# Robotic surgery in paediatric patients: Our initial experience and roadmap for successful implementation of robotic surgery programme

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## Abstract

**Introduction:** The popularity of robot-assisted surgeries has accelerated since its advent in 1990s. Recently, we procured da Vinci surgical system in our institution; and here, we present our initial experience of robot-assisted surgeries at our hospital. We also discuss the stepwise approach for successful implementation of the robotic surgical programme at our institute. Moreover, the importance of efficient use of this advanced but expensive technology has been highlighted.

**Materials and Methods:** Retrospective analysis of the medical record of all the paediatric patients between the age ranges of 1–18 years who had undergone robotic-assisted laparoscopic surgery during April 2019–April 2019 was done. Medical record was reviewed for descriptive data, clinical presentation, investigations, operative details and follow-up. Statistical data were also obtained from medical superintendent office.

**Results:** During April 2018–April 2019, total of 111 cases were operated across six specialities. Approximately 73% of cases (81/111) belonged to adult urology and gynaecology speciality. Less than 5% (5/111) of patients were in paediatric age group. The department of paediatric surgery performed one pyeloplasty, 3 ureteric reimplantation and 1 bladder diverticulum excision with robot assistance. The operative duration of the cases was comparable to the standard laparoscopic techniques. All patients are asymptomatic on follow-up visits.

**Conclusion:** The robotic surgery is feasible in paediatric population and has favourable post-operative outcomes. Detailed planning and stepwise approach is key to the establishment of new robotic surgery programme in any institute.

**Keywords:** Bladder diverticulum, paediatric, pyeloplasty, robotic surgery, ureteric reimplantation

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**INTRODUCTION**

Robotic surgery is the paradigm of the most advanced form of minimally invasive surgery. The prime highlights of using robot-assisted laparoscopic surgery (RLS) include three-dimensional (3D) and highly magnified view, wristed hand instruments with seven degrees of freedom, complete tremor cancellation, adequate exposure leading to precise suturing, operator-controlled camera movement and annulment of fulcrum effect of

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conventional laparoscopy. All of these form a basis to use robotic assistance for complex reconstructive surgeries. Urology has been the branch suited most for robot-assisted surgeries. Although earlier it was thought that robot-assisted surgeries were technically difficult to perform in paediatric patients; however, the trend is changing currently where multiple complex urological surgeries have been performed in paediatric patients successfully, with robot-assisted pyeloplasty leading the charts. Robot-assisted laparoscopic pyeloplasty (RALP) is now becoming the standard of care for paediatric patients presenting with pelviureteric junction obstruction.

Recently, we procured da Vinci surgical system (Intuitive Surgical, Inc., Sunnyvale, California, USA) in our institution and about 111 cases have been performed across specialties since then. We present here our experience of robotic surgery in paediatric patients and discuss our journey of establishing robotic surgery programme at our institute and outline the approach to achieve a successful transition to adopt this most advanced technology in the surgical field.

MATERIALS AND METHODS

Retrospective analysis of the medical record of all the paediatric patients between the age ranges of 1–18 years who had undergone RALS during April 2018–April 2019 was done. The medical record was reviewed for descriptive data, clinical presentation, investigations, operative details and follow-up. Statistical data were also obtained from medical superintendent office about the total number of robotic surgeries performed in the institute, operating specialty, operating time, docking time, conversion rate and intraoperative complications. Data were entered into Excel worksheet. The analysis was done using IBM SPSS Statistics for Windows, version 23.0. Armonk, NY, USA. The demographic and descriptive characters were reported in percentage.

RESULTS

During April 2018–April 2019, total of 111 cases were operated across six specialities [Figure 1]. Approximately 73% of cases (81/111) belonged to adult urology and gynaecology speciality. Less than 5% (5/111) of patients were in paediatric age group. Average docking time was 11 min. Average operating time of pyeloplasty in adult patients in the past five cases was 3 h 10 min Average operative time of hysterectomy in the past five cases was 3 h 53 min. There were five conversions to open surgery. The cause of conversion was bleeding in one case, technical difficulty and anatomical/pathological difficulty in two each.

One pyeloplasty, three ureteric reimplantation and one bladder diverticulectomy were done in paediatric patients [Table 1 and Figures 2–4]. In paediatric patients, age ranged from 5 to 17 years with a mean age of 10 years. There was no conversion in paediatric patients. Mean follow-up was 3 months (range 2–6 months). One patient of bladder diverticulum developed features of intestinal obstruction postoperatively. She underwent laparoscopic exploration and repair of ileal perforation. There was no mortality.

DISCUSSION

Our institute procured da Vinci robotic system in April 2018, and first robotic surgery at our institute was a case of a pyeloplasty in an adult patient. Installation of robotic surgery brings about a high cost. Initial investment and maintenance both demand huge financial expenses. Increasing the number of surgeries is one of the ways to decrease the fixed cost. Thus, sharing of the robot by multiple specialities makes it more cost-effective for the institute. As the number of trained surgeons increase along with the workload, then each speciality may procure its own robot. In our institute also, multiple specialities are sharing the single robot to make it more cost-effective.

Lots of planning and hard work was involved in the preparation of performing successful robotic surgery case and ensuring smooth conduction of robotic surgery programme at our institute. It began with the training of the surgeons across speciality in robotic surgery. The manufacturer gave initial training to surgeons. During the initial phase, eight surgeons were trained in robotic surgery across six specialities including urology, gynaecology, gastrointestinal surgery, surgical oncology, general surgery and paediatric surgery. The robotic surgical training was concurrent with the hours of training on the simulator. The simulator is known to improve the surgical skill
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Another measure taken to prevent any mishap during the initial learning curve was to perform the procedure under the guidance of an experienced mentor from a reputed academic institute. One technical staff from the installation team was also requested to be present during the initial few cases performed by surgeons across all specialities. This ensured that the backup of an experienced professional is always there during any technical or surgical difficulties. Once the surgeon of any speciality has performed enough number of cases to be acquainted with the technical intricacies of the robotic surgery then he mentored the other trained robotic surgeons.

We also focused on teamwork and ensured that there is constant communication between the assistant surgeon, staff nurse and technician right from the pre-operative planning to the actual performance of the surgery. Proper training of the assistant surgeon is also ensured so that he can take control of the theatre when the robotic surgeon is immersed in the da Vinci console.

During the past 1 year (April 2018–April 2019), 111 cases have been performed across all specialities [Figure 1]. Approximately 73% of cases (81/111) belonged to adult urology and gynaecology speciality. Less than 5% (5/111) of patients were in paediatric age group. Average docking time was 11 min, and it decreased from 18 min in the initial 10 cases to 5 min in the past 10 cases.

The learning curve in robotic surgery is considered to be shorter than conventional minimal invasive surgery. Surgeons at our institute also had their own learning curve; operative time of pyeloplasty reduced from 5 h 10 min in first five cases to 3 h and 10 min in last five cases. Likewise, for hysterectomy, it decreased from 4 h 51 min to 3 h and 3 min in last five cases.

Our five cases needed to be converted out of 111 cases. Reasons of conversions included bleeding in one, technical difficulty and anatomical or pathological issue in two cases each. Our conversion rate was 6.25% cases. Cundy et al. performed meta-analysis of robotic surgery cases and found that the conversion rate of pyeloplasty was 3% and conversion rate across speciality was 2.5%–8%. Our rate of conversion to open surgery is at par with that reported in the literature.4

The installation of robotic surgery brings about a high cost. Initial investment and maintenance both demand huge

Table 1: Case summary of patients undergoing robot-assisted urological reconstructive procedures

| Patient | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 |
|---------|--------|--------|--------|--------|--------|
| Diagnosis | Left pelviureteric junction operative | Left grade 5 VUR | O/C/O PUV with B/L VUR | B/L VUR | 3 large bladder diverticula |
| Procedure  | Left pyeloplasty | Left ureteric reimplantation | B/L ureteric reimplantation | B/L ureteric reimplantation | Bladder diverticulum excision |
| Age (years) | 12 | 5 | 5 | 11 | 17 |
| Operating time (min) | 120 | 180 | 240 | 180 | 350 |
| Day of catheter removal | POD 4 | POD 2 | POD 8 | POD 4 | POD 3 |
| Complications | None | None | Iatrogenic ileal perforation | None | None |
| Post-operative stay duration | POD 5 | POD 3 | POD 10 | POD 4 | POD 4 |

BL: Bilateral, POD: Post-operative day, VUR: Vesicoureteral reflux, PUV: Posterior Urethral Valve

Figure 2: Port sites for robotic pyeloplasty

Figure 3: Port sites for robotic ureteric re-implantation
financial expenses. Increasing the number of surgeries is one of the ways to decrease the fixed cost. Thus, sharing of the robot by multiple specialities makes it more cost-effective for the institute. As the number of trained surgeons increase along with the workload with the gradual establishment of the faith of the public in robotic surgery, then each speciality may procure its own robot.

The pioneers in paediatric robot-assisted urological surgeries were Oslen and Jorgenson who published their case series of a total of 15 children undergoing robot-assisted pyeloplasty. Since then, robotic reconstructive surgeries have revolutionised the branch of minimally invasive surgeries. The first case (Nissen fundoplication) of robotic minimally invasive surgery in children was reported in the year 2001. The pioneers in paediatric robot-assisted urological surgeries were Oslen and Jorgenson who published their case series of a total of 15 children undergoing robot-assisted pyeloplasty. Since then, robotic reconstructive surgeries have revolutionised the branch of minimally invasive surgeries. The first case (Nissen fundoplication) of robotic minimally invasive surgery in children was reported in the year 2001. Paediatric laparoscopic surgeons have not embraced robotic surgery as enthusiastically as their adult surgical counterparts have. There is also a lack of high-level data exhibiting the benefit of robotic surgery over conventional laparoscopic surgery. There is no denying of the fact that technical capability of robotic surgery can be beneficial in complex paediatric surgical cases requiring sophisticated dissection and reconstruction. However, there are quite a few challenges faced in performing robotic surgery in paediatric age. Port placement is a major challenge in paediatric patients as first, the abdominal wall of children is laxer as compared to adults; and thus, there is a higher chance of injury to visceras or major vessels during port placement. Second, due to smaller abdomen in paediatric patients, lesser intracorporal space is available and port placement should be carefully pre-determined so as to prevent collision of ports during dissection and difficult suturing. This is technically difficult in younger children, especially the neonatal age group. The manufacturer of da Vinci robotic surgical system recommends a minimum of 8 cm distance between two ports. The da Vinci surgical system offers two types of endoscopes 8 mm 3D and 12 mm 3D. In addition, the instruments are also available in 8 mm and 5 mm sizes. The 3 mm instruments, which are usually preferred in neonatal laparoscopic surgeries, are yet not commercially available with the robotic system. Finkelstein et al. reported that a distance of at least 13 cm is required between the two anterior superior iliac spines for performing lower urinary tract operations and a puboxiphoid distance of at least 15 cm was suitable for selecting neonates for robot-assisted upper urinary tract procedures. A note should be taken of the insufflation pressures which are also age-dependent. The Intraabdominal pressures between 8 and 10 mmHg are suitable in babies <2 years of age and for children between 2 and 10 years the optimum pressure ranges between 10 and 12 mmHg.

Children also have a lesser gastric emptying time, which thereby causes small bowel distention, further compromising the visibility. Cost is a major limiting factor in robotic surgery. Apart from the initial purchasing cost, the maintenance cost of a robot and the cost of its disposable supplies are beyond the budget of a standalone hospital.

Despite these difficulties, RALS offers an array of benefits both for the operating surgeon and for the patients. Superior ergonomics as compared to conventional laparoscopic surgeries enhances the feasibility of long-duration surgeries. In addition, 3D-view helps the surgeon to identify and preserve minute structures, which are otherwise missed in open surgeries. Intracorporal laparoscopic suturing has always been challenging; however, robotic platform provides greater degrees of freedom and tremor cancellation thereby enhancing suturing skills.

Despite the multitude of benefits, offered by RALP, the first few cases were quite challenging for us. One patient with bilateral ureteric reimplantation developed features of intestinal perforation in the post-operative period. On reviewing the operative videos, we were unable to find any iatrogenic perforation, and we suspect that it could have been caused due to capacitative coupling due to the use of electrosurgical instruments. Capacitative coupling is the establishment of current in other metal instruments which are lying parallel to the active electrode, even if a direct contact is absent. The risk of capacitative coupling is inversely related to the distance between the instruments. This risk is reduced by the use of metallic ports as these increase the surface area over which the

Figure 4: Intraoperative image of dissection of the ureter
stored energy is dissipated, thereby causing less thermal damage to tissues.\(^{[11]}\)

We suggest that in intracorporal space, cautery must always touch the tissue, which we intend to coagulate or cut, before starting coagulation mode as else the energy may get dissipated, and cause injury to surrounding tissues.

**CONCLUSION**

Robotic surgery is an important tool in the armamentarium of a surgeon performing advanced surgeries. Considering a small number of cases suited for robotic surgery in paediatric patients, it is much more cost-effective to share the robot with other speciality having high surgical turnover. Proper planning and meticulous execution of robotic surgery programme is the key to success. The results of our initial few cases with RALS indicate that robotic surgery can be helpful in performing minimally invasive surgery in paediatric patients also. It needs to be reiterated once again that the instrumentation and ergonomics of robotics are yet not ideal for paediatric patients. It needs further miniaturisation of the trocars, instruments and docking system so as to optimise the surgery in small surface area and intracorporeal space of young paediatric patients.

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**Conflicts of interest**

There are no conflicts of interest.

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