

Preoperative imaging is essential for pathologically complete resection of the urachal remnant without unnecessary and excessive surgical invasion

Yoichi NAKAGAWA

Nagoya University Graduate School of Medicine

Wataru SUMIDA

Nagoya University Graduate School of Medicine

Hizuru AMANO

Nagoya University Graduate School of Medicine

Hiroo UCHIDA (✉ hiro2013@med.nagoya-u.ac.jp)

Nagoya University Graduate School of Medicine

Akinari HINOKI

Nagoya University Graduate School of Medicine

Chiyoe SHIROTA

Nagoya University Graduate School of Medicine

Satoshi MAKITA

Nagoya University Graduate School of Medicine

Masamune OKAMOTO

Nagoya University Graduate School of Medicine

Seiya OGATA

Nagoya University Graduate School of Medicine

Aitaro TAKIMOTO

Nagoya University Graduate School of Medicine

Shunya TAKADA

Nagoya University Graduate School of Medicine

Daiki KATO

Nagoya University Graduate School of Medicine

Yousuke GOHDA

Nagoya University Graduate School of Medicine

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Abstract

Background

We aimed to determine whether our policy of selecting the appropriate urachal remnant (UR) resection approach is valid. We performed preoperative imaging to examine whether the UR continued toward the bladder apex. If the UR continued toward the bladder apex, then we excised the UR and bladder apex using the trans-umbilical approach adding laparoscopy in needed. If preoperative imaging indicated that the UR ended near the umbilicus, then we resected the UR from the umbilicus to the duct end. Pathological evaluations were performed to determine the appropriateness of the surgical approach indicated by preoperative imaging.

Methods

We retrospectively reviewed pediatric UR patients who underwent surgery between 2015 and 2021. Their background characteristics and surgical outcomes were evaluated.

Results

Twenty UR patients were evaluated (median age, 7 years; range, 8 days-12 years). The UR continued toward the bladder apex in 10 patients and ended near the umbilicus in 10 patients. Urachus tissue at the bladder site was observed when the UR and bladder apex were excised. When the UR was resected from the umbilicus to the duct end, urachus tissue was not pathologically detected at the resection margin.

Conclusions

Our policy leads to complete resection without excessive surgical invasion.

Background

The urachus is an embryonic structure that connects the bladder to the allantois during early embryonic development. Occasionally, it fails to disappear at birth, leading to the urachal remnant (UR), which is observed during up to 32% of bladder examinations of adults older than 32 years [1]. Treatment of the UR consists of conservative therapy and surgery. Historically, resection of the UR has been recommended to prevent urachal carcinomas; however, a recent study proposed that 5721 urachal remnants would need to be excised to prevent a single case of urachal adenocarcinoma [2]. For symptomatic cases, surgical resection is an appropriate treatment option; however, excision of the bladder apex in all cases is controversial.

At our institution, we have performed surgical intervention for symptomatic UR. Our policy regarding the UR involves preoperative imaging to assess whether the UR continues toward bladder in all cases so that complete resection can be performed and pathologically confirmed. The trans-umbilicus (TU) approach was first selected to excise the UR; however, laparoscopy was added (laparoscopy-assisted trans-umbilicus [LATU] approach) when the bladder apex could not be removed from the umbilical site because the UR was present at the bladder apex. When preoperative imaging showed the UR near the umbilicus and intraoperative findings indicated that the UR did not continue to the bladder apex, the UR was resected at the fibromuscular cord-like structure and the bladder apex was not excised. If the UR continued to the bladder apex, then the UR and bladder apex were both excised.

Several studies have evaluated the operative time, cosmetic appearance, and surgical outcomes of the TU approach and LATU approach for UR excision [3–5]. However, no studies have discussed whether an appropriate approach to UR excision was determined using preoperative imaging and confirmed by pathological findings. During this study, we evaluated pathological examination results to assess the validity of our policy of performing preoperative imaging to determine the appropriate UR resection approach.

Methods

We retrospectively reviewed pediatric UR cases that underwent surgery at our department between 2015 and 2021. We collected background characteristics, preoperative imaging results, surgical procedures, pathological examination results, and surgical outcomes from the medical records of the patients.

We performed preoperative imaging, including ultrasonography (US), computed tomography (CT), and magnetic resonance imaging (MRI), of all UR cases and preoperatively determined whether the UR continued toward the bladder apex. When it was preoperatively determined that the UR was not near the umbilicus, the TU approach was selected. When it was preoperatively determined that the UR continued toward the bladder apex, either the TU approach or the LATU approach was selected. We used the TU approach for the UR at first; however, the LATU approach was added when we could not remove the bladder apex from the umbilical site. In our experience, the LATU approach was usually added when the patient was older than 3 years because it was difficult to completely resect the UR at the bladder apex using only the TU approach for these patients (Fig. 1).

Surgical procedure: TU approach

The patient was placed in the supine position while under general anesthesia administered by tracheal intubation. Then, a urethral catheter was placed in the bladder. A circumumbilical incision (subumbilical arch) was performed and the linea alba was cut caudally from the umbilicus. The urachus (median umbilical ligament) located in the preperitoneal fat was identified and traced to the bladder apex to some extent without opening the abdominal cavity. The umbilicus skin attached to the urachus was removed. When it was preoperatively determined that the UR did not continue to the bladder apex, the end of the UR

was identified during surgery and completely resected. When it was preoperatively determined that the UR continued to the bladder apex, the UR was traced to the bladder apex, if possible. If the bladder apex could not be removed using the TU approach, then the LATU approach was added.

Surgical procedure: LATU approach

When it was preoperatively determined that the UR continued to the bladder apex in patients older than 3 years, the LAUT approach was added. The aforementioned surgical procedure was performed similarly. After tracing the UR, Alexis® wound protector retractors (XS-size; Applied Medical Resources Corporation, Rancho Santa Margarita, CA, USA) were inserted in the abdominal cavity, and FREE ACCESS (XS-size; TOP Corporation, Tokyo, Japan) with two 5-mm trocars was attached to allow a camera port and a working port. Another 5-mm trocar was inserted at the left lateral abdominal wall to allow a working port. Using laparoscopy, the urachus was identified and dissected stepwise toward the bladder apex. The urachus was completely extracted along with the bladder muscular layer with or without perforation of the bladder membrane. The resected site of the bladder muscle was ligated with 5 - 0 absorbable sutures or Endoloop PDS II (Ethicon Inc., Cincinnati, OH, USA). Then, the bladder was filled with saline solution using the urethral catheter to check for any perforations.

Postoperative course

Three hours after recovering from anesthesia, oral intake was allowed. After resection of the bladder apex, a urethral catheter was placed for 2 days and removed on postoperative day 2. If resection of the bladder apex was not performed, then the urethral catheter was removed on mobilization day.

Statistical analysis

Continuous variables are expressed as the median and range. The Mann-Whitney U-test was performed to compare continuous variables; $p < 0.05$ was considered statistically significant. All statistical analyses were performed using R software 4.1.2 [6]. We evaluated whether the policy of our institution to determine the surgical approach based on the preoperative imaging results and the age of the patient was appropriate.

Ethical approval

This study was performed in accordance with the ethical standards indicated in the 2000 Declaration of Helsinki and its later amendments or comparable ethical standards. Written informed consent was obtained from the legal guardians of the patients. This study was approved by the institutional review board of Nagoya University Graduate School of Medicine (number 2021-0395).

Results

Twenty UR patients were included in this study. All patients had symptoms such as abdominal pain, exudates, and infection. The median patient age was 7 years (range, 8 days-12 years). Boys comprised

75% of the patients (15/20 patients). Preoperative imaging was performed for all patients. All 20 patients underwent US and were diagnosed with UR. Five UR cases were diagnosed by US only. Six cases were evaluated with MRI because US could not determine whether the UR existed at the bladder apex. Nine cases were evaluated with CT: one was suspected to be a malignant bladder tumor and required differentiation; two involved abscess formation and more detailed information was required before surgery; and six did not require a CT evaluation, but it had already been performed at another hospital before the patients were referred to our institution.

Ten UR cases were found near the umbilicus; therefore, the UR was excised at the fibromuscular cord-like structure using the TU approach. Another 10 UR cases continued toward the bladder apex. Three UR cases observed in patients younger than 3 years were resected using only the TU approach. The other seven UR cases were observed in patients older than 3 years and required the LATU approach.

No early or long-term postoperative complications occurred. The operative time for UR cases near the umbilicus was significantly shorter than that of UR cases that continued toward the bladder apex (near the umbilicus: 50 min [range, 35-104 min] vs. 106.5 min [range, 53-150 min]; $p = 0.003$). Both the LATU approach and TU approach were performed for UR cases that continued toward the bladder apex. The LATU approach involved a longer operative time than the TU approach (LATU: 131 min [range, 92-150 min] vs. TU: 59 min [range, 53-81 min]; $p = 0.003$). The median hospitalization period was 3 days and the median urinary catheter placement period was 2 days for UR cases that continued toward the bladder apex. However, the median hospitalization period was 1 day and the median urinary catheter placement period was 0 days for UR cases near the umbilicus (Table 1).

Pathological findings indicated that urachus tissue at the bladder site was present when preoperative imaging showed that the UR continued toward the bladder apex. When preoperative imaging showed that the UR did not continue to the bladder apex, urachus tissue was present at the umbilicus in some cases but ended at the fibromuscular cord-like structure and did not exist at the resected margin. A pathological examination of the resected sites (i.e., fibromuscular cord-like structure) revealed no urachus tissue; however, urachus tissue was pathologically observed near the umbilicus. All UR cases that did not continue to the bladder apex were appropriately resected with negative pathological margins (Table 2).

Some imaging results and pathological findings are shown in Figs. 2-4. Fig. 2 shows a 6-year-old boy whose preoperative US evaluation indicated that the UR continued toward the bladder apex. To excise the UR including the bladder apex, the LATU approach was required. Pathological findings revealed the existence of urachus tissue at the bladder apex. Fig. 3 shows an 11-year-old girl whose preoperative CT evaluation indicated that UR existed at the bladder apex. To excise the UR including the bladder apex, the LATU approach was required. Pathological findings revealed the existence of urachus tissue at the bladder apex. Fig. 4 shows a 10-year-old boy whose preoperative MRI evaluation indicated that the UR did not continue toward the bladder apex. The TU approach was sufficient for complete excision of the UR. The UR was resected at the fibromuscular cord-like structure. Pathological findings revealed fibrous tissue but no urachus tissue at the resected margin.

Discussion

During this study, the preoperative imaging findings indicating whether the UR continued toward the bladder apex were consistent with the positive pathological findings at the bladder site. However, when preoperative imaging showed that the UR was near the umbilicus and did not continue toward the bladder apex, both the intraoperative findings and pathological examination results revealed fibromuscular tissue only; there was no urachus tissue at the resected site and the UR ended near the umbilicus. All UR cases were appropriately resected and there was a negative pathological remnant. Our institution's policy (i.e., obtaining preoperative imaging findings and intraoperative findings to determine whether bladder apex removal is necessary) of determining the surgical approach for UR treatment was found to be acceptable.

UR cases usually present with lower abdominal pain and infection near the umbilicus. For pediatric cases, the differential diagnosis of these symptoms includes omphalitis, omphalomesenteric duct, and umbilical granuloma. Umbilical pilonidal sinus is also one of the possibilities for adult cases. Imaging methods such as US are useful for diagnosis; however, a definitive diagnosis confirmed by pathology is essential. There are four types of UR: patent urachus, umbilical-urachal sinus, urachal cyst, and vesico-urachal diverticulum [7]. Nine of the 20 (45%) patients in our study had an umbilical-urachal sinus UR that continued toward the bladder apex.

The treatment strategy for UR is controversial. Complete resection of the UR has been historically performed because of the risk of urachal carcinoma for both adults and children attributable to epithelial or mesenchymal urachal neoplasms that can occur with the UR [8, 9]. Malignant urachal neoplasms are usually low-grade and diagnosed at advanced stages [10]. Therefore, complete excision of an asymptomatic UR, even in pediatric patients, has been performed to prevent future malignant neoplasms. However, a recent study showed that only one out of every 5721 UR cases leads to urachal adenocarcinoma [2]. Another study reported that conservative follow-up is an option for UR patients younger than 1 year [11, 12] and for UR patients after undergoing initial drainage treatment [13]. Each individual pediatric patient with UR should be treated based on the imaging results. In some cases, simple and asymptomatic lesions are not excised; however, in other cases, large and suspicious lesions are excised [2]. We treated symptomatic UR cases; however, we do not consider prophylactic excision of asymptomatic UR to be necessary for children.

There are two approaches to UR excision, TU and LATU. Laparoscopic excision of the UR was first reported in 1992 [14]. Since then, several modified laparoscopic surgery techniques for UR have been developed and reported, with similar surgical outcomes and good cosmetic appearance [3, 4]. There are several laparoscopic UR excision methods in terms of port placement, arrangements, and bladder suturing; however, we adopted the LATU approach for excising UR. We considered preoperative imaging of the UR to be appropriate for determining the surgical approach and margin. Compared to the LATU approach, the TU approach has the advantage of being able to be performed in the preperitoneal space without opening the abdominal cavity to prevent late complications of postoperative obstruction. For children younger than 3 years, the TU approach is sufficient for complete excision of the UR including the

bladder apex without opening the abdominal cavity. However, based on our experience, for children older than 3 years old or those younger than 3 years with a large body for their age, it is difficult to use the TU approach to completely excise the UR without adding the Y-shape midline skin incision. The cosmetic appearance is an important factor for pediatric UR patients; therefore, we select the LATU approach for children older than 3 years.

US, CT, and MRI are useful for diagnosing UR [15, 16]. We performed preoperative imaging for all patients. US is the first choice for diagnosing UR at our institution and was performed for all patients. We consider US to be sufficient for diagnosing UR. Because of the risk of radiation exposure, other imaging methods, especially CT, should be adopted only when it cannot be determined whether the UR exists at the bladder apex. MRI does not expose patients to radiation; however, obtaining images with MRI is time-consuming and often requires sedation for young children. It is easier to perform imaging examinations when the bladder is distended with urine to determine whether the UR is at the apex of the bladder; US can be repeated and performed with the bladder distended [15, 16]. Considering its simplicity and noninvasiveness, US is the best method for diagnosing the UR. However, intestinal gas or the abdominal wall thickness can prevent a detailed examination of the bladder site when using US. In such cases, MRI is an alternative option. CT is a useful tool, but it exposes patients to radiation, which is a disadvantage, especially for young children; therefore, its use should be limited as much as possible.

Our pathological examinations revealed that our surgical approach to UR allowed for complete UR excision. The results of preoperative imaging of the UR to determine its presence or absence were consistent with the pathological findings of the UR. When the UR ended before the bladder apex according to preoperative imaging, urachus tissue existed at the umbilicus but not at the fibromuscular cord-like structure according to intraoperative findings. These findings were also demonstrated pathologically. Therefore, the use of preoperative imaging was appropriate for determining the surgical margin and procedure. Our study proved that our surgical strategy for symptomatic UR results in appropriate surgical margins and avoids unnecessary and excessive surgical invasion.

This study had several limitations. It was single-center, retrospective case series. Our sample size was small; therefore, the results should be validated in a large population and at other institutions. Long-term follow-up was not performed; therefore, the potential risk of UR recurrence when complete excision was not achieved was not evaluated.

Conclusions

When preoperative imaging revealed that the UR continued toward the bladder apex, the pathological findings also indicated the UR in the bladder margin. Both the TU approach for patients younger than 3 years and the LATU approach for patients older than 3 years were sufficient for complete UR resection at the bladder apex. However, when preoperative imaging showed no UR near the bladder apex, the pathological findings indicated the UR near the umbilicus without continuing toward the bladder apex, and the TU approach was considered sufficiently appropriate for complete excision of the UR. Our

institution's policy of determining the surgical approach based on preoperative imaging results is considered suitable for UR treatment in terms of complete UR resection and the avoidance of excessive surgical invasion.

Abbreviations

CT; computed tomography, LATU; laparoscopy-assisted trans-umbilicus, MRI; magnetic resonance imaging, TU; trans-umbilical, UR; urachal remnant, US; ultrasonography

Declarations

Ethics approval and consent to participate

This study was approved by the institutional review board of Nagoya University Graduate School of Medicine (number 2021-0395). This study is retrospective study. Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written informed consent. We applied Opt-out method to obtain consent on this study by the poster approved by the Institutional Review Board of Nagoya University Graduate School of Medicine.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

None declared.

Funding

None declared.

Authors' contributions

Yoichi NAKAGAWA: Data Curation, Investigation, Methodology, Writing - Original Draft, Writing – Review & Editing. Wataru SUMIDA: Conceptualization, Data Curation, Investigation, Methodology. Hizuru AMANO: Validation, Writing - Review & Editing. Hiroo UCHIDA: Supervision, Validation, Writing - Review & Editing. Akinari HINOKI: Validation. Chiyo SHIROTA: Validation, Writing – Review & Editing. Satoshi MAKITA:

Validation. Masamune OKAMOTO: Validation. Seiya OGATA: Validation. Aitaro TAKIMOTO: Validation. Shunya TAKADA: Validation. Daiki KATO: Validation. Yousuke GOHDA: Validation.

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Tables

Table 1 Patients' background and surgical outcomes

	Preoperative UR imaging		
	Continued toward the bladder apex (n = 10)	Near the umbilicus (n = 10)	
Approach	TU: 3 cases	LATU: 7 cases	TU: 10 cases
Patients' background			
Age (year)	1 (0-2)	10 (6-13)	6.5 (0-12)
Sex (male), n (%)	2 (67%)	5 (71%)	8 (80%)
Preoperative imaging			
Continue toward the bladder apex	3	7	0
Near the umbilicus	0	0	5
Continue caudally from the umbilicus (not continue toward the bladder)	0	0	5
Surgical outcomes			
Operation time (min)*	59 (53-81)	108 (92-150)	50 (35-104)
Hospitalization (day)*	3 (3-4)	3 (2-4)	1(1-3)
Balloon (day)*	2 (2-3)	2 (1-4)	0 (0-1)
Complications, n (%)	0 (0)	0 (0)	0 (0)
UR; urachal remnant			
*: Median (range)			

Table 2 Pathological diagnosis compared with preoperative imaging

	Preoperative UR imaging	
	Continued toward the bladder apex (n = 10)	Near the umbilicus (n = 10)
Pathological diagnosis		
Urachal remnant	10	6
Umbilical polyp	0	1
Granulation tissue	0	1
Uncertain cases	0	2
Resected margin		
UR existed at the bladder site	Positive in 9 cases	None
UR; urachal remnant		
*: Median (range)		

Figures

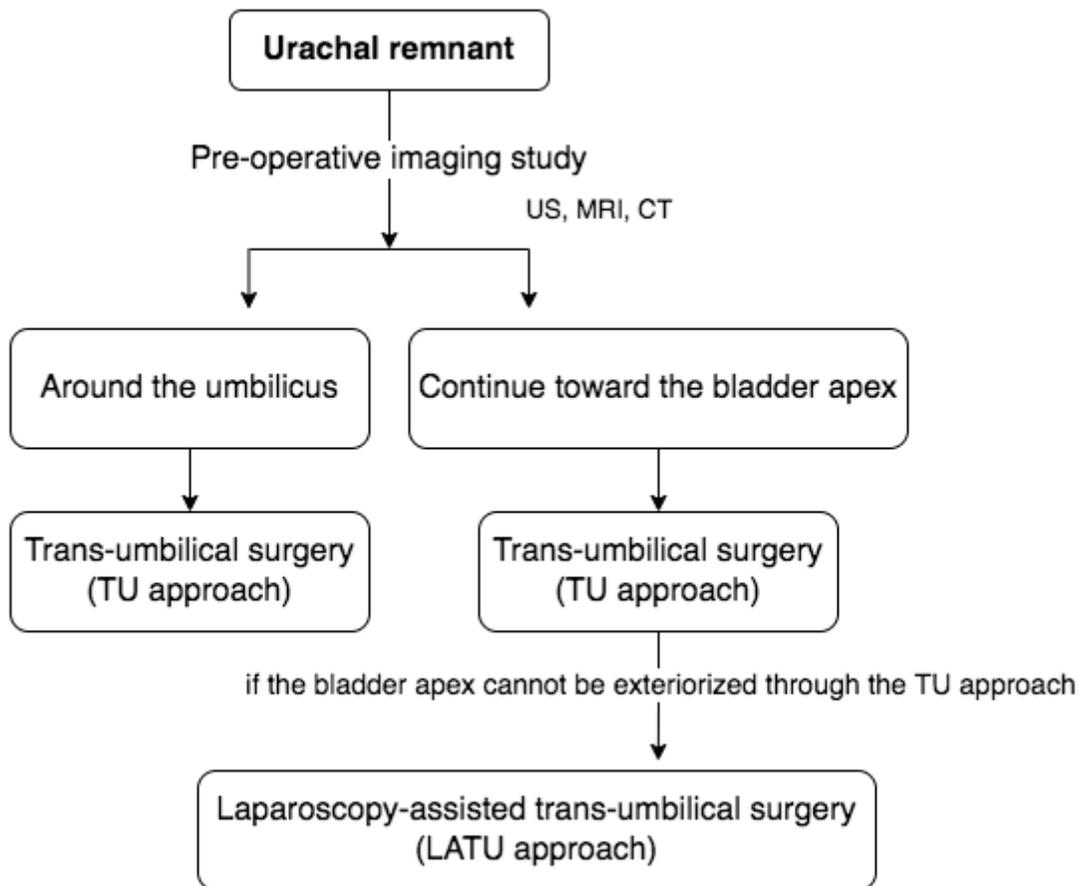


Figure 1

Flowchart showing how the surgical approach was selected for the urachal remnant.

Figure 2

Ultrasonography showed that the urachal remnant continued toward the bladder apex. Pathological findings indicated urachus tissue at the bladder apex.

Figure 3

Computed tomography showed the urachal remnant at the bladder apex (white arrow). Pathological findings indicated urachus tissue at the bladder apex.

Figure 4

Magnetic resonance imaging showed that there was no urachal remnant at the bladder apex (white arrow). The urachal remnant was resected at the fibromuscular cord-like structure (black arrow). Pathological findings indicated urachus tissue at the umbilicus site and no urachus tissue at the fibromuscular cord-like structure; only fibrous tissue was observed.