A 59-year-old man with a history of asthma and prior intubation presented to the ED with increasing dyspnea. On evaluation, he was in visible distress, requiring immediate placement of bilevel positive airway pressure therapy for impending respiratory failure. He was treated empirically for an asthma exacerbation with around-the-clock beta agonists, corticosteroids, and azithromycin. He quickly recovered to his baseline and was admitted. However, he had continued paroxysms of hypoxic respiratory distress, prompting ICU transfer. Chest CT scans revealed pneumonia, but no pulmonary embolism. He improved with antibiotics and breathing treatments but had continued episodic respiratory distress and stridorous breathing. We then performed bedside point-of-care ultrasonography of his larynx, visualizing the cords during the respiratory cycle, with prompted inhalation and special attention to the inspiratory phase (Video 1).

**Question:** Based on available information including the ultrasound imaging, what is the most likely diagnosis? What further testing may confirm this diagnosis?
Answer: Given suspicion of vocal cord dysfunction, ultrasonography was performed of the larynx (Fig 1). A translaryngeal ultrasound approach was used to visualize the vocal cords during the respiratory cycle, with specific attention during inspiration, which demonstrated paradoxical adduction of hypoechoic structures (vocalis muscle), and confirming the paradoxical vocal cord closure seen with vocal cord dysfunction. Concurrent awake laryngoscopy was performed to directly visualize the vocal cords and confirmed ultrasound findings (Video 2).

Discussion
Vocal cord dysfunction was first described as a mimic of asthma and is characterized by paradoxical vocal cord movement during inspiration. Instead of the typical abduction of the vocal cords during inspiration, the vocal cords adduct, narrowing the airway aperture. Respiratory patterns at presentation can appear quite distressing, and urgent diagnosis is needed to avoid unnecessary invasive procedures such as endotracheal intubation. However, establishing the diagnosis may be difficult because VCD may be intermittent or present with symptoms mimicking asthma. An accurate diagnosis is important because speech therapy is first-line therapy for VCD.

Point-of-care ultrasonography in the past decade has revolutionized medical practice; however, ultrasonography of the vocal cords remains an underused tool. The diagnostic accuracy of translaryngeal ultrasound (TLUS) has been compared with direct visualization of the larynx using video endoscopy. Shah and colleagues, comparing postoperative patients undergoing thyroidectomies with video laryngoscopies, followed by real-time ultrasonography reported sensitivity of 75%, specificity of 95%, positive predictive value of 60%, and negative predictive value of 97.5% in identifying normal and abnormal vocal cord movements. A retrospective study of 668 patients by Kynazeva and colleagues found a preoperative TLUS sensitivity of 67% and specificity of 100%, and a postoperative sensitivity of 86% and specificity of 99% when compared with endoscopic imaging. In the ICU, TLUS has been used to rapidly assess for vocal cord injury, specifically complications of endotracheal intubation, with high sensitivity and specificity, using combined frontal and lateral visualization. Others have confirmed utility, reproducibility, and accuracy among multiple providers in pediatric patients for the assessment of vocal cord function and paralysis. However, TLUS use in VCD and asthma has not been previously reported and represents a unique application.

Although the use of TLUS has been promising, several limitations exist. Accurate image capture is operator-dependent and requires familiarity with ultrasound and laryngeal structures. Kandil and colleagues found that preoperative TLUS missed 6 of 13 patients with vocal fold paralysis (46%), and postoperative TLUS missed 12 of 27 patients (44%), perhaps from incorrect identification of laryngeal structures. Lower detection was noted in overweight patients (defined as BMI > 25). Difficulty in obtaining adequate images has been attributed to acoustic extinction from calcification of laryngeal cartilages in

Figure 1 – Laryngeal anatomy under translaryngeal ultrasonography (TLUS). AC = arytenoid cartilages; VC = vocal cords; VM = vocalis muscle.
older patients as well as sex and BMI. Nevertheless, the learning curve and proficiency is probably no worse than any other ultrasonic technique.

Imaging technique in TLUS uses a high frequency (>5 MHz), linear probe that is placed transversely over the anterior aspect on the midline of the thyroid cartilage (Fig 2). The transducer is tilted craniocaudally until there is visualization of the true vocal cords and muscles, which are hypoechoic structures under the thyroid cartilage (Fig 3). Having the patient hum helps identify the vocal cords as they oscillate and are seen to adduct with narrowing of the vocal cord aperture. The motion of the vocal cords can then be assessed during inspiratory and expiratory cycle (Narration Video).

This approach permits timely evaluation of patients with possible VCD at the point of care, allows upright patient positioning, and does not require specialty equipment. Bedside ultrasounds are readily available in most hospitals and the ED, and identification of suspected VCD can dramatically change the approach to patient management.

With these limitations in mind, we propose the use of ultrasound in the hands of trained professionals and appropriate clinical context as an adjunctive tool to diagnose VCD. Initial evaluation would still involve routine laboratory and imaging studies. If VCD is suspected, TLUS can assess vocal cord motion during the inspiratory and expiratory cycle. Expected vocal cord movement during respiratory distress should effectively eliminate the possibility of VCD.

Reverberations
1. VCD is a condition in which the vocal cords adduct paradoxically during inspiration.
2. VCD presents a diagnostic challenge because it may mimic severe respiratory distress and asthma. Quick, accurate diagnosis is needed to avoid invasive procedures such as endotracheal intubation and incorrect therapy such as high-dose corticosteroids.
3. TLUS is a novel modality to aid in the diagnosis of VCD.

Figure 2 – Transverse positioning of the probe to view the vocal cords using a 6- to 13-MHz linear probe.

Figure 3 – Ultrasound of the vocal cords in a control subject before and during humming. Before initiating humming the vocal cords are both abducted and during humming the vocal cords are adducted. TC = thyroid cartilage. See Figure 1 legend for expansion of other abbreviations.
4. TLUS has compared favorably to the current gold standard for diagnosis (i.e., video laryngoscopy).

5. Limitations of TLUS may include operator factors (probe, image capture) and subject factors (obesity, sex, age, and anatomic variations).

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Additional information: To analyze this case with the videos, see the online version of this article.

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