The First Robotic Bariatric Surgery Performed in Thailand – Surgical Techniques and Review of the Literature

Voraboot Taweerutchana, M.D.*, Tharathorn Suwatthanarak, M.D.*, Nicha Srisuworanan, M.D.*, Nicole Christienne Rich, M.D., MPH**

**Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand, **University of California, San Francisco, USA.*

ABSTRACT

Morbid obesity is associated with multiple life-threatening comorbidities. Bariatric surgery is the most effective intervention to achieve the long-term weight loss required to reverse many of these comorbid conditions. Laparoscopic bariatric surgery is the current gold standard approach; however the robotic approach has potential intraoperative and postoperative advantages that may be realized if limitations to instrument torque effect are overcome. We review the literature about the robotic bariatric surgery and describe our first robotic sleeve gastrectomy (RSG) and a single docking operative approach to robotic Roux-en-Y gastric bypass (RRYGB) in Siriraj Hospital, and also the first in Thailand. We demonstrate the operative room setup, the port sites, the technical details, and the key step illustrations, that both operative procedures were performed using the da Vinci® Si platform. According to the literature review, a robotic approach to bariatric surgery is an alternative option with comparable outcomes to laparoscopic approach and the potential for intraoperative and postoperative advantages. It is safe, feasible, and provides good clinical outcomes that are comparable to a conventional laparoscopic method.

Keywords: Bariatric surgery; robotic bariatric surgery; robotic Roux-en-Y gastric bypass; robotic sleeve gastrectomy; robotic surgery (Siriraj Med J 2020; 72: 181-187)

INTRODUCTION

Morbid obesity has become a serious worldwide health issue because it is associated with multiple life-threatening comorbidities. Bariatric surgery is considered to be the most effective strategy to achieve long-term and sustained meaningful weight loss for obese patients with very low postoperative morbidity and mortality. Although conventional laparoscopy is the current gold standard for almost all bariatric procedures, there are some limitations of the laparoscopic approach, especially in super morbidly obese patients. Laparoscopic procedures in the super morbidly obese can be physically challenging for the surgeon and for the equipment due to limited torque effect of instruments in patients with hepatomegaly, increased intraabdominal fat, and extremely thick abdominal walls.[1-3]

Robotic surgical systems were introduced in 1997 to overcome the disadvantages of a traditional laparoscopic approach. The application of robotic surgery has increased significantly in the field of general surgery and has become

Corresponding Author: Tharathorn Suwatthanarak
E-mail: bankythara@gmail.com
Received 21 October 2019 Revised 11 December 2019 Accepted 16 December 2019
ORCID ID: http://orcid.org/0000-0002-5409-284X
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more popular in bariatric procedures. The advantages of using robotic systems include better surgeon's ergonomics, a magnified 3D imaging system from the very stable camera controlled by surgeon, the articulated robotic wrists that increase degrees of movement degree in enclosed spaces, and precision in tissue manipulation with tremor filtration for the surgeon. Potential benefits to our patients include safer procedures, less complications, less pain, and faster recovery, while the other benefits of minimally-invasive surgery are preserved. Horgan and Vanuno described the first Roux-en-Y gastric bypass (RYGB) performing by the robotic system in 2001, and Mohr and team reported the technique of a totally robotic RYGB with a single docking position in 2005.[1,3-7]

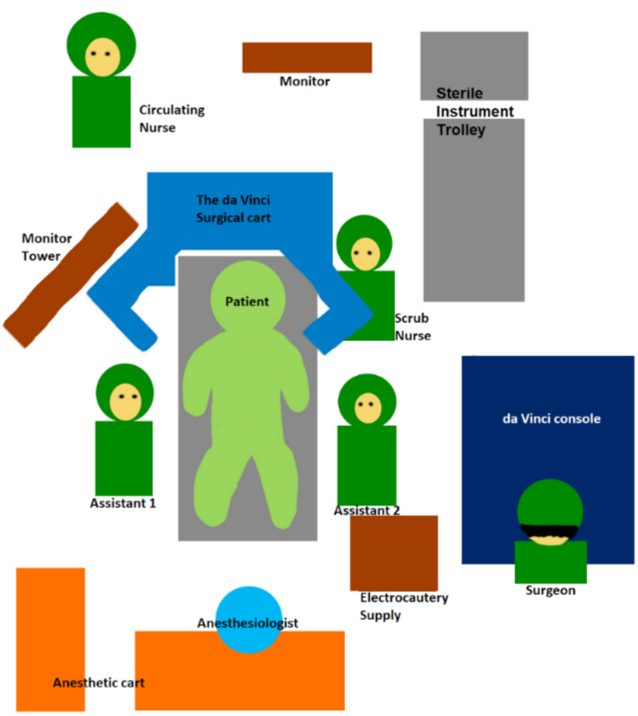

Fig 1. Operating room set up for robotic bariatric procedures.

In this manuscript, we describe our initial experiences with a robotic approach to bariatric surgery at Siriraj Hospital, Bangkok, Thailand. We present our step-by-step single docking robotic approach to operate sleeve gastrectomy and Roux-en-Y gastric bypass by the da Vinci® Si robotic system (Intuitive Surgical, Sunnyvale, CA, USA).

The Surgical Techniques of Robotic Sleeve Gastrectomy (RSG):

The patient was positioned supine with both arms adduction. A 36-French orogastric tube was placed. A Veress needle was used to enter the abdomen at Palmer's point and the abdomen was insufflated with carbon dioxide gas to 15-18 mmHg. A 12-mm camera port was placed 18 cm inferior to the xiphoid and 4 cm to the left of midline using an Optiview trocar and a 10-mm zero-degree laparoscope in visual entry fashion. After entry, this was exchanged for a 30-degree laparoscope. Under direct visualization, the Veress needle was removed after confirming no injury was sustained upon insufflation. Additional 8-mm ports were placed 2 cm below the right costal margin in the midclavicular line, and 2 cm below the left costal margin in the anterior axillary line. Finally, a 15-mm laparoscopic assistant's port was placed 18 cm inferior to the xiphoid and 2 cm to the right of midline. Another small stab incision was made in the epigastric area, 1 cm right of midline, then the strong arm Nathanson liver retractor was advanced through this incision to elevate the left hepatic lobe so that the inferior phrenic vein was clearly identified. The patient was set in reverse Trendelenburg position. Two working arms of the da Vinci® Si system were docked to the 8-mm port sites, and an additional arm was docked to the 12-mm camera port. The robotic Harmonic shears were used to divide

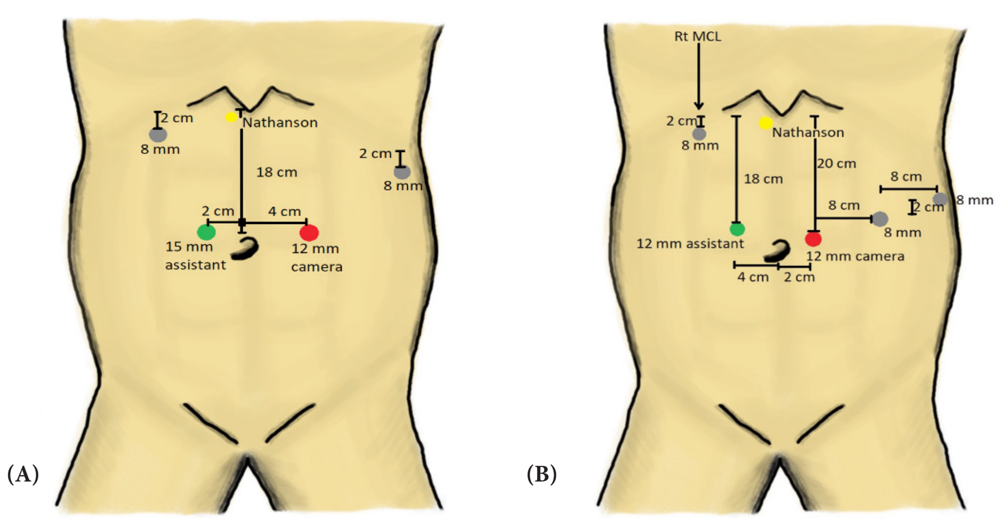

Fig 2. **(A)** Port placement for robotic sleeve gastrectomy **(B)** Port placement for robotic RYGB

the greater omentum from the gastric greater curvature, from 6 cm proximal to the pyloric ring to the angle of His. The short gastric arteries were also ligated with Harmonic shears, double-shot technique, during dissection.

Using the OG tube as a guide, the robotic hook cautery was used to mark the planned line of resection. The iDrive™ Stapling System (Medtronic, Dublin, Ireland) was then introduced via the laparoscopic assistant's port, and using multiple fires of 60-mm iDrive™ black and purple cartridges, the gastric greater curvature was stapled off. The posterior wall of the gastric tube was secured to the posterior fat pad with interrupted 2-0 Ti-Cron stitches (Medtronic, Minneapolis, USA).

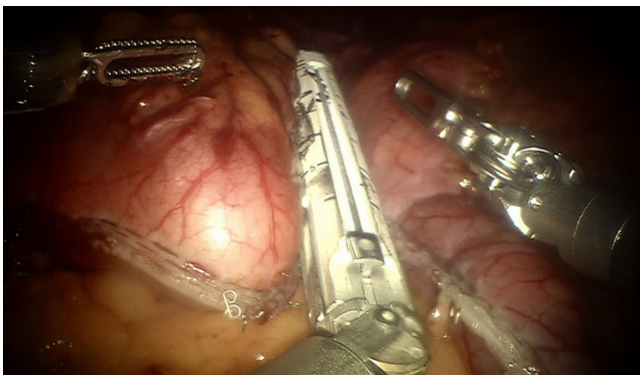

Fig 3. Gastric division by autostapler via assistant port.

Hemostasis was checked then the resected stomach was removed using an EndoBag (Medtronic, Dublin, Ireland) via the 15-mm port incision. The 12 and 15-mm port sites were closed using 1-0 Vicryl suture on a suture passer. All ports were removed, the robotic system was undocked, and the skin was closed in standard fashion.

The Surgical Techniques of Robotic Roux-En-Y Gastric Bypass (RRYGB):

The patient was positioned supine with both arms tucked. A 36-French orogastric tube was placed. A Veress needle was used to enter the abdomen at Palmer's point and the abdomen was insufflated with carbon dioxide gas to 15-18 mmHg. A 12-mm camera port was placed 20 cm inferior to the xiphoid and 2 cm to the left of midline using an Optiview trocar and a 10-mm zero-degree laparoscope in visual entry fashion. The camera was exchanged for a 30-degree laparoscope, the Veress needle was removed, then two additional 8-mm working ports were placed to the left of the camera port; the first with 8 cm of lateral clearance and approximately 2 cm superior to the camera port, the second at 8 cm lateral to and 2 cm superior to the former 8-mm port. An additional 8-mm working port was placed in the right upper quadrant, 2 cm below right costal margin in midclavicular line, and then a 12-mm laparoscopic assistant's port was placed 18 cm inferior to the xiphoid and 4 cm to the right of midline.

Another small stab incision was made in the epigastric area, 1 cm right of midline, and the strong arm Nathanson liver retractor was advanced through this incision to elevate the left hepatic lobe so that the inferior phrenic vein was clearly identified. Using a laparoscopic Harmonic scalpel, the greater omentum was split in a left paramedian plane to 1 cm away from the transverse colon. While the assistant retracted the mesocolon caudally, the Ligament of Treitz was identified. Two interrupted 3-0 Vicryl stitches were placed to mark the jejunum at 100 cm and 200 cm. The loop of jejunum marked at 100 cm distal to the Treitz's ligament was then sutured to the anterior gastric antral wall using two interrupted 3-0 Vicryl stitches.

Fig 4. The marked jejunal loop was fixed to gastric antrum.

The patient was then placed in reverse Trendelenburg position and three working arms and a camera arm of the da Vinci Si® robotic system were docked to the 8-mm ports and the 12-mm camera port, respectively. Using the robotic hook cautery, the lesser omentum was entered at the level of the second vein (about 6 cm from the esophagogastric junction) to create the gastric pouch. Then the iDrive™ Stapling System with a 45-mm purple cartridge was introduced via the laparoscopic assistant's port and fired horizontally across the stomach from the defect in the lesser omentum. Sequential vertical fires of the iDriveTM Stapling System with 60-mm purple cartridges were used to carry the staple line upward to a point just lateral to the angle of His, ensuring complete gastrogastric division.

Using the hook electrocautery, enterotomies were made in the posterior wall of the gastric pouch and the jejunum that had been previously tacked to the greater curvature of stomach. The tacking stitches were removed and a 45-mm purple cartridge in the iDrive™ Stapling System was used to create a 2-cm linear gastrojejunostomy.

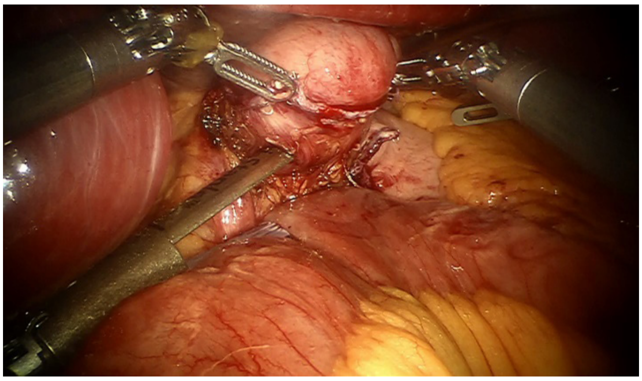

Fig 5. Gastrojejunostomy creation using the iDrive™ Stapling System with 45-mm purple cartridge.

A 60-mm tan cartridge was used to divide the biliopancreatic limb just proximal to the gastrojejunostomy. The hook cautery was used to create enterotomies in the distal biliopancreatic limb and at the site of the jejunal marking stitch that had been previously placed at 200 cm beyond the Ligament of Treitz. Using a 45-mm tan cartridge, a 45-mm stapled jejunojejunostomy was made between the biliopancreatic limb and jejunum to create a 100-cm Roux limb. The enterotomy site was closed using continuous 3-0 Vicryl suture and the mesenteric defect was closed to its base with continuous 2-0 Ti-Cron suture. Reinforcing and anti-kink stitches were placed between the biliopancreatic and Roux limbs using 3-0 Vicryl suture.

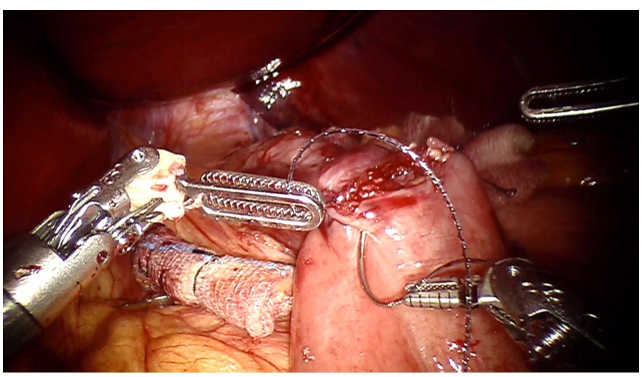

Fig 6. Gastrojejunostomy defect closure by intracorporeal robotic suturing.

The gastrojejunal enterotomy site was closed using running 3-0 absorbable V-loc suture (Medtronic, Dublin, Ireland) and the corners were reinforced with interrupted 2-0 Ti-Cron stitches. A leak test was then performed by instilling 50 mL of dilute methylene blue solution (2 mL per 100 mL of normal saline solution) into the orogastric tube. The Petersen's defect was closed by suturing the mesentery of the Roux limb to the transverse mesocolon using running 2-0 Ti-Cron suture. The liver retractor was removed and a 10-French JP drain was placed near the gastrojejunostomy through the left upper quadrant port site. The 12 and 15-mm port sites were closed using 1-0 Vicryl on a suture passer. All ports were removed, the robotic system was undocked, and the skin was closed in standard fashion.

The Siriraj's Experience in Robotic Surgery and Robotic Bariatric Surgery

About the first robotic platform in Siriraj Hospital, the da Vinci® S robot was purchased in 2007 which the main users were the urological surgeons. The robotic operation for general surgery field in Siriraj Hospital was started in 2008 then the robotic approach in general surgery were developed consistently. Robotic-assisted complete excision of choledochal cyst type I with hepaticojejunostomy was the first international report of our institute by Minimally Invasive Surgery team in 2010. The da Vinci® Si Surgical System was our second model that introduced to Siriraj Hospital since 2012, and the latest one, da Vinci® Xi robotic platform, was imported to our center in August 2019. Most of the general surgery cases operated by robotic approach were funded by Siriraj Foundation for educational purpose in general surgery training program.[8]

Our first robotic operations for bariatric surgery in Siriraj Hospital, and also first in Thailand, were performed on March 6th, 2017 by Dr. Voraboot Taweerutchana and team. Our first patient for robotic sleeve gastrectomy is a 26-year-old female with body weight 93 kg (BMI 40.79 kg/m^2) and no comorbid disease. And our first patient for robotic Roux-en-Y gastric bypass is a 38-year-old woman who weighed 110 kg (BMI 40.40 kg/m^2) and comorbidity of dyslipidemia. In our first two patients undergoing robotic bariatric surgery, total operative time for robotic SG and robotic RYGB was 160 and 285 minutes, respectively. The estimated blood loss was 20 mL in both cases. Their postoperative pain was managed by intravenous PCA routinely by the acute pain service team. The postoperative average pain scores, visual analog scale, at 2 hours, 12 hours, and 24 hours were 10, 5.5, and 4.58 in the patient who underwent RSG, and the scores were 9, 5.4, and 4.2 in the patient who underwent RRYGB. Intravenous PCA can be discontinued on postoperative day 2 in RSG and day 3 in RRYGB patients. No further requirement of oral paracetamol after 2-day around-the-clock prescription in both patients. The patients were both discharged from the hospital on postoperative day 4. No open conversion, immediate complication, or 30-day mortality was observed. The total hospital costs were 336,629 THB (Thai baht) and 402,333 THB for robotic

SG and robotic RYGB, respectively. Excess weight loss (EWL) at 6 months post robotic SG and robotic RYGB were 60% and 52%, and at 12 months were 60% and 65%, respectively. The comorbidity of dyslipidemia in the patient who underwent RRYGB has significantly improved and oral medication has been discontinued.

One of the challenges of the da Vinci® Si platform is the inability to adjust the craniocaudal tilt of the operative table once the robot has been docked to the port sites, which makes it difficult to perform multi-quadrant procedures, like Roux-en-Y gastric bypass. Therefore, in our institute, we initiated the robotic RYGB with the single docking technique by performing the infracolic phase using a laparoscopic approach, followed by a robotic approach to the supracolic phase of the procedure, that considered as the hybrid robotic operation. In the infracolic phase, we placed marking stitches to the jejunum at 100 cm and 200 cm from Treitz's ligament to identify the site of the biliopancreatic limb and Roux limb to avoid the need for running the small bowel once the robotic system has been docked. Then we secured the jejunum to the greater curvature of stomach, making it easier to grasp the Roux limb while performing the gastrojejunostomy with robotic instruments in the supracolic phase. Nowadays, we perform the totally robotic RYGB that infra- and supracolic phases performed under the reverse Trendelenburg position with hand-sewn gastrojejunostomy anastomosis by that the report is now in process of the data collection and analysis.

Laparoscopic Versus Robotic Approach to Bariatric Surgery

The field of bariatric surgery has evolved worldwide in the recent decades due to its excellent results in treating morbid obesity and its related comorbidities. With the introduction of robotic surgery in recent years to the practice of minimally invasive general surgeons, efficient applications of robotic technology to bariatric surgery have been sought. The advanced technology of the robotic system enables the surgeon to operate the complex surgical tasks, e.g. the hand-sewn gastrojejunostomy in Roux-en-Y gastric bypass with more precision.[1,2,6,9]

Laparoscopic RYGB remains a complex bariatric procedure with a steep learning curve. It requires advanced laparoscopic skills, such as intracorporeal suturing, knot tying for the multiple anastomoses, fine manipulation in various abdominal compartments, and redoubled abdominal torque causing the operator's fatigue. In the former reports, the learning curve for robotic RYGB seems to be shorter than that for laparoscopic RYGB, 10-20 cases versus ≥ 100 cases, respectively.[4,5,10,11]

The disadvantages of robotic surgery are the larger sized ports than used in traditional laparoscopic surgery (8-mm versus 5-mm) and loss of tactile sensation and force feedback, which may lead to bowel wall or visceral injury during manipulation. The benefits of the robotic approach over laparoscopic bariatric surgery are still debated and controversial. Multiple case series have shown the feasibility and clinical safety of robotic bariatric surgery, and also shown comparable results with laparoscopic bariatric procedures, but some authors believe that there is no advantage over standard laparoscopic techniques.[1,2,6,9,10]

In our initial experience at Siriraj Hospital, the results of robotic bariatric surgery demonstrated good clinical outcomes. No immediate complication, leakage, or mortality was detected in 30-day postoperative follow-up. Excess weight loss and resolution of comorbidity at 6- and 12-months were comparable to a conventional laparoscopic approach.

In terms of weight reduction, the robotic approach has comparable results to laparoscopic bariatric surgery in previously published reports. One meta-analysis showed EWL of 34-67% at 6 months and 48-67.3% at 12 months in the laparoscopic sleeve gastrectomy group, while EWL was comparable at 39-66% at 6 months and 48.89-65.5% at 12 months in the robotic approach for sleeve gastrectomy. Other reports described excess BMI loss after Roux-en-Y gastric bypass at 1 month of 26.2% in the robotic group and 26.3% in the laparoscopic group, and at 12 months, 79.7% in the robotic group and 83.9% in the laparoscopic group. In our cases, EWL at 12 months was 60% in our RSG patient and 65% in our RRYGB patient.[12,13]

Systematic reviews and meta-analysis have shown no significant differences between robotic and laparoscopic bariatric procedures with regards to reoperation, open conversion, the hospital stay interval, overall postoperative complications, major complications, and mortality, however there are some differences in outcomes as follows.[1,4,9,13] Anastomotic leakage were significantly decreased overall after robotic bariatric procedures compared with laparoscopic procedures (OR 0.5, p = 0.005) and totally-robotic RYGB compared with laparoscopic RYGB (OR 0.22, p = 0.001). The additive learning effect from laparoscopic cases performed prior to the introduction of robotics and more precision in anastomosis suturing by robotic systems may be the reasons for these results. Moreover, minor complication rates were significantly decreased after totally-robotic RYGB compared with laparoscopic RYGB (OR 0.68, p = 0.04). Robotic sleeve gastrectomy reduced the postoperative bleeding (0.16% vs. 0.43%; p < 0.001) and stricture (0.19% vs. 0.33%;

$p = 0.04$) significantly when compared with traditional laparoscopic sleeve gastrectomy.[1,2,14,15]

In review of the literature, no significant difference of the operative time was found between totally-robotic RYGB and laparoscopic RYGB ($p = 0.42$). On the other hand, there was increased operative time for robotic-assisted RYGB versus laparoscopic RYGB (158.29 ± 65 vs. 120.17 ± 56; $P < 0.001$), and for robotic sleeve gastrectomy compared with laparoscopic sleeve gastrectomy (102.58 ± 46 vs. 73.38 ± 36; $P < 0.001$). A robotic set up time did not vary significantly and remained at a mean of 13 ± 4 min in the previous report. Finally, we believe that the operative time in robotic approach can be reduced once the learning curve is overcome, just as with other robotic procedures.[1,13-15]

Although robotic procedures seem to be more expensive than laparoscopic surgery due to initial purchase costs of the robot and the robotic instruments and accessories, as well as yearly maintenance fees that are associated with significant costs. From the University Health System Consortium (UHC) Clinical Database, the mean cost of robotic gastric bypass was $12,670, versus $10,105 for laparoscopic RYGB ($p < 0.05$). Moreover, the mean costs of robotic and laparoscopic sleeve gastrectomy were $10,556 versus $8,795 ($p < 0.05$), respectively. Despite this, previous analyses have concluded that robotic RYGB can be cost effective as a result of a decrease of costly anastomotic complications and avoiding stapler use in the case of hand-sewn anastomoses. In the event of postoperative leak, readmission is costly, and these authors demonstrated higher leak rates in the laparoscopic group.[1,16,17]

The Future Trends in Robotic Bariatric Surgery

The new medical technologies, included the robotic surgery system, are always updated to provide the patients' benefit. Nevertheless, the overall costs of robotic approach for bariatric surgery seemed to be more expensive than the laparoscopic surgery, which is the standard treatment in this era, and there were a few evidences to support the clear benefit of robot over the laparoscopic one, the usages of robot in bariatric surgery remained controversial, especially in the expert bariatric surgeons who familiar with their laparoscopic skills.

As the oldest and largest hospital and medical school in Thailand, Siriraj Hospital cannot avert the robotic surgery due to academic purposes. To utilize the maximal technology abilities, to clearify the cost-effectiveness of the robotic approach by the data analyses and publications, and to manage the efficient usages of the robotic system are Siriraj's duties. The robotic bariatric surgery cases will be maintained for these objectives in Siriraj Hospital. Although Siriraj Foundation was the main supporter in funding of robotic approach in general surgery cases, the effective hospital resource management can also reduce the overall robotic surgery costs, for example, to increase the robotic case volume and the patient flow.[8]

Furthermore, revisional bariatric surgery may be a field that robotic bariatric surgery becomes a favored approach, because of its ability to provide fine movement and a high-degree of articulation in a challenging operative field. These special properties of the robotic system facilitate the surgeon's ability to perform a difficult operation more precisely and comfortably, despite intraabdominal adhesions and distorted anatomy.

Although there were some potential advantages of the robotic approach in bariatric surgery from the previous studies as mentioned above, there have been no well-designed randomized trials to compare the outcomes between conventional laparoscopic bariatric surgery with the robotic surgery. To improve the value of this research field, a large-scale comparative study using a randomized controlled trial technique should be considered. In the future, if the clear benefits of using robots in bariatric surgery are well-supported, the robotic system investors will be increased in the market and the overall robotic costs will be reduced. Moreover, the treatment costs by robotic system may be concerned and covered by the health insurance system.

CONCLUSION

Using robotic approach in bariatric surgery is still controversial due to its cost and availability. The operative room setup, the port sites, the instruments, the technical details, and the key step illustrations for robotic SG and robotic RYGB are described by Siriraj's experiences. From the current evidences, a robotic approach for bariatric surgery is demonstrated to be a feasible alternative to laparoscopic bariatric surgery. It is shown to be equally as effective and safe as a laparoscopic approach, and provides comparable clinical outcomes to the conventional laparoscopic method.

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