Implementing a pediatric robotic surgery program: future perspectives

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ABSTRACT

Abstract. The minimally invasive approach using robotic technology is fully incorporated in the treatment of adult pathologies.

The first international pediatric studies with a robotic approach date from 2002, and in Spain, from 2009. We present the implementation of a Pediatric Robotic Surgery program in our setting.

Materials and methods. A proposal for the application of robotic technology in pediatrics was developed, and after the acquisition of a Da Vinci Xi system at our center, a program was initiated under the guidance of a pediatric surgeon experienced in this approach.

Results. 32 patients with a median age of 12 years (7 months-17 years) have been operated on since January 2019. 56% of the procedures were abdominal. 3 thoracic approaches and 11 urologic procedures were carried out. 1 conversion to open surgery was performed during a fundoplication. The median combined duration of abdominal and thoracic approaches was 155 minutes (70-380 minutes). There were no anesthetic or hemodynamic complications. The postoperative period in the cases in which the procedure was completed was uneventful, and patients were discharged after a median of 2 days (1-16 days).

Conclusion. The main advantage of robotic procedures is the symmetrical movement in line with the surgeon's hands, which makes the learning curve shorter. In our experience, the robotic approach has allowed for greater precision in the surgical technique, favoring the patient's recovery.

KEY WORDS: Pediatric robotic surgery; Pediatric robotic urology; Robotic lung resection.

IMPLEMENTACIÓN DE UN PROGRAMA DE CIRUGÍA ROBÓTICA PEDIÁTRICA. PERSPECTIVAS FUTURAS

RESUMEN

Introducción. El abordaje mínimamente invasivo empleando tecnología robótica está plenamente incorporado a la patología del adulto.

Las primeras series pediátricas internacionales con abordaje robótico datan del año 2002 y en España del 2009. Presentamos la implementación de un programa de Cirugía Robótica Pediátrica en nuestro centro.

Material y método. Se elaboró una propuesta de aplicación de la tecnología robótica en el área pediátrica y tras la adquisición de una plataforma Da Vinci Xi en nuestro centro, se procedió al inicio del programa bajo la tutorización de un cirujano pediátrico experimentado en este abordaje.

Resultados. Se han intervenido 32 pacientes con una mediana de edad de 12 años (7 meses-17 años) desde enero de 2019. El 56% de los procedimientos fueron abdominales. Se realizaron tres abordajes torácicos y 11 procedimientos urológicos. Se realizó una conversión a cirugía abierta durante una fundoplicatura. La mediana de la duración en conjunto de los abordajes abdominales y torácicos fue de 155 minutos (70-380 minutos). No hubo complicaciones anestésicas ni hemodinámicas. El postoperatorio en los casos en los que se concluyó el procedimiento no presentó incidencias y el alta se realizó con una mediana de 2 días (1-16 días).

Conclusión. La principal ventaja de los procedimientos robóticos es el movimiento simétrico en línea con las manos del cirujano, lo que hace que la curva de aprendizaje sea más corta. En nuestra experiencia, el abordaje robótico nos ha permitido una mayor precisión en la técnica quirúrgica favoreciendo la recuperación del paciente.

PALABRAS CLAVE: Cirugía pediátrica robótica; Urología pediátrica robótica; Resección pulmonar robótica.

INTRODUCTION

The minimally invasive approach is an inexorable part of our routine practice, so much so that for certain pathologies it has become the gold standard (cholecystectomy[1], fundoplication[2], pyeloplasty[3], pulmonary malformation[4]). Advances in the adaptation of instru-

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ments to pediatric size has allowed for the incorporation of minimally invasive surgery in neonatal surgery, as in esophageal atresia[5], congenital diaphragmatic hernia[6], or cases of nesidioblastosis[7].

Some years ago, when the first steps in robotic surgery were being made at an international level, our center took the opportunity to position itself as a leading institution in the robotic surgery approach. Since 2009, 2,367 patients have undergone surgery (annual median of 118 cases). The predominant service is the Urology Department, with 59.7% of the procedures.

It is considered the procedure of choice in surgeries such as radical prostatectomy or colectomy and coloanal anastomosis[8,9].

The first articles on robotic surgery in pediatrics began to appear around 2000[10,11]. The development of this approach in certain urological, digestive, and pelvic procedures in children[12,13] has become common in the United States, where it is widely offered in all pediatric centers, as well as in some settings in Europe.

In Spain, the first pediatric robotic approach dates from 2009 at the Vall d'Hebron Hospital, which published its first study of 8 patients over 10 months. Patients were aged 7 to 15 years old and had a mean weight of 42 kg[14]. Since then, contributions on the experience using this system in Spain have been limited to the field of pediatric urology, belonging to the same surgical group[15,16].

The approaches in which robotic technology provides the most advantages are those that require very careful dissection, those that are performed in places that are difficult to access (such as the pelvis), and those that require suturing – the most difficult activity in conventional laparoscopic surgery.

We present the implementation of a Pediatric Robotic Surgery program at our center.

MATERIALS AND METHODS

A proposal for the application of robotic technology in pediatrics was developed after updating the robotic system available at our center.

An analysis of this type of approach was carried out by consulting extensive pediatric studies[17,18]. Indications in the field of our specialty that are widely recognized in the literature were considered[19]. Two surgeons were trained through an online program of theoretical and practical training, training in experimental animals and a visit to a pediatric robotic surgery center. The program was initiated under the guidance of a pediatric surgeon experienced in this approach.

The system used was the Da Vinci Xi, which has four robotic arms and improves on previous versions in terms of their orientation on the patient. This makes the docking period almost non-existent, since the system automatically provides the orientation of the robotic arms by selecting the body area to be worked on (upper abdomen/lower abdomen; right/left), facilitating the docking of the arms to the ports.

The pathology treated, the surgical time employed (from the beginning to the end of the skin incision), hospital stay, conversions to open or laparoscopic surgery, intraoperative complications, and the approximate cost of consumables for the use of the robotic approach were evaluated.

RESULTS

In our institution, 32 patients have undergone surgery using the robotic approach since January 2019.

In 62% (20/32) of cases, only three robotic arms and a 5 mm auxiliary port were used. Occasionally, a 12 mm one was used, on which the 8 mm robotic port was placed for the introduction of clips or endostaplers, without the need for another auxiliary port.

Regarding instruments, most of the dissection was performed with Maryland and/or Cadiere forceps, and as energy instruments, the hook, the vessel sealer, or the bipolar forceps itself. In cases where suturing was required, a needle driver was used, generally the smallest available (black diamond micro forceps).

Most of the instruments have 10 uses, so it is necessary to define them beforehand to avoid "wasting" unnecessary uses that increase the cost of the procedure.

The median age of the patients was 12 years old, ranging from 7 months to 17 years old. 9 patients were younger than 7 years old, and 6 were 5 years old. The 7-month-old patient underwent surgery once it had been determined that the distance between ports would allow for the necessary maneuverability with three robotic arms (Fig. 1).

Abdominal (for digestive and urological pathologies) and thoracic approaches were conducted. In both cases, the program started off with simpler pathologies. This allowed the necessary skills to be acquired for the increasing complexity of the procedures. Table 1 shows the surgical time and hospital stay for the different procedures carried out.

Abdominal approach

The most frequent procedures were cholecystectomy for cholelithiasis 27.6% (8/29) and ureteropyeloplasty as a result of ureteropelvic stenosis (UPS) 17% (5/29).

Three splenectomies were performed, two for splenic tumor (Fig. 2) and one for hereditary spherocytosis (Table I).

In the patient with hereditary spherocytosis and large splenomegaly, the surgical time was prolonged due to the rupture of the spleen extraction bag.

1 patient with gastro-esophageal reflux (GERD), with spastic cerebral palsy, underwent Nissen fundoplication, gastrostomy, adenoidectomy, and tonsillectomy at the same

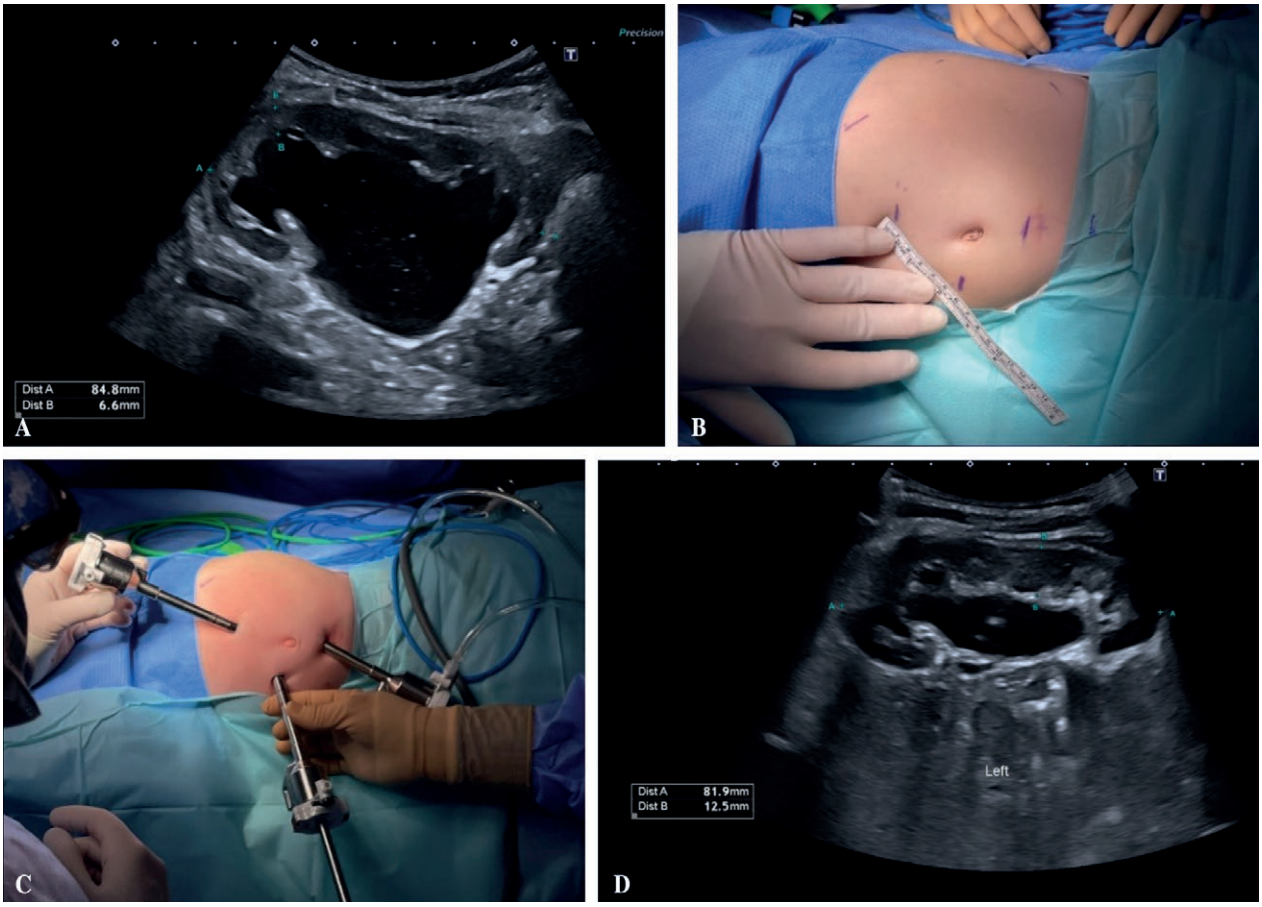

Figure 1. 7-month-old patient with left ureteropelvic stenosis (A). Measurement of the minimum distance between ports greater than 4 cm (B). Placement of robotic ports for access to the left renal capsule (C). Ultrasonography of the ureteropelvic junction 3 months after ureteropyeloplasty (D).

Table I. Robotic procedures carried out by our Department from January 2019 to June 2022. Operating times and hospital stay (median and range) are featured.

Procedure	*Patients n = 31*	*Operating time (minutes) (median)*	*Range (minutes)*	*Hospital stay (days) (median)*	*Range (days)*
Digestive/oncological pathology					
Cholecystectomy	8	132	86-160	1	1
Splenectomy	3	290	70-380	3	2-4
Abdominal tumor	2	125	125	2	1-3
Gastroesophageal reflux*	1	270	–	3	–
Deferred appendectomy	2	100	45-155	1	1
Crohn's disease	1	–	–	14	–
Total	**17**	**142**	**45-380**	**1**	**1-14**
Urological pathology					
Ureteropyeloplasty	5	190	145-225	3	1-3
Nephrectomy	2	185	155-215	2	2
Heminephrectomy	3	170	139-230	3	2-3
Bladder augmentation	1	380	–	16	–
Total	**11**	**190**	**139-380**	**3**	**1-16**
Thoracic pathology					
Recurrent pneumothorax	2	90,5	81-100	2	1-3
Pulmonary sequestration	1	108	–	2	–
Total	**3**	**100**	**81-108**	**2**	**1-3**

**Patients requiring conversion to open surgery was excluded.*

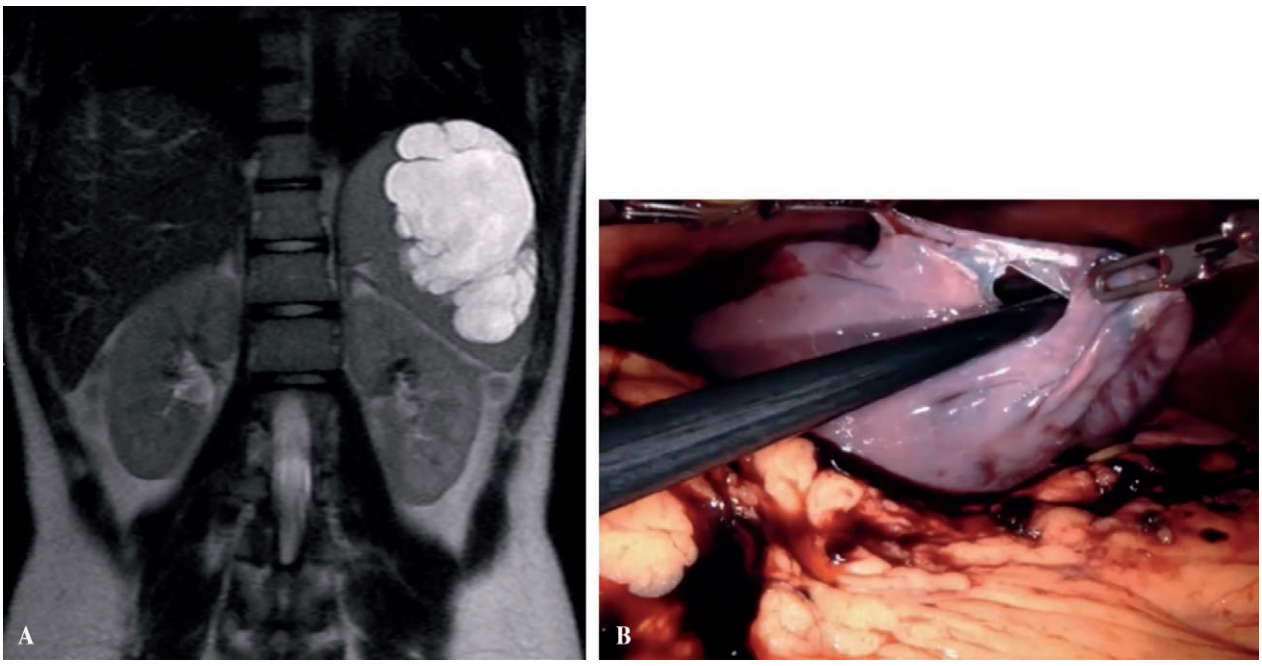

Figure 2. Multicystic splenic lesion (A). Aspiration after splenectomy to facilitate removal (B).

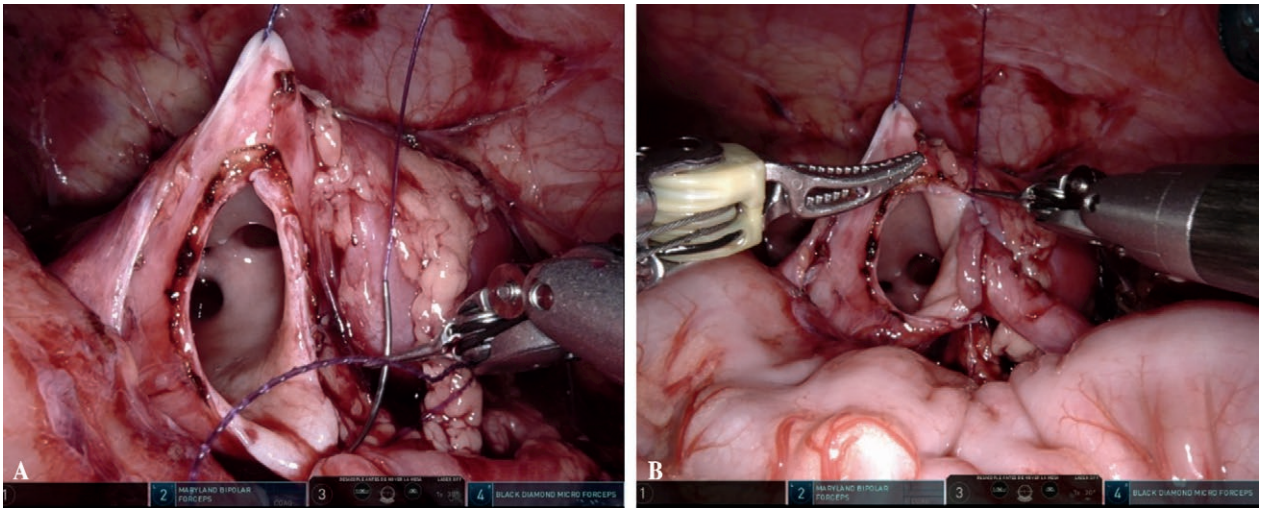

Figure 3. Ureteropyeloplasty as a result of left UPS. Extracorporeal pelvic suspension attachment point (A). 4/0* continuous barbed suture on two sides (B). **4/0 barbed suture, 3/8 needle, cylindrical 17 mm.*

time. The other patient with GERD required conversion to open surgery due to esophageal perforation caused by severe esophagitis.

The patient with Crohn's disease underwent right ileocolectomy for stricture of the terminal ileum. Extracorporeal ileocolic stapled suture was used.

There were no other postoperative complications or incidents.

The surgical time in urological pathologies was longer than in digestive pathologies (Table I). In the case of UPS, in the first two cases, a stent was placed in the ureteropelvic junction in an antegrade manner, which proved to be somewhat difficult. Consequently, in the following cases, retrograde ureteral catheterization was performed beforehand. The ureteropelvic suture was performed with a barbed suture after exerting traction through the suspension point of the renal pelvis (Fig. 3).

Bladder augmentation was carried out with an ileal loop in a 12-year-old patient with neurogenic bladder secondary to myelomeningocele. The 4 robotic arms and two

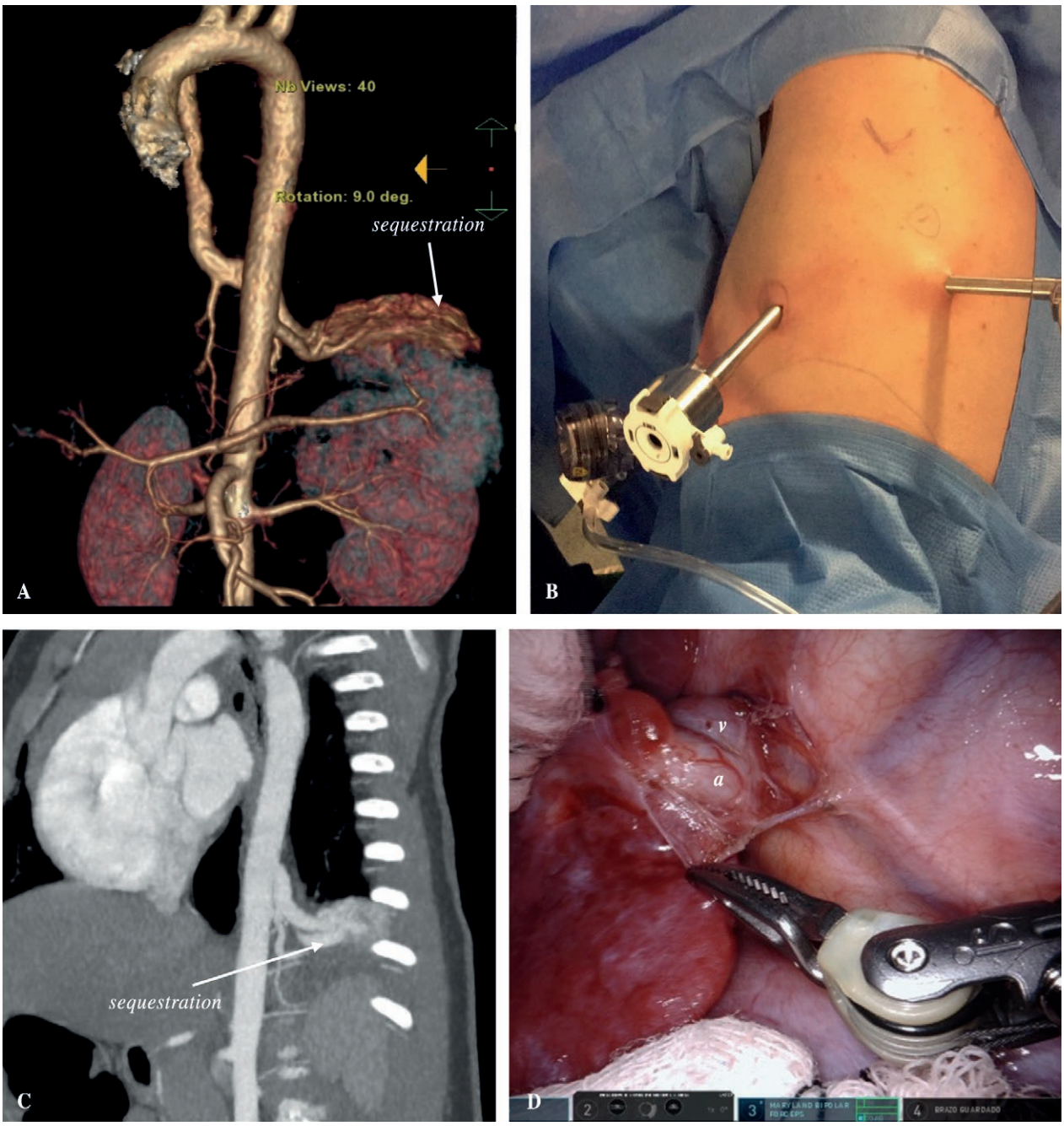

Figure 4. Two-and-a-half-year-old patient with left extralobar sequestration (A). Fitting of 3 robotic and auxiliary ports (B). Vascular pedicle with systemic artery (a) and pulmonary venous drainage (v).

auxiliary ports, 12 and 5 mm, were used. Stents were also previously placed in both ureters.

There were no complications in the urological patients treated. Hospital stay is featured in table I.

Thoracic approach

Three patients underwent surgery, two adolescents for recurrent left pneumothorax (both 17 years old) and one patient aged two and a half years old for extralobar sequestration (Fig. 4).

The ports were placed in the 7th and 8th intercostal spaces, and the scope was placed in the anterior port under the scapular tip.

In all cases, three robotic ports and a 12 mm or a 5 mm auxiliary port were placed for the endostapler and aspiration. Surgery duration and hospital stay are featured in table I.

Figure 5. 19-month-old patient. Right upper heminephrectomy. Three robotic ports, one 5 mm port, and one 3 mm port. Cosmetic result at 12 months.

Progression and cosmetic results

There were no mediate or late complications in the procedures performed.

There were no surgical wound infections, and scarring was adequate in all patients (Fig. 5).

Economic data

To evaluate efficiency in the use of consumable instruments, data was collected on the robotic material used in each procedure. A distinction was made between procedures that required vascular dissection and division, and those that also required intracorporeal suturing (fundoplication, ureteropelvic stenosis, bladder augmentation). The cost per basic procedure is shown in table II.

DISCUSSION

The first pediatric patients undergoing surgery using a robotic approach date back to 2002[10,11]. In the last 20 years, an increasing number of studies have been published, demonstrating the increase in the use of robotic technology among the pediatric age group, from 3 publications in 2002 to 43 in 2021, mainly in the urological field[20,21]. The main drawbacks reported by Denning et al.[22] of the use of the robotic system in pediatric patients are the lack of availability of 5mm instruments in the Xi model, and the fact the size of the patient limits the working field and the possibility of using the fourth robotic arm. In our study, we only used the 4th arm in 12 cases – these were the most complex cases or those in which the size of the patient allowed for it.

Patient age and/or weight has been considered limiting for the use of the robotic system. Recent works such as that of Rague et al.[23] show a study of 101 patients with a median age of 7.2 months and a weight of 8 kg undergoing ureteropyeloplasty (78.2%) or ipsilateral ureteroureterostomy (21.8%). Our youngest patient was 7 months old. Of the children under 5 years of age who underwent surgery,

Table II. Cost of expendable robotic surgery instruments required in a "typical" dissection (abdominal tumor) and dissection and suture (ureteropyeloplasty) procedure.

Da Vinci consumables *Dissection surgery: abdominal tumor*	*Unit cost*	*Cost per use*
Monopolar hook (10 uses)	€3,472.70	€347.27
Maryland bipolar forceps (14 uses)	€3,472.70	€248.05
Arm drape	€90.02 (4)	€360.08
Camera drape	€31.16	€31.16
		€986.56
Da Vinci consumables *Dissection and suture surgery: ureteropyeloplasty*	*Unit cost*	*Cost per use*
Monopolar hook (10 uses)	€3,472.70	€347.27
Maryland bipolar forceps (14 uses)	€3,472.70	€248.05
Cadiere forceps (10 uses)	€3,484.80	€348.48
Fine needle driver (10 uses)	€4,356.00	€435.6
Scissors (10 uses)	€5,575.68	€557.57
Arm drape	€90.02 (4)	€360.08
Camera drape	€31.16	€31.16
		€2,328.21

4 had urological pathologies, 2 had ureteropelvic stenosis, and 2 underwent upper heminephrectomy as a result of duplex kidney.

The distribution of pathologies reported by other studies[24] shows higher prevalence of urological pathologies, which in our case represented 35%. Digestive/tumor pathologies are overrepresented in our study because minor abdominal procedures such as appendectomy or cholecystectomy have been used as a starting point for robotic surgery programs[25]. In our study, two delayed appendicectomies and 8 cholecystectomies for cholelithiasis were conducted, mainly at the beginning of the learning curve. However, robotic surgery does not seem to bring benefits in cholecystectomy, with similar operating times and length of stay but with an increase in the cost per surgery[1].

Studies by Minkes et al.[26] and Feng et al.[27] highlighted the advantages of the laparoscopic approach in cases of splenectomy in the pediatric population. Recently, Shelby et al.[28] compared laparoscopic splenectomy (LS) (14 patients) vs. robotic splenectomy (RS) (10 patients), with a similar duration of the surgical procedure (RS 140.5 vs. LS 154.9 min), but with a significant decrease in hospital stay, 2.1 days for RS vs. 3.2 days in LS cases ($p = 0.02$). The median length of stay in the 3 splenectomy cases we performed was 3 days, similar to that in laparoscopic procedures[29]. In the case of splenomegaly due to spherocytosis, the rupture of the morcellation extraction bag prolonged the surgical time considerably (380 minutes). Some authors have highlighted the added difficulty in cases of massive splenomegaly[30] and, at times, even questioned the benefits of this type of approach[31].

In our study, the median operating time in patients with an abdominal approach for urological pathologies was longer than in patients undergoing surgery for digestive/tumor pathologies – 190 vs. 143.5 minutes.

According to Seideman et al.[32], the appropriate time for the robotic treatment of ureteropelvic stenosis should be around 120 minutes, and according to Sorensen et al.[33], after 15–20 pyeloplasties, operating times yield a standard deviation of 1 over operating times in open surgery.

In the five cases of ureteropyeloplasty in our study, the median duration of the procedure was 190 minutes, similar to that described by Asensio in 2013[15]. Figure 6 shows the downward progression of the surgical time employed as a function of the learning curve, with a final value of 145 minutes.

The duration of the procedure is generally associated with more complex cases as reported by Pini Prato et al.[34], who reached 420 minutes in their study of Soave pull-through in cases of Hirschsprung's disease. However, in these cases, the robotic approach increases the precision of perirectal dissection and is accessible even in infants younger than 12 months, as described in the study by Delgado and Camps[35] – although they used the Da Vinci Si system, which allows 5 mm ports to be used.

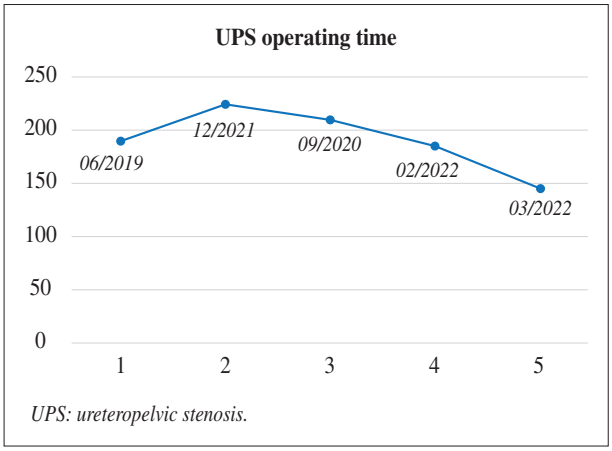

Figure 6. Evolution of operating time (minutes) in ureteropyeloplasty in relation to the learning curve of the same console surgeon.

Pediatric pathologies treated with minimally invasive robotic surgery have progressively increased, and there are important studies of more complex procedures such as common bile duct cyst resection with robotic hepaticoduodenostomy reconstruction[36].

The robotic thoracic approach is in full development, with clear indications for resection in lung cancer[37], and even the esophageal approach has been internationally agreed upon[38]. In 2020, Durand et al.[39] published the first study of robotic lobectomy in seven pediatric patients. Comparison with 11 similar patients treated by thoracoscopy showed a longer operating time in the robotic approach (247 ± 50 vs. 152 ± 57 min, $p = 0.008$), but conversion to open surgery was not required in the robotic approach while it was necessary in 45% of the cases treated by thoracoscopy (5/11 patients).

Recently, a French multicenter study[40] presented 18 patients with esophageal robotic-assisted thoracoscopic surgery (ERATS), with a mean age of 7.1 ± 5.6 years. The main limitation of thoracic approaches is the discrepancy between port size and the patient's intercostal space[39].

Most of the oncological robotic procedures published so far were isolated cases[41-43]. Recently, a multicenter study of 100 oncological cases was published, with a predominance of neuroendocrine tumors (31 cases) and adrenal tumors (13 cases), demonstrating that the robotic approach is safe, although the indications should be discussed in multidisciplinary forums. The minimally invasive approach offered by robotic surgery seems to be a good option to expand the possibilities of complex resection in pediatric cancer, reducing the postoperative recovery period and its sequelae[44].

All early robotic programs have been characterized by varied pathologies and disparate complexity[25,45], similar to our own experience. The learning curve for robotic surgery appears to be shorter than for conventional lap-

aroscopy. This factor is particularly important in a field such as pediatric surgery, where the limited number of cases and the wide variety of procedures make it difficult to complete a learning curve similar to that of adult surgery. In our experience, the robotic approach allows for greater precision in procedures that require meticulous dissection and suturing.

The future focus should be placed on further development of the robotic surgery instruments needed for pediatric patients of all ages, wider availability, and clear cost-effectiveness[46] as a reliable option for complex procedures that are currently difficult to approach laparoscopically[47].

The analysis of the added cost of robotic instruments in our study ranged from 986.56 € to 2,328.21 €, similar to that reported by Boia and David[48].

One of the main disadvantages of our specialty is the scarce casuistry, which makes it very difficult to obtain sufficient experience to justify investment in new technologies. We therefore believe that pediatric surgeons in Spain should try to gain full access to this technology by forging partnerships and forcing technological development, as it was the case with traditional laparoscopy.

REFERENCES

1. Kulaylat AN, Richards H, Yada K, Coyle D, Shelby R, Onwuka AJ, et al. Comparative analysis of robotic-assisted versus laparoscopic cholecystectomy in pediatric patients. J Pediatr Surg. 2021; 56(10): 1876-80.
2. Stellato RK, Colmer N, Tytgat SHA, van der Zee DC, van de Peppel-Mauritz FA, Lindeboom MYA. Five-year outcome of laparoscopic fundoplication in pediatric gerd patients: A multicenter, prospective cohort study. J Gastrointest Surg Off J Soc Surg Aliment Tract. 2021; 25(6): 1412-8.
3. Pérez-Bertólez S, Martín-Solé O, García-Aparicio L. Comparison between mini-laparoscopy, conventional laparoscopy and open approach for ureteropelvic junction obstruction treatment in children. Scand J Urol. 2021; 55(4): 307-12.
4. Esposito C, Bonnard A, Till H, Leva E, Khen-Dunlop N, Zanini A, et al. Thoracoscopic management of pediatric patients with congenital lung malformations: Results of a European Multicenter Survey. J Laparoendosc Adv Surg Tech A. 2021; 31(3): 355-62.
5. van Tuyll van Serooskerken ES, Tytgat SHAJ, Verweij JW, Reuling EMBP, Ruiterkamp J, Witvliet MJ, et al. Thoracoscopic repair of esophageal atresia. J Laparoendosc Adv Surg Tech A. 2021; 31(10): 1162-7.
6. Wagner R, Mayer S, Feng X, Gosemann JH, Zimmermann P, Lacher M. Thoracoscopic repair of congenital diaphragmatic hernia. Eur J Pediatr Surg. 2020; 30(2): 137-41.
7. Wakfie-Corieh CG, Rodríguez Rey C, Ortega Candil A, Ávila Ramírez LF, Pérez Rodríguez O, Carreras Delgado JL. Focal form of congenital hyperinsulinism in a newborn diagnosed with 18F-DOPA PET/CT allows laparoscopic surgical approach. Rev Espanola Med Nucl E Imagen Mol. 2021; 40(5): 318-9.
8. Minafra P, Carbonara U, Vitarelli A, Lucarelli G, Battaglia M, Ditonno P. Robotic radical perineal prostatectomy: tradition and evolution in the robotic era. Curr Opin Urol. 2021; 31(1): 11-7.
9. Grosek J, Ales Kosir J, Sever P, Erculj V, Tomazic A. Robotic versus laparoscopic surgery for colorectal cancer: a case-control study. Radiol Oncol. 2021; 55(4): 433-8.
10. Hollands CM, Dixey LN. Applications of robotic surgery in pediatric patients. Surg Laparosc Endosc Percutan Tech. 2002; 12(1): 71-6.
11. Gutt CN, Markus B, Kim ZG, Meininger D, Brinkmann L, Heller K. Early experiences of robotic surgery in children. Surg Endosc. 2002; 16(7): 1083-6.
12. Chan YY, Durbin-Johnson B, Sturm RM, Kurzrock EA. Outcomes after pediatric open, laparoscopic, and robotic pyeloplasty at academic institutions. J Pediatr Urol. 2017; 13(1): 49.e1-6.
13. Hambraeus M, Arnbjörnsson E, Anderberg M. A literature review of the outcomes after robot-assisted laparoscopic and conventional laparoscopic Nissen fundoplication for gastro-esophageal reflux disease in children. Int J Med Robot. 2013; 9(4): 428-32.
14. Marhuenda C, Giné C, Asensio M, Guillén G, Martínez Ibáñez V. [Robotic surgery: first pediatric series in Spain]. Cirugia Pediatr. 2011; 24(2): 90-2.
15. Asensio M, Gander R, Royo G. [Robotic pyeloplasty: first experiences]. Cirugia Pediatr. 2013; 26(3): 124-8.
16. Asensio M, Gander R, Royo GF, Lloret J. Failed pyeloplasty in children: Is robot-assisted laparoscopic reoperative repair feasible? J Pediatr Urol. 2015; 11(2): 69.e1-6.
17. Cundy TP, Harley SJD, Marcus HJ, Hughes-Hallett A, Khurana S. Global trends in paediatric robot-assisted urological surgery: a bibliometric and Progressive Scholarly Acceptance analysis. J Robot Surg. 2018; 12(1): 109-15.
18. Varda BK, Wang Y, Chung BI, Lee RS, Kurtz MP, Nelson CP, et al. Has the robot caught up? National trends in utilization, perioperative outcomes, and cost for open, laparoscopic, and robotic pediatric pyeloplasty in the United States from 2003 to 2015. J Pediatr Urol. 2018; 14(4): 336.e1-8.
19. Wakimoto M, Michalsky M, Nafiu O, Tobias J. anesthetic implications of robotic-assisted surgery in pediatric patients. Robot Surg Res Rev. 2021; 8: 9-19.
20. Stern N, Wang P, Dave S. Instituting robotic pediatric urologic surgery in the Canadian healthcare system: Evaluating the feasibility and outcomes of robot-assisted pyeloplasty and ureteric reimplantation. Can Urol Assoc J. 2021; 15(4): E215-20.
21. Esposito C, Castagnetti M, Autorino G, Coppola V, Cerulo M, Esposito G, et al. Robot-Assisted laparoscopic extra-vesical ureteral reimplantation (Ralur/Revur) for pediatric vesicoureteral reflux: A systematic review of literature. Urology. 2021; 156: e1-11.
22. Denning NL, Kallis MP, Prince JM. pediatric robotic surgery. Surg Clin North Am. 2020; 100(2): 431-43.
23. Ragué JT, Shannon R, Rosoklija I, Lindgren BW, Gong EM. Robot-assisted laparoscopic urologic surgery in infants weighing ≤10 kg: A weight stratified analysis. J Pediatr Urol. 2021; 17(6): 857.e1-7.
24. Esposito C, Masieri L, Castagnetti M, Pelizzo G, De Gennaro M, Lisi G, et al. Current status of pediatric robot-assisted surgery in Italy: Epidemiologic national survey and future directions. J Laparoendosc Adv Surg Tech A [online]. 2020.
25. Bütter A, Merritt N, Dave S. Establishing a pediatric robotic surgery program in Canada. J Robot Surg. 2017; 11(2): 207-10.
26. Minkes RK, Lagzdins M, Langer JC. Laparoscopic versus open splenectomy in children. J Pediatr Surg. 2000; 35(5): 699-701.
27. Feng S, Qiu Y, Li X, Yang H, Wang C, Yang J, et al. Laparoscopic versus open splenectomy in children: a systematic review and meta-analysis. Pediatr Surg Int. 2016; 32(3): 253-9.

28. Shelby R, Kulaylat AN, Villella A, Michalsky MP, Diefenbach KA, Aldrink JH. A comparison of robotic-assisted splenectomy and laparoscopic splenectomy for children with hematologic disorders. J Pediatr Surg. 2021; 56(5): 1047-50.
29. Utria AF, Goffredo P, Keck K, Shelton JS, Shilyansky J, Hassan I. Laparoscopic splenectomy: Has it become the standard surgical approach in pediatric patients? J Surg Res. 2019; 240: 109-14.
30. Qureshi FG, Ergun O, Sandulache VC, Nadler EP, Ford HR, Hackam DJ, et al. Laparoscopic splenectomy in children. JSLS. 2005; 9(4): 389-92.
31. Esposito C, Corcione F, Ascione G, Garipoli V, Di Pietto F, De Pasquale M. Splenectomy in childhood. The laparoscopic approach. Surg Endosc. 1998; 12(12): 1445-8.
32. Seideman CA, Sleeper JP, Lotan Y. Cost comparison of robot-assisted and laparoscopic pyeloplasty. J Endourol. 2012; 26(8): 1044-8.
33. Sorensen MD, Delostrinos C, Johnson MH, Grady RW, Lendvay TS. Comparison of the learning curve and outcomes of robotic assisted pediatric pyeloplasty. J Urol. 2011; 185 (6 suppl): 2517-22.
34. Pini Prato A, Arnoldi R, Dusio MP, Cimorelli A, Barbetta V, Felici E, et al. Totally robotic soave pull-through procedure for Hirschsprung's disease: lessons learned from 11 consecutive pediatric patients. Pediatr Surg Int. 2020; 36(2): 209-18.
35. Delgado-Miguel C, Camps JI. Robotic Soave pull-through procedure for Hirschsprung's disease in children under 12-months: long-term outcomes. Pediatr Surg Int. 2022; 38(1): 51-7.
36. Nazki S, Kanojia RP, Bawa M, Binu V, Lal S, Sood A, et al. Robotic excision of choledochal cyst with Hepaticoduodenostomy (HD): Report of HD technique, initial experience, and early outcome. Eur J Pediatr Surg. 2020; 31(03): 286-91.
37. Gallina FT, Melis E, Forcella D, Mercadante E, Marinelli D, Ceddia S, et al. Nodal upstaging evaluation after robotic-assisted lobectomy for early-stage non-small cell lung cancer compared to video-assisted thoracic surgery and thoracotomy: A retrospective single center analysis. Front Surg. 2021; 8: 666158.
38. Li B, Yang Y, Toker A, Yu B, Kang CH, Abbas G, et al. International consensus statement on robot-assisted minimally invasive esophagectomy (RAMIE). J Thorac Dis. 2020; 12(12): 7387-401.
39. Durand M, Musleh L, Vatta F, Orofino G, Querciagrossa S, Jugie M, et al. Robotic lobectomy in children with severe bronchiectasis: A worthwhile new technology. J Pediatr Surg. 2021; 56(9): 1606-10.
40. Ferrero PA, Blanc T, Binet A, Arnaud A, Abbo O, Vatta F, et al. The potential and the limitations of esophageal robotic surgery in children. Eur J Pediatr Surg. 2022; 32(2): 170-6.
41. Liang M, Jiang J, Dai H, Hong X, Han X, Cong L, et al. Robotic enucleation for pediatric insulinoma with MEN1 syndrome: a case report and literature review. BMC Surg. 2018; 18: 44.
42. Criss CN, Grant C, Ralls MW, Geiger JD. Robotic resection of recurrent pediatric lipoblastoma. Asian J Endosc Surg [Internet]. 2019; 12(1): 128-31.
43. Sala LFM, Guglielmetti GB, Coelho RF. Bilateral nephrectomy robotic-assisted laparoscopic in children with bilateral Wilms' tumor. Urol Case Rep. 2020; 31: 101146.
44. Blanc T, Meignan P, Vinit N, Ballouhey Q, Pio L, Capito C, et al. Correction to: Robotic surgery in pediatric oncology: Lessons learned from the first 100 tumors—A Nationwide Experience. Ann Surg Oncol. 2021; 28 (suppl 3): 901.
45. Sinha A, Pathak M, Vig A, Saxena R. Robotic surgery in paediatric patients: Our initial experience and roadmap for successful implementation of robotic surgery programme. J Minimal Access Surg. 2021; 17(1): 32-6.
46. Gundeti MS, Castellan MA. Editorial: Robotic Assisted Laparoscopic Surgery (RALS) in Pediatric Urology. Front Pediatr. 2020; 8: 85.
47. Grammens J, Schechter MY, Desender L, Claeys T, Sinatti C, VandeWalle J, et al. Pediatric challenges in robot-assisted kidney transplantation. Front Surg. 2021; 8: 649418.
48. Boia ES, David VL. The financial burden of setting up a pediatric robotic surgery program. Med Kaunas Lith. 2019; 55(11): E739.