Robot-assisted laparoscopic partial cystectomy for urachal carcinoma: A case report

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Abstract. Urachal carcinoma is a rare and aggressive malignancy with an unknown aetiology and poor prognosis. The present case report described a 31-year-old male patient who initially presented with a 5-day history of haematuria. FDG-PET/CT demonstrated nodules in the anterior wall of the bladder with increased glucose metabolism, which were suggestive of malignancy. A cystoscopic biopsy confirmed the diagnosis of urachal carcinoma. The patient underwent en bloc robot-assisted laparoscopic modified partial cystectomy, along the umbilicus and urachus resection, and pelvic lymph node dissection. The patient recovered within 2 weeks postoperatively, with complete tumour resection confirmed by pathological analysis, which showed negative margins and no recurrence was detected during a 5-month follow-up. The current case highlighted the potential of robot-assisted laparoscopic surgery as an effective treatment option for urachal carcinoma, offering insights for further optimization and broader clinical application, and reviewed the currently available literature.

Introduction

Urachal carcinoma is a rare malignancy originating from the urachus, a structure that exists during embryonic development and connects the bladder to the umbilicus (1). Urachal carcinoma accounts for 0.01% of all malignancies (2), and 0.35-0.7% of all bladder cancers (3). In the normal course of development, the urachus usually degenerates into a fibrous cord, known as the median umbilical ligament, after birth (4). However, in some cases, remnants of the urachus can persist, which may potentially undergo malignant transformation, which leads to the development of urachal carcinoma (5).

Urachal carcinoma comprises <1% of all bladder carcinomas (6). The most commonly encountered histological subtype is adenocarcinoma (7). Owing to its nonspecific symptoms and clinical manifestation, a large proportion of patients are diagnosed at an advanced stage, with one-fifth of patients having distant metastasis at their initial visit (8). The 5-year overall cancer-specific survival rate is in the range of 43-61%, as per previous studies (6,9,10).

Currently, there is no standard treatment for urachal carcinoma. Surgical resection is the preferred treatment for limited-stage urachal carcinoma (11). Conventional approaches, such as open and laparoscopic partial cystectomy, have been commonly employed. However, these methods have lower precision and flexibility (12), and doctors are prone to fatigue. In recent years, robot-assisted surgery has been increasingly extended to urological procedures (13). Robot-assisted laparoscopic surgery reduces the risk of complications due to its enhanced precision, as it allows accurate excision of the tumour and does not cause damage to the surrounding tissues, thereby reducing blood loss. Moreover, high-definition visualization allows for improved identification and control of blood vessels (14). Despite the growing use of robot-assisted surgery in urology, there are currently few reports of its use in robotic partial cystectomy, especially in the treatment of primary urachal carcinoma (15).

Case report

A 31-year-old male presented to Guangdong Provincial People's Hospital (Guangzhou, China) with a 5-day history of painless, gross haematuria in July 2024. Laboratory test results demonstrated normal tumor marker levels: Carcinoembryonic antigen (CEA), $1.46x10^{-3}$ ng/l (normal range, $0\text{-}5x10^{-3}$ ng/l); alpha-fetoprotein, $2.4x10^{-3}$ ng/l (normal range, $0\text{-}9x10^{-3}$ ng/l); and prostate-specific antigen (PSA), $0.93x10^{-3}$ ng/l (normal range, $0\text{-}4x10^{-3}$ ng/l). An ^{18}F-FDG-PET/CT scan demonstrated a nodular lesion on the anterior bladder wall with increased glucose metabolism, which suggested malignancy and a potential diagnosis of urachal carcinoma (Fig. 1). No malignant metabolic lesions were observed in other parts of the body. To further confirm the diagnosis, a cystoscopy was performed,

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which demonstrated a cauliflower-like mass on the bladder dome that was ~3x2 cm in size. The bilateral ureteral orifices appeared normal and no other bladder wall masses or abnormalities were noted. Biopsy samples from three different areas of the mass were obtained and histopathological examination confirmed adenocarcinoma. A diagnosis of urachal carcinoma was established on the basis of imaging, cystoscopic findings and pathological results.

Following comprehensive preoperative preparations, the patient underwent robot-assisted laparoscopic partial cystectomy, urachal and umbilical resection, and pelvic lymph node dissection using the da Vinci-Xi robotic system (Intuitive Surgical Operations, Inc.) in July 2024. After successful induction of anaesthesia, the patient was placed in the Trendelenburg position at an angle of ~30˚. A small incision was made above the umbilicus. A Veress pneumoperitoneum needle was subsequently employed to establish a stable pneumoperitoneum; four 8-mm and one 12-mm trocars were inserted at predetermined positions (Fig. 2) and then connected to the robotic system. The bladder was first emptied, after which a routine pelvic lymph node dissection was precisely performed. The peritoneal reflection was opened and the bladder was dissected anteriorly. Dissection was performed along the urachus until the linea alba was reached. A 3x3 cm mass was visible at the junction of the urachus and the bladder (Fig. 3A). The mass was firm and protruded into the bladder. The bladder was incised around the mass, and the tumour along with a part of the bladder wall was completely resected (Fig. 3B). The urachus was further dissected up to the umbilicus. The umbilical incision was extended, and the umbilicus, urachus, bladder wall and mass were completely removed. The estimated intraoperative blood loss was ~20 ml.

Postoperative tissues were fixed in 10% neutral buffered formalin for 24 h at room temperature, embedded in paraffin and sectioned into 4 μm slices. Hematoxylin and eosin staining was performed using standard protocols (hematoxylin for 5 min at room temperature and eosin for 2 min at room temperature), visualized using a light microscope (x10 and x20 magnification), revealing low-grade adenocarcinoma of the urachus and part of the bladder, with areas showing mucinous adenocarcinoma (Fig. 4A and B). The surgical margins were negative and no cancer metastasis was observed in the bilateral iliac lymph nodes.

Paraffin-embedded tissues were sectioned at 4 μm thickness, microwave-treated in sodium citrate buffer (pH 6) for 10 min for antigen retrieval and processed for immunohistochemistry. After permeabilization with 0.1% Triton X-100 and blocking with 5% goat serum (cat. no. ab7481; Abcam) at room temperature for 30 min. Subsequently, sections were incubated overnight at 4˚C with rabbit primary antibodies against CK20 (cat. no. ab64090; 1:100; Abcam), caudal type homeobox 2 (CDX2; cat. no. ab101532; 1:100; Abcam), β-catenin (cat. no. ab32572; 1:500; Abcam) and Ki-67 (cat. no. ab15580; 1:100; Abcam). Biotinylated goat anti-rabbit IgG secondary antibodies (cat. no. ab6720; 1:2,000; Abcam) was applied for 30 min at room temperature, followed by diaminobenzidine chromogen detection. Sections were counterstained with hematoxylin for 5 min at room temperature and staining scores were independently evaluated by two pathologists in a blinded manner. Images were captured using a light microscope at x20 magnification. The results were as follows: CK20 (positive, +), CDX2 (negative, -), CK7 (-), CK34BE12 (-), β-catenin (membrane +) and Ki-67 (hot spot area, 50%+; Fig. 4C-F). Based on these findings, the patient was diagnosed with Sheldon stage IIIa urachal carcinoma. Postoperatively, the patient was transferred to the oncology department for chemotherapy with a gemcitabine and cisplatin regimen (gemcitabine 1,000 mg/m^2 intravneously on days 1 and 8; cisplatin 70 mg/m^2 intravenously on day 1; 21-day cycle, 6 cycles total). At the latest follow-up (March 2025), which was 5 months after surgery, the patient was monitored with physical examinations and pelvic CT scans. No signs of tumour recurrence were observed.

Discussion

Urachal carcinoma, a rare and highly invasive malignancy, was first described by Begg in 1931 (16). Urachal carcinoma predominantly affects middle-aged and elderly adults, particularly males >50 years old. The most prevalent symptom is macroscopic haematuria, followed by lower urinary tract symptoms, abdominal masses, mucusuria and abdominal pain (5). Currently, the diagnostic criteria for urachal carcinoma remain controversial. The modified diagnostic criteria for urachal carcinoma proposed in studies such as that by Gopalan *et al* (17) are as follows: i) A tumour located at the anterior or apical wall of the bladder; ii) the main body of the tumour is within the bladder wall; iii) there is no extensive cystic or glandular cystitis outside the anterior or apical walls of the bladder; and iv) there is no known primary tumour in other organs. The patient in the present study met these diagnostic criteria. At present, there are two main distinct staging standards for urachal carcinoma: i) The Sheldon staging system (18); and ii) the Mayo staging system (19), both of which can predict the survival time of patients with urachal carcinoma. The Sheldon tumour-node-metastasis staging system (18) was first proposed in 1984, is widely recognized and used in clinical practice as a staging diagnostic criterion (17,20). The Sheldon staging system classifies urachal carcinoma as follows: Stage I, the tumour is confined to the urachal mucosa; stage II, tumour with invasion confined to the urachus itself; stage IIIA, tumour with local extension to the bladder; stage IIIB, tumour with local extension to the abdominal wall; stage IIIC, tumour invading the peritoneum; stage IIID, tumour invading local viscera other than the bladder; stage IVA, urachal cancer with metastasis to the lymph nodes; and stage IVB, urachal cancer with distant metastases (18). In the present study, the patient was diagnosed with stage IIIA urachal carcinoma.

Urachal cancer is primarily diagnosed on the basis of the results of serum tumour marker tests, imaging examinations and cystoscopy (21). Clinically significant serum tumour markers in patients with urachal cancer primarily include CEA, CA724, CA199 and CA125. The expression levels of tumour markers are usually positively correlated with tumour stage, and these markers can significantly decrease after surgery or chemotherapy (22). Typically, one-half of all patients with urachal cancer of have elevated levels of CEA, CA724, CA19-9 and CA125, and all of these markers may increase in the event of tumour metastasis or recurrence (7,23). While serum tumour markers may assist in the diagnosis and monitoring

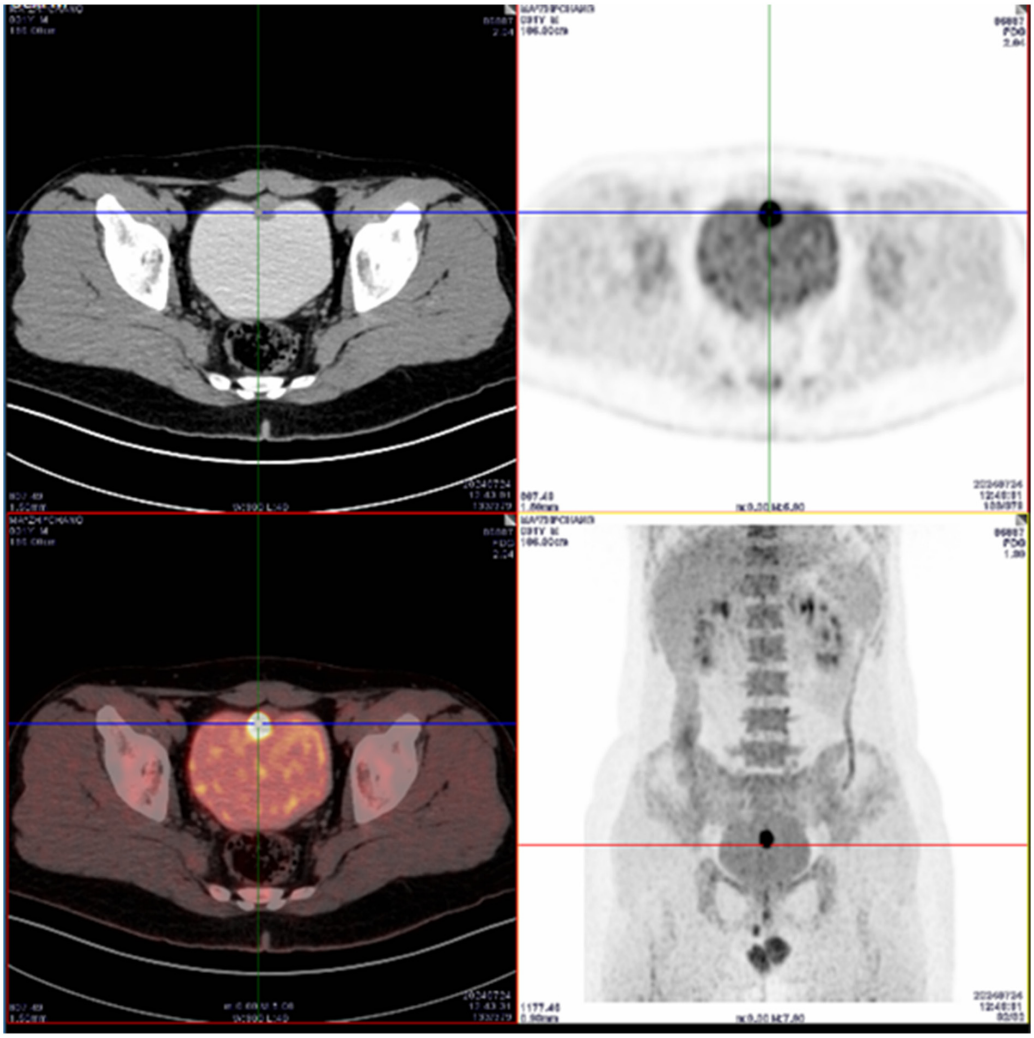

Figure 1. Preoperative ^{18}F-FDG-PET/CT results showed a 1.9x1.8 cm hypermetabolic nodule at the bladder dome. Standardized Uptake Value maximum=20.4 on delayed imaging). No regional lymphadenopathy or distant metastases were detected.

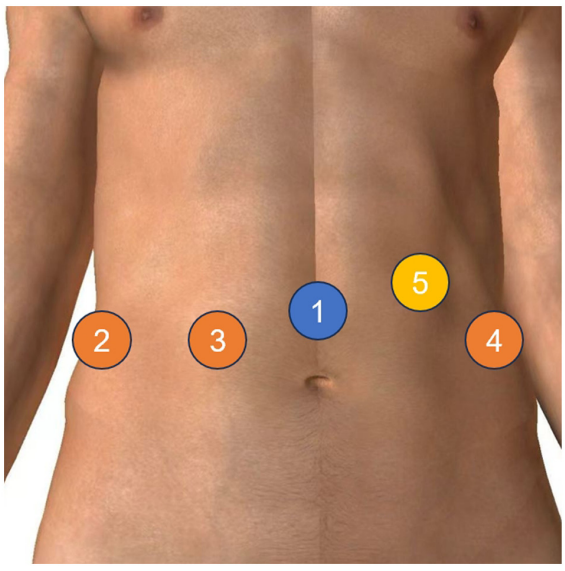

Figure 2. Port-site locations for robot-assisted laparoscopic surgery. The blue circle labelled 1 is the location of a 12-mm observation port placed 2 cm above the umbilicus for camera insertion. The orange circles labelled 2, 3 and 4 are locations of 8-mm robotic arm ports. The yellow circle labelled 5 is the location of an assistant suction port.

of urachal cancer, they lack specificity and some case reports have documented instances where serum tumour marker levels do not increase (24-26). In the present study, the serum tumour marker levels of the patients were also normal. The imaging methods used for examining urachal cancer mainly include contrast-enhanced CT, MRI, FDG-PET/CT and ultrasound imaging (18). Pelvic ultrasound typically demonstrates a complex cystic mass above the bladder, which may be considered an echo-enhancing lesion and suggests calcification (27). On CT and MRI scans, urachal cancer usually presents as a cystic-solid mass in the midline of the urachal tract, extending from the umbilicus to the top of the bladder, with visible central or peripheral calcification (28,29). FDG-PET/CT imaging has demonstrated variability among patients with urachal cancer, possibly because a large proportion of cases of urachal cancer are adenocarcinomas, some of which are mucin-rich, which leads to poor FDG uptake and visualization (30,31). Cystoscopy serves a key role in the visualization and histological diagnosis of urachal cancer, with numerous lesions appearing as cauliflower-like neoplasms at the top or anterior wall of the bladder (21).

The most common pathological type of urachal cancer is adenocarcinoma, with mucinous adenocarcinoma being the

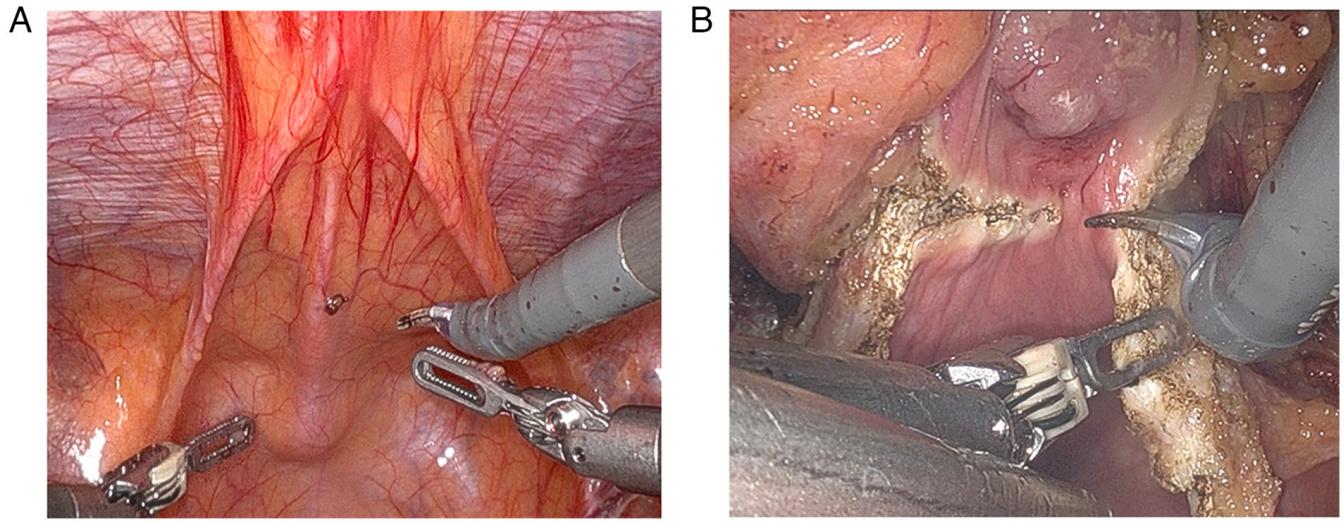

Figure 3. Intraoperative images of robot-assisted laparoscopic partial cystectomy for urachal carcinoma. (A) Confirmation of the location of the urachal carcinoma. (B) Removal of part of the bladder 3 cm from the tumour margin.

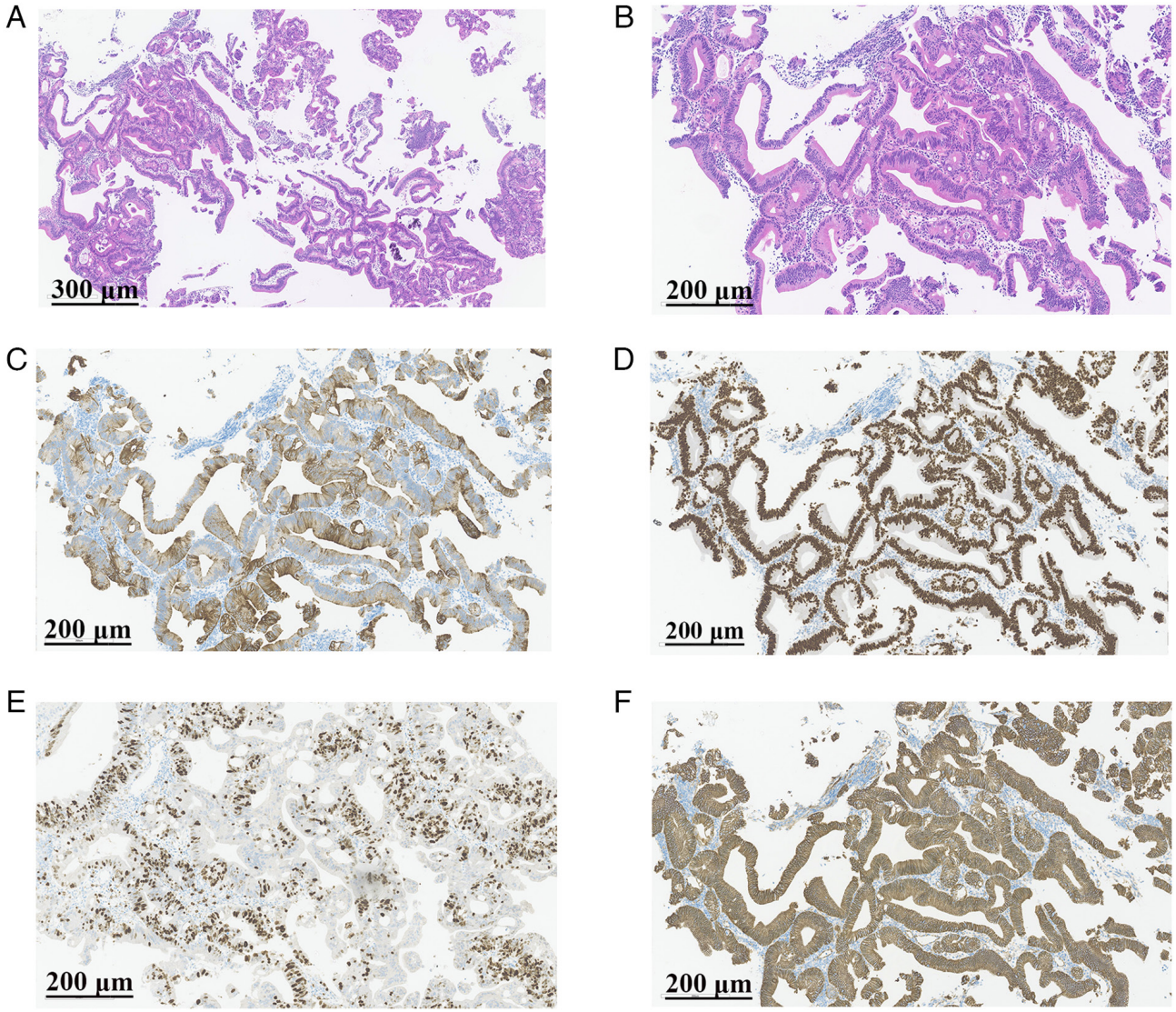

Figure 4. Representative images of immunohistochemistry results. (A) H&E staining (magnification, x10; scale bar, 300 μm). (B) H&E staining (magnification, x20; scale bar, 200 μm). (C) Positive expression of CK20 (magnification, x20; scale bar, 200 μm). (D) Positive expression of caudal type homeobox 2 (magnification, x20; scale bar, 200 μm). (E) Ki-67 staining demonstrates ~50% positive cells in the hot-spot area (magnification, x20; scale bar, 200 μm). (F) Positive membrane-bound expression of β-catenin (magnification, x20; scale bar, 200 μm). H&E, hematoxylin and eosin.

most common; urachal adenocarcinoma accounts for ~20-39% of all types of primary bladder adenocarcinoma (18). Primary bladder adenocarcinomas share immunohistochemical similarities with colorectal adenocarcinomas that invade the bladder, which may be due to the common embryological origin of the urachus, bladder and colon, which leads to a tendency for intestinal metaplasia in the urachus (17). In a study by Wang *et al* (32), the expression levels of CK7, CK20, CDX2 and nuclear β-catenin in urachal adenocarcinoma were 50, 100, 85 and 6%, respectively. In mucinous urachal adenocarcinoma, CDX2 is highly expressed, whereas nuclear β-catenin is not expressed. In the present study, the patient's tumour markers CK20, CDX2 and membrane β-catenin were positive, whereas CK7 and CK34BE12 were negative, which is consistent with the immunohistochemical features of urachal cancer.

The main treatment for localized urachal cancer is surgery, although there is no consensus on the specific surgical approach. Surgical options include radical cystectomy (RC), partial cystectomy (PC) and en bloc resection of the urachus and umbilicus (33). A study by Knoedler *et al* (34) demonstrated no significant differences in survival between patients who underwent RC and those who underwent PC; however, PC may offer a better quality of life due to bladder preservation, making it more commonly utilized in clinical practice (35,36). A previous study reported that umbilical resection is an independent prognostic factor for overall survival in patients with urachal cancer (37). Thus, complete resection of the umbilicus is recommended. There was no significant difference in survival between patients who underwent pelvic lymph node dissection and those who did not (33,35). However, patients with pathologically positive lymph nodes (without distant metastasis) have a poor prognosis similar to that of patients with distant metastasis, suggesting that pelvic lymph node dissection may be beneficial (6). According to the expert consensus reached by the Canadian Urological Association in 2016, the preferred intervention for localized urachal cancer was surgery involving resection of the umbilicus, urachus and partial cystectomy, combined with pelvic lymph node dissection. In cases where partial cystectomy cannot achieve negative surgical margins, RC with en bloc removal of the urachus and umbilicus should be considered (36). Surgical approaches can include open surgery, laparoscopic surgery or robot-assisted laparoscopic surgery. In 2006, Milhoua *et al* (38) performed laparoscopic partial cystectomy with en bloc resection of the urachus and umbilicus for patients with urachal cancer, with no signs of recurrence at the 1.5-year follow-up. Compared with open surgery, laparoscopic surgery reduces intraoperative blood loss, shortens the hospital stay and accelerates recovery (39). In the field of urology, robotic surgery is more commonly used in prostate and kidney surgeries, with fewer reports of robot-assisted laparoscopic partial cystectomy. In 2015, James *et al* (40) reported the use of robot-assisted laparoscopic partial cystectomy in 8 patients with urachal cancer and achieved similar tumour resection results as those of open surgery, but with a lower incidence of perioperative complications. At a median follow-up of 32 months, there was no sign of recurrence, which indicated that robot-assisted partial cystectomy is a feasible and safe approach. In the present study, the patient underwent robot-assisted laparoscopic extended partial cystectomy without difficulty or postoperative complications, resulting in good surgical outcomes. Compared with open and laparoscopic surgery, robotic surgery offers notable advantages, including improved mobility and flexibility, high-definition visualization, stability and precision, as well as improved suturing capabilities (41). However, robot-assisted laparoscopic surgery also has disadvantages. The most notable of these is the high cost, which impedes the distribution of the technology in numerous countries (42). Additionally, device malfunctions, such as instrument breakage, electrical arcing or system errors (43) and a steep learning curve requiring extensive training are significant drawbacks of this method (44). In teaching hospitals, the cost of the procedure may also deprive junior residents of the opportunity to gain laparoscopic experience.

For patients with positive lymph nodes, peritoneal involvement, positive surgical margins or a high likelihood of recurrence, postoperative chemotherapy is recommended (1). Owing to the rarity of urachal cancer, there is no standard chemotherapy regimen. Commonly used regimens include platinum-based therapies or 5-FU, with gemcitabine being increasingly included in treatment plans (45). A previous study demonstrated that platinum-based chemotherapy is more effective compared with nonplatinum chemotherapy for disease control (median progression-free survival, 8.23 vs. 3.80 months) (46). In the present study, the patient was treated with a cisplatin and gemcitabine regimen, and no tumour recurrence was detected at the latest follow-up in March 2025.

Limitations of the present study should be noted. First, the lack of a cystoscopic images due to non-collection during the cystoscopy procedure limits the visual demonstration of the tumour. Second, a single patient may not fully represent the overall situation of patients with urachal carcinoma. Third, the relatively short follow-up period (5 months) may not be sufficient to evaluate the long-term recurrence rate and survival rate accurately.

Urachal cancer is a rare and aggressive malignancy with a poor prognosis. For localized urachal cancer, surgery remains the primary treatment modality, which should completely resect part of the bladder, urachus and umbilicus. The present study described a case of a 31-year-old urachal carcinoma patient successfully treated using robot-assisted laparoscopic modified partial cystectomy. Such a case is rare in the literature and therefore provides important clinical experience. Future research should aim to include larger sample sizes and long-term follow-up studies to comprehensively evaluate the efficacy, safety and potential broader application of robot-assisted laparoscopic partial cystectomy as a minimally invasive treatment for urachal carcinoma.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

CY, QX and XP drafted the manuscript and conceptualized the present study. ZL and KW participated in the analysis, collection and interpretation of data. FZ obtained the PET/CT images and analysed patient data. FZ, WK and ZL confirm the authenticity of all the raw data. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

The authors obtained the patient's written informed consent. The patient was informed of privacy protection and the potential uses of the published content. A copy of the signed consent form is retained and ethical and legal standards adhered to during the publication process.

Competing interests

The authors declare that they have no competing interests.

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