Case Report

First case report of robot-assisted radical cystectomy and intracorporeal urinary diversion using the hinotori Surgical Robot System

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Background: The field of robotic surgery is still continuously advancing, with several cutting-edge robotic systems currently under development. This study aimed to present the methodology and perioperative outcomes of robot-assisted radical cystectomy (RARC) and intracorporeal urinary diversion (ICUD) in patient with muscle invasive bladder cancer (MIBC) by utilizing the hinotori Surgical Robot System, a recently developed robot-assisted surgical platform.

Case Description: A 79-year-old man with MIBC, cT2N0M0, received RARC and ICUD after two courses of neoadjuvant chemotherapy. We performed RARC and ICUD using hinotori, with a total operation time of 476 minutes. The insufflation time was 424 minutes, and the console time was 396 minutes. Total blood loss was 562 mL and no blood transfusion was necessary. During the perioperative period, a paralytic ileus occurred, although no severe adverse events were observed. The pathological examination showed ypT0N0M0, and no recurrence was observed by computed tomography scan up to 8 months postoperatively.

Conclusions: This report demonstrates the successfully implementation of RARC and ICUD using the hinotori system, without perioperative adverse effects. While further exploration is required to assess the long-term and large-scale implications of RARC and ICUD using hinotori on oncologic and functional outcomes, these initial findings suggest that the hinotori Surgical Robot System holds promise as an application for RARC and ICUD in patients with MIBC.

Keywords: Hinotori; robot-assisted radical cystectomy (RARC); intracorporeal urinary diversion (ICUD); muscle invasive bladder cancer (MIBC); case report

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Introduction

Background

Muscle invasive bladder cancer (MIBC) necessitates radical cystectomy as the standard treatment approach. Nonetheless, open radical cystectomy carries a significant morbidity burden, and it links to a higher rate of complications. To address these challenges, robot-assisted surgery has emerged as a standard therapeutic modality in urologic cancer surgery, including MIBC. Robotic assisted radical cystectomy (RARC) offers the advantages of minimally invasive surgery and is now routinely performed at esteemed medial institutions worldwide.

Although innovation of robotic surgery is still actively

growing and the field of robotic surgery continues to witness ongoing innovation, with several new robotic systems currently under development. However, the da Vinci surgical system (Intuitive Surgical, Inc., Sunnyvale, CA, USA) has maintained its position as the leading player in robot-assisted surgical systems for nearly two decades. Meanwhile, the hinotori Surgical Robot System (hinotori), a novel robot-assisted surgical system, was developed by Medicaroid Corporation (Kobe, Hyogo, Japan) with joint funding from Kawasaki Heavy Industries, Ltd. (Kobe, Hyogo, Japan) and Sysmex Corporation (Kobe, Hyogo, Japan).

Rationale and knowledge gap

The hinotori system distinguishes itself with a compact operation arm featuring eight axes of motion, one more than the da Vinci system. This design ensures reduced interference between arms and minimizes disruption to the surgeon at the bedside. The features hold significant clinical benefits and contribute to its seamless integration in urologic cancer surgeries. Notably, the application of hinotori in robot-assisted radical prostatectomy (RARP) and partial nephrectomy has demonstrated safe and favorable operative outcomes (1,2). Furthermore, radical cystectomy encompasses two pivotal stages: the bladder extirpation phase and the urinary reconstructive phase, both of which are technically demanding. The bladder extirpation phase, known as RARC, involves intricate procedures within the confined pelvic region, including precise incisions and dissections. In contrast, the urinary reconstructive phase, referred to as intracorporeal urinary diversion (ICUD), necessitates complex techniques such as incisions, dissection, suturing and anastomosis. Interestingly, a meta-analysis indicated that ICUD provided comparable complication rates, improved perioperative outcomes, and similar oncological outcomes when compared to extracorporeal urinary diversion (ECUD) (3). These findings contribute to accelerate ICUD, as a technically intricate procedure, highlighting its potential benefits.

Highlight box

Key findings

- Robot-assisted radical cystectomy (RARC) and intracorporeal urinary diversion (ICUD) are feasible with the hinotori system and may easily reproduce all standard steps of this complex surgical procedure.

What is known and what is new?

- The recent integration of robotic surgery into routine clinical practice has revolutionized minimally invasive procedures. Among these, RARC and ICUD stand out as one of the most complex surgical interventions for urologic cancer.
- Introducing the hinotori Surgical Robot System, a groundbreaking robot-assisted surgical platform developed in Japan, we successfully performed RARC and ICUD using this system for the first time. The procedures were completed as planned, and no significant perioperative adverse effects were observed. The hinotori system consists of a compact operation arm and reduces interference between arms as well as minimizes disruption to the surgeon at the bedside, which contribute to its seamless integration.

What is the implication, and what should change now?

- Employing the hinotori system for RARC and ICUD in patients with muscle invasive bladder cancer holds promise for achieving favorable outcomes in terms of safety and disease control.

Objective

We present our experience with RARC and ICUD using the hinotori system and discuss important considerations that must be taken into account when performing this procedure. We present this case in accordance with the CARE reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-991/rc).

Case presentation

Surgical robot system

The hinotori robotic system used in this study comprises three units: an operation unit, a surgical cockpit, and a vision unit (*Figure 1*) (1). Each operating arm possesses eight axes of freedom and is equipped with an anti-shake mechanism controlled by a computer system. This design minimizes interference between the arms during surgery. Additionally, the forceps were designed to enable control without docking the arm and port, allowing for an ample working area around the port and reducing extracorporeal interference with the surgeon at the bedside. The instruments used in this study included bipolar fenestrated forceps, bipolar Maryland forceps, monopolar curved scissors, Croce grasping forceps, and a needle holder. The AUTOCON III 400 electric knife (KARL STORZ SE & Co. KG, Tuttlingen, Germany) was used and the intestinal auto-anastomosis device during the ileal conduit procedure was the powered ECHELON FLEX (Ethicon, Inc., New Jersey, USA).

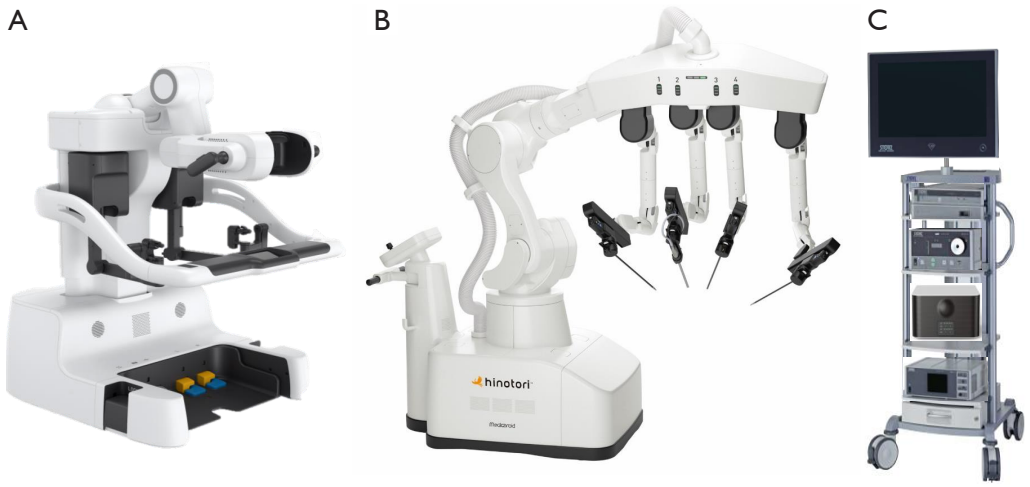

Figure 1 The hinotori Surgical Robot System: (A) surgeon's cockpit, (B) operation unit, and (C) monitor cart, which are designed to reduce the burden on the surgeon, with the vision unit displaying a high-definition endoscopic image in 3D.

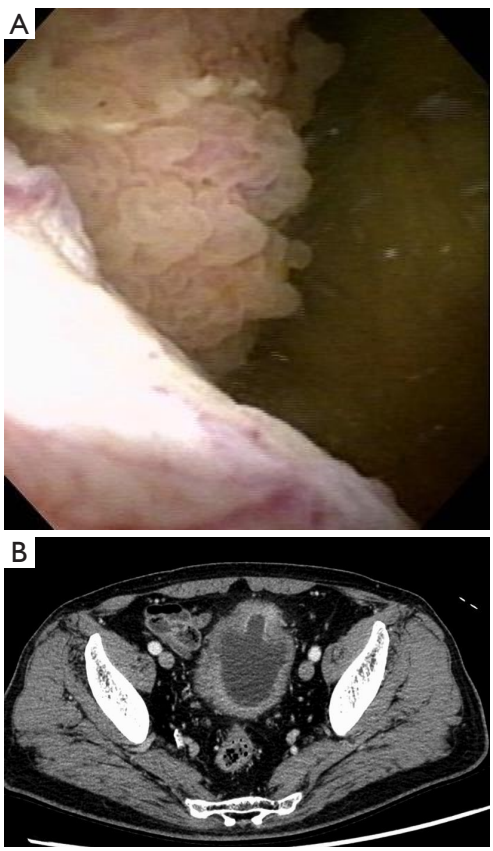

Figure 2 Multiple papillary and invasive bladder tumors were identified on cystoscopy (A) and CT imaging (B). CT, computed tomography.

Presentation of case

A 79-year-old man presented to our hospital with symptoms of pollakisuria and a feeling of residual urine. Cystoscopy and computed tomography (CT) imaging (*Figure 2A,2B*) revealed the presence of multiple papillary and invasive bladder tumors. He had suffered from cardiomyopathy in the past; however, he had not undergone any surgery in his abdomen. Subsequent transurethral resection of bladder tumor (TURBT) confirmed MIBC, staging cT2N0M0. Following two courses of neoadjuvant chemotherapy, we proceeded with RARC and ICUD using the hinotori system.

The procedures for RARC using the hinotori were conducted as follow.

(I) The patient was placed under general anesthesia, and the robotic and assistant ports were positioned according to our standard locations for RARC (*Figure 3*). In brief, four trocars were used for the robotic arms and three trocars, including AirSeal iFS (CONMED Japan KK, Tokyo, Japan), were employed for the assistant's ports. The surgery commenced with the patient positioned at a 25-degree head-down angle.

(II) Once pneumoperitoneum was established, the physiological adhesions were dissected. The peritoneum was incised to visualize the ureters, which were then gently grasped and dissected until reaching the ureterovesical junction.

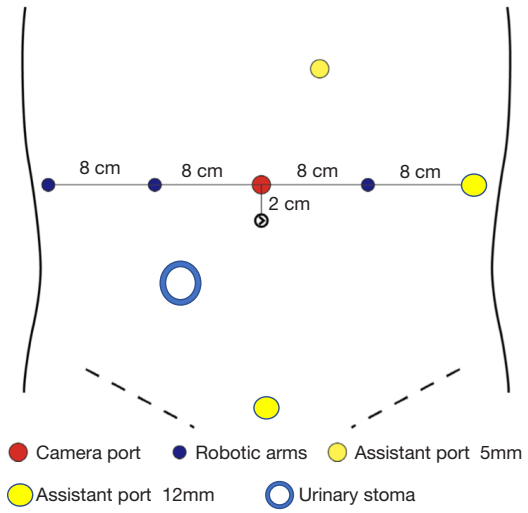

Figure 3 Port positions for RARC and ICUD. RARC, robot-assisted radical cystectomy; ICUD, intracorporeal urinary diversion.

Subsequently, the ureter was clipped and cut, and a rapid pathological examination confirmed the absence of malignant findings in the bilateral ureteral margins.

(III) After dissection of the seminal duct, a bilateral lymph node dissection was performed, targeting the common iliac, external iliac, internal iliac, obturator and median sacral lymph nodes (*Figure 4A*).

(IV) Radical cystoprostatectomy with urethral resection was performed. Briefly, the peritoneum was incised at the douglas fossa between the right and left peritoneal incisions, following ureter dissection (*Figure 4B*). The vas deferens and seminal vesicles were identified and dissected. Then, Denonvilliers' fascia was identified (*Fig*ure 4C) and dissected from the prostate following a nerve-sparing approach. The dorsal vein complex and puboprostatic ligaments were divided and the urethra was dissected (*Figure 4D*). Finally, the bladder and prostate, along urethra, were completely resected (*Figure 4E*) and collected in a specimen bag.

Then, we followed the procedure of ICUD using the hinotori system.

(V) The left ureter was carefully mobilized from the retroperitoneal along the dorsal surface of the sigmoid colon, toward the right side. Subsequently, both the left and right ureters were transected at the 12 o'clock position. A side-to-side anastomosis of the ureters was performed using a continuous suture with 5-0 vicryl, for Wallace ureteroenteric anastomosis (*Figure 5A*).

(VI) A paper measure was inserted into the body, and using 2-0 vicryl, we marked the points on the ileum that were 15 and 30 cm away from the ileocecal junction. Following this, the mesentery of the ileum was incised, and segment of the ileum designated for the ileal conduit procedure was cut. To facilitate this, an automatic anastomotic device was employed through the assistant port, allowing for stapling of the ileal segment.

(VII) An approximately 1 cm incision was made on the opposite side of the ileum's mesentery to enable a side-to-side anastomosis. Additionally, a 12-mm assistant port was created above the pubic bone to accommodate the intestinal auto-anastomosis device (*Figure 2*). The device was then inserted to perform the side-to-side anastomosis of the ileum (*Figure 5B,5C*).

(VIII) The proximal end of the ileal conduit was trimmed, and a suturing technique using 4-0 vicryl was employed to suture the right ureteral wall to the dorsal side of the conduit (*Figure 5D*). Bilateral ureteral stents were then inserted into the ureters (*Figure 5E*). Then, the left ureteral wall was sutured to the ventral side of the conduit using 4-0 vicryl.

(IX) The distal end of the ileal conduit was brought to the stoma site, and retroperitonealization of the ileal conduit was performed.

The total duration of the operation was 7 hours and 56 minutes, with an insufflation time of 7 hours and 4 minutes, and a console time of 6 hours and 36 minutes. The total blood loss during the procedure was 562 mL, and no blood transfusion was required. The pathological examination showed an ypT0N0M0 stage.

In the postoperative course, the patient began oral intake of water and initiated walking activities on the first day after the operation. Unfortunately, paralytic ileus occurred, requiring the placement of an ileus tube (Clavien-Dindo classification: 3a) to address the condition. However, no recurrence was detected during follow-up CT scans conducted up to 8 months postoperatively. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committees and with the Helsinki Declaration (as revised in 2013). Written informed consent for publication of this case report and accompanying images was not obtained from the

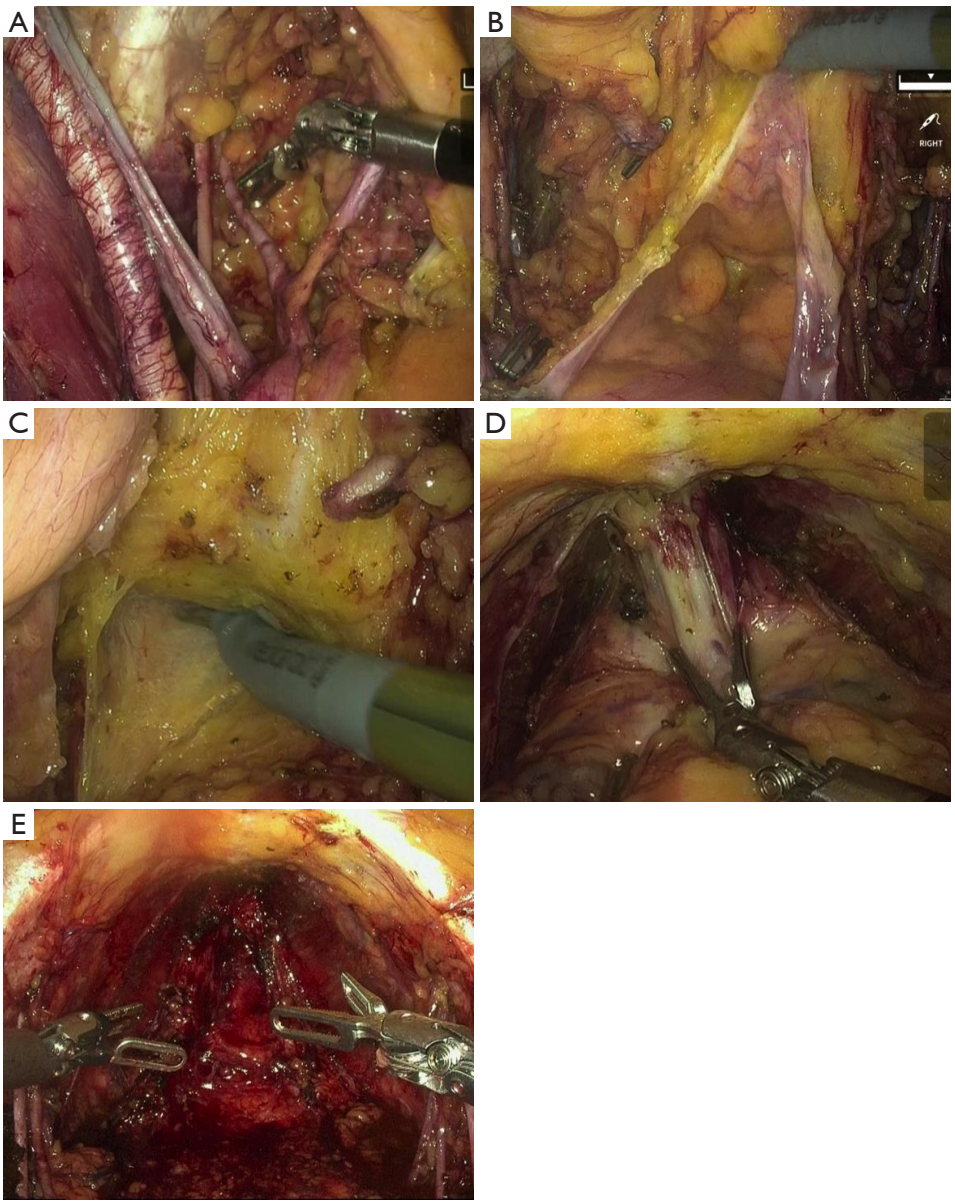

Figure 4 Procedures for RARC using the hinotori system. (A) Lymph node dissection in left pelvis. (B) Cutting the peritoneum at douglas fossa between right and left peritoneal incisions by ureter dissection. (C) Denonvilliers' fascia was identified and dissected from prostate. (D) Dorsal vein complex and puboprostatic ligaments were cut. (E) Bladder and prostate with urethra were completely resected. RARC, robot-assisted radical cystectomy.

patient or the relatives after all possible attempts were made.

Discussion

Key findings

In the two decades since the introduction of the da Vinci system, significant advancements have been made in the development of new robot-assisted surgery systems. Among these advancements is the hinotori system, which we used in this study to perform the first-ever reported case of RARC and ICUD.

Strengths and limitations

The recent introduction of robotic surgery into routine

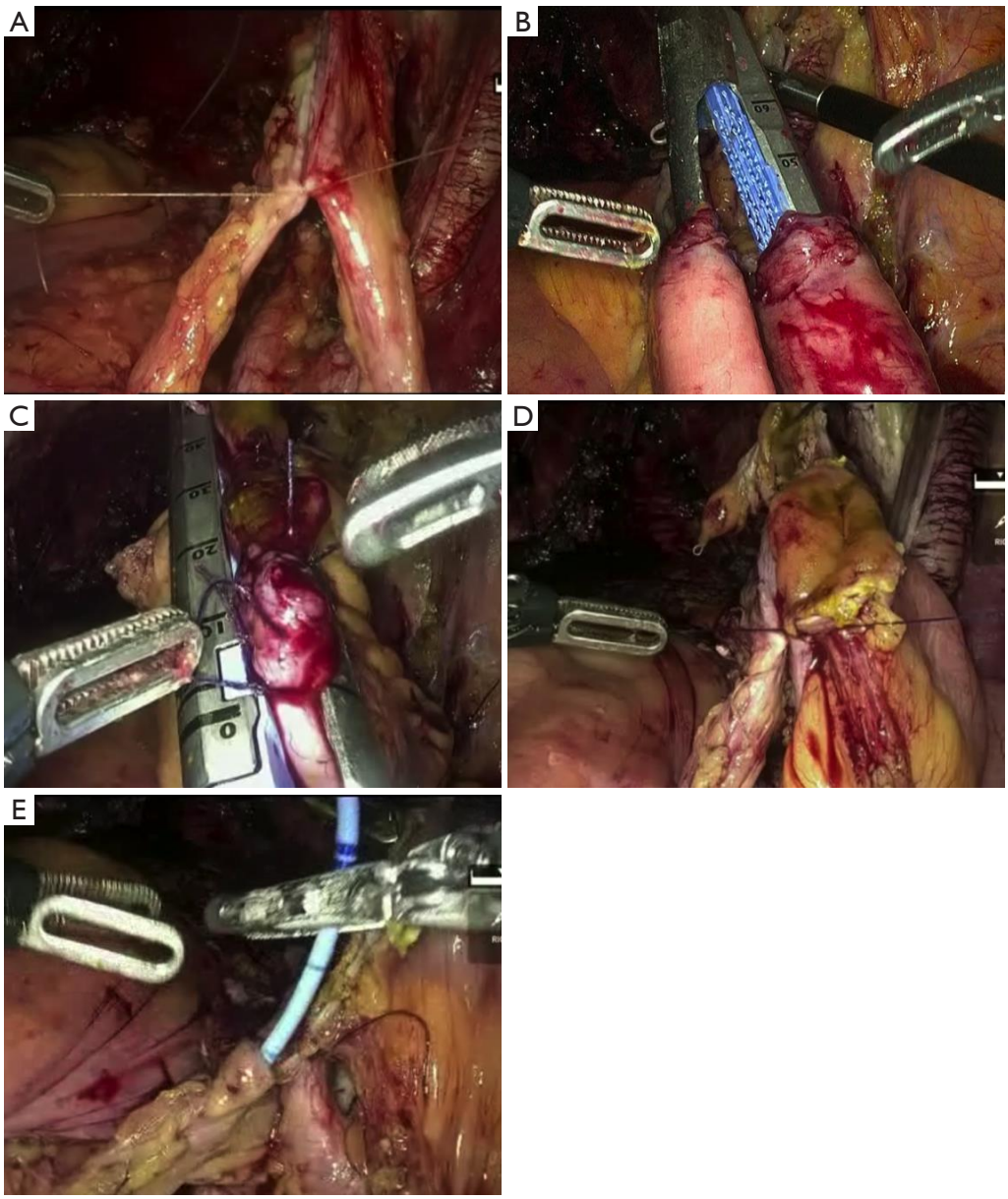

Figure 5 Procedures for ICUD using the hinotori system. (A) Left and right ureters were sutured side-to-side anastomosis for Wallace ureteroenteric anastomosis. (B,C) The intestinal auto-anastomosis device performs the side-to-side anastomosis of the ileum. (D) The right ureteral wall was sutured to the ventral side of the conduit using 4-0 vicryl. (E) Bilateral ureteral stents were inserted into the ureters. ICUD, intracorporeal urinary diversion.

clinical practice has revolutionized minimally invasive surgery, expanding its indications to include more complex procedures. Robotic systems offer several advantageous characteristics that enable these advancements, such as articulating wrists that provide multiple degrees of motion, 3-dimensional visualization, magnified vision, elimination of physiologic tremors, and improved dexterity (4).

Robotic surgery has become widely accepted as the standard approach in various urologic surgeries, including radical prostatectomy, partial nephrectomy, and radical cystectomy (5). The da Vinci surgical system has dominated the surgical robot market for the past two decades, but recently, novel robotic platforms with distinct technical features have emerged (1,6-9). Among them, hinotori stands

out as the first surgical robotic system developed in Japan. It consists of three components similar to the da Vinci system: the patient cart, surgeon's cockpit, and vision unit. However, hinotori offers several unique characteristics not found in da Vinci. The hinotori provides a spacious and clean surgical field for surgeons and incorporates compact robotic arms with eight axes of motion, allowing for precise and intricate manipulations. In addition, this design ensures reduced interference between arms and minimizes disruption to the surgeon at the bedside, especially for RARC with ICUD, the most complicated procedure in urologic cancer surgery. These features make hinotori an innovative addition to the field of robotic surgery.

The hinotori system received regulatory approval in Japan in 2020, and since then, its utilization in routine clinical practice has been gradually increasing within the field of urology. Preclinical and clinical studies focusing on RARP have demonstrated the safety and efficacy of the hinotoyi system (1). Furthermore, the application of hinotori in robot-assisted partial nephrectomy (RAPN) for 30 patients with small renal tumors has shown favorable perioperative outcomes (2). These studies have indicated that hinotori provides an expanded working space around the abdominal wall and trocars, enhancing the functionality of the assistant surgeon and facilitating improved visualization of the patient's body surface and any abnormalities.

We believe that advantages offered by the hinotori system are instrumental in performing RARC and ICUD, which are among the most intricate surgical procedures in the field of urologic cancer. These procedures encompass various complex steps, including lymph node dissection throughout the pelvis region, anastomosis of the ileum and ureter, and the construction of a urinary stoma. Although this report represents the first case RARC and ICUD using the hinotori system, this novel robotic platform enabled us to successfully execute the planned procedures. Novel robotic platforms might increase the chance to receive minimally invasive surgery for patients with MIBC.

This study has certain limitations. Firstly, it is based on a single case report, which limits the generalizability of the findings. Additionally, the follow-up period in this study short. Therefore, large-scale clinical trials are required to prove the clinical advantages of the hinotori system. Nevertheless, this study represents the first experience demonstrating the safe utilization of the hinotori system in RARC and ICUD.

Comparison with similar research

A study involving 1,094 patients who underwent RARC and ICUD using the da Vinci system reported a median operative time of 5 hours and 57 minutes, a median blood loss of 300 mL, a blood transfusions rate of 4%, and a complication rate of 57% (10). However, these results were mainly obtained from the high-volume institution specializing in RARC. We had experienced nine cases of RARC and ICUD with da Vinci before our first experience with hinotori. The mean operation time was 7 hours and 39 minutes, and the mean blood loss was 425 mL in those nine cases. These results were similar to those of the case presented herein. To make a meaningful comparison between different surgical robotic systems, there is a need for a sufficient accumulation of cases involving RARC and ICUD using hinotori.

Hugo RAS system (Medtronic, Minneapolis, MN, USA) is another novel robotic platform. Recently, the first case report of RARC using Hugo RAS was published (11). The console times of RARC without urinary diversion were 3 hours and 7 minutes and 2 hours and 57 minutes in their first and second cases, respectively. The authors concluded that RARC with the Hugo RAS system is feasible and may easily reproduce all standard steps of the surgical procedure using da Vinci.

Explanations of findings

Our findings suggest that RARC and ICUD using hinotori can achieve satisfactory outcomes in terms of safety and disease control for patients with MIBC. However, our study is a case report, and further evaluation through multi-center and large-scale prospective studies, comparing hinotori to da Vinci, is necessary. Currently, da Vinci has received approvals for various gastrointestinal surgeries, whereas hinotori has mainly been used in urologic surgeries with limited devices for gastrointestinal procedures as of 2022. For ICUD, the adaption of the hinotori port requires specific devices for intestinal auto-anastomosis. In fact, since the hinotori system does not have a stapling device for bowel anastomosis for robotic arms, we made additional port above the pubic bone to use the intestinal auto-anastomosis device for laparoscopic surgery. The development of new devices for intestinal auto-anastomosis will certainly facilitate the implementation of ICUD using

hinotori. Therefore, it is important to establish close collaboration between industrial robot engineers, medical device engineers, and surgeons involved in robotic surgery to improve novel surgical devices and procedures. Despite these considerations, we firmly believe that hinotori can be safely applied to RARC and ICUD, which are the most complex procedures in urologic surgery.

Implications and actions needed

Radical cystectomy with pelvic lymph node dissection is the standard treatment for patients with MIBC and very high-risk non-MIBC (12). The adoption of RARC in 2003 has led to a steady increase in its global adoption. RARC offers the potential to reduce complications, improve perioperative outcomes, and maintain oncologic efficacy (13-17). Several randomized controlled trials revealed that RARC with ECUD did not significantly improve complication rates compared to open radical cystectomy (18,19). The urinary reconstructive phase of the surgery is a major contributor to morbidity. In an effort to address these concerns, ICUD has been introduced with the aim of reducing complications, such as bowel occlusion, wound-related complications, and anastomotic stricture. While no randomized trials have directly compared ICUD and ECUD, a meta-analysis has indicated that ICUD can provide comparable complications and superior perioperative outcomes (3). We believe that the use of complete pneumoperitoneum and minimally invasive surgery in RARC can improve surgical outcomes for patients. The field of robotic surgery is actively growing with various novel robotic systems under development. The expiration of some of certain da Vinci patents has spurred the development of new robotic platforms with distinct technical refinements (1,6-9). We anticipate that the competition among these novel robotic platforms will ultimately enhance the outcomes of RARC and ICUD procedures.

Conclusions

We conducted RARC and ICUD using the newly developed hinotori surgical system for the first time, and the procedures were successfully executed as planned. While hinotori has already demonstrated its safety and efficacy in clinical practices like RARP and RAPN, the application of hinotori in RARC and ICUD requires careful consideration in daily practice. Further clinical experience and studies are necessary to evaluate the clinical efficacy of RARC and ICUD using hinotori.

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Footnote

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-23-991/coif). The series "Current Status of Robotic Surgery for Genitourinary Diseases in Japan" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committees and with the Helsinki Declaration (as revised in 2013). Written informed consent for publication of this case report and accompanying images was not obtained from the patient or the relatives after all possible attempts were made.

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