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Rise of pediatric robotic surgery in Italy: a multicenter observational retrospective study

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Abstract

Background: The minimally invasive surgery (MIS) in term of robot-assisted surgery changed in a dramatic way the surgical approach either in adults or children. For many specialties (urology, gynecology, general surgery) robotic surgery rapidly became the gold standard for some procedures, while the experience in pediatric population is not wide for some reasons. The aim of this study is to retrospective analyze trends of application of robotic surgery in pediatric patients across the country, focusing on indications, limitations, development, and training acquired by national experience and in comparison to the literature.

Methods: We made a retrospective multicenter study on behalf of Italian Society of Pediatric Surgery. We performed a census among all pediatric surgery units in the country to enroll those performing robotic surgery on children between 2013 and 2019.

Results: We enrolled 7 pediatric surgery referral Centers (Ancona, Bologna, Brescia, Genova, Pavia, Pescara, Siena). A total of 303 patients were included in the study, 164 males (54%) and 139 females (46%). The most commonly performed interventions for each anatomic area were respectively atypical pulmonary resection (38%), pyeloplasty (49%), and fundoplication (30%).

Conclusions: Since its first application in Italy, about 10 years ago, several considerations were made about application and feasibility of robotics in children.

Keywords: Robotic, Surgery, Child

Background

The minimally invasive surgery (MIS) era changed in a dramatic way the surgical approach both in adults and children [1]. The availability of small instruments and better magnification with a camera view allowed to perform all kinds of surgery obtaining better outcomes. In the last decade the introduction of robot-assisted surgery represents the further step in the evolution of MIS.

Surgical Robot as Da Vinci[®] offers three-dimensional (3D) visualization, a significantly improved instrumentation dexterity coupled with motion scaling, allowing surgeons to easily perform complex reconstructive procedures [2]. For some specialties, such as urology, gynecology and colorectal surgery, robotic surgery rapidly became the gold standard for some procedures in adults [3]. The experience in pediatric population is not wide for many reasons. The need to work in small and constrained cavities, the lack of instruments developed for children, the ratio between trocar and small body dimension, and the cost of the system represent the most common limits for application in children [4, 5]. Since its first application in Italy about 10 years ago, several considerations

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were made about application and feasibility of robotics in children. The aim of our study is to retrospectively analyze trends of application of robotic surgery in pediatric patients across the country, focusing on indications, limitations, development and training acquired by national experience and in comparison to the literature.

Methods

We made a retrospective multicenter study on behalf of Italian Society of Pediatric Surgery.

We performed a census among all pediatric surgery units in the country to enroll those performing robotic surgery on children between 2013 and 2019. All the cases were treated with the da Vinci Surgical System® (Intuitive Surgical, Inc., Sunnyvale, CA, USA). From each center data collection included demographic patients’ data (age, sex, diagnosis), pre-operative (nature of the procedure, operative time, conversion) and postoperative data (complications, length of stay). All data were

identified. We divided surgical interventions into three groups, according to the anatomical district: thoracic, abdominal and genitourinary surgery.

Statistics

We used GraphPad Prism6 (GraphPad Software Inc., San Diego, CA, USA) for statistical analysis. Data were presented as mean ± SD, comparisons between groups performed using Student’s *t* test for unpaired data. A *p* value < 0.05 was considered significant.

Results

We enrolled 7 pediatric surgery referral Centers (Ancona, Bologna, Brescia, Genova, Pavia, Pescara, Siena). A total of 303 patients were included in the study, 164 males (54%) and 139 females (46%). All demographic data are summarized in Table 1. According to anatomic area the number of surgical interventions was 13 thoracic surgeries (6%), 106 abdominal (34%) and 184 genitourinary (60%) as shown in Fig. 1. The most commonly performed interventions for each anatomical area were respectively atypical pulmonary resection (38%), pyeloplasty (49%), and fundoplication (30%). The total number for each anatomic area is shown in Fig. 2a–c. Through the period of the study, we observed an overall increasing trend in the application of robotic surgery in children, with average one procedure a month for each center. In the last year of the study there was a decrease in trend due to the unavailability of the Robot among 2 centers, as shown in Fig. 3a. Mean operative time was 158 min with

Table 1 Demographic data of the patients

Patients	303
Males/females	164/139
Mean age at intervention	144 months (8–216 m)
Mean weight at intervention	38 kg (7–120 kg)
Operative time	158 min (40–450 min)
Hospitalization	7 days (5–13 days)
Complications	55 (18%)
Conversions	11 (3%)

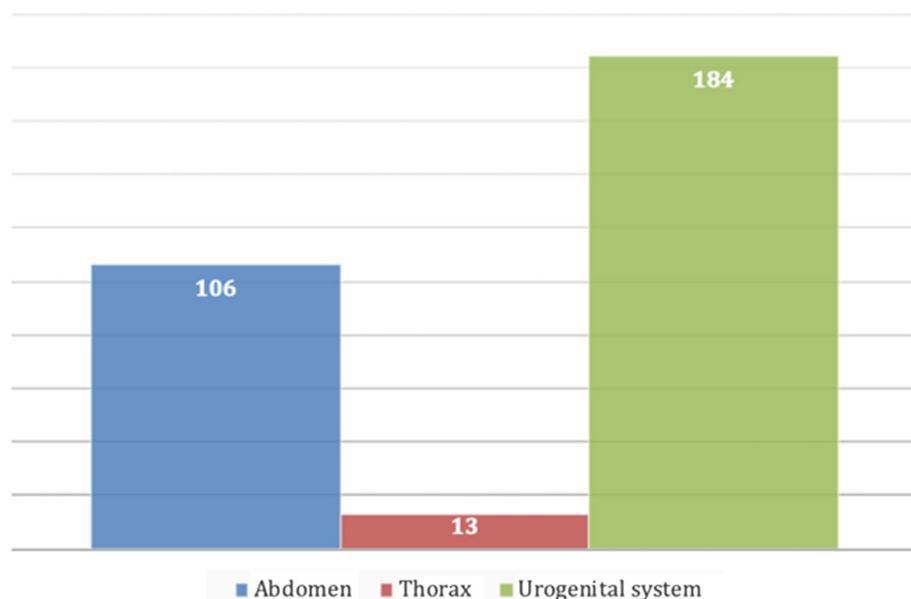
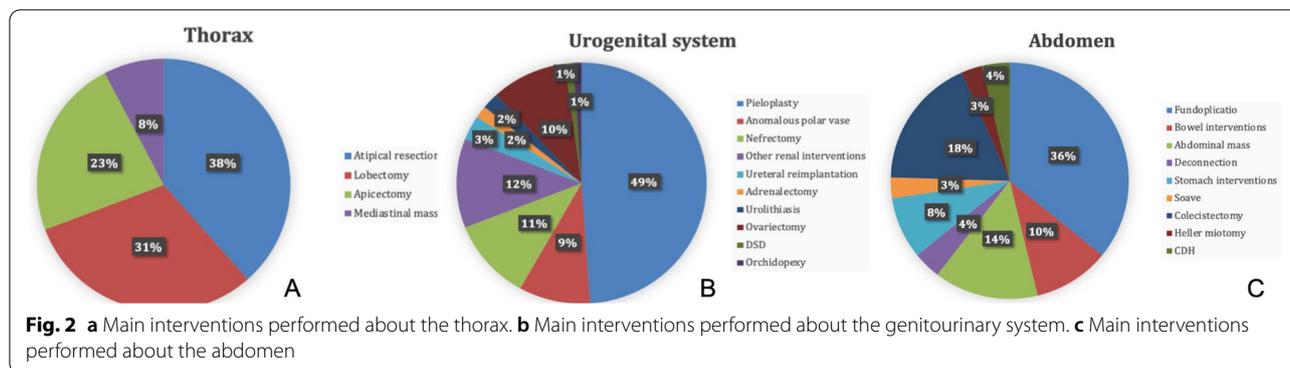


Fig. 1 Number of intervention for each anatomic district



no difference according to anatomic district (149 for thoracic surgery, 162 min for abdominal surgery and 148 for genitourinary surgery) (Fig. 3b).

Conversion rate was 3%: three patients for thoracic surgery, three patients for abdominal surgery and five patients for genitourinary surgery (Fig. 3c). Majority of complications occurred during thoracic surgery (61%), followed by abdominal surgery (16%) and genitourinary surgery (15%) (Fig. 3d). There was no significant difference in terms of operative time, complications, and conversions between the three groups.

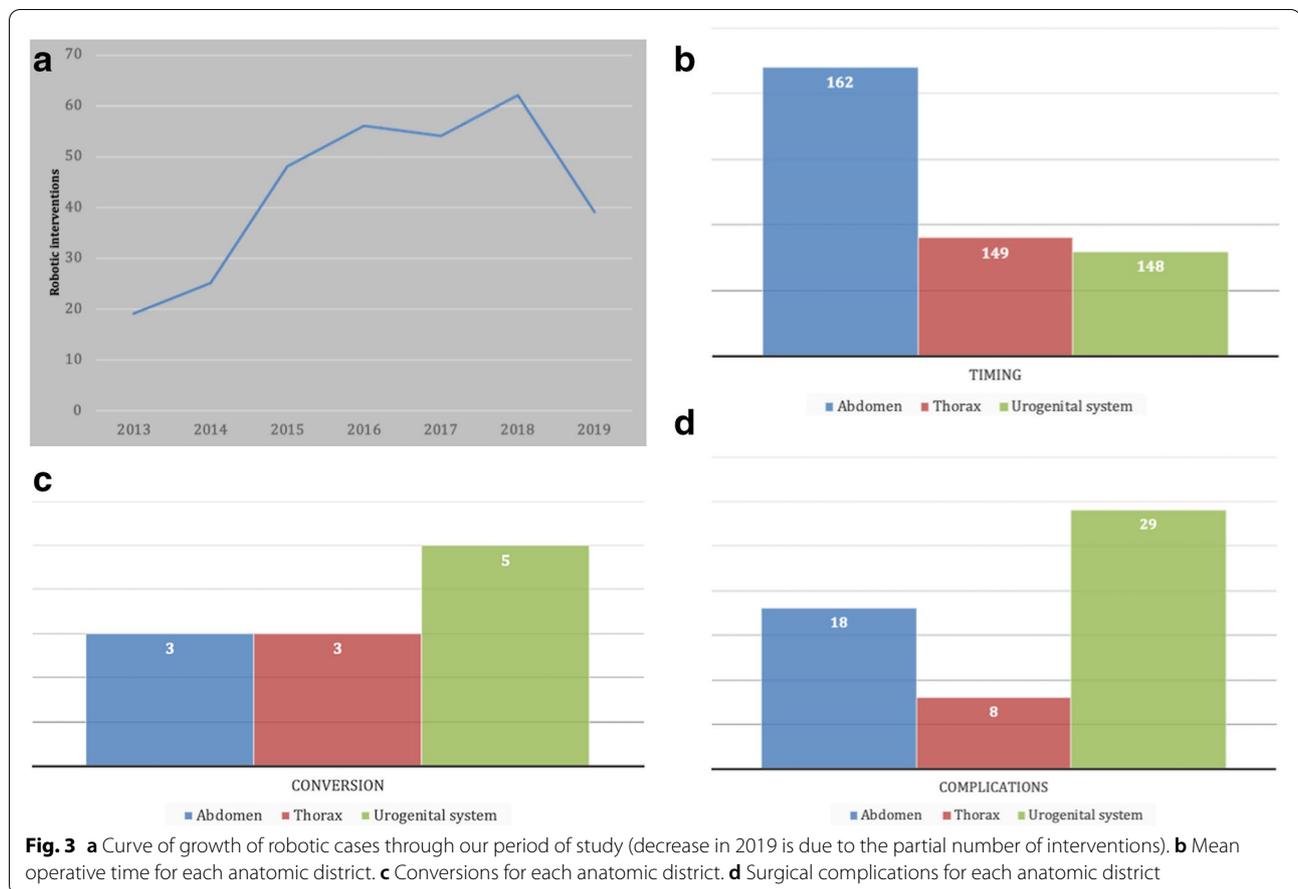
Discussion

Robot-assisted surgery, at the beginning, was conceived as a military tool for remote surgical care of the injured soldier, and later, in the 1990s, was introduced in the clinical practice [6]. Despite the fact that robotic surgery has reached high levels of expertise in adults with some procedures done as a gold standard yet the size and variety of available robotic instrumentation represent a limit for pediatric patients and the overall size of the robotic system can restrict the surgical indications [7]. The first report describing the use of robotic surgical systems for abdominal procedures in children were published was published by Heller and colleagues in 2002 [8]. They reported a series of 11 children who underwent Thal or Nissen fundoplication for treatment of gastroesophageal reflux disease using a Da Vinci system. Mean patient age was 12 years and no complications were reported. From that time the applicability of robotic surgery in pediatric fields has made important progress and the indications for the intervention have been extended to other pathologies and to patients of lower age and weight. A retrospective study in 2019 [9] demonstrated that weight cannot be considered an absolute limit for robotic surgery. The improvement of instruments permits to perform complex surgical procedures in low-weight children without additional difficulties. Also, other studies [10, 11] reported case series that demonstrated the safety and feasibility of

robot in pediatric surgery. Our results confirm this process of growth in Italy: there is an evident and progressive increase in the number of interventions every year. This finding not only certified the rise of pediatric surgical indications, but also an improvement in the learning curve. A systematic review in 2013 showed an increase, through the years, both in case volumes of robotic surgical procedures in children and in the published literature on this subject. The Authors describe fundoplication, pyeloplasty and pulmonary resection as main procedures performed with robot [12]. These data are in agreement with our results that confirm a shared consent in considering robot-assisted surgery a gold standard for the treatment of gastroesophageal reflux and for ureteropelvic junction obstruction.

Several studies demonstrated no significant differences in outcomes and complications between laparoscopy and robot in the approach of these diseases [13–15]. In our case series, we observed a high prevalence of cholecystectomy and nephrectomy. There is a wide consensus in considering robotic unappropriated for these interventions, since both can be safely performed laparoscopically with a low risk of complications, lower cost, and same cosmetic result [16–21].

We could explain this application of robotic in Italy according to the availability of device. In many centers, pediatric surgeons share the robotic system with general surgeons and urologists, and this made possible to lower costs, widen surgical indications and increase the learning curve for robotic surgery. Thoracic surgery presents a different situation, with a few number of interventions performed both in our series and literature. In pediatric population majority of thoracic diseases are congenital (CPAM, lobar emphysema, lung sequestration) and they need an intervention in the first months of life, which is impossible due to lack of suitable instrument size, until now, the use of robot according to unavailability of small size instruments. Even in toddlers, the thoracic cavity is small and trocar positioning with triangulation and are



difficult. There is also a need for single lung ventilation that makes it a challenge also for the anesthesiologists [5]. In the Italian experience, the pulmonary partial resection for the treatment of pleural blebs is the most common indication for thoracic robotic surgery. This is a common disease in teenagers and young adults, who present dimensions of thorax more suitable for robotic approach.

Conclusions

The results of this work give the reason to believe that in Italy, as in the rest of Europe and in the USA, pediatric robotic surgery is a field in development which presents a progressive growth. Pyeloplasty and fundoplication are, to date, the most frequent surgeries performed in children, where outcomes are recognized as at least equivalent to the open or laparoscopic procedures. The robotic pyeloplasty is the most commonly practiced procedure with the least operative complications in our series. Many other procedures have been reported, and still under evaluation with more data expected in the near future. A further increase of learning curve and improvements of robotic surgery can be the next step to do to widen the application of robot-assisted surgery. Further prospective

studies comparing the robotic surgery with the conventional techniques to justify why should we dwell on such expensive approach.

Abbreviations

MIS: Minimally invasive surgery; CPAM: Congenital pulmonary airway malformations.

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Authors' contributions

All authors equally contributed to collect analyzed and interpreted data. Rossella Angotti and Alessandro Raffaele were major contributors in writing the manuscript. Prof. Mario Lima was a supervisor. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article. The original datasets are available by each institution's dataset.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

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