Editorial

A tale of two techniques—thoracoscopic and robotic surgery for congenital lung lesions

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We read with great interest the retrospective study by Li *et al.* describing their single center experience with pediatric robotic pulmonary resection (RPR) for congenital pulmonary airway malformation (CPAM) and intralobar pulmonary sequestration (IPS) (1). In this study, the authors compare outcomes of consecutive patients undergoing minimally invasive pulmonary resection via RPR (n=29) or thoracoscopic pulmonary resection (TPR; n=42) over a 4-year period by a single pediatric surgeon and assistant. The median age at surgery was 81 and 72 months for RPR and TPR respectively, with the youngest RPR patient being 6 months old and weighing 8 kg. The authors provide detailed descriptions and photos of their robotic and thoracoscopic techniques. Regarding outcomes, the authors found that RPR had a longer total operative time but shorter "pure" operative time once docking, undocking, and instrument exchanges were deducted. Importantly, the mental and physical workload for the operating surgeon was also significantly lower in the RPR cohort, as reported by National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire completed by the operating surgeon. There were no significant differences in conversion rates to open surgery, surgery-specific complications (e.g., prolonged air leak), chest tube drainage time, length of hospital stay, or cosmetic outcome. All patients were followed to 2 years after discharge. To our knowledge, this is the first and largest series of its kind and we commend the authors for their clear reporting on their experience.

Robotic surgery is widely utilized in the adult surgical population and has made significant inroads into pediatric surgical practice as an alternative minimally invasive approach since its first reported use in pediatric patients two decades ago (2). Optical advantages of the robotic platform include three-dimensional visualization, enhanced magnification, motion downscaling between the surgeon at the console and the operative field, and a hand tremor filtration system (3). Additionally, more than two robotic arms can be used by the same surgeon as working arms and for tissue retraction. These arms have superior articulating capacity and range of movement, which facilitates dissection, suturing, and knot tying in small pediatric spaces (3). This may be advantageous when dissecting out pulmonary artery branches or if one opts to tie or suture ligate vessels and bronchial segments during pediatric thoracic surgery. The ergonomic advantages of operating with the robot in a seated position at a console have also been reported (4,5) and are further validated by the findings in this study. The surgeon in this study reported significant improvements in several workload items that factor into the NASA-TLX score, including mental demand, physical demand, frustration, and performance. The field of surgical

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ergonomics is burgeoning rapidly as more and more evidence of the detrimental physical and health outcomes of poor surgical posture and suboptimal ergonomics is made available (6).

Disadvantages of current robotic technology include the added time necessary for docking, undocking, and instrument exchange, as well as the absence of haptic feedback for the surgeon. A major issue in translating the robotic platform to newborn and infant surgery is the larger diameter instruments and endoscopes. Thoracoscopic lobectomy can be performed in infants with smaller trocars—generally two 3 mm trocars for the endoscope and assistant instrument or energy device, and a 5 mm trocar for a stapler when needed (e.g., for bronchus and pulmonary vein). In the United States, most congenital lung lesions are diagnosed prenatally, and surgery for asymptomatic lesions is typically performed before the age of 6 months but can be performed safely before 3 months of age. Early surgery is well tolerated, minimizes the risk of developing symptoms or acquired infections prior to surgery, and permits compensatory lung growth after surgery. Small rib spaces in these neonates and infants prohibit safe entry for the larger robotic endoscopes and instruments. In this study, 8 kg (6 months of age) was the smallest patient on which RPR was attempted. The majority of patients in large case series of TPR have a mean weight less than this (7,8). For example, in a report on 100 elective thoracoscopic lobectomies by Laje *et al.*, patients had a mean weigh at surgery of 4.8 kg and a mean age at surgery of 7.3 weeks (8). Other disadvantages of current robotic technology include the limited domain in small patients for adequate spacing of the trocars to prevent robot arm collisions and issues with required minimum trocar depths to permit proper instrument function and articulation; however, technical adaptations and workarounds have been described and successfully employed (9).

We commend the clear reporting and surgical expertise of the operating surgeon and his team. Minimally invasive thoracic pediatric surgery is technically demanding, and the reported outcomes in this study are excellent with very few conversions to thoracotomy and no serious long-term morbidities. Nonetheless, certain methodological aspects of this study make us cautious about the generalizability of the findings. First of all, operative approach was not randomized. As reported by the authors, operative approach was based on parent or guardian preference after review of a table providing information about the robotic *vs.* thoracoscopic approach. This table was designed by the surgeon and may be subject to subtle preference biases. For example, RPR was described as featuring "greater magnification, clearer images and more flexible and stable instruments" than TPR. While this statement is putatively true, we wonder why some of the advantages of TPR weren't more effectively outlined with simpler and descriptive language for the parent/guardian. For example, the authors may have described TPR as having "fewer and smaller incisions" rather than listing technical details about the potential number and size of incisions, which can be confusing to parents without surgical expertise. The authors also don't report any measurements of post-operative pain, and one wonders if pain scores and required pain medications favor the smaller and often fewer incisions of TPR. The TPR group number actually exceeded the RPR group number (42 and 29, respectively), although it is unclear whether these were truly intermixed over time or if there was a degree of temporal skew favoring RPR later in the study dates. A second issue is that only one pediatric surgeon performed all the cases in this study, which weakens the generalizability of the findings. Finally, patients with a history of empyema, lung abscess, or more than three episodes of pneumonia were excluded from the study, presumably due to the higher risk of conversion to open surgery. Data are lacking to support the idea that previous infection worsens outcomes after minimally invasive pulmonary resection, and a recent study showed that a minimally invasive approach to these patients is safe with a low risk of conversion in experienced hands (10). With the median age of the RPR and TPR cohorts being so high at the time of surgery and the risk of infection increasing with age (11), there may have been a significant number of patients excluded from the study. Including these patients would have created a more realistic and representative cohort and been informative. All in all, despite these methodological issues and the relatively small sample size, this retrospective study remains informative and follows Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.

We also have a few observations and comments regarding the technical approach and post-operative care. We favor performing lobectomy for most congenital lung lesions as opposed to segmental resections, as the latter operation is technically demanding and often unnecessary when operating on single lobe disease because of robust compensatory lung growth when surgery is performed early in life. In this study, pulmonary segmental resection was performed in 15% of cases (5/29 RPR, 6/42 TPR), specifically when the lesion was "confined to the lung segment without any severe infection" and was less than

50% of the volume of the lobe. In our experience, it is often very difficult to discern the true borders of a CPAM or bronchopulmonary sequestration (BPS) either on pre-operative computed tomography angiography (CTA) or visually in the operating room (OR), and there is a veritable risk of leaving behind residual disease that can be prone to infection, pneumothorax, and potentially malignant change. One small study from Korea found remnant lesions in 10% of their open segmental resections and a longer operative time when compared to lobectomy (12). On the other hand, a small thoracoscopic series of segmental resections by a single surgeon revealed success in 22/23 cases with only one patient having residual disease that required repeat thoracoscopic surgery several years later, and similar mean operative times to lobectomy (13). In that study, patient selection was based on preoperative imaging lesion characteristics and corroboration of those findings in the OR. We believe the current evidence supports the limited use of pulmonary segmentectomy for congenital lung lesions, such as in the case of multilobar or bilateral disease. Regarding post-operative care in the study by Li *et al.* (1), the chest tube remained in place for a mean duration of nearly 2 days and the patients remained in the hospital for a mean of 3–4 days. In our experience, most patients can have their chest tube removed within 24–48 hours and be discharged within a few hours of removal. In neonates and infants, it is important to minimize narcotic use to avoid respiratory drive suppression, and regional anesthesia techniques (e.g., intercostal nerve blocks, chest wall pain catheters, etc.) are very effective and facilitate early discharge.

In conclusion, this study is unique in the field of pediatric thoracic surgery, and we commend the authors for clearly reporting their comparative experience with RPR and TPR for CPAM and IPS. Pediatric thoracic surgery is becoming safer, more efficient, and less invasive, and our patients across the globe will benefit from this. As robotic technology continues to evolve, we are confident that it will have more potential applications in the smallest of patients.

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Footnote

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