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CLINICAL REPORT

# Robot-Assisted Roux-en-Y Gastric Bypass for Super Obese Patients: A Comparative Study

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**Abstract** Superobese patients (SO) (body mass index (BMI)≥50 kg/m$^2$) represent a real surgical challenge and the best management remains debatable. While the safety of a laparoscopic approach has been questioned for this population, robotics has been introduced in the armamentarium of the bariatric surgeon, yet its role remains poorly assessed, especially for a very high BMI. The study aim is thus to report our experience with robot-assisted Roux-en-Y gastric bypass (RYGB) for SO. From July 2006 to May 2012, 288 consecutive robot-assisted RYGB procedures have been performed at a single institution. All data were collected prospectively in a dedicated database. Among those patients, 41 were SO (14.2 %). All the peri- and postoperative parameters were compared to the morbidly obese (MO) group (BMI<50). Data have been reviewed retrospectively. The SO group presented a higher ASA score and more male patients. The operative time was similar between both groups, yet there were more conversions in the SO group (two versus one for MO; $p$=0.05). The morbidity and mortality rates were similar between both groups. The length of stay was longer for the SO population (7 vs. 6 days; $p$=0.03). The percent BMI loss was similar at 1 year (34 vs. 34 %; $p$=1), but the percent excess BMI loss was higher for the MO group (83 vs. 65 % for the SO group; $p$=0.0007). Robot-assisted RYGB can be performed safely for SO, with complication rates and functional results at 1 year comparable to MO, yet this approach for SO has been associated with a slightly increased conversion rate and length of stay.

**Keywords** Super obese · Robot · Gastric bypass · BMI · Outcomes

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## Introduction

Obesity is a worldwide health problem, and its management concerns all the medical and surgical fields. The superobese patients (SO) are a special category of patients with a body mass index (BMI) superior or equal to 50 kg/m$^2$. The management of this population remains a challenge [1]. In addition, there is no real consensus concerning the surgical procedure to perform for SO [2]. For morbidly obese (MO; BMI<50) patients, laparoscopic Roux-en-Y gastric bypass (RYGB) is considered as the gold standard surgical procedure by many specialists [3, 4]. The overall results have been shown to be very good not only in terms of weight loss but also in terms of improvement of comorbidities [5], yet in the case of SO, the surgical and anesthesiological approach becomes more challenging. This fragile population has benefited from different procedures: sleeve gastrectomy, duodenal switch, gastric banding, and RYGB have all been reported as relatively safe [1, 6–12].

While these procedures can and should be performed by a minimally invasive approach, it remains challenging as it requires advanced laparoscopic skills. The introduction of robotics in the armamentarium of the bariatric surgeon has been seen by several groups as a real improvement [13–16]. The technical advantages of robotic technology have led to a diminution of anastomotic complications after RYGB, for example, as reported by several authors [14, 15, 17]. For SO patients, sleeve gastrectomy and duodenal switch have been performed safely by a robotic approach as well [18, 19], but specific results for RYGB in those very high BMI patients are difficult to find.

The study aim was thus to report our experience with robot-assisted RYGB for SO patients, comparing these results to the MO population.

## Materials and Methods

From July 2006 to May 2012, 288 consecutive robot-assisted RYGB were performed at a single institution. Among the 288 robot-assisted RYGB, 41 were performed for SO (14.2 %).

All of the procedures were performed by four different experienced laparoscopic and robotic surgeons (>100 advanced cases of minimally invasive surgery each) using the same standardized hybrid technique as already described thoroughly elsewhere [13, 20]. Patients included in the bariatric program met the criteria of the Swiss Society for the Study of Morbid Obesity and Metabolic Disorders [21]. All of those patients were eligible for a robotic approach and there were no selection criteria specific for robotics. The exclusion criteria were the same as for laparoscopy (anesthesiological contraindication, evident hostile abdomen) [20]. Data were entered prospectively into a dedicated bariatric database and retrospectively reviewed. Follow-up was organized by a research nurse especially dedicated to the bariatric program according to our national guidelines.

### Variables

A SO was defined as a patient with a BMI≥50 kg/m$^2$. The MO group consisting of 247 patients (85.8 %) was defined as patients with a BMI<50. The operative time was defined as the time between the first skin incision and the last skin closure. A conversion was defined as the need to terminate the procedure by an approach other than robotic (laparoscopy or open). The percent of BMI loss (%BMI loss) was defined as the operative BMI minus the follow-up BMI divided by the operative BMI [22]. The percent of excess BMI loss (%EBMIL) was defined as: 100−((follow up BMI−25)/(beginning BMI−25)×100), where 25 is defined as the limit of a normal BMI [22].

### Statistics

The results of parametric and nonparametric data were expressed as mean±standard deviation (SD) and median (range), respectively. GraphPad Software (GraphPad, La Jolla, CA, USA) was used for all statistical analyses. Confidence intervals were set at 95 %. A two-sided $P$ value of≤ 0.05 was considered as statistically significant. Comparisons between both groups were determined using Fisher's exact test for discrete variables and Student's t-test for continuous variables.

## Results

During the study period, 41 SO underwent a robot-assisted RYGB. The MO group consisted of 247 patients. The clinical data of both groups are summarized in Table 1.

When comparing the population of SO group and MO group, there were statistically significant differences: there were more male patients in the SO group (41.5 vs. 22.7 % for MO; $p$=0.02), and the American Society of Anesthesiologists (ASA) score was higher for this group as well (2.46 vs. 2; $p$= 0.001). Concerning comorbidities, there was no difference.

For the operative data (Table 2), the operative time has been shown to be similar between both groups, yet there were more conversions in the SO group (4.9 vs. 0.4 % for MO; $p$=0.05). In the SO group, we noticed two conversions: one because of the misfiring of a stapler and one because of the impossibility to reduce a large hiatal hernia. In the MO group, there was only one conversion because of massive adhesions.

**Table 1** Demographic and clinical data

| | Superobese ($n$=41) | Morbidly obese ($n$=247) | $P$ value |
|---|---|---|---|
| Gender | | | |
| Male | 17 (41.5 %) | 56 (22.7 %) | 0.02 |
| Female | 24 (58.5 %) | 191 (77.3 %) | |
| Age (years), mean ± SD | 40.8±11 | 44±10.5 | 0.07 |
| ASA score, mean ± SD | 2.46±0.5 | 2±0.4 | 0.001 |
| Initial BMI (kg/m$^2$), mean ± SD | 53.1±3 | 43±3.3 | 0.0001 |
| Initial weight (kg), mean ± SD | 150.3±17.3 | 118±15.6 | 0.0001 |
| Comorbidities | | | |
| Hypertension | 16 (39 %) | 79 (32 %) | 0.38 |
| Diabetes | 9 (22 %) | 46 (18.6 %) | 0.67 |
| Sleep obstructive apnea syndrome | 8 (19.5 %) | 60 (24.3 %) | 0.56 |

*SD* standard deviation, *ASA* American Society of Anesthesiologists, *BMI* body mass index

**Table 2** Perioperative results and short-term outcomes

| | Superobese ($n$=41) | Morbidly obese ($n$=247) | $P$ value |
|---|---|---|---|
| Operative time (min), mean ± SD | 249.7±92.4 | 253±96.5 | 0.84 |
| Conversion | 2 (4.9 %) | 1 (0.4 %) | 0.05 |
| Intra-operative complications | 1 (2.4 %) | 1 (0.4 %) | 0.26 |
| Postoperative complications | 6 (14.6 %) | 27 (10.9 %) | 0.44 |
| Mortality | 0 (0 %) | 1 (0.4 %) | 1 |
| Length of stay (days), mean ± SD | 7±3.33 | 6±2.7 | 0.03 |

*SD* standard deviation

There was no difference concerning the intra-operative complications (one in each group). There were a misfiring of a stapler in the SO group as mentioned before and an intra-operative perforation of the gastric pouch by the nasogastric tube requiring a redo of the pouch by a robotic approach.

Concerning the early postoperative complications, the overall rate was statistically similar in both groups (14.6 vs. 10.9 %; $p$=0.44). In the SO group, we had six complications: one hypoxemia due to bilateral basal atelectasia, one pneumonia, one anastomotic bleeding due to an ulcer requiring endoscopic hemostasis, two pulmonary embolism, and finally one mild dysesthesia interesting the arm. In the MO group, 27 complications were recorded: 11 pulmonary embolisms, three anastomotic edema that were successfully treated conservatively, two atelectasias, two bacteremias, two neurological complications (leg paresthesia), one hemorrhage on the stapled line requiring a reoperation, one incisional hernia requiring a reoperation, one urinary infection, one superficial phlebitis, one hematemesis requiring an endoscopy, one laryngeal edema, and one wound seroma.

The risk of pulmonary embolism was the same between both groups (4.9 vs. 4.5 %; $p$=1). There was only one late stricture in the MO group treated by one session of endoscopic dilation and none in the SO group ($p$=1). Of note, there was no leak in the entire series.

We had one death in the MO group and none in the SO group ($p$=1). This 40-year-old lady was classified ASA 3 and had a BMI of 44. Her past medical history was significant for a coagulopathy, and unfortunately at postoperative day 1 she presented a massive pulmonary embolism and a complete bilateral carotid thrombus. She was immediately treated by endovascular thromboaspiration. Unfortunately, she developed a massive reperfusion cerebral edema and passed away at postoperative day 2.

Finally, considering the functional results, the diminution of BMI up to 1 year was seen to be satisfactory (Table 3; Fig. 1). At 12 months, the SO group lost more unit of BMI than the MO group (18.3 vs. 14.4; $p$=0.0001). If we consider only the percent of BMI loss at 12 months, there was no difference between both groups. Not surprisingly, the %EBMIL at 1 year was significantly higher for the MO group than for the SO group.

## Discussion

Today the surgical challenge that represents the SO population remains real, even with the introduction of minimally invasive surgery. Different procedures have been tried with success. Sleeve gastrectomy, biliopancreatic diversion with duodenal switch, and RYGB have all been reported as safe and effective [1, 6–12]. Several data confirmed that biliopancreatic diversion seems to be the most effective procedure in the SO population [8, 9, 23], but with a higher morbidity rate. Thus, the debate still exists [2, 24].

From a surgical point of view, SO remains a difficult population to manage, usually with outcomes slightly less favorable than for MO [6, 11]. SO patients tend to have a thicker abdominal wall, greater amount of peri-visceral fat in the abdominal cavity, and fatty infiltration of liver, all of these facts leading to a more difficult operation [25]. In addition, in the present study, the SO population had clearly a higher ASA score and consisted in more male patients, as already reported by others [11]. Male patients have been seen as a more difficult group to operate on, especially because of the distribution of fat (central obesity) [1, 25]. In addition, like others [11, 25], we did not notice any difference of age between both groups, contradicting the fact that weight gain is a continuum.

**Table 3** Evolution of BMI and results at 1 year

| | Superobese group | Morbidly obese group | $P$ value |
|---|---|---|---|
| BMI loss at 1 month, mean ± SD | 6.3±2.11 | 4.5±1.4 | 0.0001 |
| BMI loss at 3 months, mean ± SD | 12.6±8.8 | 8.6±2.3 | 0.0001 |
| BMI loss at 6 months, mean ± SD | 14.5±3.9 | 11.1±2.7 | 0.0001 |
| BMI loss at 12 months, mean ± SD | 18.3±4.4 | 14.4±3.3 | 0.0001 |
| Percent BMI loss at 12 months, mean ± SD (%) | 34±8 | 34±7 | 1 |
| Percent excess BMI loss at 12 months, mean ± SD (%) | 65±15 | 83±22 | 0.0007 |

*BMI* body mass index, *SD* standard deviation

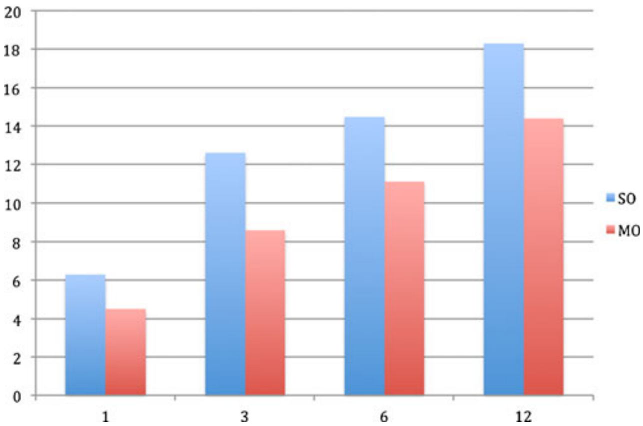


**Fig. 1** Evolution of BMI loss between superobese (SO in *blue*) and morbidly obese (MO in *red*) during 12 months

We present herein one of the first series of robotic RYGB with a special focus on the outcomes for SO. This large comparative study showed globally good results, with no anastomotic leak after more than 280 patients. From a statistical point of view, we found more conversion in the SO group when compared to the MO group. On the other hand, in a comparative study between super-superobese (BMI>60) and none super-superobese, Gould et al. [25] found no statistical difference for the conversion rate. The relation between BMI and conversion rate has been shown for other indications [26], but for RYGB the relation is less clear [27], though we had more conversion in the SO group, even if the reasons that conducted to an open procedure were not directly related to the high BMI (technical problem with a stapler and difficulty to reduce a hiatal hernia).

In addition, we found a longer length of stay for the SO group (+1 day), yet from a clinical point of view, this difference is minimal. The difference in terms of complications was maybe more interesting though. Even if there was no statistical difference, the clinical difference is important with almost 50 % of increased complication rate for SO. Interestingly, this complication rate is at least similar if not better than previously reported for laparoscopic RYGB in SO [1, 9, 11, 12, 25, 28]. More specifically, Oliak et al. [28] reported a higher risk to develop gastrointestinal leak and postoperative complications when performing laparoscopic RYGB for patients with BMI >60. Even if we extrapolate these data to our SO population, we cannot confirm these results because fortunately we had no leak so far.

There is no real consensus concerning the choice of the procedure for SO. Globally, in critically morbid patients, a sleeve gastrectomy can be considered as a first step in a two-stage procedure [7] or can even be considered more and more often as a single-stage procedure [29]. The outcomes reported so far are encouraging, but only few data are available for the long-term follow-up [30]. In a two-stage procedure, a duodenal switch (or a RYGB) is usually proposed, requiring advanced laparoscopic skills. The development of robotics was seen as a real technological help in performing anastomosis and complex dissection or reconstruction [31–33]. For bariatric surgery, the introduction of robotic technology has slowly gained an increased interest, notably by obtaining better outcomes. Very recently, the largest series of robot-assisted RYGB reported a leak rate of 0.09 % [34]. In fact, this dual-center study reported only one leak after 1,100 procedures [34]. The gastrojejunal leak rate after laparoscopic RYGB is classically higher with a range reported to be between 1 and 4 % [11, 14]. Several comparative series have clearly shown a reduced anastomotic complication rate after RYGB [14, 15, 35]. Finally, in a systematic review, Markar and colleagues [35] found a reduced incidence of anastomotic stricture with the robotic approach when compared to laparoscopy.

However, robotic technology is often criticized for the longer operative time associated to its use, even if this difference did not reach a statistical significance in a recent systematic review [35]. In the present series, contrary to other laparoscopic series [11], we have shown that there was no difference in terms of operative time between both groups of patients, yet it can be considered longer than previously reported for the laparoscopic approach [9, 11] but relatively similar to other robotic series [16, 36], with a short learning curve [13].

The functional outcomes were also promising with similar %BMI loss at 1 year between both groups. If other centers have reported high weight loss failure rates following RYGB after a long-term follow up [37], in our series we did not confirm this fact so far, yet our follow-up is still short and requires long-term outcomes. Suter et al. [11] have also compared SO and MO after laparoscopic RYGB. They did find that many SO patients remain in the severely obese or MO category, but with a significant improvement in terms of quality of life. This fact was confirmed by others as well [25], yet the quality of life was beyond the scope of our study and we are not able to confirm these data for the robotic approach.

This study has several limitations that deserve comments. First, this is a comparative study between SO and MO, not between the laparoscopic and robotic approach. The interest on such a study could be important since the debate on the real advantages of robotic technology continues [38], yet this series is one of the first to evaluate specifically the value of robotic RYGB for SO and the outcomes are more than favorable. Then, economical evaluation was not carried on. However, we already know from a precedent series that reducing the anastomotic leak rate can reduce the cost when using the robotic technology [14]. Finally, long-term follow-up is still required before drawing definitive conclusions.

## Conclusions

Robot-assisted RYGB can be performed safely for SO, with low complication rates and satisfactory results at 1 year. These results were comparable to MO, yet this approach for SO has been associated with significantly, even if limited, increased conversion rate and length of stay. The real advantages in comparison to the laparoscopic approach are still debated and require further studies for this subpopulation of SO.

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