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# *Robot Offers no Advantages in Roux-En-Y Gastric Bypass: Analysis of the NIS Database*

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## Abstract

### *Background*

*Gastric bypass is most commonly performed via the laparoscopic approach. However, some believe that the robotic approach could overcome limitations of laparoscopic surgery. In this study we seek to compare the outcomes of robotic and laparoscopic approaches to gastric bypass.*

### *Methods*

*We analyzed data of patients who underwent gastric bypass surgery using the National Inpatient Sample database between 2008-2013. Utilization and outcome measures including demographics, primary expected payer, in-hospital mortality, pre-existing comorbidities, complications, length of hospital stay, and total hospital charge were compared between the two different surgical approaches. These parameters were analyzed by chi-square, non-parametric tests and multivariate linear regression.*

### *Results*

*The six-year number of patients who underwent elective Roux-en-Y gastric bypass procedures in the United States from 2008 to 2013 is estimated to be 395,954. Of these, 97.9% were conducted via the laparoscopic approach, while 2.1% were conducted via the robot-assisted approach. The mean ages at the time of procedure were 44.82 ± 11.9 and 46.19 ± 12.2 in laparoscopic and robotic approaches, respectively ($p<0.001$). Females represented most of the patients (79% and 76.5% in laparoscopic and robotic groups, respectively, $p=0.013$). No significant differences existed between the two groups when compared in respect to race, diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease, and chronic obstructive pulmonary disease (COPD). Postoperative complications were comparable between groups with respect to pulmonary embolism, deep venous thrombosis, pain, bleeding, bowel obstruction, paralytic ileus, abscess, atelectasis, adhesion, and anastomotic leak. The overall mortality was similar between both the laparoscopic and robot-assisted groups (0.1% vs. 0.2%, respectively, $p=0.44$). Length of hospital stay was statistically significantly longer in the robotic*

*approach (mean 2.7 days vs. 2.4 days, p<0.001). Patients who underwent robotic surgery had significantly higher total hospital charges compared to patients who underwent laparoscopic surgery (median $56,114 vs. $39,765 USD, p<0.001).*

***Conclusions***

*Most gastric bypass procedures are done via the laparoscopic approach. The robotic technique has no clinical advantages in relation to morbidity and mortality. Additionally, the robotic procedure has significantly higher total charges.*

**Keywords:** *Bypass surgery; Laparoscopic; Laparoscopic surgery*

## Introduction

Morbid obesity is a health issue often necessitating surgical intervention [1]. In an observational cohort study, Nicolas et al. showed that weight-loss surgery significantly reduced mortality in morbidly obese patients [2]. Different options for surgical weight loss include gastric band, sleeve gastrectomy and the Roux-en-Y gastric bypass surgery. The most drastic weight loss is associated with Roux-en-Y bypass, as it involves both reducing the size of the stomach and significant malabsorption [3,4]. Gastric bypass surgery is the second most common bariatric procedure performed in the United States (30 to 40%) and has emerged as one of the most effective strategies to surgically treat morbid obesity and other obese-related comorbidities. More specifically, laparoscopic Roux-en-Y gastric bypass is now by far the gold standard of bariatric surgery and surgical weight loss [5-7]. The first laparoscopic Roux-en-Y gastric bypass was performed in 1993. Laparoscopic Roux-en-Y patients experience less postoperative pain, shorter length of hospital stay, faster time of recovery, less risk of infection, and a smaller surgical scar when compared to the open approach [8]. However, the laparoscopic approach has some technical limitations related to the articulated movements of instruments against the thickness of the intraabdominal fat and left- sided hepatomegaly [8,9]. In 2000, the US Food and Drug Administration approved the robot-assisted laparoscopic surgery for clinical use [10]. An advantage of this approach is that it helps overcome some of the limitations of standard laparoscopic surgery by offering three-dimensional imaging and seven degrees of freedom; which serves to improve physician dexterity, ergonomic positioning, and reduction of physiologic tremor [7,8,10]. As a result of these advantages, many hospitals invested in robotic surgical equipment. Despite the perceived advantages, there are several conflicting studies including one by, James et al.; which reported no clinical advantages associated with the robotic approach in comparison with standard laparoscopic surgery [10]. A more recent study has since shown that after controlling for patient characteristics, patients undergoing robotic-assisted Roux-en-Y gastric bypass had higher rates of early morbidity as compared to laparoscopic Roux-en-Y gastric bypass [11].

The principal aim of this study is to make a comparison of the utility and effectiveness between robotic-assisted Roux-en-Y gastric bypass and laparoscopic Roux-en Y gastric bypass.

## Materials and Methods

### Data source

We utilized data from the National Inpatient Sample (NIS) database (2008-2013) to conduct a retrospective cohort study. The NIS is the largest available all-payer inpatient hospital care database in the United States. It was developed for the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality (AHRQ). The database contains a 20% stratified sample of discharge records from all United States community hospitals that participated in HCUP from 1988 to 2013. The NIS includes all patients: those with Medicare, Medicaid, those who are privately insured as well as those who are uninsured. Hospital discharge data is collected annually and the weighted data represents over 7 million hospital admissions nationally. NIS maintains

information for each hospital admission including: patient's demographics (e.g. age, sex, race, hospital regions, and academic hospital status), primary payment types, primary and secondary diagnosis, procedures performed, in-hospital mortality, length of hospital stay and total hospital charge. All patient and physician identifiers have been removed from this data set. Approval from the institutional review board (IRB) was not required to conduct this analysis.

**Patient Selection**

The International Classification of Disease, 9th Revision, clinical modifications (ICD-9-CM) was used to select patients who underwent a Roux-en-Y gastric bypass procedure. Patients were divided into two groups based on the surgical approach: standard laparoscopy (ICD9; 44.38) and robot-assisted laparoscopy (ICD9; 17.42). There were no exclusion criteria. Comparative analyses were performed in regards to: patient's demographics, primary payment types, comorbidities (diabetes mellitus, hypertension, ischemic heart disease, chronic kidney disease and chronic obstructive pulmonary disease), postoperative complications (bleeding, pain, nausea, atelectasis, pulmonary embolism, deep venous thrombosis, bowel obstruction, adhesion, ileus, and anastomotic leak), in-hospital mortality, length of hospital stay and total hospital charge.

**Statistical Analysis**

Statistical analyses were performed using IBM's Statistical Package for Social Sciences (SPSS), ver. (IBM Corp., Armonk, New York, USA). Continuous variables were presented as a mean in the case of normal distribution or a median in the case of non-normal distribution. Discrete variables were presented as a rate. Adjusted weights to discharge were used for a nationwide estimation number. Continuous variables were compared via t-test or nonparametric test while discrete variables were compared via chi-square test. A linear regression analysis was used to analyze length of hospital stay and total hospital charge. The alpha error was set at 0.05, and all P-values indicated two-sided tests.

**Results**

**Patient Demographics and comorbidities**

The six-year number of morbidly obese patients who underwent elective Roux-en-Y gastric bypass procedures in the United States from 2008 to 2013 was estimated to be 395,954. Of these, 97.9% were conducted via the laparoscopic approach, while 2.1% were completed via robot-assisted approach. The estimated total number of annual cases remained stable: 72,051, 80,154, 69,847, 54,246, 63,130 and 56,525 in the years 2008 to 2013, respectively (**Figure 1**). During the six-year evaluation period, the rate of robot-assisted approach steadily increased from 0.2% in 2008 to 5.3% in 2013, $p < 0.05$ (**Figure 2**).

The mean overall age of patients who underwent the laparoscopic approach was 44.82 ± 11.9 (male 47.3 ± 12.1, female 44.2 ± 11.8). They were significantly younger than those who underwent the robot-assisted approach (overall 46.19 ± 12.2, male 49.3 ± 12.3, and female 45.2 ± 11.9) $p < 0.001$. The majority were females (79% and 76.5% in laparoscopic and robot-assisted approaches, respectively $p=0.013$). The greatest rate was found in White (70.5%), African American (14%), and Hispanic populations (10.8%). Whites and African Americans had a significantly higher utilization of robot-assisted approach compared to the Hispanic population (2.3%, 2.5%, and 1.8%, respectively $p < 0.05$). The rate of robot-assisted surgery was highest in individuals with Medicare coverage (2.9%, $p < 0.05$). Patients with Medicaid had a rate of 2.3%. Patients with private insurance coverage (1.9%) and self-pay patients (1.4%) had the lowest rates for the robot-assisted approach ($p < 0.05$).

There was no statistically significant difference between groups in terms of common comorbidities including; diabetes mellitus (36.5% *vs.* 37.9%, $p=0.24$), hypertension (59% *vs.* 59.5%, $p=0.7$), ischemic heart disease (4.7% *vs.* 5.6%, $p=0.1$), chronic kidney disease (1.7% *vs.* 2%, $p=0.29$) and chronic obstructive pulmonary disease (19.6% *vs.* 20.2%, $p=0.57$). More patient demographics and clinical characteristics are shown in **Table 1**.

## Regions and academic hospital status

Most robot cases were performed in the South (44.6%, N 3,677, p<0.05); followed by the Northeast (28.8%, N 2.371, p<0.05); then the Midwest (13.7%, N 1,129); and the least were in the West (13%, N 1.068). However, after adjustment by population, the use of the robot-assisted approach was highest in the Northeast (0.7/100,000 population) and then the South (0.5/100,000 population). The Midwest and the West had the lowest rates of robot utilization (0.3/100,000 population). The majority of robotic cases were performed in urban teaching hospitals (66%, N 5.441) while rural hospitals performed almost all cases (99.9%) via a standard laparoscopic approach (p<0.05).

## Clinical outcomes

The overall mortality was similar between both laparoscopic and robot-assisted groups (0.1% vs. 0.2%, respectively, p=0.44). For both groups, postoperative individual complications were similar; including pulmonary embolism, deep venous thrombosis, postoperative pain, bleeding, bowel obstruction, paralytic ileus, abscess, atelectasis and anastomotic leak. See **Table 2**.

The mean length of hospital stay for patients who underwent the laparoscopic approach was shorter than for those who underwent the robot-assisted approach (2.47 ± 3.7 *vs.* 2.7 ± 3.5 days, p<0.001). Patients with the following postoperative complications were significantly more likely to have a longer length of stay: wound infection (regression coefficient [COEF]=13.03), deep venous thrombosis (COEF=13.70), pulmonary embolism (COEF =6.62), anastomotic leak (COEF=4.41), bleeding (COEF=2.99), paralytic ileus (COEF =2.75), and atelectasis (COEF=1.77).

The median total hospital charge for the laparoscopic group was $39,765 (mean $47,325 +39.494). For those in the robot-assisted group, the median total charge was $56,114 (mean $68,783 ± 63,579, p<0.001). Type of surgical approach (COEF=19,754), increased LOS (COEF=9,912), male sex (COEF=4,027), nonteaching and teaching compared to rural hospital status (COEF=16,822 and 11,617, respectively), and African American, Hispanic, and Asian/Pacific Islander compared to other races (COEF=6,407, 8,263 and 15,302 respectively) significantly impacted the total hospital charge. Anastomotic leak (COEF= 22,998) and atelectasis (COEF=13.788) also significantly affected the total charge.

## Discussion

Roux-en-Y gastric bypass is proven to be the most effective treatment for morbid obesity and controlling obesity related comorbidities [12]. Roux-en-Y gastric bypass (RYGB) is one of the most widely performed bariatric surgeries in the world. Robotics in bariatric surgery has still not come into the mainstream; utilized in only 2.1% of all gastric bypass cases as compared to the standard laparoscopic approach (97.9%). Some of the possible explanations for decreased application are the cost of equipment and perceived cumbersome procedures involving multiple dockings and complicated port positioning [13]. The robotic approach employs more sophisticated tools and more advanced skills are necessary for the operation. However, the rate of utilization of the robot approach increased from 0.2% in 2008 to 5.3% in 2013 [14,15].

In concordance with our findings, most studies published comparing the costs between robotic bariatric procedures to laparoscopic procedures reveal higher cost associated with the robotic RYGB. Focusing on hospital charges, our study revealed median hospital charge for the standard laparoscopic group was $39,765. For those in the robot-assisted group, the median total charge was $56,114 p<0.001. The high costs of robot-assisted surgery can be attributed to long operation room time and the actual cost of the robot and its maintenance. The Breitenstein study calculated costs as time (min) spent in the operating room and found that the amortized cost for robotic surgery was $1275, while the amortized cost for laparoscopic surgery was only $38.30 per minute [16]. This price may be decreased in the future as more hospitals buy robots and laws of supply and demand prevail. However Bailey et al. demonstrated expected costs of robotic surgery would not become equivalent to those of laparoscopic surgery even if fifty procedures were performed per month, assuming that the

lower limit of robot-specific costs was incurred ($13,453 *vs.* $11,956, respectively) [17].

We found the rate of utilization of the services among the Medicare patients was 2.9% ($p < 0.05$) and for Medicaid patients was 2.3% while those with private insurance coverage were 1.9%. This could be explained by the percentage of cost covered by the insurance companies, leading to reduced costs among the covered patients. These patients tend to utilize the best services in the system since they do not directly sustain the costs [18]. The rate of utilization of robot-assisted approach among self-pay patients was 1.4% ($p<0.05$).

The robot-assisted approach was practiced mostly in urban teaching hospitals (66% of robot-assisted approach cases). One explanation for this discrepancy is the infrastructure in urban regions ranging from steady supply to meet the demand, more individuals with medical coverage, Medicaid, and the availability of specialists [19]. The hospitals offering the robot-assisted Roux-en-Y G-bypass are located in learning institutions as the procedure is sophisticated and requires consistent training of the staff. Most urban areas are located in the Northeast; hence the robot-assisted procedure is frequently conducted in this region [20]. Rural areas may not have the caseload and payer mix to justify the expenditures associated with robotic technology [20]. The relatively cheaper and simple standard laparoscopic approach was utilized at the rate of 99% for all laparoscopic cases ($P< 0.05$).

The overall complications arising from the procedures were found to be relatively similar in the robotic approach compared to laparoscopy. There was no significant difference in rates of complications between the two groups. In a meta-analysis by Markar, there was a significantly reduced incidence of anastomotic stricture in the robotic group (POR=0.43; 95% CI=0.19 to 0.98; p=0.04). There was no significant difference between robotic and laparoscopic groups for anastomotic leak, post-operative complications, operative time and length of hospital stay [8]. In agreement with our study, a review of 7 studies in 2013 by Bailey and Hayden, found no significant difference in overall morbidity and specific morbidities such as anastomotic leak or stricture [17]. Despite no significant differences in postoperative complications, we found the robotic approach had a longer length of hospital stay with associated higher total hospital charges. These results suggest laparoscopic and robot-assisted approaches in Roux-en-Y gastric bypass procedures are comparable in terms of patient safety and clinical outcomes.

This study faced some limitations that resulted from use of nationwide data. The data was obtained from the NIS database, which provided a large number of samples, but the study was retrospective, making it difficult to reach a concrete conclusion. The data from NIS could not evaluate whether all the procedures were applied simultaneously (e.g., if a gastric bypass surgery was performed completely robotically or if only part of the operation was performed robotically such as gastro jejunal anastomosis; leading to under-coding for patients having both approaches). Also the expertise of the specialists, duration of operations, rates of conversion and readmission of patients was not indicated. As far as financial outcomes, NIS data only included hospital charges, excluding the difference in costs of each procedure individually. Given the nature of the NIS database, we were unable to provide statistics regarding follow-up which prevented comparison of long-term outcomes of laparoscopic versus robotic approaches. Despite these limitations, to date, our study is the first nationwide study to analyze the clinical outcomes between laparoscopic and robot-assisted Roux-en-Y gastric bypass procedures.

## Conclusions

Nationwide, most gastric bypass procedures are done via laparoscopic approach. Compared to laparoscopic approach, robotic approach has no clinical advantages observed in relation to morbidity and mortality. However, robotic procedure has a significantly higher total charge to the patient.

## Conflict of Interest

The authors declare no conflict of interest.

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Nil.

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| Characteristic | Overall | laparoscopic | Robot-assisted | |
|---|---|---|---|---|
| Estimated NO. Of patients | 3,95,954 | 3,87,710 | 8244 | |
| Age at diagnosis (years) | | | | |
| Mean | 44.8 ± 11.9 | 44.8 ± 11.9 | 46.2 ± 12.1 | P<0.001 |
| Median | 45 | 45 | 46 | |
| Gender | | | | |
| Female | 78.90% | 79% | 76.50% | P=0.013 |
| Male | 21.10% | 21% | 23.50% | |
| Race | | | | |
| White | 70.50% | 97.70% | 2.30% | |
| Black | 14% | 97.50% | 2.50% | |
| Hispanic | 10.80% | 98.20% | 1.80% | |
| Asian/Pacific Islander | 0.70% | 97.40% | 2.60% | |
| Native American | 0.50% | 97.80% | 2.20% | |
| Other | 3.50% | 98.80% | 1.20% | |
| Comorbidities | | | | |
| Diabetes mellitus | 36.50% | 36.50% | 37.90% | P=0.24 |
| Hypertension | 59% | 59% | 59.50% | P=0.7 |
| Ischemic heart disease | 4.70% | 4.70% | 5.60% | P=0.1 |
| Chronic kidney disease | 1.70% | 1.70% | 2% | P=0.29 |
| Chronic obstructive pulmonary disease | 19.60% | 19.6 | 20.20% | P=0.57 |

**Table 1: Demographic and clinical characteristics of patients underwent Roux-en-Y gastric bypass procedure in the United State from 2008 to 2013 (NIS)**

| | Laparoscopic | Robot assisted | P value |
|---|---|---|---|
| | % | % | |
| PE | 0.10% | 0.10% | 1 |
| DVT | 0.10% | 0.10% | 0.63 |
| Postoperative pain | 0.60% | 0.50% | 0.75 |
| Bleeding | 1.40% | 1.50% | 0.77 |
| Bowel obstruction | 0.20% | 0.10% | 1 |
| paralytic ileus | 1.20% | 1.20% | 0.83 |
| Abscess | 0.10% | 0.20% | 0.45 |
| Atelectasis | 2.20% | 2.20% | 0.94 |
| Anastomotic leak | 1% | 0.60% | 0.21 |

**Table 2: Rate of post-operative gastric bypass procedures complications in the United State from 2008 to 2013 (NIS)**

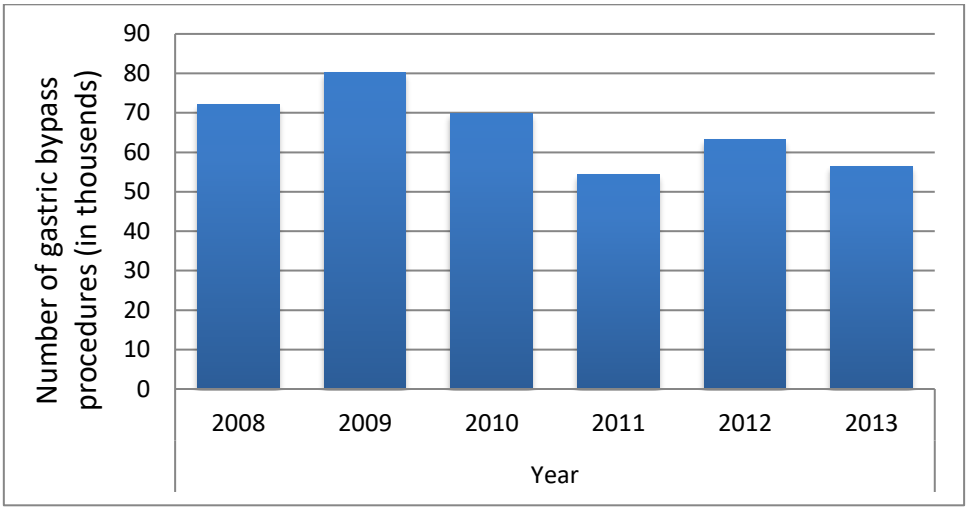


**Figure 1: Estimated annual number of gastric bypass procedures in the United State from 2008 to 2013 (NIS)**

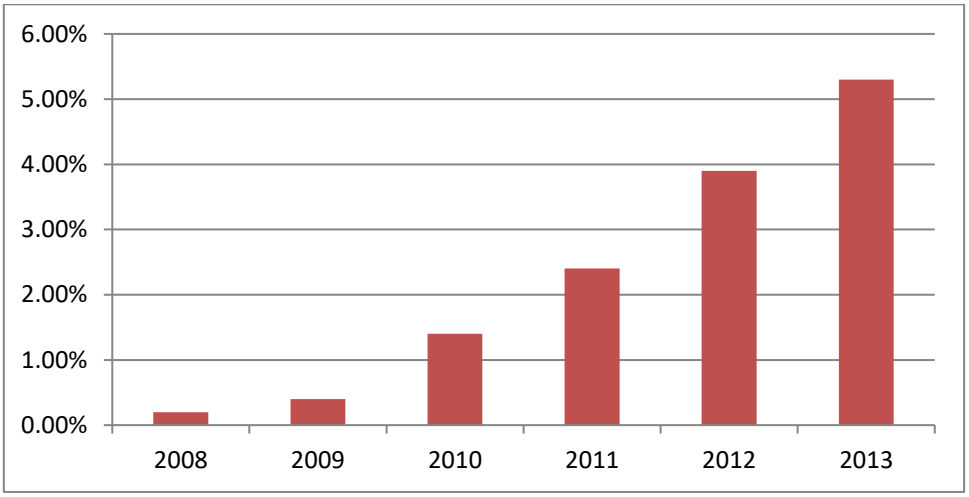


**Figure 2: Estimated annual percentage robot assisted procedures in the United State from 2008 to 2013 (NIS)**

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