Limitations and complications of robotic urological surgery in younger children: debunking old beliefs

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ABSTRACT

Introduction. Even though certain technical limitations associated with the small size of the patients were taken for granted in the advent of pediatric robotic surgery, we could now be facing a paradigm shift challenging these old beliefs.

Materials and methods. A retrospective study of patients undergoing Da-Vinci-Xi(IS4000)-assisted urological surgery from May 2022 to October 2023 was carried out. Patients were divided into two groups –Group A < 15 kg and Group B ≥ 15 kg. Operating times, hospital stay, and intra- and postoperative complications were compared.

Results. 17 patients (9 in Group A, 8 in Group B) underwent surgery. Median age was 29 months (A) and 109 months (B) (p< 0.001). Median weight was 12.0 kg (A) and 31.5 kg (p< 0.001). Operating time was 162 min (A) and 130 min (p= 0.203). Console time was 99 min (A) and 70 min (B) (p= 0.065). Mean hospital stay was 2 days (A) and 3 days (B) (p= 0.41). No differences were found in terms of intraoperative (p= 0.453) or postoperative (p= 0.485) complications.

Conclusion. Even though operating on younger children seemed more complicated than on older ones in the advent of robotic surgery, the results in our series were similar. The fact patients under 12 months of age were not included means larger studies are required to prove this.

KEY WORDS: Robotic surgical procedures; Urology; Child.

LIMITACIONES Y COMPLICACIONES DE LA CIRUGÍA UROLÓGICA ROBÓTICA EN NIÑOS PEQUEÑOS. DESMONTANDO VIEJAS CREENCIAS

RESUMEN

Introducción. Aunque en los inicios de la cirugía robótica pediátrica solíamos asumir la existencia de ciertas limitaciones técnicas asociadas al pequeño tamaño de nuestros pacientes, podríamos encontrarnos ante un cambio de paradigma y cuestionar estas antiguas creencias.

Material y métodos. Estudio retrospectivo que incluye los pacientes a los que se les practicó una cirugía urológica asistida por robot Da Vinci Xi (IS4000), entre mayo de 2022 y octubre de 2023. Se dividieron en dos grupos: A < 15 kg, B ≥ 15 kg. Se compararon tiempos quirúrgicos, estancia hospitalaria y complicaciones intra y postoperatorias.

Resultados. Intervenimos 17 pacientes (9 A, 8 B). Edad mediana 29 (A) y 109 meses (B) (p < 0,001). Peso mediano A: 12 kg, B 31,5 kg (p < 0,001). Tiempo quirúrgico A 162 min, B 130 min (p= 0,203). Tiempo de consola A 99 min, B 70 min (p= 0,065). Estancia media A 2, B 3 días (p= 0,41). No se encontraron diferencias en la tasa de complicaciones intraoperatorias (p= 0,453) ni postoperatorias (p= 0,485).

Conclusión. A pesar de que al comienzo de la cirugía robótica se pensaba que sería más complicado operar a los niños pequeños que a los más mayores, en nuestra serie los resultados son similares. Por no incluir menores de 12 meses, necesitamos estudios más extensos para probar estas afirmaciones.

PALABRAS CLAVE: Cirugía robótica; Urología pediátrica; Niños

INTRODUCTION

The treatment of pathologies that are increasingly challenging from a technical point of view, as well as the growing demand by healthcare systems and patients themselves to accelerate postoperative recovery and reduce normal life resumption times, is causing minimally invasive surgery to explore more and newer fields where there is room for improvement[1,2].

Within this context, a California-based company launched the Da Vinci robot in 1999[2] –the first surgical robot approved for use in clinical practice[3]. Robotic surgery was therefore born with the objective of becoming the perfect union of open and conventional laparoscopic surgery, combining the advantages of both. Articulated instruments allow movements to be performed along the three axes of the space, thus limiting human joint articulation. It would be like introducing our hands inside the patient to conduct an accurate surgery. Thanks to the 3D

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view provided by the Da Vinci robot vs. laparoscopy, as well as to other advantages such as neutralization of trembling and ergonomic improvement for the surgeon[4-6] when conducting the procedure, the robot is considered by many physicians as their primary working tool in daily practice.

Now that the first surgeries in the field of pediatric robotic urology have been carried out, we would like to share our experience with them, in an attempt to challenge and even refute certain old beliefs that are deeply rooted in the collective imagination. Our objective is to analyze whether there are any actual technical limitations as a result of working in the small operating fields[7,8] of pediatric patients. Today, the most widely extended idea is not to use the robot in younger children due to the higher number of internal and external space conflicts, but this is something we would like to challenge with this work.

MATERIALS AND METHODS

A retrospective study of patients undergoing Da-Vinci-Xi(IS4000)-assisted laparoscopic pediatric urological surgery in a single third-level pediatric institution was carried out.

Demographic data (sex, age in months), weight in kilograms, preoperative diagnosis, surgery performed, operating times, intraoperative complications, postoperative complications, need for reconversion or not, and hospital stay were collected from electronic medical records.

In order to analyze and compare our results on a weight-based manner, and using the cut-off points established in the few literature references currently available, our sample was divided into two groups. Children < 15 kg were allocated to Group A, whereas children ≥ 15 kg were ascribed to Group B.

Categorical variables were expressed as frequencies and percentages, whereas parametrical continuous variables were featured as median and standard deviation. Statistical significance was established at $p \leq 0.05$.

Statistical analysis was carried out using the *Jamovi* software, version 2.5 (https://www.jamovi.org). Quantitative variables were compared through Mann-Whitney U test, whereas qualitative variables were compared by means of the chi-squared test. Statistical significance was established at $p< 0.05$.

RESULTS

In the study period, a total of 17 patients underwent surgery –9 in Group A and 8 in Group B. The most common procedure was nephrectomy (5), followed by pyeloplasty (4). All surgeries are featured in Table 1.

The two groups significantly differed in terms of patient weight and age. Median age in the younger children group (A) was 29 months, that is, 2.4 years, whereas median age in the older children group (B) was 109 months, that is, 9.1 years ($p< 0.001$). Median weight was 12.0 kg for Group A (10-14 kg) and 31.5 kg for Group B (16-65 kg) ($p< 0.001$). Demographic characteristics are featured in Table 2.

Regarding operating times, there were no significant differences between both groups, consistent with the literature[2]. Total operating time was 155 min (122-240 min) in the younger children group (A), and 148 min (42-215 min) in the older children group (B) ($p= 0.203$). As for console time alone, it was slightly shorter in the older children group, but without significant differences between the two groups –103 min (76-120 min) for Group A vs. 85

Table 1. Surgeries performed in chronological order.

Patient	*Group*	*Procedure*
1	A	Pyeloplasty
2	A	Nephrectomy
3	B	Pyeloplasty
4	A	Heminephrectomy
5	B	Nephrectomy
6	A	Nephrectomy
7	B	Pyeloplasty
8	B	Ureteral reimplantation
9	A	Heminephrectomy
10	A	Ureteral reimplantation
11	B	Palomo technique
12	B	Palomo technique
13	A	Pyeloplasty
14	A	Heminephrectomy
15	A	Nephrectomy
16	B	Nephrectomy
17	B	Urachal remnant removal

Table 2. Demographic characteristics.

		Group		
		A	*B*	*p*
Age (months)	Median	29	109	< 0.001
	Min	17	34	
	Max	38	41	
Weight (kg)	Median	12	31.5	< 0.001
	Min	10	16	
	Max	14	65	

Table 3. Operating times.

		Group A	*Group B*	*p*
Operating time	Median	155	148	0.203
	Minimum	122	42	
	Maximum	240	215	
Console time	Median	103	85	0.065
	Minimum	76	17	
	Maximum	120	115	
Docking time	Median	64	63	0.869
	Minimum	31	20	
	Maximum	120	100	

Table 4. Intraoperative complications.

	Group A	*Group B*	*p*
N	1	2	0.453
Percentage	11%	25%	
Detail	Extubation	One external space conflict and one reconversion due to bleeding	

Table 5. Postoperative complications.

	A	*B*	*p*	*Clavien-Dindo*
Urinary leakage	0	1 (12%)	0.274	IIIA
Acute urinary retention	0	1 (12%)	0.274	I
Vomit	1 (11%)	1 (12%)	0.929	I
Paralytic ileus	1 (11%)	1 (12%)	0.929	I
Urinary tract infection	0	0	-	-

min (17-115) for Group B (p= 0.065). Docking + closure time was 64 min in Group A (31-120 min) vs. 63 min in Group B (20-100 min) (p= 0.869). Operating times are detailed in Table 3.

In terms of intraoperative complications, paradoxically enough, they were more frequent in the older children group than in the younger children one. In Group A, there was an extubation during surgery that forced to remove the robotic arms from the surgical field and to subsequently conduct a new docking. Reconversion was required in two cases from Group B –one to conventional laparoscopy and the other one to open surgery. The first reconversion occurred in a urachal remnant removal surgery as a result of how these remnants were arranged within the abdominal wall. This particular arrangement led to an external space conflict that prevented robotic movements from being conducted in a safe and accurate fashion, since they would hit the patient's head. Additionally, in the same patient, a self-limited bleeding of the greater omentum occurred when placing a robotic port. The second reconversion took place during nephrectomy as a result of renal vessel bleeding during ligation. None of the bleedings required transfusion or caused hemodynamic instability. Intraoperative complications are featured in Table 4.

Regarding complications in the immediate postoperative period, the younger children group did not experience more complications, but quite the opposite. Minor complications occurred in one patient from Group A (11%) and in two patients from Group B (25%) (p= 0.453).

In the younger children group (A), one patient had paralytic ileus and self-limited vomit in the immediate postoperative period (Clavien-Dindo I). In the older children group (B), one patient had similar vomit as a result of paralytic ileus, one patient had acute urinary retention, and one patient had urinary leakage following pyeloplasty to manage an extrinsic stenosis of the ureteropelvic junction through a polar vessel. This complication required nephrostomy (Clavien-Dindo IIIA). No instances of urinary tract infection were noted in any patient. Postoperative complications are featured in Table 5.

Mean hospital stay was comparable in both groups –2 days for the younger children group and 3 days for the older children one (p= 0.41).

DISCUSSION

The Da Vinci robot was launched on the market in 1999 as a novel surgical tool to facilitate surgeries at the most complex locations for laparoscopy, such as the male and female pelvis[6]. It is known to provide surgeons with greater accuracy in the surgical technique, and it allows them to conduct movements that are similar to those of the human hand, with the added benefit of a 3D view. Surgeons achieve a stereoscopic vision that produces a 3D image with a 10-15-fold magnification of the surgical field[9]. This translates into significant benefits for the patient in terms of safety, while preserving the classical advantages of minimally invasive surgery, such as shorter hospital stay, faster recovery and normal life resumption, less postoperative main, and a better cosmetic result at incision sites[10].

The robot was introduced in Spain in 2005, and in July, the first robotic surgery –a radical prostatectomy in an adult patient– was carried out in a Barcelona hospital[9].

In adults, robotic surgery became widespread relatively quickly, but in pediatric patients, implementation is being slower and more limited.

In Spain, the first series of Da Vinci-assisted laparoscopic surgeries in children was published in 2011, with the authors highlighting "adequate port planning" as the primary difficulty in pediatrics owing to the small size of the surgical field[11]. After performing their first pediatric robotic procedures, other surgeons agree that, in children, robotic surgery is limited by patient size, age, and weight.

For these and other reasons, pediatric surgeons still challenge the actual usefulness or feasibility of robotic surgery in daily practice. Many of them are reluctant to use this approach based on the theory that the robot was designed for adult patients, and they believe its elements and instruments cannot be employed to operate on children –at least the younger ones[7,8]. Some conducted their first robotic surgeries in older children, and in light of the positive results achieved, they have gradually lowered the weight and age threshold of their patients.

In our case, even though our experience with it is still short, we can claim a non-negligeable number of surgeries have been conducted in children of different ages, weights, and sizes in a safe[6] and successful manner. We started with infants and younger children, but this has not represented an increase in the rate of intra- or postoperative complications. After these months of experience with robotic surgery, we could say that the most frequent surgical procedures in pediatric urology can be carried out in a safe and effective fashion by conducting an adequate docking and respecting the basic distance and alignment principles established by robotic surgery. In our experience, the distance among ports only had to be reduced below the recommended threshold –up to 4 cm– in younger children, and this did not prove disadvantageous when performing the surgeries.

We would also like to briefly discuss the operating times in our series, since they were similar to those described in the literature in larger ones[12-14]. Indeed, as reported by many colleagues, the robotic learning curve for experienced surgeons in open and laparoscopic surgery is relatively short[11,13] thanks to its ergonomic advantages.

In conclusion, even though robotic surgery was first hypothesized to be more complex in younger children than in older ones, the results from our series were similar in both groups. In our view, robotic surgery stands as a state-of-the-art technology that improves surgeons' ergonomics[4-6], allows surgeries in complex locations to be carried out more easily[5,6], and maintains the advantages of conventional laparoscopic surgery, without being a limited tool according to patient weight or size[15].

The main limitation of this study lies in the fact infants under 1 year of age[14] were not included in the robotic urological surgery program. Therefore, it cannot be concluded whether there is a lower weight and size threshold for safe and effective robotic surgeries in children.

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