

Current Status of Pediatric Robot-Assisted Surgery in Italy Part 2: National Survey on a 5-Year Period 2020–2025

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Abstract

Introduction: Following a previous study focused on the status of robotic surgery in Italy in 2020, we aimed to present the updated study reflecting data up to 2025.

Patients and Methods: An online questionnaire has been sent to robotic pediatric centers in Italy. The duration of robotic activity, the number of surgeons performing robot-assisted surgery (RAS), the modality of training, volume, type, and outcome of RAS in each participating center have been collected and analyzed.

Results: The number of centers practicing robotic surgery in Italy increased by 55.5% rate. All 14 centers adopted the Da Vinci Intuitive console. Three out of 14 centers have a dedicated console, while 11 out of 14 centers share the robotic platform with adult surgeons. Nine out of 14 centers routinely adopted a fourth 5-mm laparoscopic trocar for the bedside surgeon. About 1105 robotic procedures have been performed, the majority were still urological (46.7%). The others were gastrointestinal 18%, oncological 17.1%, gynecological 10.9%, and thoracic 3.6%. The rest (3.7%) were considered varia. All centers prefer to operate patients weighing more than 10–15 kg.

Conclusions: Robotic pediatric activity in Italy has had an important development in the last 5 years. Although there has been a significant increase, the majority of centers (78.6%) have a minimal robotic activity. Future directions are going to be the presence of robotic platforms in every pediatric centers; in this way, the robots can be adopted routinely in the pediatric surgical practice as laparoscopy. For pediatric surgery, we also need smaller instruments because 8 mm cannot be adopted in neonates and smaller infants.

Keywords: robotic surgery, pediatric surgery, Italy, survey, children

Introduction

Pediatric robot-assisted surgery (RAS) has gained increasing diffusion since its introduction in 2001, progressively

becoming no longer an exclusive domain of adult surgery.¹ The known advantages of RAS are enhanced precision and dexterity, improved visualization, with 3D optics, keeping the minimally invasive approach, greater ergonomic comfort for

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the surgeon especially in long-lasting surgeries, the possibility of training and reproducibility, better access to complex anatomical regions, and potential for reduced complication rates.¹⁻³

The Endo-Wrist technology with 7 degrees of freedom and 90° articulation have revolutionized minimally invasive surgery, enabling complex intracorporeal sutures even in narrow and difficult anatomical regions.^{2,3} The instruments of RAS are mainly 8 mm wide with long arms; these and the size of the robot itself are still a huge barrier when it comes to surgery for younger children, so that it is difficult to perform RAS on neonates or children less than 12–15 kg.^{4,5}

We aimed to assess the growth of pediatric RAS in Italy compared with our previous survey published 5 years ago that analyzed the period from 2010 to 2019.⁴

Until 2019, all the centers adopted only the Da Vinci Intuitive platform, and the main field of application was certainly urology with the pyeloplasty as the cornerstone.^{5,6}

Having acknowledged already the qualities, advantages, and limitations of pediatric robotic surgery, this study aims to analyze its developments in Italy over the past years, willing to understand progress and innovations.^{1,2,6}

Patients and Methods

A questionnaire-based survey was sent via mail to the most well-known Pediatric Surgery units in Italy, and the answers were collected through Google Form. A total of 14 participants responded to the Pediatric Robotic Surgery Survey 2025 out of 14 centers (100% response rate), providing insights into their experience, training, and surgical practices using robotic-assisted systems in pediatric surgery, and the data about the robotic activity of all these centers were collected and analyzed alone and in comparison with the old article.⁴

This survey covered the period from March 8, 2020, to March 8, 2025, and assessed the duration of robotic activity, the number of surgeons performing RAS, and the frequency of RAS in each center, including allocation and models of robots and the possibility of frequent use. It has also been evaluated the modality of training by each participating surgeon, in cases where it was carried out, before starting RAS. Finally, we assessed volume, as the number of surgical interventions; type, as the field of surgery and specific surgeries; complications and outcome of RAS in each participating center and compared them with the 2020 published study. This study received the appropriate Institutional Review Board approval from the Ethics Committee of the University Federico II as the main center.

Results

In 14 centers, more than half of the participants (64.2%—8 centers) reported initiating their robotic surgery activity 5 years ago or more, indicating an experienced cohort. Most centers (92.8%—13 centers) have 1–2 console surgeons, while only one center (7.8%) operates with more than 10 console surgeons.

Robotic platforms are predominantly shared with other specialties. Most respondents (78.6%—10 centers) perform robotic surgeries monthly with shared equipment. Only a minority (21.4%—4 centers) have access to an exclusive platform enabling them to use it more often, weekly or even

TABLE 1. DATA FROM 14 ROBOTIC PEDIATRIC CENTERS

	Start date	Console surgeon	Frequency and robot property	Laparoscopic experience	Training certificate	Proctorship	Robot model	Laparoscopic assistant port	Intraoperative complications	Postoperative complications	Laparoscopic conversion	Open conversion
1	<1 year	2	Monthly, shared	100–300	Yes not specified	10	Da Vinci Xi	>50%	0%	0%	0	0%
2	<1 year	1	Monthly, shared	>1000	Naples (Italy)	10	Da Vinci Xi	>50%	0%	0%	0	0%
3	>5 years	1	Daily, exclusive	>1000	Milan	20	Da Vinci Xi	<50%	1%	9%	0%	8.30%
4	>5 years	>10	Monthly, shared	>1000	No	10	Da Vinci Xi	100%	<1%	<1%	2%	0%
5	>5 years	2	Weekly, exclusive	100–300	Yes not specified	Yes	Da Vinci Xi	100%	8%	10%	5%	8%
6	<5 years	2	Weekly, exclusive	100–300	Milano	15	Da Vinci Xi	>50%	0%	0%	0%	0%
7	>5 years	2	Weekly, shared	300–500	London, Naples	10	Da Vinci Xi	100%	5%	0%	0%	2.5%
8	>5 years	2	Monthly, shared	300–500	Naples (Italy)	2	Da Vinci Si and Xi	100%	2%	0%	0%	4%
9	>5 years	2	Monthly, shared	>1000	London and Leeds	50	Da Vinci Xi	100%	1%	0%	2%	<1%
10	Less than 1 year	2	Monthly, shared	100–300	Ghent	15	Da Vinci Xi	100%	0%	0%	0%	0%
11	3–4 years	2	Rare, shared	100–300	No	Still proctoring	Da Vinci Xi	100%	0%	0%	0%	1%
12	>5 years	2	Weekly, shared	>1000	Naples (Italy)	10	Da Vinci Xi	<50%	1%	0%	1%	1%
13	>5 years	2	Weekly, exclusive	>1000	Naples (Italy)	12	Da Vinci Xi	>50%	<2%	0%	0%	0%
14	<5 years	2	Monthly, shared	100–300	Naples (Italy)	10	Da Vinci Xi	100%	0%	0%	2%	2%

daily. Prior to transitioning to robotic surgery, all respondents had laparoscopic experience, with 42.8% (6 centers) having performed more than 1000 procedures. The majority of participants hold a formal training certificate from institutions such as Milan, Naples, London, and Ghent, with only two (14.2%) centers do not have a certificate up to date. Every center has implemented proctorship during initial robotic procedures, often for up to 10 cases. The Da Vinci Xi system is universally adopted among respondents (100%). Only one center reported using both systems, Da Vinci Xi and the older Da Vinci Si. The use of a laparoscopic assistant port is standard in more than half of every case, with 85.7% (12 centers) of participants using it in every robotic surgery.

Intraoperative complication rates were nonexistent or generally low, with only one center reporting an 8% rate and one a 5% rate, while the others attested a rate under 2%. Postoperative complications were low: 11 centers have never had postoperative complications, while 2 centers attested a 9% or a 10% rate, and 1 center had <1%. Conversion from robotic to laparoscopic surgery occurred in 5 centers (35.7% reported at least one conversion), and for conversion to open surgery, 6 centers attested 0% rate, while the others stood between 1% and 8.3% (Table 1). The majority of robotic procedures were urological, with a total of 517 out of 1105 procedures declared (46.7%). Gynecological, gastrointestinal, and thoracic procedures were performed to a lesser extent. Gastrointestinal total was 200 (18% of total). Oncology-related robotic surgeries were performed by several respondents, for abdominal masses, with one center reporting up to 90 procedures in this category and a total of 189 (17.1%).

Gynecological total was 121 (10.9% of total), with one center attested to have performed 70 of them and thoracic 40 (4%). Other surgeries (3.7%) were classified as varia (Fig. 1). Pyeloplasty was the most commonly performed procedure, with 207 procedures (about 18.7% of total procedures), followed by urological procedure including ureterocalicostomy, renal cyst excision, and ureteral surgery. Procedures like bladder neck reconstruction, urachal cyst excision, and

ureteral reimplantation were less common but still present. Extravesical ureteral reimplantation had only one center with 94 cases; the majority of participants attested from 0 up to 10 cases, with a total of 123 (11.1%). Varicocelectomy was performed in up to 41 cases in a single center, with a total of 89 cases (8.5%), and 7 centers with no experience at all. Antireflux surgery for gastroesophageal reflux disease was performed in up to 20 cases in a single center, with a total of 92 (8.3%).

Cholecystectomy was performed in up to 30 cases in a single center, with a total of 99 cases (8.9%). Ovarian masses were treated in up to 35 cases in a single center, with a total of 69 cases (6.2%) (Fig. 2). In these centers, lobectomy for congenital pulmonary airway malformation, pulmonary sequestration, or esophageal atresia has never been attempted in robotic surgery. Thus, the thoracic approach in robotic surgery does not appear to be well explored yet. The respondents also reported more complex or rare robotic procedures, including posterior tracheopexy, esophagogastric dissociation, biliodigestive reconstructions (hepaticojejunostomy), Mitrofanoff procedures, robotic gastric sleeve resections, esophageal achalasia and congenital esophageal stenosis, median arcuate ligament release, and distal pancreatectomy for pseudopapillary tumors.

Discussion

Compared to the old survey, it appears that the experience of the cohort has risen with 55.5%—8 centers attested to have 5 years or more of experience. The total number of procedures has risen exponentially from 2019, with 1105 procedures performed from 2020 to March 2025, compared to 209 from the previous study.⁴ While up to 2019 urological procedures were 56.9% of the total, it appears that they are 46.7% thus far, meaning that robotic surgery is evolving also in other fields. A similar trend has been observed in gynecological procedures, which decreased from 14.8% to 10.9%, while oncological surgeries have increased significantly, rising from 5.7% to 17.1%, and gastrointestinal surgeries kept

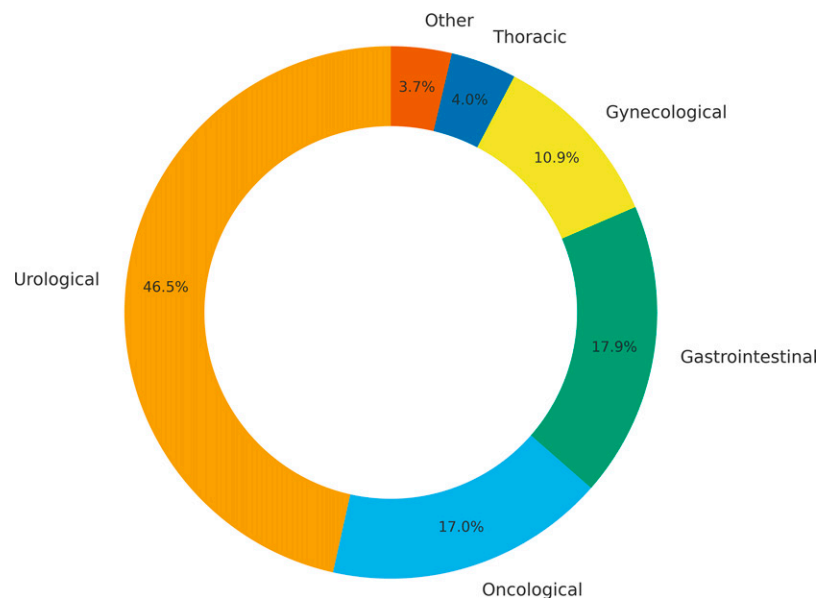


FIG. 1. Percentage distribution of robotic surgeries by fields.

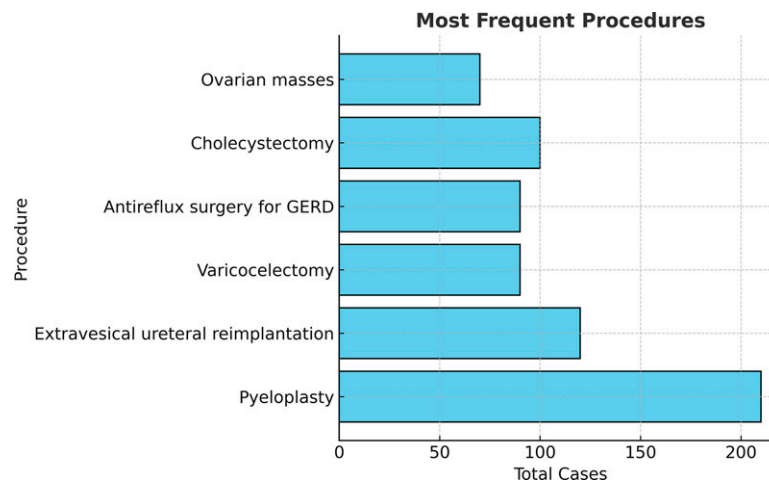


FIG. 2. Distribution of surgical procedures. GERD, gastroesophageal reflux disease.

almost the same rate during these years. Intraoperative complications were recorded in 16 cases (1.6%) instead of 4 cases (1.9%). The complication rate has significantly decreased compared with our study published in 2020. Postoperative complications occurred in only 46 (4.7%) instead of 17 out of 209 cases (8.1%).⁷ Conversion to laparoscopy was needed in only 6 cases (0.6%) instead of 4 cases (1.9%), whereas conversion to open surgery was required in 35 cases (3.58%) instead of 6 cases (2.8%). This last figure is probably due to the greater number of advanced procedures implemented in the last 5 years. This survey reveals an advanced and diverse use of RAS in pediatric settings, particularly in urology. Most respondents are highly experienced, trained in dedicated centers, and supported by structured proctorship.^{8,9} While the Da Vinci Xi is the standard system adopted, the spectrum of procedures spans from routine to complex, confirming the maturation and expansion of pediatric robotic surgery programs.^{8,9} The swing in the percentages of pediatric robotic procedures across different specialties compared with the previous survey indicates that robotic surgery is expanding into fields beyond urology, which has traditionally represented its primary area of application and development.^{5,10-22} Robotic oncologic surgery, in particular, has made significant progress over the past years; thus, urology is still present and remains the undisputed leader of the group, as seen in numerous recent studies.²³⁻²⁷ It also appears that the total rate of conversion is increased from 2019, this is likely due to the fact that more complex procedures are performed as surgical experience rises and the increasing number of conversion in open surgery while decreasing the laparoscopic one may be considered a safer approach by surgeons when a minimally invasive technique has not been deemed sufficiently reliable.^{14,22,23,26} The lowest percentage of postoperative complications can be explained by a better understanding of RAS and raised experience.⁷ In conclusion, although there has been a significant increase in pediatric robotic activity in Italy, the majority of centers (78.6%) still have a minimal robotic activity with 1–2 robotic sessions per month, and only few centers (22.4%) have a dedicated console to pediatric surgery. One of the most relevant limitations is the absence of dedicated pediatric robotic platforms in the majority of institutions, which limits training opportunities, procedure frequency, and long-term program

development.^{4,5} Like in the previous study of 2020, also in this last survey of 2025, the Da Vinci Intuitive platform is the only platform adopted in all centers. The main flaw of RAS is the high cost of this technology, it is expensive not only to buy and collocate the robot in surgery rooms but also to use it in every possible surgeries due to the high maintenance costs and the frequent use of disposable instruments during surgical operations.³ Future directions should be the presence of robotic platforms in every pediatric centers. In this way, the robots can be adopted routinely in the pediatric surgical practice for laparoscopy.¹⁻⁴ We believe also that after the unsatisfactory spread of RAS in pediatric centers, the large instruments are another main barrier. This size mismatch increases the difficulty of certain procedures and limits the use of robotic surgery in infants and neonates. The development and regulatory approval of miniaturized tools (3–5 mm) specifically designed for pediatric use could significantly broaden the applicability of RAS in children, offering improved ergonomics and reduced invasiveness.^{3-5,7} Another main point is that individual procedures are often too expensive for hospitals, even though the benefits for both surgeons and patients are well known. As a result, the use of robotic surgery remains a niche choice, reserved for the most complex operations. A significant breakthrough would be to lower both the purchase and operational costs of this technology, enabling its broader adoption in the future.⁶

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No competing financial interests exist. No personal interests to disclose.

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