A new approach for achieving successful introduction of robotic sleeve gastrectomy

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Short Report

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Abstract

Purpose The use of robotic surgery has increased exponentially worldwide, as robots have versatile functions that can amplify the surgeon's skill. At the same time, reports of robotic approach for bariatric surgery are increasing. However, a common problem with the introduction of novel surgeries is a prolonged operation time. Therefore, an innovative approach should be developed prior to the introduction of a novel surgery to ensure patient safety.

Method This article describes robotic sleeve gastrectomy using the stapling-first technique in accordance with our newly revised task protocol, and evaluates the preliminary clinical results of robotic sleeve gastrectomy performed by a single surgeon between June 2021 and December 2022.

Results The cohort comprised 10 patients with a median body mass index of 40.3 (range, 38.1–45.8) kg/m². The median operation time was 230 (range, 178–281) minutes and median console operation time was 164 (range, 119–204) minutes. The median time for each surgical phase was 72 (range, 39–86) minutes for stomach stapling, 46 (range, 34–66) minutes for suturing the staple line, and 36 (range, 24–48) minutes for stomach dissection. The median blood loss was 15 (range, 5–78) g. Our task protocol was accomplished in all patients and only case 1 was converted to laparoscopic sleeve gastrectomy. No patients experienced postoperative complications or gastroesophageal reflux.

Conclusion Robotic sleeve gastrectomy using the stapling-first technique was safely performed in the introductory phase by following the task protocol.

Introduction

More than 5500 da Vinci® Surgical Systems (Intuitive Surgical Inc., Sunnyvale, CA, USA) were installed worldwide in 2020, and this system is currently used to perform nearly 1.25 million surgeries annually.¹ Robotic surgery has the potential to overcome the disadvantages of conventional laparoscopic surgery through the use of wristed instruments, tremor filtering, and high-resolution 3D images.² There are increasing reports of robotic surgery being used for sleeve gastrectomy (RSG) and Roux-en-Y gastric bypass for patients with severe obesity worldwide.³⁴ Recently, RSG has been performed more frequently than Roux-en-Y gastric bypass in robotic bariatric surgery.⁵ In Japan, laparoscopic sleeve gastrectomy (LSG) has been approved by the public health insurance system and is being increasingly performed,⁶⁷ while RSG has not yet been approved. We perform LSG using the “stapling-first” technique (SF technique) in which the greater curvature is devascularized after stapling.⁸⁹ This technique is also used in RSG. However, the safe introduction and optimized surgical procedure of RSG have not yet been established and there is no consensus on the criteria for operating surgeons. Therefore, we implemented a task protocol to ensure patient safety in the introductory phase of RSG. This article includes a technical description of RSG using the SF technique and an evaluation of the preliminary surgical outcomes.

Patients And Methods
In June 2021, we introduced RSG as a treatment option after obtaining approval from the Ethical Committee of Aichi Medical University Hospital (AMU). We evaluated consecutive patients who underwent RSG using the SF technique from June 2021 to December 2022. The main surgeon for RSG in our department was a practicing doctor at a Center of Excellence in Bariatric Surgery (established by the Japanese Society for Treatment of Obesity) who routinely performed robotic gastrectomy and robotic transabdominal preperitoneal hernia repair and was certified as a proctor by the Japan Society for Endoscopic Surgery. The patients’ demographics, clinical characteristics, intraoperative data (console time, total operative time, and blood loss), and 30-day postoperative outcomes (overall complications, length of stay, and readmission) were reviewed. Postoperative complications comprised reoperation due to bleeding, surgical site infection, staple line leakage, gastroesophageal reflux, small bowel obstruction, ileus, persistent severe pain, and intra-abdominal abscess. All patients provided written informed consent before undergoing surgery. This study was approved by the Institutional Review Board of our institution (approval no. 2021-11) and was performed in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

**Task Protocol**

We reviewed 30 consecutive patients with severe obesity who underwent LSG with no operative complications between September 2018 and December 2020, corresponding to our introductory phase of LSG. Based on the LSG procedure, we developed a practical descriptive task protocol (AMU protocol) for RSG (Fig. 1a). The surgical workflow of RSG was divided into three phases: stapling, suturing, and dissecting. The operation time and maximum times (93 minutes in stapling, 72 minutes in suturing, 61 minutes in dissecting) taken to complete the three phases in LSG were set as the time limits for RSG; if a time limit was exceeded or estimated to be exceeded, RSG was converted to LSG. Specific time limits were 90 minutes from the start of opening the window to the end of the stomach resection (stapling phase), 70 minutes from the freeing the crus to imbrication of the staple line with running suture (suturing phase), and 60 minutes from stomach resection with dissection of the greater omentum to gastric sleeve fixation (dissecting phase). After discharging each patient, we created a report describing the patient’s summary profile from admission to discharge, including the surgical record, and sent this report to the Medical Safety Management office of the AMU.

**Set-up**

Under general anesthesia, the patient was placed in the reverse Trendelenburg position with open legs and carefully strapped to the operating table. An 8-mm robotic port was inserted through the umbilicus to establish pneumoperitoneum. Robotic ports (three 8-mm ports and a 12-mm assistant port) were placed in the mid-abdomen (Fig. 1b). The Xi DaVinci robot (Intuitive Surgical Inc.) was docked to the patient. A 30° rigid dual-channel endoscope was attached to the second arm. Cadiere forceps, fenestrated bipolar forceps, and bipolar Maryland forceps or SynchroSeal (Intuitive Surgical Inc.) were attached to the first, third, and fourth arms. Maryland bipolar forceps were connected to a VIO 300D electrosurgical generator.
(Erbe USA Inc., Marietta, GA, USA) in forced coagulation mode.\textsuperscript{10} The instrument attached to the third arm was replaced with a Large Suture Cut Needle Driver (Intuitive Surgical Inc.) for staple line reinforcement.

**Prior To Resection**

A 34 French gastric calibration tube was inserted and used as a guide to mark the resection line from 5 cm proximal to the pylorus to the fat pad at the angle of His (Fig. 2a). To ensure a completely uneventful introduction of the first stapler firing, the greater omentum was dissected to open a window close to the greater curvature around the marked point on the pyloric side (Fig. 2b), and the posterior gastric adhesions were divided. Next, the fat pad that covers the angle of His and surrounds the esophageal–gastric transition was resected (Fig. 2c). A piece of gauze was inserted into the space between the left crus, abdominal esophagus, and fundus as an important landmark for the final stomach resection (Fig. 2d). An articulating stapler with pre-attached synthetic tissue reinforcement (Powered ECHELON FLEX GST 60, ENDOPATH™ Staple Line Reinforcement; Ethicon Inc., Somerville, NJ, USA) was fired along the resection line of the stomach through the assistant port. Before each staple was fired, the console surgeon appropriately divided the posterior gastric adhesion to the pancreas while applying traction on the stomach with the help of an assistant and the fourth arm. A reduced stomach area (gastric sleeve) was created by firing staples sequentially along the resection line while using the weight of the greater omentum to ensure that the stomach was appropriately oriented (Fig. 3a). Four types of cartridges (black, green, gold, and blue; Ethicon Inc.) were selected based on the thickness of the gastric wall. Additionally, careful attention was paid to avoid entrapping the 34 French gastric calibration tube and retroperitoneal tissue (including the pancreas) during stapler firing. As we proceeded toward the fundus of the stomach, we divided the retrogastric adhesions so that the entire fundus could be removed (Fig. 3b), and identified the gauze inserted as a landmark of the fat pad to be removed from the posterior wall of the stomach. The gauze was extracted and the stomach was resected without tension, maintaining a distance of 1 cm from the gastroesophageal junction. These procedures are demonstrated in Video S1, S2.

**Staple Line Imbrication**

A sleeve-shaped gastric remnant was entirely freed from the left crus. Any remaining posterior adhesions of the gastric sleeve were divided. The staple line was imbricated with running suture using 3 – 0 V-Loc\textsuperscript{TM} (1/2 circle needle; Medtronic, Minneapolis, MN, USA) while the 34 French gastric tube was kept in place. During the imbrication of the staple line, the gastric sleeve was adjusted as needed to ensure that the size was appropriate (Fig. 3c).

**Stomach Resection**

After imbrication of the staple line, the greater omentum was dissected off the stomach along the greater curvature (Fig. 3d). The greater curve was devascularized and the gastrosplenic ligament was carefully
dissected. The posterior gastric artery and short gastric artery were also dissected. Gastroscopy was performed to rule out any leakage, bleeding, or obstruction. The gastric sleeve was fixed to the retroperitoneum or greater omentum. The dissected stomach was removed from the umbilicus, and a subhepatic drain was inserted. These procedures are demonstrated in Video S3, S4.

Results

Between September 2018 and December 2022, 70 patients underwent bariatric surgery in our department. Of these, 57 patients underwent LSG (81.4%), three underwent revision surgery (4.3%), and 10 (14.3%) underwent RSG. Table 1 shows the demographics, operative details, perioperative complications, and outcomes. The characteristics of the RSG group are summarized in Supplemental Table S1. The obesity treatment team at our hospital reached a consensus regarding the need for surgery for all patients. The perioperative variables are summarized in Supplemental Table S2. The results of this case series were analyzed regardless of any deviations from the AMU protocol. No patients experienced postoperative complications or gastroesophageal reflux classified as Clavien-Dindo grade 3 or above.11 No patient was readmitted to hospital within 30 days postoperatively.

All patients who were started with RSG using the SF technique had their surgery completed within the time limit specified in the AMU protocol. In nine of 10 (90%) patients, RSG using the SF technique was achieved in compliance with AMU protocol. Case 1 required conversion to LSG because the time was predicted to exceed the specified limit. Although the operating surgeon was familiar with conventional robotic surgery and completed the stapling phase within the time limit, the surgery was converted to the laparoscopic approach at 39 minutes after the start of the suturing phase.

Discussion

Creating a task protocol for the safe introduction of RSG is an innovative approach to optimize the surgical flow. The task protocol limits the prolongation of the operation time due to a lack of technical skills and surgical efficiency, which are serious problems in the introduction of a novel surgery. In general, obesity is associated with a prolonged operation time and an increased risk of complications.12 A longer operative time is considered to adversely affect the surgical outcome.13 As there are no surgeons in Japan qualified to supervise RSG, we implemented AMU protocol to avoid prolonging the operation time. This is a new strategy to ensure patient safety when introducing a novel surgery. We published reports on the application of a task protocol to robotic transabdominal preperitoneal repair for inguinal hernia that is not approved by the Japanese public health insurance system.2,14,15 We adapted this method to develop a task protocol for RSG that included time limits and conversion to LSG. RSG was performed in accordance with AMU protocol in 90% of patients, while one patient was converted to LSG because a lack of experience in forceps manipulation in the first RGS meant that the time limit for the suturing phase was estimated to be exceeded; however, the RSG might have been able to be accomplished with robotic
assistance. We consider this case series as a feasibility study for the safe introduction of RSG, and is potentially informative for bariatric surgery.

To our knowledge, this case series is the first to describe the surgical procedure of RSG using the SF technique reported by Dapri et al.\textsuperscript{8,9} The potential benefits of RSG using the SF technique are:

1. The EndoWrist\textsuperscript{®} function allows for smooth surgical procedures even under adverse conditions with poor working space due to large amount of visceral fat and/or forceps limitation due to a thick abdominal wall.\textsuperscript{16}

2. Remote center technology minimizes port-site movement and trauma at the incision site. This function may be beneficial in reducing surgical site infection in patients with severe obesity with a thick abdominal wall.\textsuperscript{17}

3. The weight of the greater omentum can be used to align the staples to the stomach, independent of the traction provided by the assistant; therefore, this technique is well suited to RSG, which is often a solo surgery

4. After the creation of a gastric sleeve, the greater curvature is devascularized and the gastrosplenic ligament is dissected; therefore, the fourth arm allows the operating surgeon to adjust the tension, which reduces the risk of bleeding.

Our study has several limitations. First, patient recruitment for RSG may be difficult, as patients or hospitals must pay the high costs of RSG in Japan. Second, few reports have evaluated the clinical efficacy of robotic approaches in the surgical treatment of severe obesity.\textsuperscript{18,19} However, surgical robotic technology is constantly evolving, having the potential to become a useful tool in bariatric surgery in the near future.

In conclusion, RSG using the SF technique, a promising alternative approach, was safely introduced by adhering to the task protocol. The implementation of a task protocol is an effective strategy for the safe introduction of a novel surgery.

**Declarations**

**Ethical approval** The protocol for this research project was approved by the Ethics Committee of our institution. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The AMU Ethics Committee and Medical Safety Management Office approved this study (approval no. 2021-011).

**Consent to participate** All patients provided signed informed consent before surgery. Identity of the patient has not been revealed. This article does not contain any studies with animals performed by any of the authors.
Consent for publication All authors have provided consent for the article to be published in Langenbeck's Archives of Surgery.

Conflict of interest The authors declare no competing interests.

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Author Contribution TS designed the study and wrote the initial draft of the article. TS contributed to data interpretation and critical revision of the article for important intellectual content. All other authors (YF, SK, and KK) contributed to the data collection and interpretation and critically reviewed the article. All authors have read and approved the final version of the article and have agreed to be accountable for all aspects of the study, ensuring that any questions related to the accuracy or integrity of any part of the work are resolved.

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Data availability Data is available on request from the corresponding author.

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1. https://isrg.intuitive.com/static-files/80b10bf5-c1da-4ad3-bb0e-8c595e2c712c.


Figure 1

(a) The practical descriptive task protocol (AMU protocol). The times required for each surgical phase are recordable and enable easy decision-making regarding the transition to the next step during robotic sleeve gastrectomy.

(b) The camera is inserted in port #2. Ports #1 and #3 are working ports, while #4 is the assistant port. All robotic ports are 8 mm. A 12-mm port to accommodate the stapler is placed for assistance. A Nathanson
liver retractor (Cook Inc., Bloomington, IN, USA) is placed in the upper abdomen for retraction of the left liver.

Figure 2

Preparation for sleeve gastrectomy with both hands. (a) A line is marked from 5 cm proximal to the pylorus to the fat pad at the angle of His. (b) The greater omentum is dissected to open a window. (c) The fat pad is resected. (d) A piece of gauze is inserted.
Figure 3

Initiation of gastric resection and completion of sleeve gastrectomy. (a) Sequential staples are fired along the resection line, using the weight of the greater omentum to maintain the appropriate stomach orientation. (b) Adhesions in the posterior portion of the stomach are divided. (c) The staple line is imbricated with running suture, and the gastric sleeve is adjusted to the appropriate size. (d) The greater omentum is dissected off the stomach along the greater curvature.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TABLE1.pptx
- SupplementalTable1.pptx
- SupplementalTable2.pptx
- SupplementalvideoS1.wmv
• SupplementalvideoS2.wmv
• SupplementalvideoS3.wmv
• SupplementalvideoS4.wmv