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DYNAMIC MANUSCRIPT

First clinical experiences of robotic gastrectomy for gastric cancer using the hinotori™ surgical robot system

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Abstract

Background Although the da Vinci™ Surgical System is the most predominantly used surgical robot worldwide, other surgical robots are being developed. The Japanese surgical robot hinotori™ Surgical Robot System was launched and approved for clinical use in Japan in November 2022. We performed the first robotic gastrectomy for gastric cancer using hinotori in the world. Here, we report our initial experience and evaluation of the feasibility and safety of robotic gastrectomy for gastric cancer using hinotori.

Methods A single-institution retrospective study was conducted. Between November 2022 and October 2023, 24 patients with gastric cancer underwent robotic gastrectomy with hinotori. Five ports, including one for an assistant, were placed in the upper abdomen, and gastric resection with standard lymphadenectomy and intracorporeal reconstruction were performed. The primary endpoint was the postoperative complication rate within 30 days after surgery. The secondary outcomes were surgical outcomes, including intraoperative adverse events, operative time, blood loss, and the number of dissected nodes.

Results Of the 24 patients, 16 (66.7%) were male. The median age and body mass index were 73.5 years and 22.9 kg/m^2, respectively. Twenty-three patients (95.8%) had tumors in the middle to lower stomach. Sixteen (66.7%) and seven (29.2%) patients had clinical stage I and II diseases, respectively. Twenty-three (95.8%) patients underwent distal gastrectomy. No patient had postoperative complications of Clavien–Dindo classification IIIa or higher, whereas two (8.3%) had the grade II complications (enteritis and pneumonia). No intraoperative adverse events, including conversion to other approaches, were observed. All patients received R0 resection. The median operative and console times were 400 and 305 min, respectively. The median blood loss was 14.5 mL, and the number of lymph nodes dissected was 51.5.

Conclusions This study found that robotic gastrectomy with standard lymphadenectomy for gastric cancer using hinotori can be safely performed.

Keywords Gastrectomy · Lymphadenectomy · Gastric Cancer · Robotic surgical procedure

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Abbreviations

RG	Robotic gastrectomy
da Vinci	da Vinci™ surgical system
RCTs	Randomized controlled trials
hinotori	hinotori™ surgical robot system
JGCA	Japan Gastric Cancer Association
JSES	Japanese Society of Endoscopic Surgery
C–D	Clavien–Dindo

Gastric cancer is a common cancer and a leading cause of cancer-related death [1]. Although the development of chemotherapy has increased the use of multidisciplinary treatment, including preoperative, postoperative, and perioperative treatments, R0 resection with lymphadenectomy is a mainstream curative treatment [2]. Minimally invasive surgery, including laparoscopic and robotic approaches, is becoming more common in the surgical treatment of gastric cancer due to advances in surgical technologies since the first robotic gastrectomy (RG) for gastric cancer was reported in 2003 [3]. The da Vinci™ Surgical System (da Vinci, Intuitive Surgical Inc. CA) is the most predominant surgical robot worldwide and features tremor reduction, articulated forceps, and a three-dimensional (3D) magnified scope, which can overcome the motion limit in conventional laparoscopy. In fact, several studies, including randomized controlled trials (RCTs), have proven the benefits of RG over conventional laparoscopic and open approaches. Based on this evidence, the Japanese government approved robotic surgery for three gastrointestinal cancers, including gastric cancer, under the national medical insurance coverage in 2018 [4]. Subsequently, robotic surgery has rapidly spread nationwide. However, as previously reported, one of the disadvantages of robotic surgery is its high cost, which has become a major problem because the number of robotic surgeries performed has increased [5]. The da Vinci has dominated the robotic surgery field since its launch in 1999, and another surgical robot has been expected to appear.

In 2020, a new Japanese surgical robot was launched, named the hinotori™ Surgical Robot System (hinotori). This made-in-Japan surgical robot was developed by Medicaroid Inc. (Kobe, Japan), which was established in 2013 as a joint venture between Kawasaki Heavy Industries, Ltd. (Tokyo, Japan) and Sysmex Corporation (Kobe, Japan). During the development of this system, “compactness,” “safety,” and “maneuverability” were emphasized. This system became the first robot-assisted surgery system created in Japan to gain Japanese regulatory approval in August 2020. In the urology field, the first human surgery using hinotori was successfully performed in December 2020 [6]. Gastrectomy using hinotori was approved by the Japanese government in November 2022.

We started RG using da Vinci in 2009 and have performed more than 800 RGs for gastric cancer. Furthermore, we reported that RG provided better surgical and comparable oncological outcomes than the conventional laparoscopic approach [7–10]. We introduced hinotori to our institution in 2020 and validated the gastrectomy procedure using hinotori in dry, cadaver, and animal models [11]. After its approval for clinical use in 2022, we performed the first RG for gastric cancer using hinotori in November 2022. This study aimed to evaluate the feasibility and safety of RG for gastric cancer using hinotori.

Methods

hinotori™ surgical robot system

Similar to da Vinci, hinotori consists of an operation unit with four arms and a surgeon cockpit (Fig. 1a, b). As points differing from the da Vinci, first, each robotic arm has eight axes that enable more flexible arm movement and reduce the interference between the arms and between the arm and the patient's body (Fig. 1c). Furthermore, the system monitors the distance between each arm, and an alarm is issued when potential interference occurs. Second, the software calibrates the fulcrum position of the trocar and instrument, which is named pivot position and similar to the remote center in da Vinci, without attaching the trocar and robotic arm (docking-free system) (Fig. 1d), which can provide a large space

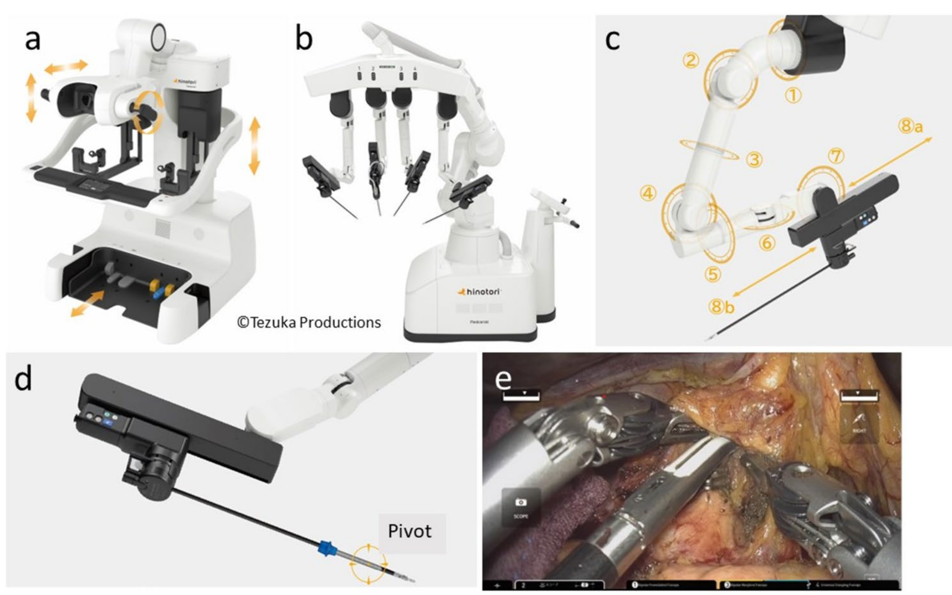

Fig. 1 The hinotori Surgical Robot System. A surgical cockpit in which a console surgeon can adjust the position of the viewer and foot pedals (**a**). An operation unit with four instruments, including a scope (**b**), four manipulating arms with eight axes without attaching the trocar (**c**, **d**). A 2 K 16:9 wide monitor (**e**)

around the trocars and prevent tissue damage to the abdominal wall by excessive traction. Third, the surgeon cockpit has a flexibly positioned 3D viewer that can reduce fatigue of the surgeon's neck and shoulder (Fig. 1a). Fourth, hinotori uses a 16:9 wide monitor, allowing a wider field of view at a time, whereas da Vinci uses a 4:3 monitor (Fig. 1e).

Patients

Demographic, clinicopathological, and treatment data were collected from the prospectively maintained surgical gastric cancer database and electronic medical records at our institution. Considering the safety of hinotori during the introductory phase, this study indicated hinotori for patients with clinical stage I or II gastric cancer for the first five cases, and patients receiving preoperative chemotherapy were considered contraindicated for hinotori. Between November 2nd, 2022, and October 5th, 2023, 111 patients with pathologically confirmed gastric cancer were indicated for surgical resection. They were evenly offered hinotori, other robotic approaches including da Vinci, conventional laparoscopic, or open approaches. Then, consecutive 24 patients who agreed to undergo surgery with hinotori were included in this study. Of the remaining 87 patients, 75 underwent other robotic gastrectomy. Clinical and pathological tumor depth (T stage), lymph node status (N stage), and TNM stage were classified according to the 6th edition of the Japan Gastric Cancer Association (JGCA) classification guidelines [2]. Our previous reports detailed the indications for physical function assessment, perioperative management, and postoperative chemotherapy, along with oncological follow-up [7]. Nine console surgeons (IU, KS, SS, MN, TT, KI, KS, AS, and YU) who experienced >30 robotic gastrectomies using da Vinci and were qualified by the Japanese Society of Endoscopic Surgery (JSES) endoscopic surgical skill qualification system, participated as a console surgeon in this study. Of the nine console surgeons (IU, KS, SS, MN, TT, KI, KS, AS, and YU), two surgeons who did not participate in the surgery independently assessed the extent of nodal dissection using a nonedited video. All patients were treated according to the Declaration of Helsinki, and this single-institutional, single-arm, retrospective cohort study was conducted after obtaining approval from the Fujita Health University Evaluating Committee for Highly Difficult New Technologies (approval number 22–06) and Institutional Review Board (approval number HM18-409).

Position and port placement

The layout of the operation room is shown in Fig. 2a. The patient was placed in the supine position with the legs apart, and the left arm extended, with a 10–15° head-up tilt. Five trocars, including one port for the assistant surgeon, were placed in the upper abdomen, and a pneumoperitoneum of 10 cmH2O was started (Fig. 2b, c). The operation unit was rolled in from the right side (Fig. 3a). Based on our experiences of da Vinci gastrectomy [7], the arm arrangement was set up to target the splenic hilum to prevent extracorporeal collision between the robotic arms (Fig. 2b). The arm base was tilted 8° to the head side. The left–right tilt of the arm base was matched to the left–right tilt of the operation bed to prevent full extension of the first and fourth robotic arms. After placing each port, the pivot was set using a pivoter (Fig. 3b). The distance between the pivots was displayed (Fig. 3c).

Devices and surgical procedures

Maryland Bipolar Forceps (Medicaroid Inc., Kobe, Japan) or Monopolar Curved Scissors (Medicaroid Inc., Kobe Japan), which were connected to an AUTOCON™ II 400 Electrosurgical Unit (KARL STORZ、Tuttlingen, Germany), and a universal grasp (Medicaroid Inc., Kobe, Japan) were used using the third and fourth arm of the robot, respectively, whereas Fenestrated Bipolar Forceps (Medicaroid Inc., Kobe, Japan) was used using the first arm of the robot (Fig. 4). The details of the surgical procedure have been previously reported [7, 12, 13]. In summary, the extent of gastrectomy and lymph node dissection was determined according to the JGCA treatment guidelines [2]. Lymph node dissection was performed using the outermost layer-oriented approach [12, 13]. For patients with cT1N0 diseases, D1 + lymph node dissection, including perigastric lymph nodes and those along the celiac trunk, left gastric, and common and proper hepatic arteries, were performed. For patients with $cT \geq 2$ N any diseases, D2 lymph node dissection, including lymph nodes along the proximal splenic artery and portal vein, in addition to D1 + lymph nodes, was performed (Fig. 5). Intracorporeal Billroth-I or Billroth-II anastomosis using linear staplers was performed following distal gastrectomy. Esophagogastrostomy was performed following proximal gastrectomy (Fig. 6). The console surgeons performed most procedures, excluding port placement and transection of stomach and duodenum, using linear staplers by the assistant surgeons. Because the vessel sealing system and suction-irrigation device are not available in hinotori, the assistant surgeons used LigaSure (Medtronic Inc, Minneapolis, MN, US) to divide thick tissue and vessels and laparoscopic suction-irrigation device (LAGIS Enterprise, Taichung, Taiwan).

Measurements and statistical analyses

All patients were observed for at least 30 days after surgery. The primary endpoint was postoperative complication rates within 30 days after surgery. The secondary endpoints

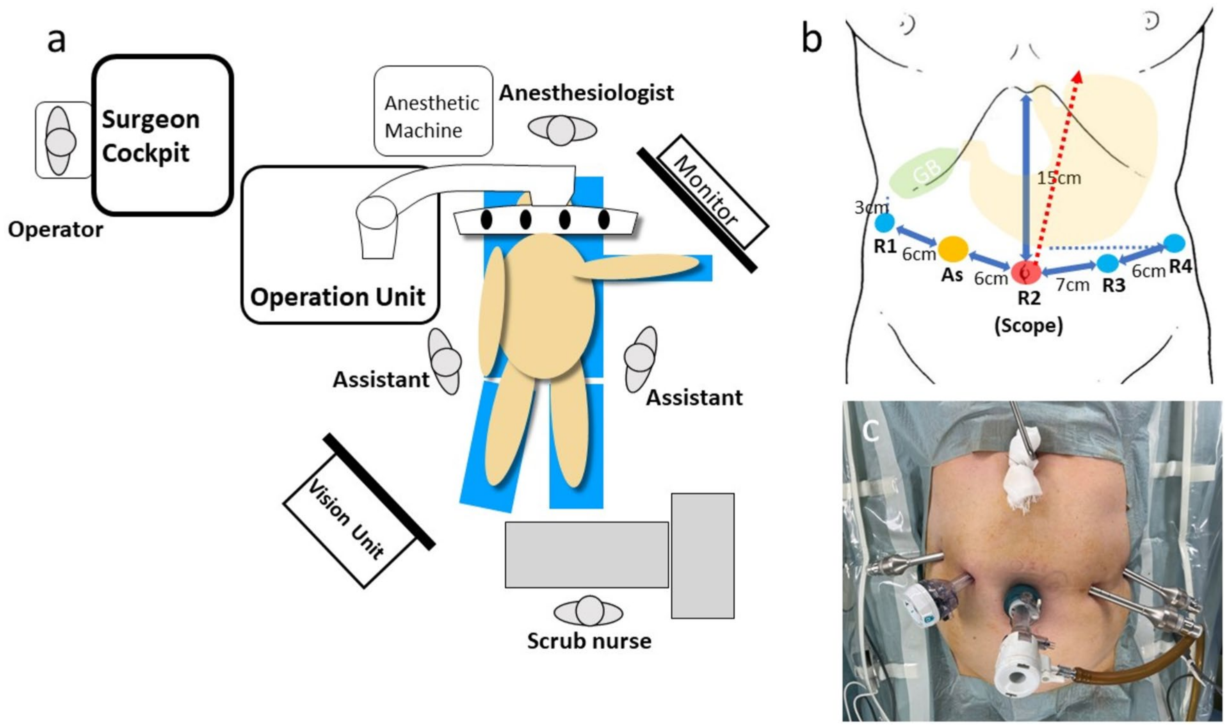

Fig. 2 Operation room equipment layout (**a**). Port placement (**b**). The 1st arm port (R1) was placed at the right abdomen and 3 cm caudal to the gallbladder. The fourth arm port (R4) The ports for robot arms (R1-4) were placed at the left abdomen, in line with the bottom line of the greater curvature. The assistant port (As) was placed between R1 and R2. The distances between each port are shown in the figure. The arm base was rotated toward the splenic hilum (red arrow). The view after port placement (**c**)

were short-term outcomes, including operative time, console time, blood loss, conversion to other approaches, the number of dissected nodes, and postoperative hospital stay. All grade II or higher postoperative complications classified according to the Clavien–Dindo (CD) classification [14] were recorded. The total operative time was defined as the duration from the start of abdominal incision to wound closure completion, and the console time was defined as the duration of the hinotori operation during surgery, including the time required to extract the resected specimen from the umbilical incision and to redock for the reconstruction. Blood loss was estimated by weighing suctioned blood and gauze pieces that had absorbed blood. Categorical variables are expressed as numbers and percentages. Continuous variables are expressed as medians and ranges. All analyses were performed using Statistical Package for the Social Sciences, version 28.0 (IBM Corp., Armonk, NY, USA).

Results

The clinicopathological characteristics of the patients are shown in Table 1. Of the 24 patients, 16 (66.7%) were male, and the median age and body mass index were 73.5 years (range, 48–88 years) and 22.9 kg/m^2 (range, 16.7–28.6 kg/m^2), respectively. Twenty-three (95.8%) patients had tumors in the middle to lower stomach. Sixteen (66.7%) and seven (29.2%) patients had clinical stage I and II diseases, respectively. The surgical outcomes are shown in Table 2. Of the 24 patients, 23 (95.8%) and nine (37.5%) underwent distal gastrectomy and D2 lymph node dissection, respectively. No intraoperative adverse events or conversion to other approaches were observed. The total operative and console times were 400 min (range, 281–515 min) and 305 min (range, 214–429 min), respectively. The median blood loss was 14.5 mL (range, 5–113 mL). Pathological and postoperative outcomes are shown in Table 3. Postoperative complications of any CD grade and CD grade II were observed in five (20.8%) and two (8.3%) patients, respectively. None of the patients had CD grade IIIa or higher complications. No reoperation or surgical mortality was observed. All patients underwent R0 resection. The median number of lymph nodes retrieved was 51.5 (range, 30–90), and the length of postoperative hospital stay was 11 days (range, 8–25 days). None of the patients were readmitted within 30 days after discharge. The video review confirmed the completion of scheduled gastrectomy with lymphadenectomy in all patients. The operation video is shown in Supplemental Video 1.

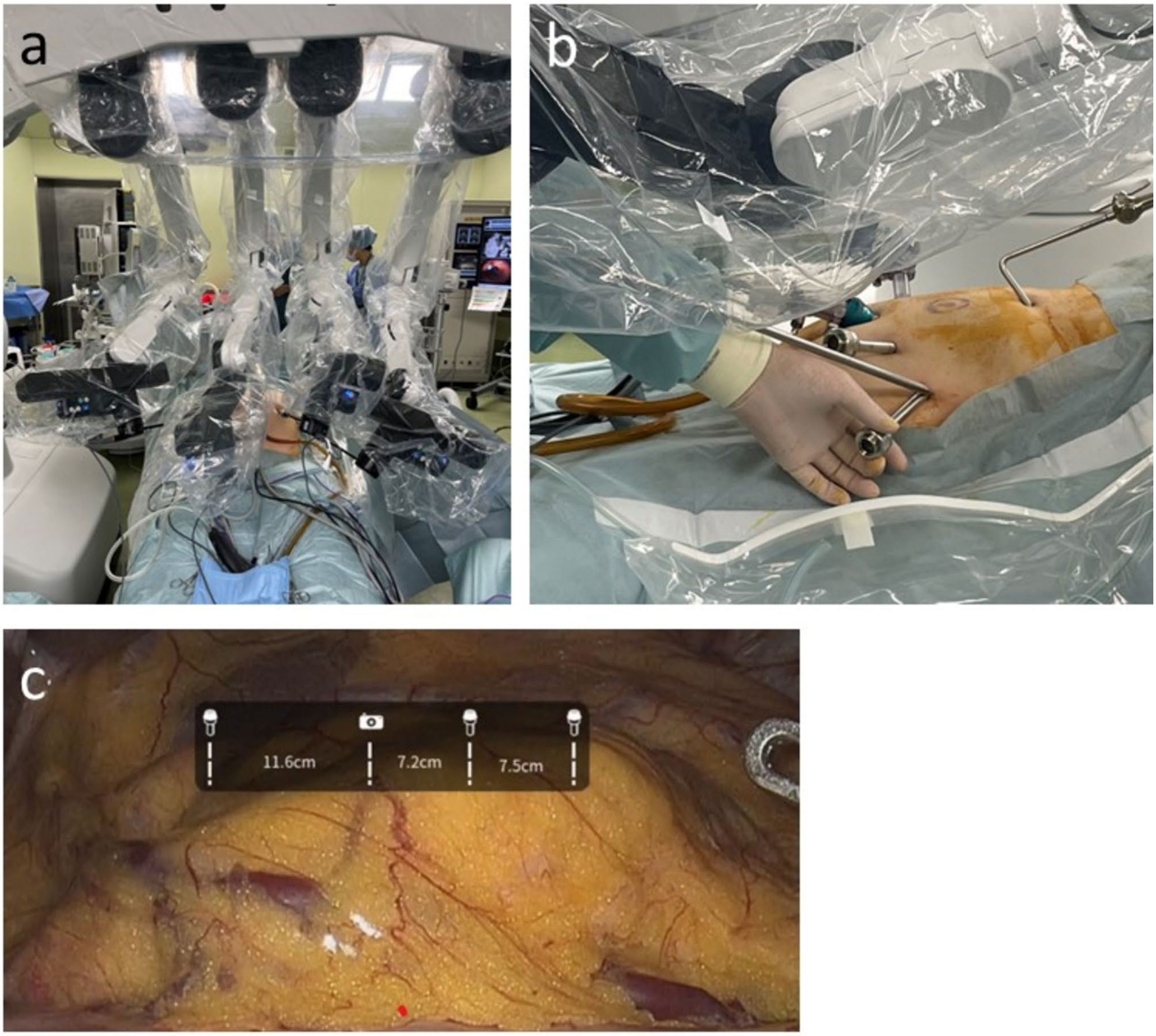

Fig. 3 The operation unit was rolled in (**a**). Pivoting using a pivoter (**b**). The distance between the pivots was displayed (**c**)

Discussion

This study found that RG with standard lymphadenectomy for gastric cancer using hinotori could be safely performed. To the best of our knowledge, this is the first study to report the clinical use of hinotori for gastric cancer surgery. No complications of CD grade IIIa or higher occurred in this study, whereas complications of CD grade II were observed in 8.3% of the patients. In RG using da Vinci for gastric cancer, the morbidity rates have been reported to range from 1.3 to 5.3% for CD grade IIIa or higher complications and from 8.8 to 9.2% for CD grade II or higher complications in several studies, including RCT and our previous studies [5, 15–19]. Furthermore, the operative time, blood loss, and number of dissected nodes in this study appeared to be similar to those reported in previous studies [15, 16]. Although this study excluded patients receiving neoadjuvant chemotherapy and patients with high advanced diseases, this study with at least comparable short-term outcomes demonstrated that RG for gastric cancer using hinotori could be safely introduced into clinical practice.

Although the basic structure of hinotori is similar to that of da Vinci in terms of the number of arms and how they are operated, hinotori is not equipped with an advanced energy device, such as a vessel sealing system and ultrasonic coagulating sears, as of October 2023 because hinotori was launched recently. Therefore, in this series, the assistant surgeons partially helped perform the

Fig. 4 Instruments available in hinotori

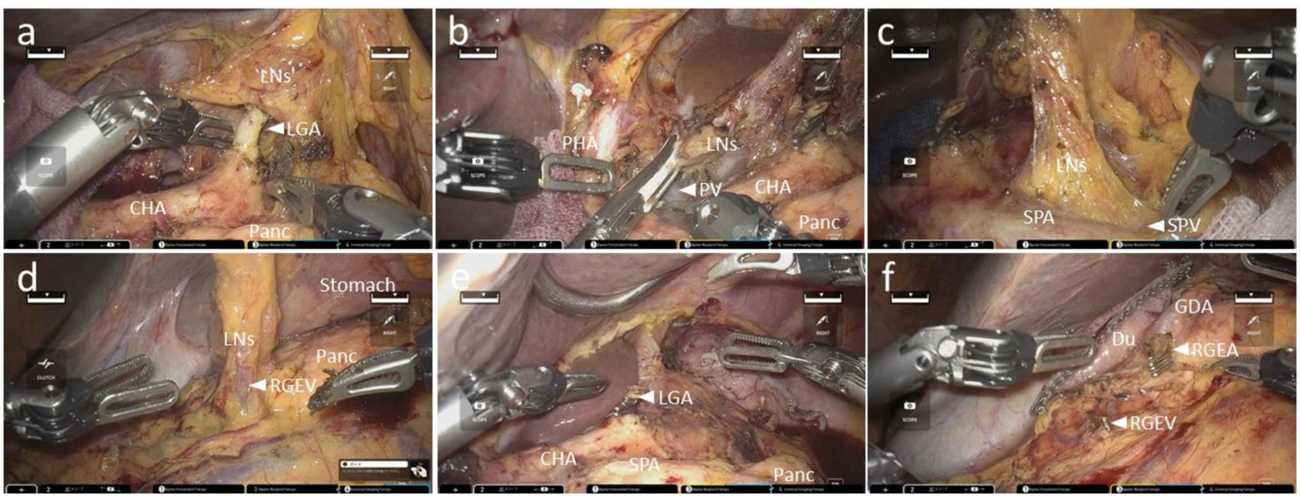

Fig. 5 D2 nodal dissection during distal gastrectomy. In the suprapancreatic lymph nodes (LNs) dissection, the left gastric artery (LGA) was divided at its root. **a**, the #8a LNs (anterosuperior LNs along the common hepatic artery (CHA)) and #12a LNs (hepatoduodenal ligament LNs along the proper hepatic artery (PHA)) were dissected. PV, portal vein; Panc, pancreas. **b**, the #11p LNs (Proximal splenic artery (SPA) LNs) and the left side of #9 LNs (Celiac artery LNs) were dissected. SPV, splenic vein (**c**), mobilization of the mesocolon and preparation of the infrapyloric LNs dissection, RGEV, right gastroepiploic vein (**d**), the final view after LNs dissection of the suprapancreatic area (**e**) and infrapyloric area, RGEV, right gastroepiploic vein (**f**)

procedures using a vessel sealing system to divide lymphatic and blood vessels, whereas we mainly used bipolar forceps as energy devices, as with the da Vinci procedure (double bipolar technique [7]). Such collaboration between console and assistant surgeons could save time exchanging robotic instruments. Therefore, the operative time might appear similar to that reported in previous publications, irrespective of the introductory nature of this study. Evaluating the benefits of such collaborative robotic surgery in hinotori by accumulating more cases is necessary. However, the assistant surgeon's forceps are linear, and their tremor cannot be reduced to zero. The assistant surgeon was also required to have a certain degree of minimally invasive surgical skill. A major advantage of surgical robots is that they overcome the limitations of forceps movement and hand tremors in conventional laparoscopic surgery. To maximize the benefits of surgical robots, developing at least vessel sealing devices for hinotori is urgently needed. In other fields, hinotori procedures have been rapidly expanding in Japan. Case reports of distal pancreatectomy for pancreatic cancer [20] and right hemicolectomy for colon cancer [21] and case series of six adrenectomies [22], 11 total hysterectomies [23], and 30 partial nephrectomies [24] have been published.

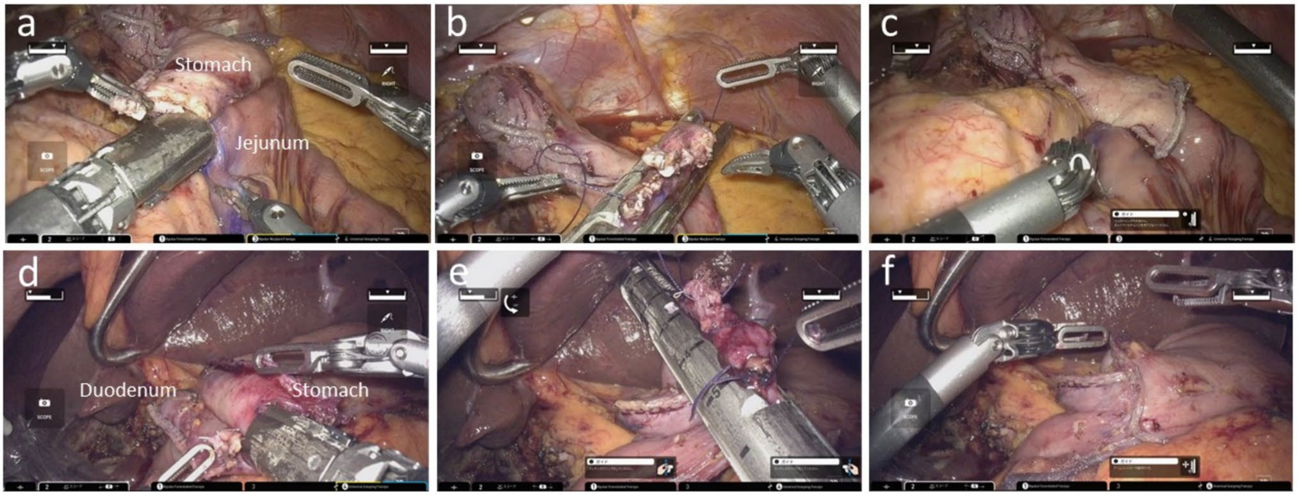

Fig. 6 Intracorporeal Billroth-II anastomosis (**a**–**c**) and Billroth-I anastomosis (**d**–**f**) using linear staplers

Table 1 Patients' demographic and clinical characteristics

Case	Age	Sex	BMI	ASA	Location	Histology	Differentiation	cTN stage	cStage
1	75	F	20.8	2	M	tub	Well	T3N−	IIB
2	60	F	19.6	2	M	por/sig	Poor	T1bN−	I
3	60	M	19.5	2	M	tub	Well	T2N−	I
4	63	M	17.1	2	M	por/sig	Poor	T1bN−	I
5	69	M	25.0	2	M	tub	Well	T1bN−	I
6	68	M	28.6	2	M	tub	Well	T1bN−	I
7	48	F	19.7	2	U	por	Mod	T2N−	I
8	65	M	27.6	2	M	tub	Mod	T1bN−	I
9	79	M	22.8	2	M	tub	Poor	T1bN−	I
10	63	M	24.5	2	M	por	Poor	T1bN−	I
11	88	M	23.3	2	M	por	Mod	T3N−	IIB
12	72	F	21.1	2	M	tub	Mod	T1bN−	I
13	81	M	20.4	2	M	por	Poor	T3N+	III
14	78	F	16.7	2	L	tub	Mod	T3N−	IIB
15	75	F	23.6	2	M	por/sig	Poor	T2N+	IIA
16	79	M	20.5	3	M	tub	Well	T1bN−	I
17	65	M	23.2	3	M	por	Poor	T1bN−	I
18	77	F	23.5	2	M	por	Poor	T3N−	IIB
19	64	M	25.2	1	L	tub	Well	T1bN−	I
20	83	M	22.2	1	M	tub	Mod	T1bN−	I
21	78	M	22.0	3	L	por	Poor	T3N−	IIB
22	85	F	23.9	2	L	tub	Mod	T1bN−	I
23	79	M	24.0	2	M	tub	Mod	T1bN−	I
24	71	M	23.0	2	M	tub	Mod	T3N−	IIB

ASA American Society of Anesthesiologists physical status; *M* male; *F* female, *U* upper stomach; *M* middle stomach; *L* lower stomach

Accumulating such clinical experiences will help Medicaroid update hinotori and develop new devices that will fully exploit the inherent advantages of the surgical robot—not only tremor reduction and instrument articulation but also collecting surgical intelligence, including operating surgeons' log information—when they appear in the near future [11].

Table 2 Surgical outcomes

Case	Operator	Type of gastrectomy	Lymphad-enectomy	Reconstruction	Operative time	Console time	Blood loss
1	1	Distal	D2	B-I	425	382	30
2	2	Distal	D1 +	B-I	303	215	5
3	2	Distal	D2	B-I	332	244	5
4	1	Distal	D1 +	B-II	354	232	6
5	3	Distal	D1 +	B-II	400	294	12
6	4	Distal	D1 +	B-II	508	334	86
7	2	Proximal	D2	Esophago-gastric	464	308	14
8	2	Distal	D1 +	B-I	444	342	113
9	3	Distal	D1 +	B-I	400	293	7
10	1	Distal	D1 +	B-I	295	245	35
11	4	Distal	D1 +	B-II	409	310	9
12	3	Distal	D1 +	B-II	300	214	15
13	4	Distal	D2	B-II	394	304	25
14	3	Distal	D2	B-I	315	228	7
15	1	Distal	D2	B-II	506	380	12
16	4	Distal	D1 +	B-II	406	305	28
17	5	Distal	D1 +	B-II	373	264	10
18	6	Distal	D2	B-I	460	355	11
19	6	Distal	D1 +	B-I	515	337	112
20	7	Distal	D1 +	B-II	395	292	16
21	3	Distal	D2	B-I	281	225	15
22	7	Distal	D1 +	B-I	449	357	5
23	8	Distal	D1 +	B-I	394	335	45
24	9	Distal	D2	B-II	478	429	53

B-I Billroth I; *B-II* Billroth II

In terms of the setting, based on our experience with da Vinci, we have reported the usefulness of "da Vinci's plane" theory and appropriate port-to-port distances to prevent extracorporeal collision between arms and the "monitor quadrisection" theory to prevent intracorporeal collision between instruments [7]. In the present study, we followed these theories and found no intraoperative collision or other adverse events, indicating that these theories are equally important in hinotori. Regarding the features of hinotori that differ from those of da Vinci, the docking-free system displays the distance between the set pivot points, allowing for intraoperative pivot adjustment, which was very useful in flexibly accommodating patients with various body shapes and establishing a highly reproducible setup. Furthermore, because the arm and port are not fixed, excessive force is not applied to the abdominal wall, which is expected to reduce the possibility of damage to the abdominal wall. On the other hand, this docking-free system requires caution in patients with high BMI. It is sometimes quite challenging to obtain a clear view during the suprapancreatic dissection in patients with high visceral fat. Unlike da Vinci, the scope trocar cannot be forcibly repositioned after docking in hinotori, so the scope trocar must be set strictly at 15 cm from the xiphoid process, regardless of the position of the umbilicus. In addition, in patients with high subcutaneous fat, the pivot setting on the body surface may require some modification, such as setting the pivot in the trocar, because the pivot set on the body surface and the point of fascial penetration, which is theoretically ideal, are misaligned. The 16:9 wide monitor provided a wide field of view, which helped understand the anatomy and prevent organ injury in the blind area. The arm with 8-axis joints and collision alarm function can help prevent arm collision and unexpected accidents caused by arm collision, which is a major concern in robotic surgery. In addition, the left–right tilt of the arm base parallel to the operation bed helped prevent full extension of the arms. Although these characteristics of hinotori were not compared with those of da Vinci in detail in this study, the usefulness of this surgical robot system is expected to be demonstrated by accumulating more cases in the future.

The hinotori has several issues to be resolved or developed. First, the docking-free system makes the instrument tip less stable than the da Vinci. An update of the software is needed. Second, the collision alarm may help prevent

Table 3 Pathological and postoperative findings

Case	Dissected lymph nodes	pTN stage	pStage	Hospital stay	Postoperative complications (CD grade)
1	54	T3N2	IIIA	25	Delayed gastric empty (I)
2	84	T1bN0	IA	10	None
3	85	T1aN0	IA	14	None
4	53	T1aN0	IA	11	None
5	32	T1bN0	IA	18	Delayed gastric empty (I)
6	32	T1aN0	IA	10	None
7	43	T4aN0	IIB	18	Lymphorrhea (I)
8	48	T1bN0	IA	10	None
9	30	T1bN0	IA	10	None
10	62	T1bN1	IB	11	None
11	45	T3N0	IIA	21	Enteritis (II)
12	58	T1aN0	IA	14	None
13	57	T3N1	IIB	10	None
14	54	T4aN3a	IIIB	8	None
15	90	T1bN0	IA	11	None
16	47	T1aN0	IA	11	None
17	31	T3N1	IIB	8	None
18	61	T1bN0	IA	11	None
19	38	T1bN0	IA	9	None
20	30	T1bN2	IIA	10	None
21	46	T3N3a	IIIB	19	Pneumonia (II)
22	60	T1bN1	IB	10	None
23	50	T1bN0	IA	10	None
24	69	T4aN1	IIIA	12	None

serious accidents, but it also detects minor collisions that the surgeon can anticipate, and the arm automatically is forced to stop. The system may make the operation smoother by detecting the degree of collision and informing the console surgeon of its risk. Third, one of the features of hinotori is remote surgery. In a preclinical study, we performed gastrectomy in an animal model between two sites approximately 30 km apart using fiber-optic lines and hinotori. And we operate with sufficient quality under a delay of about 30 ms [11]. Although guidelines need to be developed, hinotori may be useful for implementing a telesurgery platform with further improvements.

Before we performed the first case of RG for gastric cancer in this study, hinotori had only been used in prostate surgery [6]. Because there is no precedent for upper abdominal surgery, fully validating the setting and detailed procedures in dry, animal, and cadaver models would be useful [11]. The JSES has established guidelines for the safe introduction of new surgical robots and is constantly revising these guidelines. The JSES certifies RG proctors with the JSES Endoscopic Surgical Skill Qualification [25] and experience of 40 RGs. When a new robot is ready for clinical use in RG, (1) the JSES certifies a few first surgeons from the existing proctors according to a manufacturer's recommendation. (2) The first surgeons gain experience and become certified RG proctors for the new robot. (3) The RG proctors for the new robot support surgeons at other institutions (second surgeons) to start using it. Various new surgical robots have recently been introduced [26, 27]. Developing guidelines and recommendations led by each society was important for the safe introduction and spread of new surgical robots. While these regulations may assure the safe introduction of new robots, they also deprive young surgeons of the opportunity to start robotic surgery, and it is desirable to evaluate and improve whether the current safety attention is not too much.

This study had several limitations. This was a single-institution case series with a small sample size. Furthermore, almost all patients in this study had clinical stage I/II diseases. They underwent distal gastrectomy, and patients receiving preoperative chemotherapy were contraindicated for hinotori during the study period. Accumulation of clinical series with advanced diseases and further investigations are required to determine the safety and feasibility of RG with hinotori from both surgical and oncological standpoints. In terms of indication of hinotori or da Vinci for robotic gastrectomy, although this study showed that hinotori could be safely applied in RG for clinical stage I/II gastric cancer, da Vinci, which has a much longer history and more clinical experiences, maybe more widely applied in RG for gastric cancer at present. However, as mentioned above, it is expected that hinotori will be applied as widely as da Vinci to various patients with gastric cancer as advanced energy device is developed and clinical experience accumulates. Also, this study didn't investigate the cost because it is a single-arm study in the introductory phase. The high cost of robot-assisted surgery is an important issue [5]. At present, the price of the hinotori system is lower than that of da Vinci (210 million vs. 270 million Japanese Yen), whereas running costs such as instruments and maintenance are considered to be at least equivalent. The widespread use of hinotori is expected to lead to price competition and a reduction in the overall cost of robotic surgery.

Conclusions

This study found that robotic gastrectomy with standard lymphadenectomy for gastric cancer using hinotori can be safely performed.

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Declarations

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