6 Essentials and Future Directions of Robotic Bariatric Surgery

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Introduction

The rates of obesity continue to rise exponentially and represent one of the major health challenges for physicians, surgeons, health-care systems, and economies. Especially concerning is the rate of increase of patients with morbid obesity (body mass index (BMI) over 40), which increased over 70 % from 2000 to 2010 [1]. The health consequences of obesity have been recognized since the 1900s, and the development of surgical approaches to treat the obesity epidemic has paralleled the growth in both the recognition of the health consequences and the increase in the magnitude of affected patients [2].

Initial approaches included wiring of the jaw, which predictably did not enjoy widespread success. Considering today's understanding of the complex pathophysiology of obesity, this is not necessarily surprising. However, this initial observation prompted the realization that a surgical solution to obesity required more than simple restriction of oral intake [2]. Modern-day bariatric surgery started arguably with Payne et al., who performed jejunocolic and later jejunoileal bypass [2]. The evolution of the initial modern bariatric procedures has been remarkable and now includes commonly adjustable gastric banding, longitudinal sleeve gastrectomy, roux-en-Y gastric bypass, and biliopancreatic diversion with and without duodenal switch as well as an expanding field of revisional bariatric surgery. With the increasing recognition of the metabolic effects and benefits of bariatric surgery, there has been an expansion of indications and the principles of bariatric and metabolic surgery, in certain cases, such as in difficult to control diabetes in patients with lower BMIs, with promising results [3]. In the present climate of evidence-based medicine, the rate of growth of bariatric surgery has paralleled the literature supporting the notion that bariatric surgery is an effective and economically viable solution for durable weight loss as well as improvement and remission of diabetes and the comorbidities that describe metabolic syndrome [4, 5].

The past 20 years have seen an explosion of the application of minimally invasive principles to surgery for morbid obesity. Catona reported placing a nonadjustable gastric band via laparoscopy in early 1992. Broadbent et al. is credited with publishing the first report of laparoscopic surgery for obesity, also implanting a nonadjustable

This chapter contains video segments that can be found on the following URL:

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gastric band [6]. In 1993, laparoscopic adjustable gastric band placement, vertical banded gastroplasty, and roux-en-y gastric bypass were reported [6]. Today, the majority of bariatric surgery is performed in a minimally invasive manner.

Robotics and Bariatric Surgery

Since the initial report of robotic bariatric surgery in 1999, there has been increasing interest and adoption of robotic surgery to the field of bariatric surgery [7]. This has been driven by a variety of factors, including ergonomic issues, patient-related factors (abdominal wall size, subcutaneous and intraperitoneal fat), and the superior visualization and degrees of freedom offered by robotic platforms. Of increasing interest within our group in particular are the application and superb outcomes of robotic surgery to revisional bariatric surgery. Oftentimes, the biggest proponents of robotic surgery are surgeons who have adopted it as part of their practice. There is, to date, limited data with regard to outcomes and comparison with traditional laparoscopy. In 2014, A PubMed search using the terms "robotic" and "bariatric" returns less than 100 published manuscripts. We will discuss the essential principles as well as future directions of robotics in the field of bariatric surgery.

Robotics and Training

As with safe adoption of any new technology, it is imperative that surgeons who use robotics as part of their bariatric surgery practice are adequately trained in the safe application of robotics to laparoscopic bariatric surgery. Training is not only important for the surgeon but for surgical assistants, surgical technologists, and circulating nurses. It requires an investment from hospitals/health systems for maintenance for robotic platforms and team training. There are a number of tools to assist surgeons who wish to adopt robotics, including a defined curriculum created by Intuitive Surgical, Inc., (Sunnyvale, CA) as well as skills labs to introduce the robotic platform, surgical simulators, and wet labs. In addition, the first cases done should be proctored by an experienced robotic surgeon. After training and adoption of robotics, it is imperative that surgeons continue to use robotics regularly in their practice, not only to hone skills but also to increase the efficiency of the entire surgical team [8]. An increasing number of hospitals are defining milestones for robotic credentialing to ensure safe outcomes for patients. Similar to the Fundamentals of Laparoscopic Surgery curriculum now required for credentialing by the American Board of Surgery, and additionally the developing curriculum for flexible endoscopy, it is anticipated that a curriculum for robotic surgery will be required in the near future [9]. For experienced laparoscopic surgeons, the learning curve for robotic gastric bypass, for example, to achieve a significant decrease in operative time can be fewer than 10 cases, as compared to almost 100 cases (per some published reports) for laparoscopic gastric bypass surgery [10].

Robotics and Port Placement for Bariatric Surgery

Port placement for robotic-assisted laparoscopic bariatric surgery is similar to that of the laparoscopic equivalent operation and typically consists of five to six ports. The technique used by our group for nearly all bariatric and foregut surgeries is as follows. Initial entry is in the right upper quadrant with a 5 mm port using optical viewing technique. This port is later exchanged to a 5 mm robotic compatible trocar. Additional ports are placed as follows. A 12 mm camera port is placed periumbilically. In larger BMI patients, in order to reach the angle of His, this may need to be placed supra-umbilically. A 5 mm robotic compatible trocar is placed in the left upper quadrant in the anterior axillary line at the level of the periumbilical port. An additional 5 or 8 mm left upper quadrant robotic compatible trocar is placed midway between the periumbilical and lateral left upper quadrant port. A 12 mm or 15 mm assistant port is placed midway between the right upper quadrant and periumbilical port. A 15 mm port is used for adjustable gastric band placement and may facilitate specimen extraction with sleeve gastrectomy; additionally, the larger port is necessary for certain

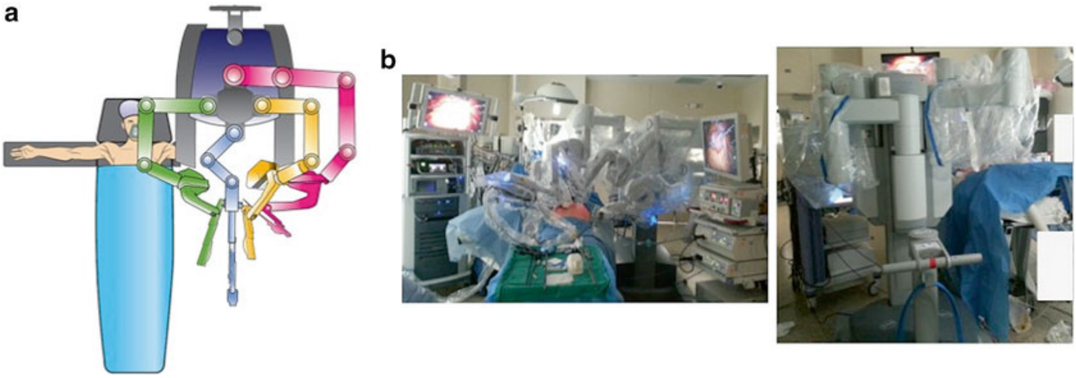

Fig. 6.1 Schematic for robotic docking for foregut surgery. (**a**) We utilize a parallel side dock technique in which the patient cart is parked parallel to the operating table next to the left shoulder. The left arm is tucked. (**b**) Intraoperative photographs demonstrating the parallel side dock technique. This technique affords functionality while leaving space at the head of the bed for access to the airway as well as for intraoperative endoscopy

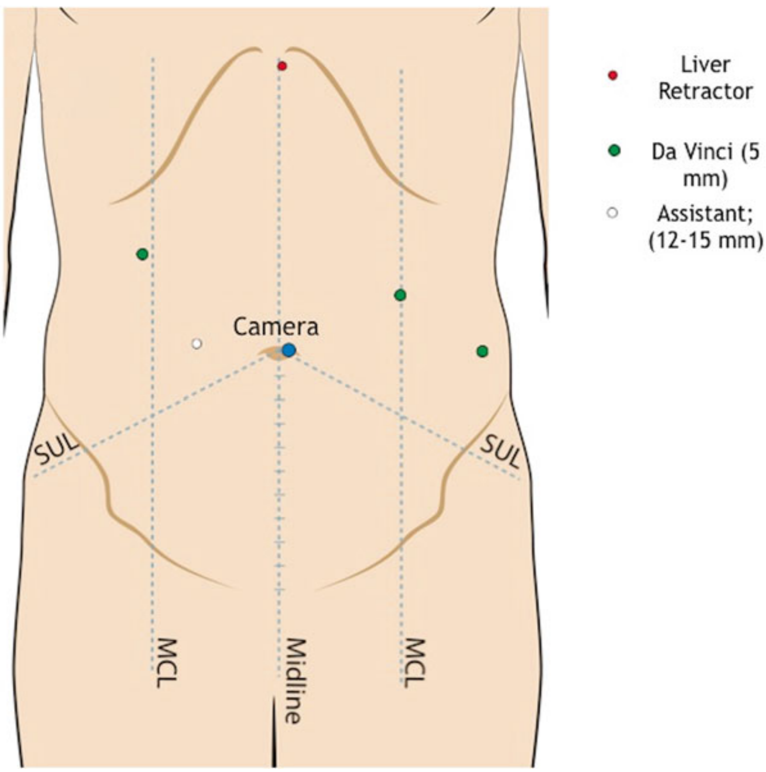

Fig. 6.2 Port placement for robotic-assisted sleeve gastrectomy

gastrointestinal staplers. Lastly, a subxiphoid incision is made to accommodate a liver retractor. In anatomically favorably situations, an internal liver retractor with sutures with or without a Penrose drain may be utilized. Our approach has been published previously [11]. The setup for biliopancreatic diversion differs slightly, and the reader is encouraged to review the references noted later in this chapter regarding this procedure. When docking the patient cart for foregut

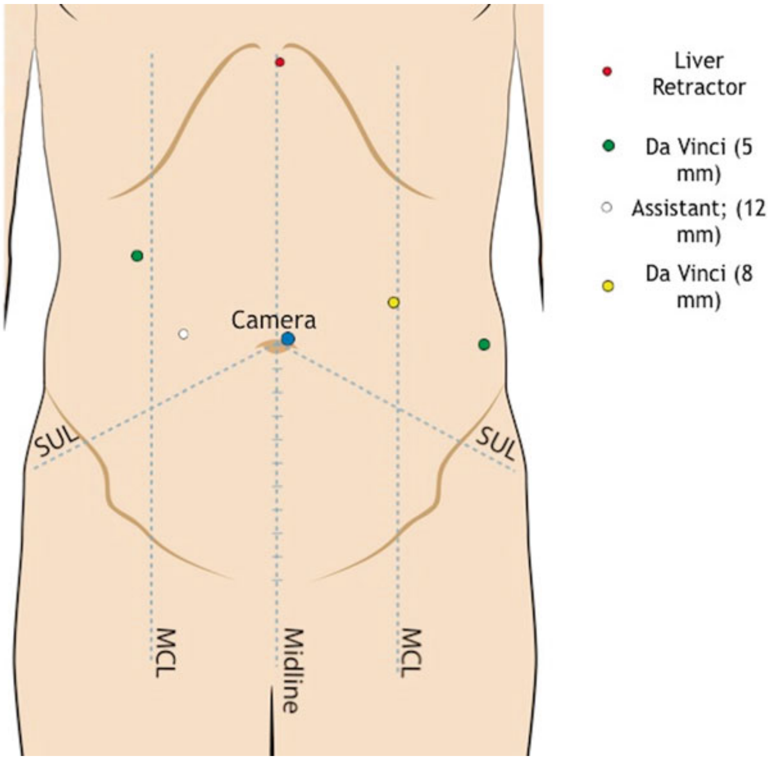

Fig. 6.3 Typical port placement for robotic-assisted roux-en-y gastric bypass

surgery, we utilize a parallel side dock technique (schematic and intraoperative figures are demonstrated in Figures 6.1a, b). Please refer to Figures 6.2 and 6.3 for our typical port placement for robotic-assisted laparoscopic sleeve gastrectomy and roux-en-y gastric bypass.

Robotics and Adjustable Gastric Bands

As the bariatric surgery climate continues to evolve, the frequency of placement of adjustable gastric bands has continued to decrease for a number of reasons, including relatively low excess weight loss, long-term surgical complications including band slip and erosion, as well as the not insignificant rate of revisions of gastric bands to another weight loss operation [12]. Today, most robotic surgeons would argue that the platform is most useful when revising patients with previous adjustable gastric band to another operation. However, there may still be some utility in primary placement of adjustable gastric bands. Edelson et al. published the largest (407 patients) comparison of robotic-assisted (287 patients) to conventional laparoscopic (120 patients) placement of adjustable gastric bands and noted no difference in hospital stay or operating time for everyone except those with a BMI greater than 50, in which there was a time advantage with the robotic approach [13].

Robotics and Longitudinal Sleeve Gastrectomy

The fall in the number of adjustable gastric bands being placed by surgeons has been relatively paralleled by the increase in patients and surgeons choosing longitudinal sleeve gastrectomy as the initial weight loss operation [12]. Diamantis et al. reported a series of 19 patients undergoing robotic-assisted sleeve gastrectomy and reported equivalent operative time when compared to the laparoscopic approach [14].

The technique reported to have used only three of four robotic arms and employed two bedside assistants (including one to hold a liver retractor). With the port technique used by our group, there is only one bedside assistant needed for stapling. A representative robotic-assisted sleeve gastrectomy (with the bedside assistant firing the staplers) is demonstrated in Video 6.1. With the introduction of robotic staplers, it is possible that the entire operation can be performed without the use of an assistant port. Ayloo et al. reported a comparison of 30 robotic-assisted sleeve gastrectomies to 39 laparoscopic sleeve gastrectomies in patients with an average BMI of over 55. The robotic technique was longer by 21 min; however, all patients in the robotic group had their staple lines oversewn as opposed to none of the patients in the laparoscopic group. There were no differences in complications between either group [15]. Vilallonga et al. reported their experience of 100 robotic and 100 laparoscopic sleeve gastrectomies, noting increased operative time in the robotic group [16]. Similar results were noted by Romero et al. comparing 134 robotic-assisted sleeve gastrectomies to a literature review of 3,148 laparoscopic sleeve gastrectomies noting increased surgical time but a shorter hospital length of stay [17]. A robotic technique for vertical sleeve gastrectomy without the use of staples has also been described. In this technique, the stomach is divided between two laparoscopic clamps; the stomach is then sewn shut with a running absorbable suture. There is a learning curve for robotic-assisted laparoscopic sleeve gastrectomy. Sequential cases improve efficiency and decrease docking and operative times. Vilallonga et al. reported that the learning curve was about twenty cases [18, 19].

The limitation of all of the studies describing robotic-assisted laparoscopic sleeve gastrectomy includes all the limitations of nonrandomized clinical trials. It is a legitimate debate as to the usefulness of the robotic platform for sleeve gastrectomy. Several reasons to adopt a robotic technique may include increasing surgeon and operative team experience with the robotic platform with a relatively straightforward procedure in preparation for more complex procedures. Robotics offers a distinct advantage in situations requiring suturing, including patients with large hiatal hernias requiring repair. The utility of routine crural repair during sleeve gastrectomy is currently the subject of a clinical trial (NCT01554553, www.clinicaltrials.gov).

Robotics and Roux-en-Y Gastric Bypass and Biliopancreatic Diversion/Duodenal Switch

Perhaps one of the most obvious benefits of robotics in bariatric surgery is in operations requiring a large degree of suturing, as in gastric bypass and related operations in which surgeons may be using hand-sewn techniques for anastomoses. A number of studies have been published evaluating the utility of robotics in roux-en-y gastric bypass. Mohr et al. reported one of the first series of totally robotic roux-en-y gastric bypass procedures. When comparing 10 robotic to 10 laparoscopic procedures, they noted a decreased median surgical time for the robotic procedures [20]. Multiple additional series have been performed, most noting similar outcomes with the robotic platform as compared to laparoscopy. Most series note increased operative time with the robotic platform, with decreased time as institution and surgeon experience increases [21–24]. Certain series have noted a lower leak rate with robotic-assisted laparoscopic roux-en-y gastric bypass [25]. A two center report with one of the largest reported experiences in the world (1,100 robotic gastric bypasses) noted 1 leak (0.09 %) in the entire series [26]. A review of seven studies and 1,686 patients demonstrated a significant reduction in anastomotic strictures with robotic gastric bypass as compared to the laparoscopic approach with no other differences noted [27].

Robotic biliopancreatic diversion with duodenal switch was initially reported in 2007 in a published series of 47 patients. There was an 8 % incidence of leaks (4/47 patients) with three patients requiring conversion to open operation. This initial series demonstrated the feasibility of robotic biliopancreatic diversion [28].

One advantage to the robotic technique for roux-en-y gastric bypass is that most studies indicate that the learning curve for the robotic approach is significantly less (reported by some authors as being <20 cases) [29–31]. In surgeons starting to do gastric bypass, the robotic approach leads to shorter operative times during the learning curve, with the difference magnified as BMI increases [32]. In an operation in which complications, specifically leaks, can be disastrous, the robotic platform has been shown to allow for excellent outcomes during the learning curve [33]. The rate of leak during the learning curve for laparoscopic roux-en-y gastric bypass has been reported as high as 10 % [28]. The learning curve for robotic-assisted biliopancreatic diversion with duodenal switch has been reported to be about 50 cases [34].

As documented by most studies which evaluated this variable, costs are higher with the robotic approach. A systematic review of 10 studies (2,557 patients) noted that the expected costs for robotics as compared to laparoscopic roux-en-y gastric bypass was about $3,500 more expensive [35, 36]. This is likely to decrease with the introduction of new robotic platforms and increased competition. With the ability to more easily perform hand-sewn anastomoses, the lower learning curve, decreased leak rate during the learning curve, the avoidance of staplers, as well as the likely continued decrease in costs of robotic platforms with increasing competition, some suggest an actual cost advantage to robotic gastric bypass as compared to laparoscopic or open procedures [37]. An example of a robotic-assisted laparoscopic roux-en-y gastric bypass is noted in Video 6.2.

Robotics and Revisional Bariatric Surgery

As the number of primary bariatric procedures continues to increase, the number and complexity of revisional cases will also increase. Commonly, patients undergo revision from an older generation of bariatric procedures such as vertical banded gastroplasty and fixed gastric bands as well as revisions from adjustable gastric bands (Video 6.3), sleeve gastrectomies, and failed gastric bypass. Particularly relevant to the field of robotic bariatric surgery is the enormous opportunity to achieve excellent outcomes and low conversion and complication rates with robotic-assisted revisional bariatric surgery as compared to a totally laparoscopic approach. There is limited literature on this topic, but it suggests superiority of the robotic approach.

Snyder et al. published a series of 99 revisional bariatric operations over a 7-year period and noted zero leaks and an average hospital length of stay of 2.3 days. There were no conversions to open operations [38]. Buchs reported a series of 60 revisional operations, including open, laparoscopic, and robotic approaches. The robotic approach was noted to have no conversions to an open procedure (14.3 % for the laparoscopic group) with significantly less complications and a shorter hospital length of stay [39]. One of the largest series (154 patients) of laparoscopic revisional bariatric surgery reports a 10.4 % rate of conversion to open operation [40]. Although more studies are needed, in the area of revisional bariatric surgery, the robotic platform appears to have the most promise, especially when it comes to decreasing the rate of conversion to an open procedure.

Robotics and Bariatric Surgery in Adolescents

The role of bariatric surgery in morbidly obese children and adolescents is sometimes a controversial topic to discuss. We do not wish to delve into the many issues that surround this topic; rather, we would just like to note robotics has been used successfully when performed in children and adolescents. Alqahtani reported a comparison of laparoscopic adjustable gastric banding as compared to a robotic-assisted approach. There were no significant differences between the two approaches except that the robotic approach took longer (24 min longer on average) [41]. As the number of bariatric procedures performed in morbidly obese adolescents continues to increase, we should expect more data on robotic approaches to pediatric bariatric surgery.

Conclusions

Since the initial report in the literature in 1999, there has been a significant increase in the number of surgeons using robotics in the field of bariatric surgery [7]. With that, the literature surrounding this topic, albeit still limited, has increased. The promise of robotics likely has yet to be fully realized. Almost all will agree that, especially in the field of revisional bariatric surgery, it offers much promise.

Current and future platforms may also increase the complexity and scope of endoscopic and natural orifice surgery. With the continued evolution of augmented reality and the ability to assimilate imaging and other technologies, the robotic console has the promise to integrate the patient's medical information seamlessly with the surgical procedure. It is easy to see how the ability to evaluate radiological imaging and the actual surgical field concurrently at the console can make for a more efficient and safer operation, especially with difficult dissections around vital structures. Although there are divergent opinions regarding the use of robotics for bariatric surgery, it is important to objectively evaluate the evidence and published data while laying a framework for true randomized comparative trials. The superior visualization, increased degrees of movement, technological promise, and ergonomic advantages exist, but these strengths alone have not led to more widespread adoption of this technology.

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