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# Laparoscopic surgery of urachal remnants in children: 3-center experience and comparison to an open approach

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## Abstract

**Background:** Since the first description by Trondsen in 1993, laparoscopy has become the preferred method of surgery of urachal remnants in children. Some authors call it the “gold standard.” Nonetheless, the comparison with open surgery in the literature is limited to several tens of patients. In this paper, we aim to summarize our experience reporting data of a large group of patients.

**Results:** We conducted a retrospective analysis of anonymized data from patients who underwent surgical interventions at three clinical centers. A total of 78 boys and 33 girls (M:F 2.36:1) were included in our study. Eighty-seven of them underwent mini-invasive surgery (group 1); 24 were operated in a conventional manner (group 2). The predominant form of the urachal anomaly found was the cyst (58.5%), while an umbilical sinus was present in 47 patients (42.3%), a bladder diverticulum in 7 (6.3%), and a patent urachus in 3 cases (2.7%). The average duration of surgery was 60.7 min (20–192 min) in group 1 and 42.7 min (20–90 min) in group 2; excluding the cases with simultaneous interventions, the average duration was found to be 54.5 and 39.7 min, respectively. Twenty-nine simultaneous operations for associated pathologies were performed in 19 cases (21.8%) in our MIS group, in 8 of them (9.19%) for a preoperatively unknown associated pathology, compared to 4 simultaneous operations performed in 4 patients (16.7%) in the open surgery group. We observed intra-operative complications in 2 cases in Group 1; early postoperative complications included hematuria in 14 cases (16%). The duration of postoperative analgesia was significantly shorter in the MIS group.

**Conclusions:** Laparoscopic surgery has better cosmetic results and allows for additional diagnostics and simultaneous operations that in turn lead to a shorter duration of postoperative analgesia, but has a longer duration in comparison to an open technique.

## Background

Laparoscopic surgery for children with urinary duct abnormalities has been performed for a long time. The first case was described by Trondsen in 1993 [1]. Since then, a large number of works on minimally invasive operations have been published. In the case of urachal remnants, most authors are inclined to believe that laparoscopic surgery in childhood is the preferred method

of surgical treatment. For this reason, Castanheira de Oliveira M. [2] calls it the “gold standard.”

In the overwhelming majority of publications, either single cases of laparoscopic operations or small groups of patients are reported on [3–8]. Unfortunately, such data is not significant enough from a statistical point of view.

An even smaller number of studies [4, 5, 8, 9] has aimed at comparing laparoscopic and open surgery, even then the total number of enrolled patients is limited to a few tens of individuals.

Moreover, only a small number of publications pay attention to the technique of surgical intervention, as

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well as to the importance of the diagnostic role of laparoscopy and the possibility of performing simultaneous operations it offers.

In this paper, we aim to summarize the experience of three different centers in the surgical treatment of urachal abnormalities in children, analyzing data from a large group of patients:

To our knowledge, this is the largest group of patients operated for urachal remnants to be retrospectively analyzed and reported in the literature.

## Methods

In this study, we conducted a retrospective analysis based on our medical documentation. The anonymized data of 111 children, who underwent surgical treatment for urachal remnants from 1995 to 2019 in three different centers, were analyzed. The centers are as follows:

- The Izmailovskaya Pediatric Clinical Hospital (since 2014 known as the Morozovskaya Pediatric Clinical Hospital) (Russia)
- The Pediatric Hospital No. 38 in Moscow (Russia). Both hospitals are clinical departments afferent to the Chair of Pediatric Surgery, Moscow State University of Medicine and Dentistry
- The Pediatric Surgery Unit of Perugia University (Italy)

Eighty-seven out of 111 patients underwent laparoscopic or laparoscopic-assisted excision of urachal remnants (group 1); the remaining 24 children were operated on with a conventional open technique in Moscow in the period 1995–2003. They fulfill the role of the comparison group (group 2).

Depending on the clinical center, group 1 was further divided into three subgroups: one for the Izmailovskaya Pediatric Clinical Hospital (subgroup 1.1), one for the Pediatric Hospital No. 38 (subgroup 1.2), and one for the Pediatric Surgery Unit of Perugia University (subgroup 1.3)

The analysis was carried out according to the following parameters:

- Patients (demographic data)
- Type of UR
- Symptoms
- Comparison between “group 1” and “group 2” for
  - Surgical time
  - Simultaneous operations
  - Complications
  - Postoperative analgesia
  - Cosmetic results

We employed the *t* test for statistical analysis.

## Technical aspects

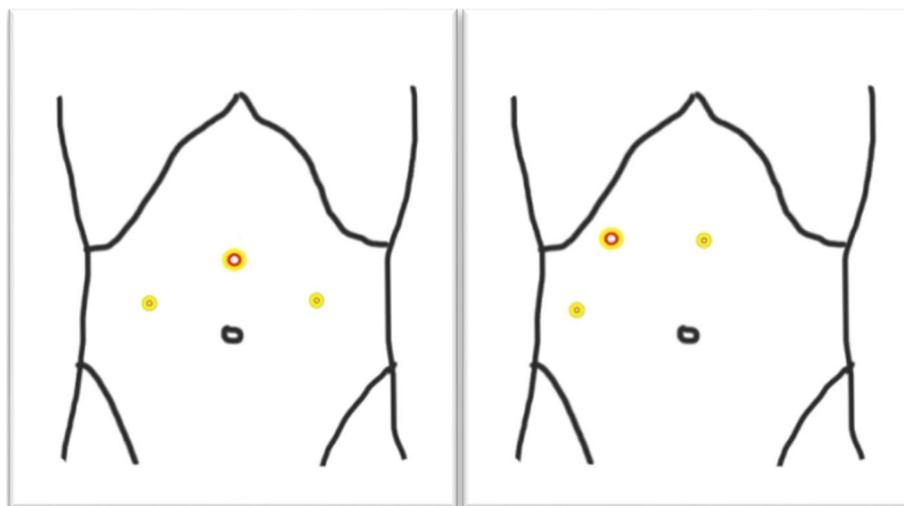
The operations were performed in a supine position, with the operating table usually fixed horizontally. Sometimes when working near the bottom of the bladder, especially in the presence of increased bowel gaseous distention, lowering the head end of the table a little (Trendelenburg position, – 15/– 30°) became necessary. This allowed us to move aside the loops of the small intestine and obtain a better view of the operative area. Bladder catheterization was performed in all cases, in order to allow filling of the bladder during surgery.

In 84 cases, we used 3 trocars: one 10-mm for the camera and two 5-mm operative trocars in triangulation; in children less than 1 year old, a 5-mm trocar for the camera and 3-mm operative trocars were used. In two cases, an additional fourth trocar (5 mm in one case and 12 mm in another) was required. In one case, removal of a urachal cyst was performed as a simultaneous intervention during a laparoscopic nephroureterectomy. For this reason, the trocar positioning differed from those employed in interventions where urachal remnant removal constituted the main procedure.

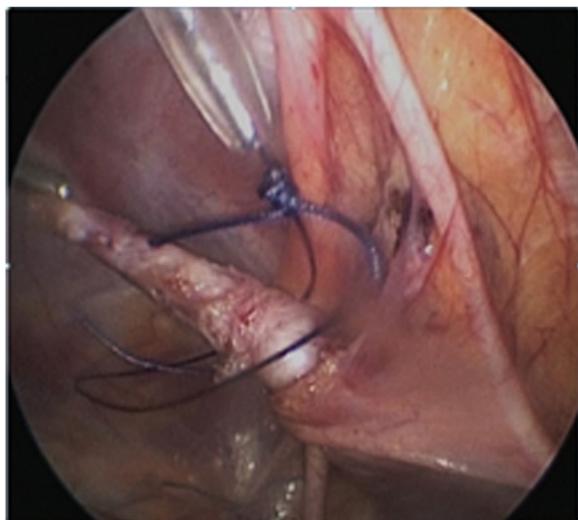
In the Moscow hospitals, the first trocar was placed at a point located one-third of the distance from the umbilicus to the xiphoid process. The second and third trocars were placed symmetrically on both sides along the midclavicular lines or slightly more laterally. Their positioning was susceptible to variations depending on the localization and the type of UR. If necessary (such as in the presence of a diverticulum of the bladder or a large urachal cyst located in the bottom of the bladder; the latter case occurring in one enrolled patient), an additional fourth trocar for an atraumatic clamp or stapler can be placed (Fig. 1A).

In Perugia, the midclavicular subcostal right place was used by default for the pure laparoscopic technique. Following the achievement of a carbopéritoneum, two other operative trocars (3 mm or 5 mm) were placed in the left upper abdominal quadrant and in the right flank (Fig. 1B). When an umbilical fistula was present, a laparoscopic-assisted excision was performed by removing the laparoscopically excised remnant through an incision practiced for fistulectomy [10].

Generally, URs can be easily identified during laparoscopy. In Moscow, all visible urachal structures were resected. Partial resection of the bladder, if technically feasible, was not performed. Clipping of the urachal structure was achieved either using bipolar coagulation and scissors and/or the Roeder loop (in the case of a thin fibrous structure) (Fig. 2) or with a stapler.



**Fig. 1** **A** Moscow scheme of trocars' disposition. **B** Perugia scheme of trocars' disposition



**Fig. 2** Laparoscopic view of Roeder loop positioning under urachal cyst

On the contrary, minimal resection of the bladder dome following the medial umbilical ligament to avoid recurrences was routinely carried out in Perugia. The bladder dome was then sutured laparoscopically.

In all centers, suturing of the parietal peritoneum was performed selectively in case of a large defect.

In the open group, either a lower median laparotomy or a Pfannenstiel incision was made, depending on the shape of the urachal remnant and the individual experience of the surgeon. Both techniques are well suited for the exposure and resection of URs.

## Results

### Patients

A total of 78 boys and 33 girls (M:F 2.36:1) were included in our study. In all subgroups, a significant predominance of male patients was noted.

The patients' age distribution for each group and subgroup is shown in Fig. 3.

### Type of the UR

The presence of an urachal cyst was found to be the predominant form of anomaly, occurring in 65 patients (58.5%) out of the total. An umbilical sinus was present in 47 patients (42.3%). A bladder diverticulum was observed in 7 children (6.3%). A patent urachus, the rarest form of anomaly, was diagnosed only in 3 cases (2.7%) (Table 1).

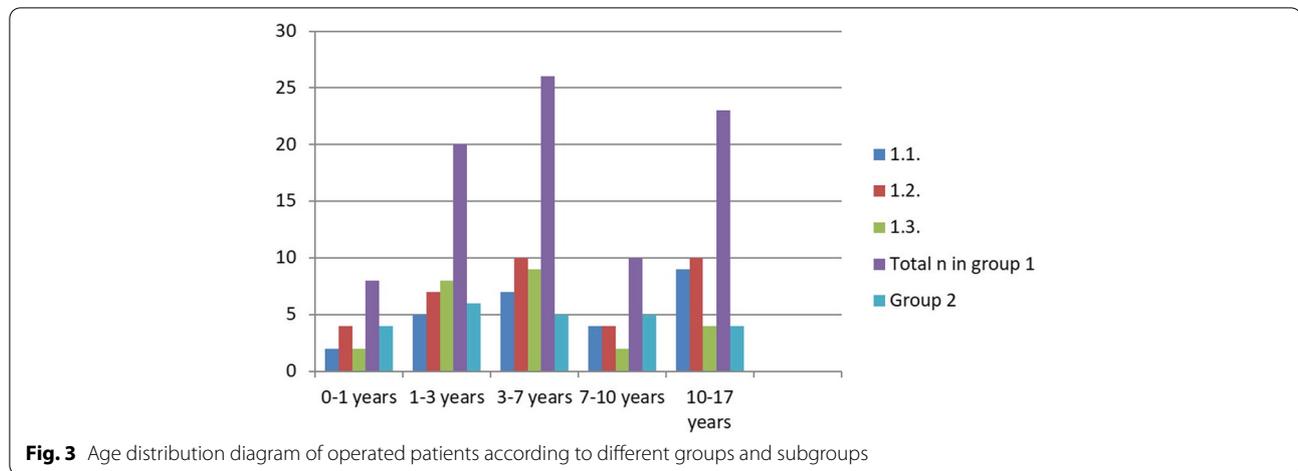
### Symptoms

In our sample, children with a symptomatic postoperative course outnumbered those with an asymptomatic one. An accurate description of symptoms and their prevalence is reported in Table 2.

### Surgical time

The average duration of laparoscopic surgery (group 1) was 60.7 min (range 20–192 min). The overall operative time in group 2 ranged from 20 to 90 min (mean time 42.7 min). In Table 3, average operative times according to groups, subgroups, and whether a simultaneous intervention was carried out or not are reported.

Operations for abnormalities of the urinary duct only were performed in 68 children (Table 3: group 1, *n*). In this group of children, the average operative



**Table 1** Different kinds of symptoms revealed in operated patients

	Group 1	Group 2	Total
Abdominal pain	24	5	29
Weeping umbilicus/umbilical discharge	16	8	24
Omphalitis	23	12	35
UTI	4	1	5
Acute abdomen	3	1	4
Asymptomatic	21	2	23

**Table 2** Different kinds founded of urachal remnants

	Group 1	Group 2	Total
Cyst	43	12	55
Sinus	32	7	39
Diverticulun	4	1	5
Patent urachus	1	1	2
Sinus + cyst	6	2	8
Divert + cyst	1	1	2

time was 54.5 min (20–125min). Excluding the cases with simultaneous interventions (Table 3: group 2, *n*), the mean time in the open group was 39.7 min (20–80 min). Other details are shown in Table 3.

**Simultaneous operations**

In group 1, 29 simultaneous operations for associated pathologies were performed in 19 patients (21.8%) while in group 2, 4 simultaneous operations were performed in 4 patients (16.7%, see Table 4).

**Complications**

*Pre-operative* In two cases (both of which in group 1), we observed an acute inflammation of a urachal cyst, with a clinical picture of acute abdomen. These patients required emergency surgery.

In one of the two cases, the cyst was found to be perforated and wrapped within the greater omentum (changes in the greater omentum required its partial resection).

*Intra-operative complications* We observed intra-operative complications in 2 cases in group 1. In one of them, this consisted in bleeding from a UR stump, which had a wide implantation base on the urinary bladder wall.

In the second case, due to an important inflammation of the remnants with tenacious attachment to the omentum and bleeding, conversion to open technique was carried out through a Pfannenstiel incision. This clinical situation stemmed from an infected urachal cyst that had initially been drained under laparoscopic vision 30 days before and subsequently treated with antibiotic therapy.

*Postoperative complications* No septic complications were observed in the postoperative period in both groups.

Hematuria was a notable postoperative complication, occurring in 14 cases (16%): macro-hematuria in 9 cases (10.3%) and micro-hematuria in 5 (5.7%).

Hematuria had its onset typically between the end of the first and the beginning of the second postoperative day. In one case, due to the presence of a significant amount of blood in urine, a child underwent cystoscopy to rule

**Table 3** Statistical analysis of operation time of the groups and subgroups

	Group 1							Group 2			
	Subgroup 1.1		Subgroup 1.2		Subgroup 1.3		Total		s	n	
	s	n	s	n	s	n	s	n			
N of operated patients	27	17	35	27	25	24	<b>87</b>	68	<b>24</b>	19	
Mean time	64.1	52.58	53.9	44.5	66.6	67.08	<b>60.72</b>	<b>54.5</b>	<b>42.7</b>	<b>39.7</b>	
Standard deviation	38.48	29.6	26.2	16.9	21.29	21.61	29.63	24.07	18.9	16.5	
Standard error	7.4	7.18	4.42	3.2	4.25	4.41	3.1	2.9	3.8	3.8	
Median	50	40	50	45	65	65	55	50	35	35	
Min time	20	20	20	20	35	35	20	20	20	20	
Max time	192	125	135	80	120	120	192	125	90	80	

Subgroups: s total number of patients (incl. simultaneous operations), n number of patients without (no) simultaneous operations

**Table 4** The different associated operations performed in patients affected by urachal remnants

Simultaneous operations	Group 1			Group 2
	1.1	1.2	1.3	
Appendectomy	2			
Hydrocele repair	1	3		1
Laparoscopic hernioraphy	4	3 (bilateral in one case)	1	
Adhesiolysis	2			
Nephroureterectomy	1			
Anoproctoplastic	1			
Urethra calibration	1			
Cystoscopy	1			
Umbilical hernia repair	3	2		2
Urethroplasty		1		
epididymal cyst removal		1		
Omental (partial) resection	1			
Nevus excision				1
Total	17 in 10 cases	11 in 8 cases	1 in 1 case	

out a bladder injury on day 3 and was diagnosed with hemorrhagic cystitis.

**Postoperative analgesia**

Analgesia in the early postoperative period was achieved for all children using NSAIDs, usually metamizole in weight-adjusted dosage (10–15 mg/kg).

In subgroups 1.1 and 1.2, after surgery, a single dose of analgesic was administered, then, during the first 2 days, pain medications were administered only as needed.

In subgroup 1.3, the following analgesic scheme was used: paracetamol 15 mg/kg i.v. intraoperatively, which was then subsequently repeated every 6–8 h for the first two postoperative days. Rescue doses with ibuprofen 5 mg/kg orally were provided.

Since laparotomy is associated with greater surgical trauma, longer use of analgesics was required in group 2, for an average of 2–4 postoperative days. Other details are shown in Table 5.

**Cosmetic results**

In our opinion laparoscopy, as expected, has a significant advantage in terms of cosmetic results, as illustrated by the scars in Fig. 4A, B.

**Discussion**

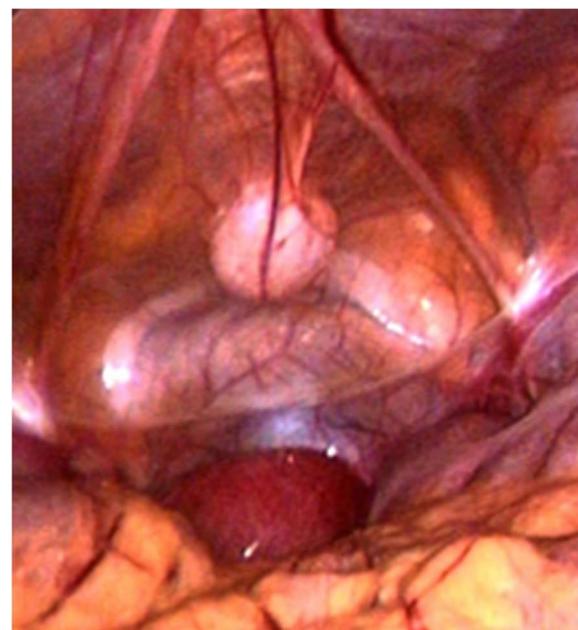
Transition from open to laparoscopic and mini-invasive surgery has taken place for a number of reasons. First, traditional surgery, especially in older children, required a wide access—a lower median laparotomy, also known as Pfannenstiel incision. In fact, small sections did not always provide sufficient visualization of the structure of

**Table 5** Analysis of postoperative analgesia between group 1 and group 2

	Group1			Group 2
	Subgroup 1.1	Subgroup 1.2	Total	
N of patients	27	35	62	24
Mean time	2.26	2.23	2.24	3.7
Median time	2	2	2	3.5
Standard deviation	2	2	2	3
Standard error	0.126	0.117	0.085	0.285
Min time	1	1	1	2
Max time	3	3	3	7

the URs. Certain technical difficulties were also associated with the intraperitoneal location of the non-obiterated portion of the urachus. Laparoscopic operations lack these disadvantages. The introduction of a laparoscopic camera through a small incision makes it possible to assess the extent of the structures to be removed, as well as to inspect the abdominal organs for combined pathology. Though the simultaneous operations in our experience mostly consisted of elective interventions that are difficult to attribute to the benefits of laparoscopic access, one should take into account the fact that in 12 patients (13.7%), 9 laparoscopic herniorrhaphies were performed and, in 4 cases, the presence of inguinal hernia was an intraoperative finding. If we further consider 2 appendectomies (in one case with omental resection) and 2 cases of adhesion dissection, we obtain a total of 14 simultaneous interventions in 12 cases (13.8%) belonging to our MIS group 1; in 8 of them (9.19%) for a condition unknown before surgery.

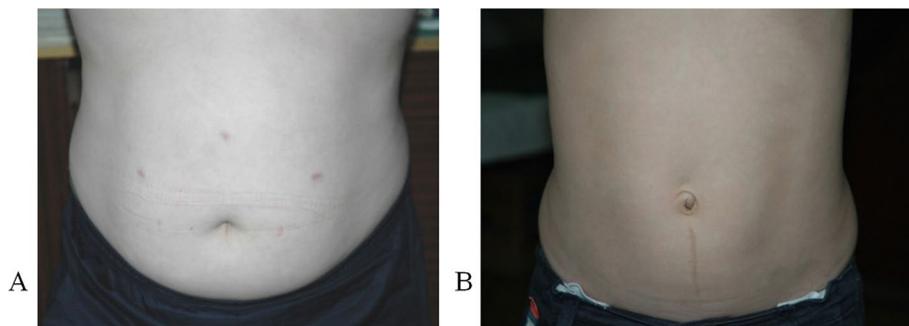
Using Student’s criterion to analyze mean operative times, we observe statistically significant differences between the open and the MIS group (39.7 vs 54.5 min).



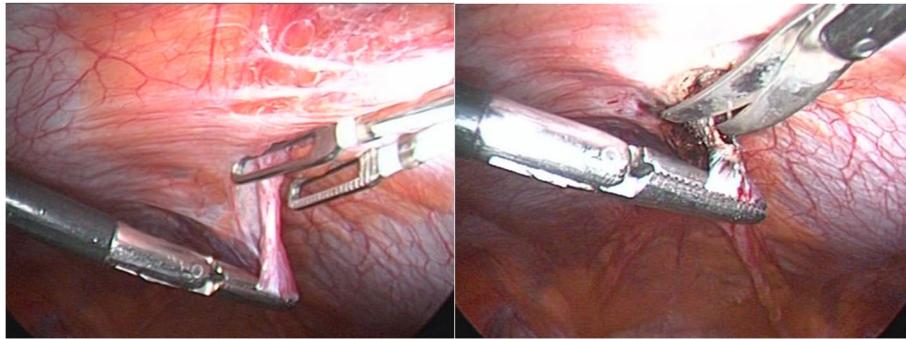
**Fig. 5** Signs of chronic inflammation

Some authors believe that treatment approaches should become more differentiated. In a paper published in 2019 by Tanaka K. et al. [8], the authors presented a comparison of the results of open and laparoscopic surgery in a sample of 30 children. The only significant difference between these approaches was the duration of the operation. In the group of children under 10 years of age, there were no cosmetic advantages of laparoscopic access, and in the group of older children, the differences in the duration of the operation were not statistically significant. In light of this, the authors recommend laparoscopic interventions in children older than 10 years.

If on the one hand we consider open surgery an acceptable alternative, it is also our opinion that the proposed



**Fig 4 A, B:** **A** Postoperative scars in a 12-year-old boy, 1 month after laparoscopic excision of the urachal remnant. **B** Postoperative scar in a 13-year-old boy, 3 years after the conventional operation



**Fig. 6** Extraperitoneal intersection of a cranial part of an urachal sinus

age level of 10 years is quite elevated. In addition, our data show that the duration of required postoperative analgesia was significantly lower in group 1 (Table 5).

As mentioned above, one of our intraoperative complications was bleeding from a stump of the UR, which had a wide base on the urinary bladder. After two Roeder loops were slipped down, the stump of the urachus was clamped with an atraumatic clamp and sutured with a continuous twisting seam. We believe that in such situations, the use of staplers should be recommended.

The underlying processes leading to hematuria remain unclear. In a few cases, hematuria occurred in situations where a bladder injury was completely excluded (3 children with umbilical sinuses), which was confirmed by reviewing the videos of the operation.

In our study, we noticed some degree of correlation between the presence of inflammatory changes in the removed part of the urachus and the occurrence of hematuria in the postoperative period: vascular turgor, hyperemia, or stiffness of the walls were noted in 7 out of 9 patients.

During laparoscopy, we repeatedly observed inflammatory alterations of varying degrees in the wall of the urachus (such as vascular turgor, Fig. 5). Usually, these children sought medical help for low-intensity episodic abdominal pain, which suggests the presence of a chronic inflammatory process.

The issue of partial omphalectomy in the presence of an umbilical sinus is currently controversial [11, 12]. There were also some differences between the Moscow group and the Perugia group in their approach. Surgeons from the Moscow group proceeded from the assumption that surgically performing the highest possible intersection of the structures of the urachus (after its mobilization and traction, Fig. 6) eliminates the cause of the clinical manifestations.

According to the surgeons from the Perugia group, in the presence of an inflamed urachal sinus and detected umbilical fistula, partial central omphalectomy appears to be the best procedure to avoid the recurrence of symptoms. This way, communication with the external environment, and thus the possibility of external contaminants causing sinus infection, is eliminated. In such cases, their group performs “laparoscopically assisted” interventions with partial omphalectomy as described above.

In the Moscow group, clinical recurrence in the form of umbilical discharge was observed only in one case. Sclerotherapy with a 10% iodine solution was performed.

Whether the excision of the bladder dome should be routinely performed remains to be assessed. Despite the existence of such recommendations due to an apparent tumor progression risk described in literature in previous years, in our recent screening study we found that the real incidence rate of URs in the general population was severely underestimated [13]. In light of this, the opportunity of such an approach should be critically revised.

In conclusion, it is our opinion that laparoscopic surgery today should be considered the gold standard for urachal anomalies surgery in children of all ages. Its most notable advantages include achieving the best cosmetic result, providing the possibility of additional diagnostics and simultaneous operations, and, despite longer average operative times, allowing for a shorter duration of postoperative analgesia.

#### Abbreviations

UR: Urachal remnants; MIS: Mini-invasive surgery; NSAIDs: Non-steroidal anti-inflammatory drugs.

**Authors' contributions**

Y.Isaev – main author, M. Bertozzi – co-author. The authors read and approved the final manuscript.

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**Availability of data and materials**

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

**Declarations****Ethics approval and consent to participate**

This article does not contain any studies with human participants or animals performed by any of the authors.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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