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Review Article

Robotic Pyeloplasty in Infants: A Review of Safety and Outcomes

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Introduction

Over the last 30 years, robotic surgery has evolved into the preferred surgical approach for many operative cases. Robotics has been associated with lower pain scales, shorter hospitalizations, and improved cosmesis. [1,2] However, its acceptance in pediatrics have been hampered by longer operative times, smaller working space, and limited fine surgical instruments.

Many find these challenges even more pronounced when performing robotic surgery in infants. Although the data in infants is less robust, many studies have shown benefits similar to the adult population. Specifically, multiple reports of robotic surgery in infants have shown lower postoperative analgesic use. Additionally, hospital stays are shorter, which may lead to quicker return to work for parents and guardians.

Multiple reports have shown low complication rates of robotic surgery in infants. When complications have occurred, they are usually Clavien Grade 1 and 2, with occasional grade 3. Often the complications are not from the robotic technique but are linked to other factors such as the ureteral stents [3,4]. Most importantly, the success rates of surgery are comparable to open surgery.

Results

When robotic surgery was introduced, there was excitement due to three-dimensional imaging, 10-fold camera magnification, tremor filtering, and new camera control by the surgeon. Also, there is instrument articulation with full range of motion. Surgeons hoped these enhancements would allow precise suturing, improve tissue handling, and increase ease of doing complex surgical cases.

A wide variety of robotic procedures have been described in children. However, reported outcomes in children (particularly in infants) are limited. To date, pyeloplasty is the primary pediatric robotic surgery with comparable safety and efficacy when compared to open or standard laparoscopic approach. This has been supported by large multi-centric studies [5]. Also, this has been supported by the European Association of Urology Pediatric guidelines. The guidelines recognize the benefits of minimally invasive surgery by stating that “in experienced hands, laparoscopic or retroperitoneoscopic techniques and robot-assisted techniques have the same success rates as standard open procedures.” Also, they state that “Robotic-assisted laparoscopic pyeloplasty has all the same advantages as laparoscopic pyeloplasty plus better maneuverability, improved vision, ease in suturing and increased ergonomics but higher costs”. However, the role for robotic pyeloplasty in infants is less supported when the EUA states “There does not seem to be any clear benefit of minimal invasive procedures in a very young child, but current data is insufficient to defer a cut-off age.” [6]

The most commonly performed urologic robotic surgery is a pyeloplasty for a ureteropelvic junction obstruction (UPJO). For many years, open pyeloplasty has been considered the gold standard for therapy [6]. Many early reports on pediatric robotic-assisted laparoscopic pyeloplasties (RALP) compared results with laparoscopic and open techniques. However, these were small, single center case series on 10 or fewer patients. [7-9].

Bauer et al compared outcomes of laparoscopic and open surgery. In 1999, they compared 42 laparoscopic and 35 open pyeloplasties. Pain relief, improved activity levels, and radiographic improvement were similar in these two groups [10]. Other series continued to show advantages relative to length of stay (LOS), pain, and cosmesis when comparing laparoscopic and open pyeloplasties [10,11].

In 2006, Lee et al compared robot assisted laparoscopic dismembered pyeloplasty (RALP) to an age matched cohort of patients undergoing open pyeloplasties (OPN). There were 33 patients in each cohort. In this series RALP was safe and effective. 31 of the 35 RALP had improvement in radiographic follow up and/or symptoms. Their LOS was shorter (2.3 days vs. 3.5 days).

RALP patients had higher intraoperative narcotic use. But use of epidurals was vastly different. 18 OPN patients had an epidural and no RALP patients had an epidural. Overall, the RALP patients had lower postoperative and total narcotic use (p=0.001). Also, linear regression analysis showed a longer LOS in the OPN group as age of patient increased. However, there was no difference in LOS for the RALP group. There was similar estimated blood loss (EBL) in both cohorts. And no blood transfusions were required for either group. Mean operative time was higher in the RALP group (219 minutes vs. 181 minutes). But this was not statistically significant (p=0.031). There were no complications in the OPN group. 1 patient from the RALP group required repeat surgery. This patient initially had a retroperitoneal surgery and crossing vessels were not recognized. Due to persistent obstruction, this patient had a temporary percutaneous nephrostomy tube and later had a transperitoneal repair. Follow up in this series was short, with a mean follow up of 10 months for the RALP cohort. Similar to other studies, increased experience correlated with quicker operative times [12].

When looking specifically at results in infants, the data is less robust. Ballouhey et al evaluated robotic surgical results in patients under and over 15 kg. They found success rates were comparable. They had 62 patients with a mean weight of 11.1 kg and 116 patients with a mean weight of 30.2 kg. The mean follows up was 37 months. The most common surgeries were pyeloplasty, nephrectomy, and fundoplication. Although set up time was longer in the smaller patients, the overall surgical time and hospital stays were not statistically different [13].

Kutikov et al had one of the earliest reports of robotic surgery in infants. They did a retrospective review of robotic pyeloplasties in 9 infants aged 3-8 months. Mean operative time was 122. 8 minutes with a mean console time of 72.1 minutes. The mean hospital stay was 1.4 days. 78% had resolution or improvement in their hydronephrosis. No patient required conversion to open or standard laparoscopic techniques [8].

Kawal et al looked at their 4 years experience of robotic pyeloplasties in 138 patients, 34 of whom were infants. In their series, multivariate and comparative analysis showed lower morphine equivalents in infants. Of note, infants had a higher chance of placing a percutaneous stent. The infant cohort had success rates of 96%. 6 patients (4%) required repeat surgery. Although infants had a 29.4% complication rate, this was similar to the older population (30.8%). Reported complications were low grade: 60% were Clavien grade 1 and 2 (pain, urinary tract infection). 40% were Clavien grade 3 (stent dislodgement and replacement). The most common complications with both infants and older children were stent related, with evaluation in the emergency room for pain and hematuria [14].

Dangle et al reviewed their experience with infant pyeloplasties comparing open and robotic approaches. They had 10 patients in each arm. Mean patient age was 3.31 months. Postoperative outcomes were similar in for the open vs. robotic arms: length of stay (2.2 vs. 2.1 days), estimated blood loss (6.5 vs. 7.6 ml), days to regular diet (1 vs. 1.1 days), and time to foley removal (1.3 vs. 1.3 days). However, total operating time was longer in the robotic group (199 vs. 242 minutes). When excluding amortization, robotic cost, maintenance and depreciation, direct costs were similar ($4410 vs $4979 per case). In regards to surgical success, improvement in hydronephrosis was identical in both groups. These authors recognize the importance of surgeon experience before performing robotic surgery infants. Their senior author had performed 28 pyeloplasties and 60 other complex robotic procedures in older children before forging into robotic surgery in infants [4].

In 2015, Avery et al reported a multi-institutional experience of infant robotic pyeloplasty. They reported the results by 6 surgeons at 5 different institutions. 60 patients under the age of 12 months underwent 62 robotic pyeloplasties. All patients had this done with a transperitoneal approach. Mean age was 7.3 months and mean weight was 8.1 kg. There was a 91% success rate with an 11% complication rate. The complications were Grade 1 (1 patient), Grade 2 (2 patients) and Grade 3 (4 patients). No visceral or vascular injuries occurred. But the complications included: two port hernias, one urine leak, one retained stent, one ileus, one renal calculus, and one urinary tract infection. 72% were discharged on postoperative day 1. All six surgeons did have more than 5 years of experience post fellowship training [3].

Since 5mm robotic instruments have a longer articulating arm, some surgeons steer away from using the 5mm instruments, in favor of 8mm instruments. Baek et al compared the perioperative parameters for infant and non-infant RALP over a 2year period of time. There were 16 infants and 49 non-infants. There was no difference in operative time, hospital pain medication use, or hospital stay. Success rates were similar: 93% for infants and 100% or non-infants (p =0.08) [15].

Overall complication rates of robotic surgery in children has been reportedly low. Bansal et al looked the complication rate by 3 surgeons during the first four years of their robotic program. This review included 10 infants but was primarily noninfant pediatric cases. 10 different surgeries were performed in 136 patients. Only one of the surgeons performed surgery on infants. They were all performed transperitoneally. There were no intraoperative complications, robotic malfunctions or conversions to open surgery. 11 patients experienced a postoperative complication. 3 of these 11 complications occurred in infants. Therefore, the complication rate for infants was 30% (3 out of 10) and 8.6% for the other pediatric patients (8 out of 126 noninfants) p=0.035. There were 2 Clavien grade 1, 7 Clavien grade II, and 2 Clavien grade IIIb. The degree of complications was not higher in the infant patients. And none of the complications were due to intraoperative or due to robotic malfunction [16].

Conclusion

Robotic surgery continues to evolve in pediatric urology. There are multiple series demonstrating excellent surgical results. The benefits of shorter hospital stay, less narcotic use, improved cosmesis has been demonstrated in both adult and pediatric populations. However, there remains limited data on robotic surgery in infants.

Robotic surgery in pediatrics had steadily gained acceptance, but there are many surgeons still hesitant to utilize this technique in infants. Concerns include the limited operative space, relatively large port sizes, increased operative time, and potential decreased anesthesia access to the patient [17,18]. National trends in pediatric pyeloplasties have remained fairly stable. The volume of robotic repairs has increased, and the number of open repairs has decreased. However, a review of national trends showed that infants were 40 times less likely to have a robotic repair when compared to older children [19].

However, hesitancy to use robotics in infants and children may be misguided. There are many reports of robotic surgery that confirm it is a safe and feasible technique. Although it has been used for a wide variety of urologic cases, its primary indication is limited to pyeloplasty. Many reports demonstrate comparable results of robotic pyeloplasty relative to open surgery.

More data is needed, but robotics is a safe and effective approach for a wide array of urologic cases, even in infants.

Acknowledgment

None.

Conflict of Interest

No conflict of interest.

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