predictive value; NPV, negative predictive value; EA, esophageal atresia.

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pediatric patients who have undergone complex esophageal and/or airway surgery, with a considerable proportion of them being asymptomatic [5]. Due to its potentially asymptomatic presentation, routine screening modalities are imperative and need to be accessible, efficient, sensitive, and well-tolerated.

Awake flexible laryngoscopy (FL) is the gold standard for evaluating vocal fold movement [6]. Unfortunately, FL requires both specialized equipment and provider expertise, and is often poorly tolerated in pediatric patients [7–9]. Moreover, it can be associated with a risk of adverse hemodynamic effects and is an aerosol generating procedure [7,10]. Laryngeal ultrasound (LUS) has been described in its application for other forms of airway evaluation such as in the assessment of cricothyroid membranes, tracheal rings, and tonsil size. Particularly, LUS has emerged as a potential non-invasive alternative in the evaluation for VFMI in the pediatric population as their laryngeal cartilages do not undergo significant calcification until early adulthood, allowing improved visualization of endolaryngeal structures with ultrasound [11–14]. Studies comparing FL to LUS have demonstrated mixed results, with few studies performed in children, small sample sizes, and none in patients with complex airway and esophageal surgery [13,15,16].

We aimed to investigate the diagnostic accuracy of laryngeal ultrasound when compared to flexible laryngoscopy in the evaluation of VFMI in children undergoing complex airway and esophageal surgery. We hypothesized that laryngeal ultrasound would be a reliable and accurate non-invasive alternative screening tool to FL.

2. Methods

2.1. Patient population

We conducted an Institutional Review Board (IRB) approved prospective, single-center, single blinded (rater) cohort study on perioperative pediatric patients at our Esophageal and Airway Treatment (EAT) center who underwent both FL and LUS. Eligible patients were children (less than 18 years of age) planning to undergo or had undergone an esophageal, airway, or great vessel operation where one or both RLNs were at risk over a two-year period between January 2021 and February 2023. At-risk esophageal procedures included primary esophageal atresia repair, traction-induced esophageal lengthening (Foker) process, esophageal stricturoplasty or stricture resection, jejunal interposition, cervical esophagostomy, esophageal duplication cyst resection, esophagectomy, esophagopulmonary fistula repair, tracheoesophageal fistula repair (primary, recurrent, or acquired), esophageal diverticulum resection, and esophageal leak or perforation repair. At-risk airway procedures included anterior or posterior tracheopexy, mainstem bronchopexy, aortopexy (any type), pulmonary arteriopexy, and tracheal diverticulum resection. At risk great vessel-related procedures included division and reimplantation of an aberrant subclavian artery (right or left), division of double aortic arch, aortic uncrossing, patent ductus arteriosus ligation, resection of diverticulum of Kommerell, and pulmonary sling repair (including tracheal resection or slide tracheoplasty).

2.2. Recruitment, FL, and LUS protocols

Eligible patients were approached and informed consent was obtained. This represented a convenience sample based on the logistics of scheduling both studies without adding undue burden onto patients. Patients enrolled in the study had baseline demographics recorded including gestational age, gender, weight at the time of FL, and pre- vs. post-operative status. We did not exclude patients with a known VFMI. Enrolled patients underwent both FL and LUS. Based on our institution's clinical protocol, patients undergo routine pre- and post-operative FL for vocal fold movement evaluation. FL and LUS assessments were paired such that both occurred either pre- or post-operatively and were compared, respectively. Enrolled patients had their FL and LUS scheduled as close as possible to each other. Post-operative FL and LUS were performed in patients once they were non-sedated, hemodynamically stable, extubated, and off positive pressure respiratory support. No sedation was given or intravenous access required for the LUS or FL.

The FL assessed for VFMI, documented as normal, hypomobile, or immobile, along with associated laterality. FL was completed by fellowship trained pediatric otorhinolaryngologists who were blinded to the LUS results. FL exams were video-recorded and stored for later review, if needed, if a contradictory LUS result was observed.

LUS assessed the presence of VFMI and overall quality of the examination by the interpreting radiologist. Ratings were given for each metric. Quality metrics were scored from 1 to 3 and diagnostic interpretation scored from 1 to 4 (Fig. 1). The LUS quality score was categorized as either optimal, suboptimal, or non-diagnostic representing the radiologist's ability to observe and evaluate critical structures, including adequate visualization of the arytenoid cartilage during vocalization. A non-diagnostic LUS was defined as one where the sonographer/radiologist could not perform the study adequately (i.e., tracheostomy inhibiting study, parent asking to stop midway, etc.) or in the setting of the blinded radiologist not being able to make a diagnosis based on an incomplete study or poor-quality images. Vocal fold movement was scored in one of four categories: bilaterally normal vocal fold motion, asymmetric motion with the left hypomobile or immobile relative to the right, asymmetric motion with the right hypomobile or immobile relative to the left, or bilaterally hypomobile or immobile vocal folds.

LUS studies performed early in this study were personally performed by a single radiologist, with subsequent studies performed by one of five trained sonographers under the direct supervision of the same fellowship trained pediatric radiologist, who was blinded to the FL results. The ultrasound examinations were performed on a GE Logiq E9 or E10 unit, using an ML6-15 transducer. Multiple [5–15] cine clips were obtained in the transverse plane, centered on the arytenoid cartilage, using copious gel for optimal skin contact, with each clip lasting 3–5 s. All images were stored in our clinical PACS for ease of review.

Non-diagnostic studies or patients unable to complete both the FL and LUS examinations were excluded from the study.

2.3. Outcomes of interest

The primary outcome measures were the overall agreement, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of LUS in detecting VFMI with FL as the standard. Secondary endpoints included the determination of patient specific factors (age, weight, operative approach, operative history, etc.) that could impact the diagnostic accuracy of LUS when compared to FL. Secondary outcomes also included the analysis of optimal and suboptimal quality categories and their associated statistical outcomes as mentioned above.

2.4. Statistical and data analysis

Descriptive characteristics for clinical features are presented as frequency (%) and median (IQR) for categorical and continuous variables, respectively. Cohen's kappa was used to obtain a chance-corrected measure of agreement between LUS versus FL in detecting injury from our sample with a 95% confidence interval to true range of kappa agreement in the pediatric population. Values of kappa greater than 0.75 are regarded as excellent agreement beyond chance. Overall agreement, sensitivity, specificity, negative

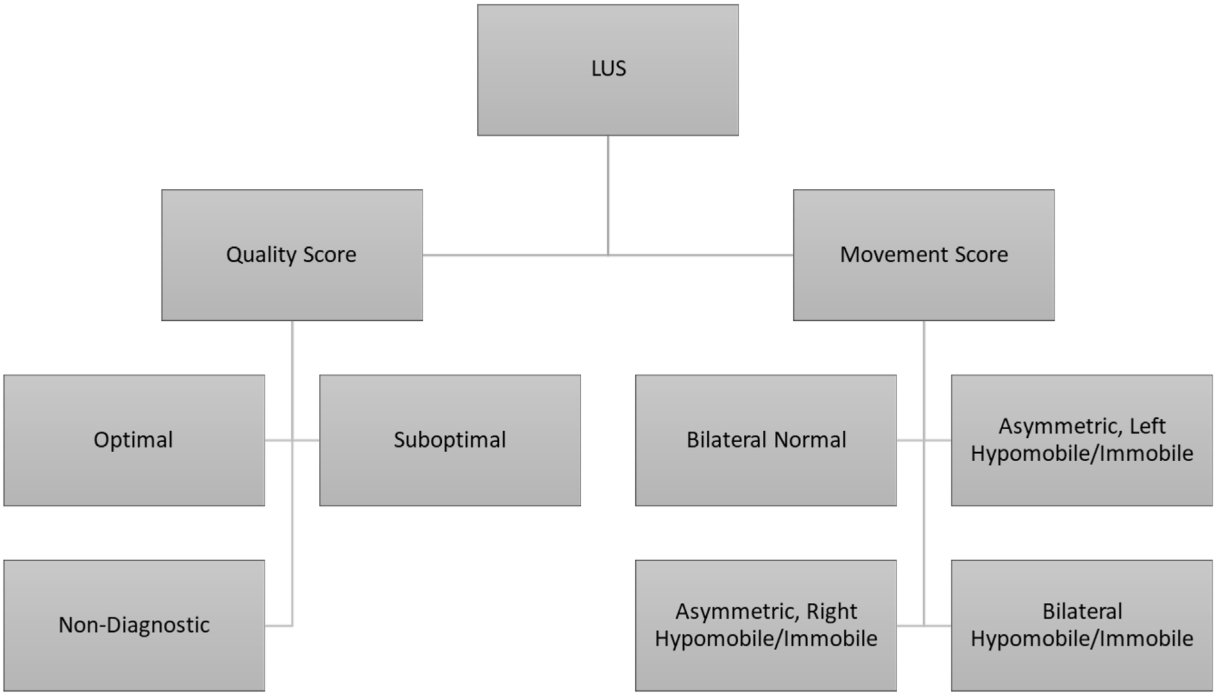

Fig. 1. Laryngeal ultrasound (LUS) assessment protocol.

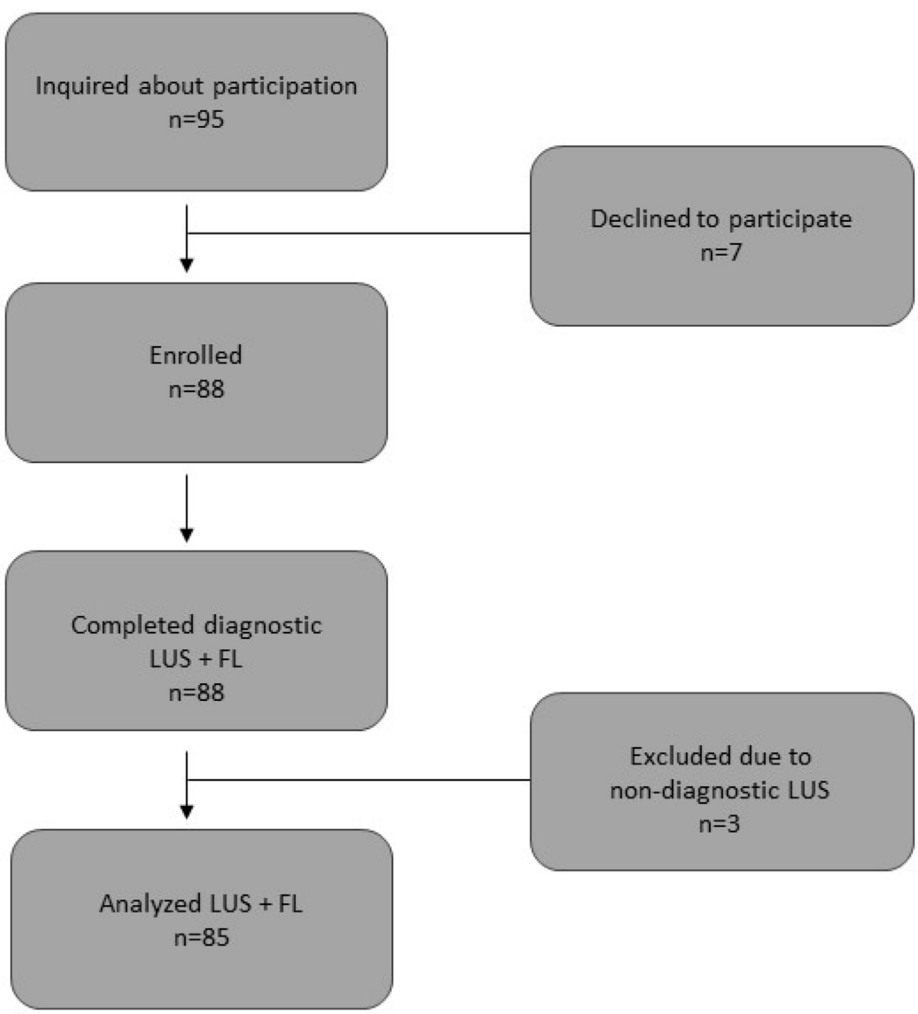

Fig. 2. Consort diagram.

predictive value (NPV), and positive predictive value (PPV) were also calculated. NPV and PPV were calculated using Bayes' formula to account for the prevalence of injury in the population [17]. Binomial exact 95% confidence intervals were calculated for selected measures. Two-tailed P-values less than 0.05 were considered significant. Fischer's exact test was utilized to compare sensitivity and specificity between cohorts. Statistical analyses were performed using Stata version 16.1 (StataCorp LLC, College Station, Texas) and JMP Pro 15 (SAS Institute, Cary, NC).

3. Results

3.1. Demographics

During the study period, 95 patients who met inclusion criteria were approached, of which 88 were enrolled for participation at our center, undergoing both FL and LUS. 3 patients were excluded for having non-diagnostic studies (n = 85); one due to early termination at the request of a parent and two due to the presence of a tracheostomy resulting in a poor sonographic window, with incomplete probe-to-skin contact and a resultant incomplete study (Fig. 2). The majority were male (62%), with a median age of 10 months (IQR: 4, 42) and median weight at the time of FL of 7.5 kg (IQR: 5.4, 13.4). The most common category of surgical procedure performed was an esophageal-focused repair from a diagnosis related to esophageal atresia (EA) with a chest only (i.e., thoracotomy) approach being the most common (Table 1).

3.2. FL vs LUS

Thirteen (15%) paired studies were done in the pre-operative period and 72 (85%) were done in the post-operative period. The median time between studies was 7 days (IQR: 2, 13). FL demonstrated a VFMI prevalence of 27.1% in our cohort. Overall absolute agreement between paired evaluations was 98.8% with a kappa value of 0.97, (95% CI: 0.91–1.00) (P < 0.001). The sensitivity and specificity of LUS in detecting VFMI was 95.7% and 100%, respectively, yielding a positive predictive value (PPV) of 100% and negative predictive value (NPV) of 98.4% (95% CI: 90–100%) (Table 2). Diagnostic accuracy was 98.8% (95% CI: 93–100%).

When stratified for LUS quality, 58 were determined to be optimal quality with 27 scored as suboptimal quality. Specificity for either LUS quality was 100%. There was no statistically significant difference between optimal and suboptimal test sensitivity (P < 0.99).

Of the 85 paired evaluations in this study, only one had an incorrect diagnosis (optimal quality study) of normal motion on LUS (false negative) with unilateral hypomobility noted on FL. No cases of hemodynamic instability or respiratory decompensation were reported during LUS within our study.

3.3. Subgroup evaluation

When stratified into subgroups corresponding to their age, weight quartile, sex, diagnosis category, procedure category, surgical approach, and time between studies, there was no statistically significant difference between their respective overall agreements, sensitivity, specificity, PPV, and NPV (Table 3). Of note, the age group '0–1 month' and diagnosis category 'other' were unable to be included in the subgroup analysis due to having too few cases.

4. Discussion

Our study results demonstrate LUS is a highly accurate modality in evaluating VFMI in children in the perioperative period. For pediatric patients who underwent both FL and LUS, overall agreement between both evaluations was excellent. LUS offers a low-risk option that can serve as an adjunct screening modality for children at risk for VFMI. While FL remains the gold standard due to its ability to diagnose other associated laryngeal pathology, the implementation of LUS can broaden our ability to provide accurate and reliable screening in children. It is particularly useful for those who are at risk for VFMI due to their complex surgical history, or when FL is not available or safe, such as in patients with tenuous cardiorespiratory status.

Our findings are consistent with previous studies that have shown the diagnostic utility of LUS in pediatric patients with vocal cord pathology [15,18–20]. Early studies focused on LUS assessment of VFMI in patients post-cardiac surgery or ear–nose–throat procedures with small sample sizes [13,16,20,21]. Furthermore, initial studies reported a wide spectrum of agreement between LUS and FL in evaluating VFMI in children, ranging from 80 to 96% [13]. A more recent study conducted on 23 patients who underwent both LUS and FL highlighted that the sensitivity, specificity, PPV, and NPV of diagnosing VFMI with LUS to all be over 90% [15].

Table 1
Demographics.

Sub-groups	Number of cases (%)
Age	
0–1 month	4 (4.7%)
2–12 months	42 (49.4%)
13–24 months	14 (16.5%)
25–144 months	20 (23.5%)
>144 months	5 (5.9%)
Weight quartile	
2.4 to <5.4 kg	21 (24.7%)
5.4 to <7.5 kg	22 (25.9%)
7.5 to <13.4 kg	20 (23.5%)
13.4–61.4 kg	22 (25.9%)
Sex	
Female	32 (37.7%)
Male	53 (62.3%)
Diagnosis category	
EA related	60 (70.5%)
Non-EA related	10 (11.7%)
Vascular ring/compression related	12 (14.1%)
Other	3 (3.5%)
Procedure category	n = 83
Esophageal repair only	41 (49.4%)
Airway repair only	8 (9.6%)
Vascular ring/compression repair	12 (14.5%)
Esophageal & airway repair	22 (26.5%)
Surgical approach	n = 79
Neck only	3 (3.8%)
Chest only	44 (55.7%)
Chest + neck	20 (25.3%)
Sternotomy only	7 (8.9%)
Sternotomy + neck	5 (6.3%)
Time between assessments	
<14 days	63 (74.1%)
≥14 days ≤31 days	17 (25.9%)
>31 days	5 (5.8%)

Table 2
Flexible laryngoscopy vs. laryngeal ultrasound for optimal + suboptimal quality score.

	VFMI on FL (gold standard)		Total
	Yes	No	
VFMI detected on LUS	22	0	22
No VFMI detected on LUS	1	62	63
Total	23	62	85

Table 3
Flexible laryngoscopy vs. laryngeal ultrasound subgroup analysis.

Sub-groups	Overall agreement	Kappa	Sensitivity	Specificity	PPV	NPV
Age						
0–1 month	100% (4/4)	[a]	[a]	[a]	[a]	[a]
2–12 months	97.6% (41/42)	0.92 ($P < 0.001$)	87.5% (7/8)	100% (34/34)	100%	97.2%
13–24 months	100% (14/14)	1.0 ($P < 0.001$)	100% (7/7)	100% (7/7)	100%	100%
25–144 months	100% (20/20)	1.0 ($P < 0.001$)	100% (7/7)	100% (13/13)	100%	100%
>144 months	100% (5/5)	1.0 ($P = 0.013$)	100% (1/1)	100% (4/4)	100%	100%
Weight quartile						
2.4 to <5.4 kg	100% (21/21)	1.0 ($P < 0.001$)	100% (3/3)	100% (18/18)	100%	100%
5.4 to <7.5 kg	95.5% (21/22)	0.89 ($P < 0.001$)	85.7% (6/7)	100% (15/15)	100%	93.8%
75 to <13.4 kg	100% (20/20)	1.0 ($P < 0.001$)	100% (6/6)	100% (14/14)	100%	100%
13.4–61.4 kg	100% (22/22)	1.0 ($P < 0.001$)	100% (7/7)	100% (15/15)	100%	100%
Sex						
Female	100% (32/32)	1.0 ($P < 0.001$)	100% (6/6)	100% (26/26)	100%	100%
Male	98.1% (52/53)	0.96 ($P < 0.001$)	94.1% (16/17)	100% (36/36)	100%	97.3%
Diagnosis category						
EA related	98.3% (59/60)	0.95 ($P < 0.001$)	91.7% (11/12)	100% (48/48)	100%	97.3%
Non-EA related	100% (10/10)	1.0 ($P < 0.001$)	100% (2/2)	100% (8/8)	100%	100%
Vascular ring/compression related	100% (12/12)	1.0 ($P < 0.001$)	100% (9/9)	100% (3/3)	100%	100%
Other	100% (3/3)	[a]	[a]	[a]	[a]	[a]
Procedure category						
Esophageal repair only	100% (41/41)	1.0 ($P < 0.001$)	100% (5/5)	100% (36/36)	100%	100%
Airway repair only	100% (8/8)	1.0 ($P = 0.002$)	100% (2/2)	100% (6/6)	100%	100%
Vascular ring/compression repair	100% (12/12)	1.0 ($P < 0.001$)	100% (9/9)	100% (3/3)	100%	100%
Esophageal & airway repair	95.5% (21/22)	0.89 ($P < 0.001$)	85.7% (6/7)	100% (15/15)	100%	93.8%
Surgical approach						
Neck only	100% (3/3)	1.0 ($P = 0.042$)	100% (1/1)	100% (2/2)	100%	100%
Chest only	100% (44/44)	1.0 ($P < 0.001$)	100% (7/7)	100% (37/37)	100%	100%
Chest + neck	95% (19/20)	0.89 ($P < 0.001$)	87.5% (7/8)	100% (12/12)	100%	92.3%
Sternotomy only	100% (7/7)	1.0 ($P = 0.004$)	100% (5/5)	100% (2/2)	100%	100%
Sternotomy + neck	100% (5/5)	1.0 ($P = 0.013$)	100% (2/2)	100% (3/3)	100%	100%
Time between studies						
<14 days	98.4% (62/63)	0.96 ($P < 0.001$)	95% (19/20)	100% (43/43)	100%	97.7%
≥14 days	100% (22/22)	1.0 ($P < 0.001$)	100% (3/3)	100% (19/19)	100%	100%

[a] Too few cases for statistical computation.

Our study, however, is one of the first and largest to date to evaluate the accuracy of LUS in the pediatric surgical population in a prospective manner, particularly in those children with complex esophageal and airway pathology. Prior work has highlighted the prevalence of VFMI in approximately 25% of children who have undergone complex esophageal and/or airway surgery, with a considerable proportion being asymptomatic [5]. This underscores the necessity for an accessible and implementable protocol to screen these patients without additional burden to an already vulnerable population.

Furthermore, our cohort of patients allowed us to look at a wide range of sub-groups to further test agreement between LUS and FL in the diagnosis of VFMI. Sub-group analysis stratified by age, weight, sex, diagnosis category, surgical approach, and time between assessments – did not demonstrate any statistical difference between overall agreements, sensitivity, specificity, PPV, or NPV highlighting the usefulness of applying LUS to a broad range of pediatric patients. In addition to this, LUS quality did not affect the sensitivity and specificity of the exam in diagnosing VFMI.

Importantly, a large subset of our patient population was between the ages of 2 and 24 months (65.9%) with the majority of those between 2 and 12 months of age (49.4%). Studies have shown that a single FL can fail to yield a diagnosis in 20% of evaluations of children under three years of age [11,13]. This may be due to a range of factors such as poor patient tolerance, airway secretions, or obstructing supraglottic pathology limiting proper view of the vocal folds. Such provides additional evidence for the use and benefit of LUS as an adjunct screening modality.

4.1. Advantages of LUS in the pediatric population

One of the main disadvantages of performing LUS in adults is the calcified profile of the laryngeal structures which creates significant posterior shadowing of the sonographic image, thereby distorting a proper view [12]. This burden is overcome in the pediatric population as their laryngeal cartilages do not undergo significant calcification until early adulthood, yielding improved visualization of endolaryngeal structures and improved diagnostic accuracy [12,14].

Advantages of LUS are that it is non-invasive, tends to be billed at a lower rate than FL, and may be better tolerated by children who have anxiety or a low pain threshold [13,22,23]. FL involves the passage of a very thin endoscope (2.5 mm or 2.8 mm) into the nares and traversed through the choana to view the glottis in the awake patient. This technique is somewhat invasive and can be limited in pediatric patients with poor patient cooperation [11]. In neonates and infants, airway secretions and common diagnoses such as laryngomalacia may render view of the glottis unobtainable. When coupled with severe reflux, FL can be associated with a risk of transient clinical deterioration and laryngospasm [7–9]. Moreover, up to 35% of EA patients have congenital heart disease which carries risk for adverse hemodynamic changes during FL [7,24]. In contrast, no cases of hemodynamic instability or respiratory decompensation were reported during LUS within our study. In addition, FL is considered an aerosolizing procedure, and during the era of COVID-19 precautions, the evaluation of vocal fold mobility via FL placed providers at risk.

4.2. Implications of practice

The reliability and diagnostic accuracy of LUS has numerous implications in the practice of how we approach patients prior to and after undergoing surgery where VFMI is a potential complication [5]. We anticipate LUS being best employed as a screening tool by centers that have the experience within their radiology department to perform efficient sonography. As in many pathologies that have an accurate screening test, a confirmatory test is often required – the FL. Although we have limited long term follow-up within our cohort, we would anticipate patients who have a LUS-diagnosed VFMI with concordant FL may be followed with interval examinations solely utilizing LUS, reducing time, patient discomfort, and improve overall ease of surveillance. As is true of other emerging techniques, expanded utilization often occurs as experience and acceptance grows.

Despite the presented data, this does not detract from the utility of FL as a fundamental component of the upper airway examination. One of the primary benefits of FL is its ability to provide a detailed and comprehensive view of the upper airway, allowing for the identification and diagnosis of a wide range of both upper airway and laryngeal pathologies, including VFMI, laryngomalacia, polyps, nodules, and tumors [25,26]. Additionally, the presence of a glottic gap, which is key in the morbidity associated with VFMI can be better assessed with direct visualization by FL [26]. There are also populations where LUS may provide limited benefit. During the study, two enrolled patients were excluded due to their inability to obtain an adequate ultrasound image in the setting of a tracheostomy. Anatomical or physical obstruction that does not allow for a proper LUS should alternatively dictate screening with FL. Despite such concerns, it is important to note 28 (33%) of our patients had a recent neck incision as part of their surgical approach, and LUS was able to be adequately performed within this subgroup.

In our study, at the time of the LUS, attention was paid to symmetrical visualization of the arytenoid cartilage. We also focused on the presence or absence of vocal fold separation at the midline, or lack thereof (Figs. 3A–B and 4A–D). In the rare situation of bilateral vocal fold abnormality, which we did accurately observe, it is particularly important to assess for, both, midline fold separation and a change in orientation/angle of the arytenoid cartilage to differentiate random, ineffective patient motion from actual vocal fold motion.

4.3. Limitations

This study has limitations that we acknowledge. Our practice and patient population are very heterogeneous and complex, and likely not reflective of other centers as we serve a large referral base for patients that often present with baseline VFMI due to their past operative history. Nonetheless, the high prevalence of VFMI within our study group allows us to draw conclusions that would otherwise not be possible. Due to difficulties in scheduling between our otolaryngology, surgery, and radiology teams, time-dependent bias is present as our median number of days between FL and LUS was 7 days, but with some exceeding 1 month between studies. Our goal was to perform both studies within a few days of each other, but there were times when specialty availability or obtaining consent from parents created a delay in obtaining either study. Despite this, we stratified our sub-group analysis to assess those with studies >14 days, and there was no statistically significant discrepancy between those sub-groups. The only incorrect diagnosis that occurred was within the <14-day window. Importantly, no form of surgical intervention or re-operation took place between paired studies to ensure validity.

Also, while LUS can visualize the vocal folds in motion, it may not be able to provide as detailed an image as FL, especially when it comes to small subtleties in vocal fold motion and mobility. Furthermore, as with all sonographic interpretations, LUS is not immune to operator-dependance, and the quality of the image may be affected by the experience of the examiner. This is apparent in our incorrect diagnosis, which was a false negative. The paired FL on this patient showed that the involved fold was hypomobile, improved from immobile on a more remote assessment. One might speculate that the degree of hypomobility was mild, perhaps explaining the lack of detection on the companion LUS. To reduce observer bias, we limited the LUS readings to a single fellowship trained pediatric radiologist who was blinded to the FL results. We aim to have future studies observe the diagnostic accuracy of LUS in

(A) (B)

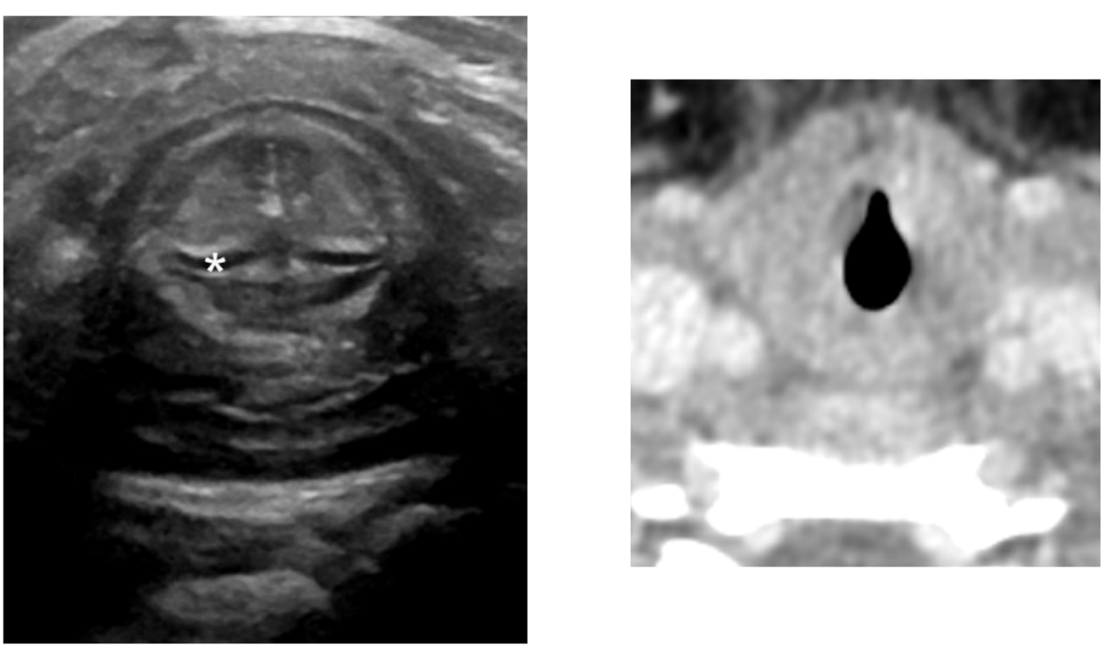

Fig. 3. Transverse plane ultrasound in a 9-month-old boy (A) and companion enhanced CT in a 4-year-old girl (B) at the level of the vocal folds. In A, the folds touch at the midline, at rest, with horizontal, wide U-shaped hypoechoic lines which are the edges of the paired arytenoid cartilage (*). While CT provides very little soft tissue resolution, high resolution ultrasound provides exquisite definition of tissue planes.

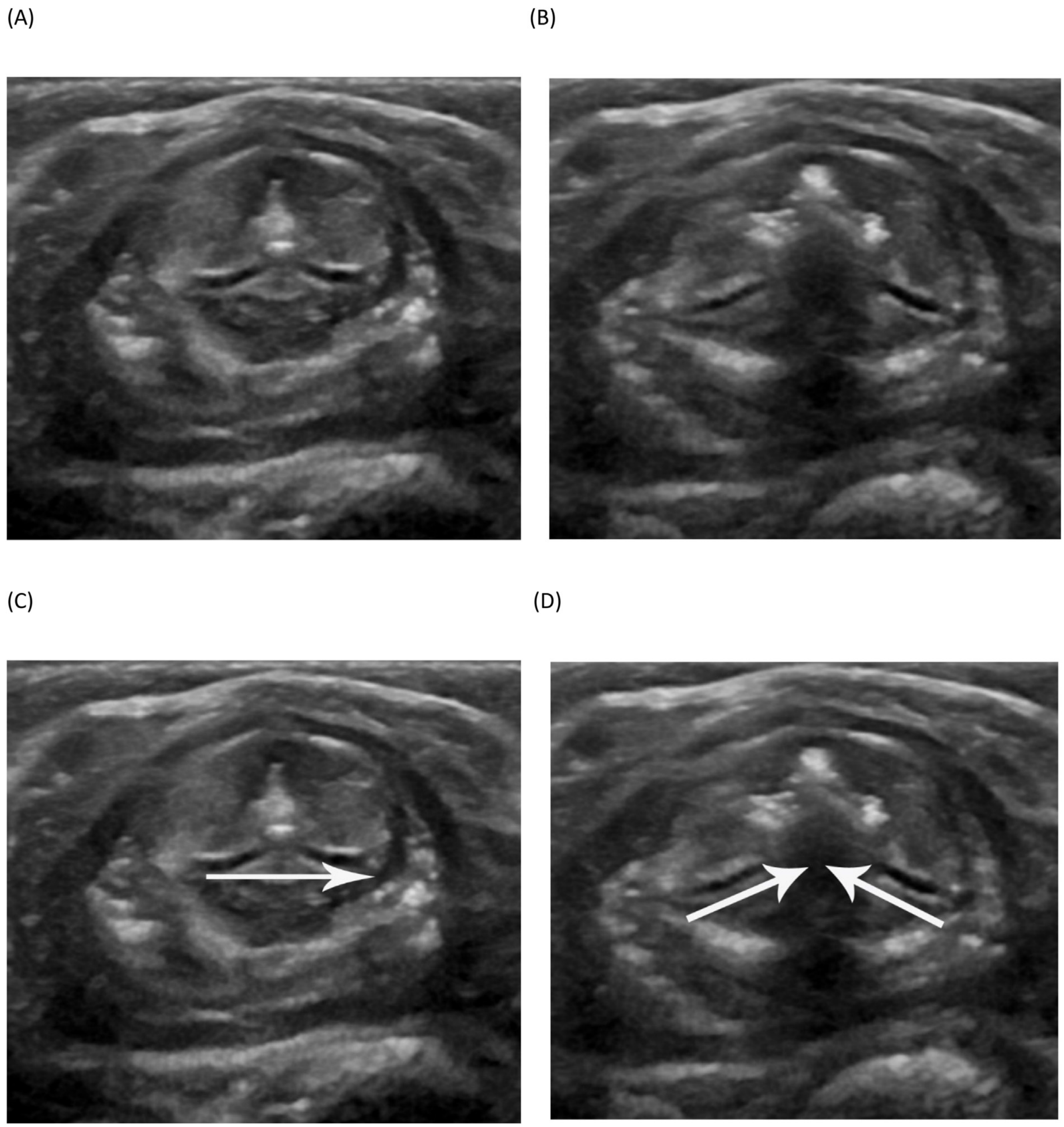

Fig. 4. Two still frames taken from a transverse laryngeal ultrasound cine clip in a 7-month-old boy with normal vocal fold motion. The paired arytenoid cartilage assumes a near horizontal plane at rest (A and C) but pulls to a symmetrical sloping plane with motion (B and D).

the setting of multiple sonographers and interpreters from different departments (i.e., otolaryngology, radiology, and surgery).

5. Conclusion

Despite FL remaining the gold standard for evaluating VFMI in children, the use of LUS allows accurate detection of VFMI in children at risk for RLN injury. Even in situations where the ultrasound image is considered suboptimal, LUS offers a well-tolerated and accessible screening option with excellent sensitivity and specificity. Given that FL can be poorly tolerated in certain patients, LUS can be employed to limit the use of FL to only those patients at high risk for abnormal findings. FL can also be used for confirmatory diagnosis when LUS cannot provide a definite assessment of VFMI due to inadequate visualization or reports of abnormality. LUS is especially useful as a screening tool in cases where FL is not available or safe, such as in patients with precarious cardiopulmonary status. LUS can also be used for monitoring recovery in patients with known VFMI. Whenever feasible, FL should be used to validate VFMI detected in LUS and to evaluate other laryngeal pathologies.

Previous communication

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