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Thoracoscopic division of vascular rings☆,☆☆

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ABSTRACT

Background/Purpose: Vascular rings are traditionally treated via an open thoracotomy. In recent years the use of thoracoscopy has increased. Herein we report our experience with thoracoscopic division of vascular rings in pediatric patients.

Methods: We reviewed all patients who underwent thoracoscopic or open division of a vascular ring at our institution between 2007 and 2015. We analyzed patient demographics, presenting symptoms, diagnostic imaging modality, ring anatomy, operative details, complications, and symptom resolution.

Results: Thirty-one patients underwent thoracoscopic division of a vascular ring while sixteen had open operations. Median age was 24 months in the thoracoscopic group and 13 months in the open group. Operative time averaged 74 min (thoracoscopic) and 95 min (open). There were no mortalities at 30 days. There was complete symptom resolution in 71% of thoracoscopic patients and 63% of open. Patients in the thoracoscopic group had decreased ICU admissions (10% vs. 94%), chest tube use (62% vs. 100%), chylothorax (6% vs. 38%) and overall length of stay (1.7 days vs. 5 days).

Conclusions: Thoracoscopic division of vascular rings in pediatric patients is a feasible alternative to open division and is associated with comparable rates of symptom resolution and decreased length of hospital stay and chylothorax.

Level of evidence: III.

Vascular rings are uncommon anomalies that form as a result of abnormal development of the arterial components of the branchial arches. These anomalies form either complete or incomplete rings around the esophagus and/or trachea and usually result in symptoms such as dysphagia, stridor, dyspnea on exertion, or chronic cough. Surgical division is the treatment of choice, traditionally approached via a thoracotomy.

Minimally invasive surgical approaches have increasingly been employed in the pediatric population because of decreased length of stay, improved pain control and cosmesis [1]. As surgical technique and instrumentation has improved, select centers have reported success in the thoracoscopic division of vascular rings with trends toward similar safety profile and operating time compared to the traditional open approach [2–10]. In this article, we report our experience of 31 cases of thoracoscopic vascular ring division in infants and children.

1. Materials and methods

Following institutional review board approval (study #15765), we retrospectively reviewed the medical records of all 31 patients who underwent thoracoscopic division of a vascular ring at our institution between 2007 and 2015. These were performed by the pediatric general and thoracic service. Initially these were done in conjunction with cardiac surgery but later in the series by the pediatric surgical service alone. We compared these cases to 16 patients who underwent open division of a vascular ring during that same time period. All of these were performed by the pediatric cardiac surgery service. We collected and analyzed patient demographics, symptoms at presentation, diagnostic imaging, ring anatomy, operative details, complications, symptom resolution, and length of stay.

Statistical analysis was performed using Mann–Whitney test, chi-squared analysis, and fisher exact test when appropriate.

2. Results

2.1. Patient characteristics

Forty-seven patients were identified that underwent an operation for division of a vascular ring. Thirty-one patients underwent thoracoscopic division and sixteen patients who underwent an open operation. Median age at operation was 24 months (range 1–212 months) in the thoracoscopic group, with weights ranging from 4.03 kg to 63.00 kg, versus 13 months (range 0.5–183 months) with weights ranging from 3.02 to 51.2 kg in the open group. Twenty-one patients in the thoracoscopic group and seven patients in the open group had a ring consisting of a right dominant aortic arch, left ligamentum

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Table 1
Types of arch anomalies.

	Thoracoscopy		Open	
Type of anomaly	No. (%)	Kommerel's Diverticulum		Kommerel's Diverticulum
Right dominant arch with				
Left ligamentum, aberrant LSCA	21 (68)	13	7 (44)	6
Double aortic arch	10 (32)	7	9 (56)	0

arteriosum, and an aberrant left subclavian artery (LSCA). The remaining 10 (thoracoscopic) and nine (open) patients had double aortic arches. In the thoracoscopic group, 20 patients had a Kommerel's diverticulum (7/10 in the double arch group and 13/21 in the right arch, left ligamentum, and aberrant LSCA group) compared to six in the open group (6/7 in the right arch, left ligamentum and aberrant LSCA group) Table 1. All patients were symptomatic preoperatively, with the most common complaints being dysphagia, chronic cough, stridor, dyspnea on exertion, and failure to thrive attributed to esophageal compression and feeding intolerance Table 2. In the thoracoscopic group, the initial diagnostic evidence of a vascular ring was seen on bronchoscopy (1 patient), CXR (2 patients), upper gastrointestinal series, UGI (4 patients), or echocardiogram (23 patients). All patients then underwent either CT Angiography (CTA) (84%) or MR angiography (MRA) (16%). Imaging findings were concordant with operative finding in all but one case in the thoracoscopic group, which was reported as a right aortic arch, left ligamentum, and aberrant LSCA on CTA, but was found to be a double aortic arch, with the ligamentous part of the anterior arch forming the ring.

2.2. Operative details for thoracoscopic repair

All patients were placed in the right lateral decubitus position. A four-port 3- or 5-mm thoracoscopic technique was used in all cases (one trocar placed in midaxillary line just inferior to the scapula in the 5th interspace, one each in the anterior and posterior axillary line in the 4th interspace, and one stab incision for a lung retractor placed in the posterior axillary line in the 7th or 8th interspace). Bronchial blockers or main stem intubation were used to provide single lung ventilation with insufflation of CO2 to 4 mmHg in all patients younger than 8 years. In the six patients who were greater than 8 years of age we used double lumen endotracheal tubes. Conversion to an open operation occurred in 1 case because of recurrent bradycardia with insufflation of the hemi-thorax. A 5-mm bipolar, vessel sealing device (Ligasure, Valley Lab) was used for ring division in 29 (94%) of cases, with the addition of clips in 7 (22%) of those cases. One ring was divided using clips and scissors only when the child was too small for the 5-mm Ligasure to be used, and one larger child required a vascular stapler because of the inability to place clips satisfactorily.

Vascular anatomy was clearly identified in all cases with visualization of the Kommerel's diverticulum if present, subclavian and aberrant subclavian artery, carotid artery, left arch and right-sided arch prior to division of the appropriate vascular structure. Patients with a double aortic arch, right side dominant, had posterior dissection such that we identified the junction of both the left and right reunion into the descending aorta in order to confirm CTA findings and assure proper structure division. This series did not involve any left dominant double arches. Structures to be divided were completely circumferentially dissected before division. We did not discover vessels more patent than had been noted on CTA or MRA. Had this been the case consideration would have been given to conversion to an open procedure. Oxygen saturation monitoring on different extremities was used in some but not all open or thoracoscopic cases. The phrenic, vagus and recurrent nerves were clearly identified in all cases and the recurrent nerve had to be moved in most instances to allow ligamentum division. Any remaining bands of connective tissue left overlying the esophagus were lysed. The Kommerel's diverticulum was left intact in all cases performed thoracoscopically as in each case once the ring was released, the diverticulum did not appear to be causing much if any constriction on the trachea or esophagus. In the open cases the diverticulum was either left alone (3), excised with the subclavian artery reimplanted (2) or was pexed laterally to the chest wall (2). Chest tubes were routinely placed in the first 19 thoracoscopic cases. In the last 12, a catheter was used to evacuate the pleural space at the end of the case without chest tube placement. All open cases had chest tube placement. Operative time averaged 74 min (range 34–123 min) which was similar to that of the open group (95 min, p-value 0.09) Table 3.

Table 2
Symptoms.

Symptoms	Thoracoscopy (%)	Open (%)
Dysphagia	17 (55)	7 (44)
Stridor	7 (23)	4 (25)
Poor growth	4 (13)	7 (44)
Chronic cough	8 (26)	3 (19)
Dyspnea on exertion	5 (16)	0

2.3. Outcomes

All patients had successful division of the vascular ring. There were no peri-operative deaths. In the thoracoscopic group 22 (71%) had complete resolution of their symptoms by 6 months, and an additional 6 (19%) reported partial symptom resolution. The remaining three patients did not have follow-up data. In the open group 5 patients had symptomatic improvement, 1 had no improvement and 9 had either short or no follow-up record and symptomatic improvement could not be determined. Thirty-day complications in the thoracoscopic group included 3 patients with vocal cord apraxia with all resolving by 6 months, and one patient with an air leak post operatively that required the chest tube to remain in until post op day 3, with discharge on day 4. Additionally, two cases had an intraoperative identification of a chyle leak. In both cases clips were used to repair the leak and there was no evidence of post-operative chylothorax in any patient. In comparison, the 30-day complications in the open group included two patients with vocal cord apraxia, and six patients with chylothorax – three of which required a subsequent operation for treatment. Additional complications in the open group included decreased pressure gradient in the left arm in 2 after Kommerel's resection and subclavian reimplantation and one with occlusion of the subclavian artery requiring reoperation Table 4.

In the thoracoscopic group, average length of stay was 1.7 days (range 1–4) for 29 of the 31 patients. Two patients were excluded from this analysis as they remained in the hospital for >2 months individually secondary to unrelated conditions. In comparison, the open group had an average length of stay of 5.0 days (range 2–10) (p-value 0.003). In addition, only 3 of the patients in the thoracoscopic group

Table 3
Patient demographics and complications.

Operative data	Thoracoscopy	Open
Age median	24 months	13 months
Age (range)	(1–212)	(0.5–183)
Weight (range)	4.03–63 kg	3.02–51.2 kg
Operative time mean (range)	74 min (34–123)	95 min (43–224)
Conversion to open	1 (3%)	n/a
Intraoperative complications	0	0
Chest tube placement	19 (62%)	16 (100%)