FULL LENGTH ARTICLE

Ultrasonography assessment of vocal cords mobility in children after cardiac surgery

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Objectives: **Upper airway obstruction after pediatric cardiac surgery is not uncommon. In the cardiac surgical population, an important etiology is vocal cord paresis or paralysis following extubation. In this study, we aimed to evaluate the feasibility and accuracy of ultrasonography (US) assessment of the vocal cords mobility and compare it to fiber-optic laryngoscope (FL).**

Material and methods: **A prospective pilot study has been conducted in Pediatric Cardiac ICU (PCICU) at King Abdulaziz Cardiac Center (KACC) from the 1st of June 2009 till the end of July 2010. Patients who had cardiac surgery and manifested with significant signs of upper airway obstruction were included. Each procedure was performed by different operators who were blinded to each other report. Results of invasive (FL) and non-invasive ultrasonography (US) investigations were compared.**

Results: **Ten patients developed persistent significant upper airway obstruction after cardiac surgery were included in the study. Their mean ± SEM of weight and age were 4.6 ± 0.4 kg and 126.4 ± 51.4 days, respectively. All patients were referred to bedside US screening for vocal cord mobility. The results of US were compared subsequently with FL findings. Results were identical in nine (90%) patients and partially different in one (10%). Six patients showed abnormal glottal movement while the other four patients demonstrated normal vocal cords mobility by FL. Sensitivity of US was 100% and specificity of 80%.**

Conclusion: **US assessment of vocal cord is simple, non-invasive and reliable tool to assess vocal cords mobility in the critical care settings. This screening tool requires skills that can be easily obtained.**

Keywords: Ultrasonography, Pediatric cardiac surgery, Vocal cord

Introduction

Upper airway obstruction after pediatric cardiac surgery is not uncommon. Causes of upper airway obstruction may include external airway compression, tracheo or bronchomalacia, subglottic stenosis and vocal cords abnormality. Due to its anatomical location, injury to the recurrent laryngeal nerve during cardiac surgery can occur particularly with surgery involving aortic

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Table 1. Patients demographics.

No.	Gender	Age days	Dx & Sx repair	BW	US (1)	US (2)	FL (AK)	Correlation
1	M	360	Criss cross heart, DORV, CoA, S/P CoA repair then Glenn	8.9	Bil vocal cords palsy	Bil vocal cords palsy	Bil vocal cords palsy	Yes
2	F	8	Di George Syndrome, S/P AoA repair, then AoA aneurysm repair	3.8	Rt vocal cord palsy	Bil vocal cords palsy	Rt vocal cord palsy	No
3	M	43	CoA, Hypoplastic AoA, Unbalanced AVSD, S/P AoA repair & PAB	2.73	Lt vocal cord palsy	Lt vocal cord palsy	Lt vocal cord palsy	Yes
4	F	40	CoA, S/P CoA repair	2.8	Lt vocal cords palsy	Lt vocal cords palsy	Lt vocal cords palsy	Yes
5	F	57	Turner Syn, CoA S/P repair	3.34	Normal	Normal	Normal	Yes
6	F	120	PA, VSD, MAPCAs, S/P palliation central shunt	3.62	Normal	Normal	Normal	Yes
7	F	480	Scimitar Syn, S/P PAPVD repair Tracheostomy	9.4	Bil vocal cords palsy	Bil vocal cords palsy	Bil vocal cords palsy	Yes
8	M	125	Down Syndrome, S/P AVSD repair	4.8	Bil vocal cords palsy	Bil vocal cords palsy	Bil vocal cords palsy	Yes
9	M	12	D-TGA IVS, S/P ASO	3.1	Normal	Normal	Normal	Yes
10	M	19	DILV, Sub-AS, CoA	3.4	Normal	Normal	Normal	yes

No.: number, Dx: diagnosis, Sx: surgical, BW: body weight, kg: kilogram, US: ultrasound, (1): operator 1, (2): operator 2, FL: fiber-optic laryngoscopy, M: male, F: female, DORV: double outlet right ventricle, CoA: coarctation of the aorta, S/P: status post, Bil: bilateral, AoA: aortic arch, Rt: right, Lt: left, ASO: arterial switch operation, PAB: pulmonary artery band, Syn: syndrome, PA: pulmonary atresia, VSD: ventricular septum defect, MAPCAs: major aorto-pulmonary collaterals, PAPVD: partial anomalous pulmonary venous drainage.

arch [1,2]. Manifestations of recurrent laryngeal nerve injury may not appear immediately after surgery while the child is still intubated and mechanically ventilated. However, after extubation, stridor and other symptoms of upper airway obstruction become apparent. Little information is available about the incidence of unilateral or bilateral vocal cord paralysis or paresis in children undergoing cardiac surgery. Injuries to the recurrent laryngeal nerve are more commonly associated with certain type of cardiac surgery such as aortic arch repair as well as in dysmorphic or syndromic infants [3–5].

Evaluation of the airway in children who present with upper airway obstruction or who failed extubation after cardiac surgery is essential. Establishing the diagnosis helps direct management and assess prognosis. Evaluation of the upper airway may require invasive intervention such as direct laryngoscopy and bronchoscopy. These invasive procedures require expertise and carry certain risk particularly in small infants and neonates.

Proper evaluation of vocal cords requires observation of opening and closing motion during spontaneous breathing. Many authors considered flexible laryngoscopy (FL) as the standard and the preferred method to diagnose vocal cords pathologies [6]. In young infants, FL is not always easy, as the larynx tends to leap during expiration causing difficulty in visualizing the vocal cords. The epiglottis may also be curled or pushed posteriorly. The tongue or the adenoids may be floppy which can further obscure the view and hinder the ability to assess vocal cords mobility leading to increased risk of trauma and injury during clinical assessment [5].

Due to the aforementioned difficulties and challenges, some researchers suggested utilizing ultrasonography (US) as possible safe and non-invasive tool to diagnoses problems associated with vocal cords motility.

Over the past two decades US has been increasingly utilized for diagnosis of fixed laryngeal lesions like cysts or nodules [7,8]. More recently, some researchers recommended the use of US to assess vocal cords mobility and suggested feasibility and validity of US in comparison to FL [9–11]. To assess the reliability of US in diagnosing vocal cords abnormality in children after pediatric cardiac surgery, we reviewed our experience with the use of this diagnostic tool in assessing children presenting with airway obstruction post cardiac surgery.

Material and methods

A prospective pilot study for children who underwent cardiac surgery was conducted in a tertiary pediatric cardiac intensive care unit (PCICU) at King Abdulaziz Cardiac Center (KACC) from the 1st June 2009 till the end of July 2010. All children who manifested with significant upper airway obstruction after cardiac surgery were included. Patients who fulfilled inclusion criteria were evaluated using US assessment of vocal cords mobility by two pediatric cardiac ICU specialists,

followed by FL examination performed by an ENT surgeon. All operators were blinded to the reports and findings of the others. Ethical approval was granted by the department research group.

US exam of the vocal cords was performed while the child was breathing spontaneously. Patients were examined in supine position with minimal neck extension to allow a space for the probe to be placed and gently manipulated on the cricoid cartilage and trachea. Linear or curve linear probes were used with a frequency of 8–12 MHz connected to Vivid i GE® ultrasonography machine. Studies were performed within at least two hours from last feeding. The probe was placed in the axial (transverse) plane on the cricoid cartilage, which was used as an acoustic landmark [12].

FL was also performed in PCICU while the child is placed in supine position. The procedure was conducted by an ENT surgeon using an Olympus® infantile flexible nasolaryngoscope. Children required no sedation for the procedure and only topical decongestant was applied to the patient's nose 2 min before the procedure was performed (Xylometazoline Hydrochloride 0.05%).

Results were analyzed. Specificity and sensitivity of US test was calculated and compared to standard FL test.

Results

Upper airway obstruction was observed in 10 out of 400 (2.5%) of the pediatric cardiac surgeries performed during study period. The five female and five male subjects had a mean ± SEM weight of 4.6 ± 0.4 kg and age of 126.4 ± 51.4 days. The cases included six aortic arch repairs (60%), one central shunt (10%), one with Scimitar syndrome post repair (10%), one atrial septal defect repair (10%) and one post arterial switch operation (10%) (Table 1).

Out of 6 patients with vocal cords paralysis US did not detect cord movement in 1 out of the 10 patients. The gold standard FL detected paretic cord movement in the same patient yielding an US diagnostic accuracy of 90% with sensitivity = 100%, specificity = 80% with positive likelihood ratio (+LR) = 5.0 (CI = 4.70–5.29) and negative likelihood ratio (−LR) = 0.0.

Discussion

Recurrent laryngeal nerve injury with subsequent vocal cord paresis or paralysis is not uncommon complication after pediatric cardiac surgery. In some series it was reported in 4% of cases undergoing cardiac surgery especially post coarctation of Aorta repair [1,2], while in our series the incidence was 2.5%.

US showed not only a good tissue differentiation as described earlier in other studies, but also had the advantage of dynamic vocal cords evaluation [9]. US is commonly used for airway management including intubation, endotracheal tube (ETT) selection and assessment of laryngeal edema [13–15].

Sudarshan and his colleagues demonstrated superiority of the US evaluation in comparison to FL [11]. Also Vats and his colleagues showed in their study a comparison of US and FL in children with concordance of 78% between both tests, a sensitivity of 80% and specificity of 66.7% [10].

In contrary Sidhu et al. reported slightly different results. In their study, US evaluation of vocal cords following thyroid and para-thyroid surgeries had a sensitivity of 62%, PPV of 73% and NPV of 95%. Nevertheless, the specificity of US in their study was 97%. They concluded that US was specific but not a sensitive tool for vocal cords evaluation [16].

From the statistical results, the US is a good test for ruling out vocal cord paralysis when the test is negative. However, when the test is positive, there is a possibility that the cord may have slight movement and is not really totally paralyzed and that is why the value of specificity is lower than sensitivity. Nevertheless, in clinical settings, the use of LR is more appropriate than using sensitivity and specificity as it is related to clinical pre-test probability. If the pre-test probability is good, the +LR will be able to rule-in the paralysis as the +LR = 5 which represents an adequate positive test that can achieve satisfactory post-test probability.

Our study has limitations in the sense that the number of patients included is small and the US exam is operator-dependent requiring skills and training. The study highlights the feasibility and reliability of the US for assessment of vocal cords problem in children after cardiac surgery but still requires further validation and confirmation on larger number of cases.

Conclusion

Our experience suggests that US can be used to assess vocal cords mobility in children with upper airway obstructions. This test is safer than FL, yields the same short-term clinical management information and can be performed immediately at bedside by the intensivist caring for the patient. FL remains the gold standard and can be reserved for selected cases where prognosis based on observation of partial paralysis is used to guide clinical decisions.

Conflict of Interest

Authors have no conflict of interest to declare.

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