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Robotic *vs* Laparoscopic vs Open Incisional Hernia Repair: A Single-Institution Analysis of 145 Consecutive Robotic Cases

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Abbreviations: FG: Full Group of Robotically Performed Procedures; SG: Age Stratified Subgroup of Robotically Performed Procedures; d: Days of Length of Stay.

Abstract

Purpose: Incisional hernias are commonly known to occur as a complication of abdominal procedures. This potentially leads to increased healthcare costs and decreased favorable patient outcomes. This study is a retrospective data analysis to compare incisional hernia repairs performed robotically to historical trends in open and laparoscopic surgeries.

Methods: 145 patients with incisional hernia repairs were retrospectively assessed between January 2013 and January of 2018. All robotics cases were performed at this single institution by a single surgeon, and cases were all comers.

Results: Mean age was considerably different between the groups. Sex ($p<0.0001$) and smoking history ($p<0.0001$) were both significant. An age adjusted robotic subgroup was created using the laparoscopic age range. Conversion rate was 1.4% in FG (full group) and 1.0% in SG (subgroup) robotics compared to 4.0% in laparoscopic ($p=0.23$). Inpatient admission was 23.4% in FG and 19.2% in SG robotics compared to 28.0% in open and 16.0% in laparoscopic ($p=0.0507$) procedures. Thirty-day readmission was 3.4% in FG and 1.0% in SG robotics compared to 9.2% in open and 6.9% in laparoscopic ($p = 0.02$) groups. Length of stay was 0.8 days in FG and 0.8 days in SG robotics compared to 2.8 days in open and 1.7 days in laparoscopic patients ($p=0.01$).

Conclusions: The data trends towards robotics procedures appear to have better outcomes. Thirty-day readmission and length of stay were significantly decreased. More power is needed to conclusively say which method is best for incisional hernia repairs.

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Introduction

Ventral hernia repairs are considered one of the most common procedures performed by general surgeons with 90,000 being performed annually [1]. Greater than 2 million abdominal procedures take place in the United States per year with ventral incisional hernias developing in an estimated 3% to 20% [2]. The high volume of procedures means optimization of the technique this used could have widespread positives for the patient and the hospital alike. The first described robotic hernia repair in literature was in 2015 and since then, popularity has been increasing in robotic hernia repairs [3]. The question of whether open procedure methods, laparoscopic procedure methods, or robotic procedure methods giving the best patient outcome is still of growing interest and debate as revealed in multiple studies [1-4]. Many of the present-day literature evaluates OR time, complications, and follow up [5-16]; however, there is a lack of evidence for conversion rate and patient admission [7,13]. Currently, there is also insufficient data published on readmission and length of stay. This study looks to fill this void on robotic surgical methods and compare them to current data known in open and laparoscopic procedures. This retrospective study examined 145 patients in a rural patient population that were categorized as an incisional/ventral hernia repairs conducted by a single surgeon. Data examined includes gender, age, BMI, length of stay, thirty-day readmissions, and conversions.

The key factors that are being assessed within this study are the length of stay, the thirty-day readmissions, inpatient admission rate, and the conversion rate. The length of stay and the thirty-day readmissions are used within the healthcare system as a marker for the quality of healthcare the patient receives. The conversion rate is a marker used by surgeons to indicate how well a method (i.e. laparoscopy or robotics) can mimic an open procedure.

Materials and methods

Retrospective data was used from robotic hernia repair surgeries conducted by a single surgeon located at a rural, northwestern-Ohio hospital. The procedures ranged from January 2013 to January 2018 and included a total robotic hernia repair sample size of 750 patients. Patients were then split into separate repair groups where patients with more than one hernia repair surgery were duplicated for their respective hernia repairs. Only patients who had undergone a ventral incisional hernia robotic repair were analyzed in this study. For the robotic repairs, the hernia sac is dissected free, opened to reduce herniated contents, and resected. The mesh is placed in the intraperitoneal position and fixated with interrupted suture at a minimum of 2 cm from the fascial edge. This amounted to 145 patients used for studying purposes. An illustration of the stratification can be seen in Figure 1.

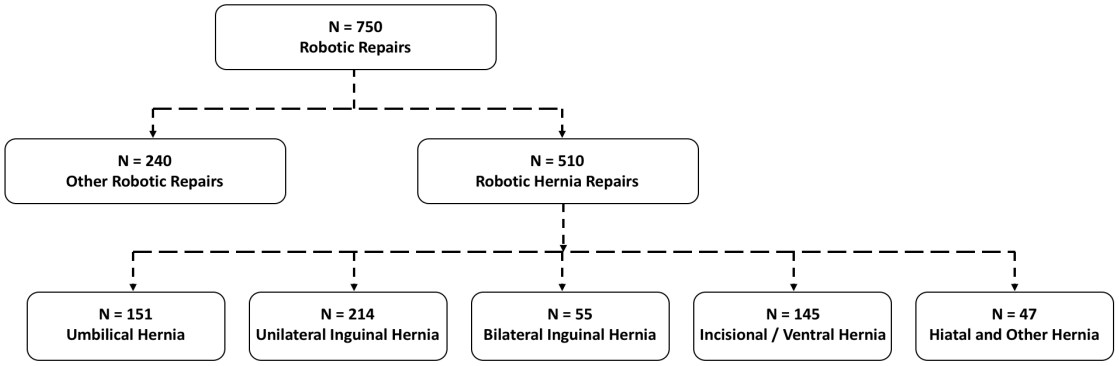

Figure 1: Hernia Repair Sample Breakdown (Microsoft PowerPoint).

The surgeon converted all ventral hernia surgeries into robotic procedures and reported 'all comers' undergoing robotic repair of ventral hernias. Patients that required additional abdominal procedures were excluded from the analysis. Additional data on demographics and comorbidities were collected from the patients' Electronic Medical Records (EMR). An IRB authorization was obtained. Study workflow and conduct were completed in accordance to the hospital's ethics and moral standards. With this being a retrospective chart review, informed patient consent was not obtained. These variables include patient demographics (age, sex, Body Mass Index (BMI) [calculated as the weight in kilograms divided by the height in meters squared]), patient comorbidities (diabetes), and outcome data (conversion rate, inpatient admission, 30 day readmission, and length of stay). The length of stay was reported as either outpatient (assigned 0.5 days) or inpatient admission with number of days recorded. Comorbidities were addressed with obesity and diabetes which were reflected in the EMR. Statistical analysis was performed using a chi squared test method *via* Prism v7.0 (GraphPad, Inc, San Diego, CA) and compared to previous literature results for open and laparoscopic hernia surgeries.

Results

From 2013 to 2018, a total of 750 patients underwent robotic hernia repair in which 145 (19%) procedures were robotic ventral/incisional hernia repairs. Two patients (1%) required conversion from the robotic to the open procedure due to technical difficulties or hemodynamic instability. This population set was label Full Group (FG) for statistical purposes. A second group was created for Subgroup Analysis (SG). In the SG group, one patient (1%) required conversion from the robotic to the open procedure due to hemodynamic instability.

Table 1 describes the demographic data and comorbidities of the patients included in the analysis. Significance was found between sex, diabetes, and tobacco use. Statistical tests were unable to be run on age or BMI, however the subgroup was used to offset age.

In the FG group, 1.4% of the patients (2 patients) were converted in robotic surgeries which is lower as compared to 4.0% in laparoscopic surgeries [17]. The rate of thirty-day readmissions was also lower in robotic surgeries at 3.4% (5 patients) as compared to 9.2% in open surgeries and 6.9% in laparoscopic surgeries [18]. Length of stay of inpatient admissions was also

lower in robotic surgeries at a mean of 0.8 days when compared to a mean of 1.4 days in open surgeries and 0.9 days in laparoscopic surgeries [17]. All of these metrics showed a decrease except for inpatient admissions, where robotics had a 23.4% (34 patients) when compared to 28.0% in open surgeries and 16.0% in laparoscopic surgeries [17].

A confounding variable that may have influence on comparing data across the different articles' sample populations was age. The hypothesis is that more complex patients were found in older age groups and were admitted for inpatient hospital stays for cardiac and anesthetics recommendations, independent of the surgery rather than surgical complications. To project the effect that age had on comparisons between groups, the SG group was created to adopt the laparoscopic data's age range and was incorporated into the same range into the surgeon's robotic data. More specifically, the age range was shift from the original 24-89 range to comparing the article's age range of 21-68 [4]. This effectively adopted a change in the age range of the robotic data in the SG analysis to 24-68 and shifted the mean age 52.3, still five years older than laparoscopic data. The age along with other comorbidities can be found in Table 1.

In the SG group, 1.0% of patients (1 patient) was converted to robotic surgeries which is lower as compared to 4.0% in laparoscopic surgeries [17]. The rate of thirty-day readmissions was also lower in robotic surgeries at 1.0% (1 patient) as compared to 9.2% in open surgeries and 6.9% in laparoscopic surgeries [18]. Length of stay of inpatient admissions was also lower in robotic surgeries at a mean of 0.8 days when compared to a mean of 2.8 days in open surgeries and 1.7 days in laparoscopic surgeries [17]. All of these metrics showed a decrease except for inpatient admissions, where robotics had a 19.2% (19 patients) when compared to 28.0% in open surgeries and 16.0% in laparoscopic surgeries [17].

These results along with statistical significance are summarized in Table 2 and graphically in Figures 2-5.

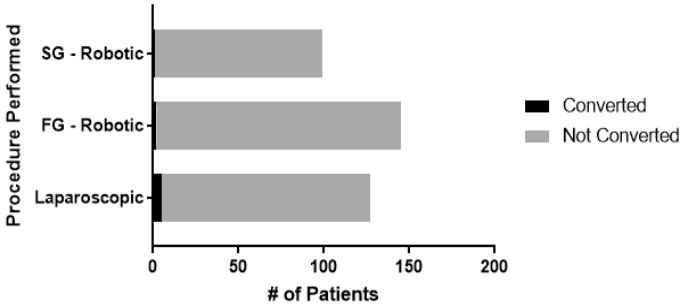

Figure 2: Conversion Rate Comparison (Prism v7.0).

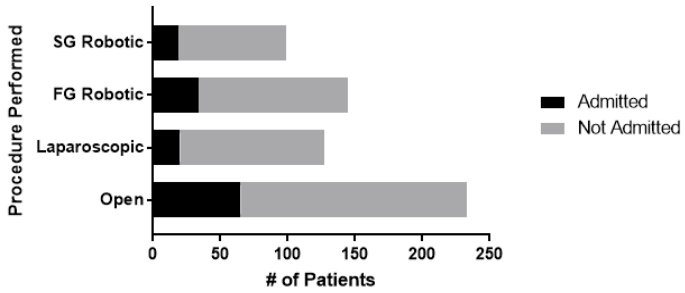

Figure 3: Readmission Rate Comparison (Prism v7.0).

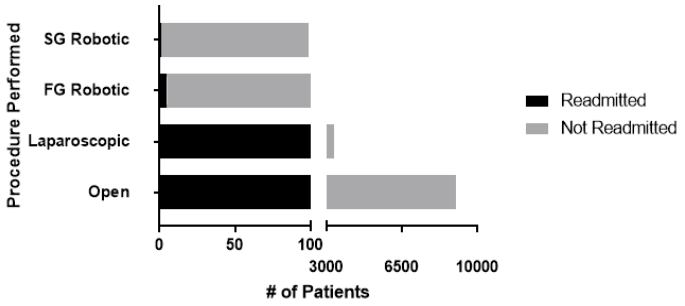

Figure 4: Readmission Rate over Thirty Days Comparison (Prism v7.0).

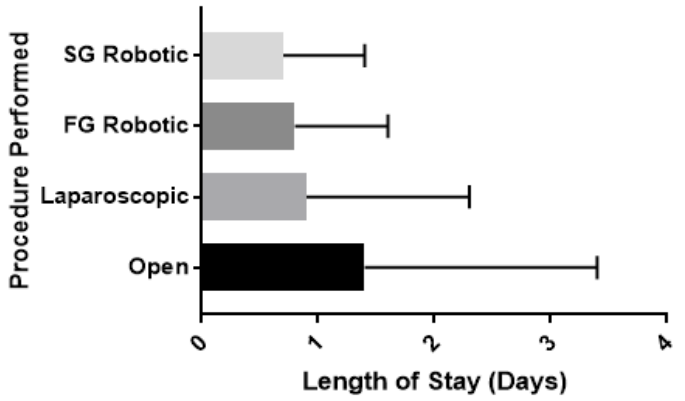

Figure 5: Length of Stay Comparison (Prism v7.0)

Table 1: Demographics and Comorbidities.

Characteristic	*Open*[A] (N = 233)	*Laparoscopic*[A] (N = 127)	*Robotic* (FG, N = 145)	*Robotic* (SG, N = 99)	P Value
Sex, No. (%)					
Women	178 (76)	106 (84)	73 (50)	52 (53)	<0.0001
Men	55 (24)	21 (16)	72 (50)	47 (47)	
Age, mean (Range)	49.9 (18-86)	47.1 (21-68)	60.1 (24-89)	52.3 (24-68)	-[B]
BMI, mean (Range)	36 (17-65)	37 (24-82)	34.3 (17-59)	35.4 (17-59)	-[B]
Diabetes mellitus, No. (%)	61 (26)	30 (24)	35 (24)	18 (18)	0.48
Tobacco use, No. (%)					
Current	49 (21)	24 (19)	21 (15)	16 (16)	<0.0001
Former	17 (7)	10 (8)	65 (45)	49 (50)	

[A]Demographics and Comorbidities from Bingener J et al [17].
[B]Previous Literature omitted data needed to complete statistics [18].
Abbreviations: FG, Full group of robotically performed procedures; SG, Age stratified subgroup of robotically performed procedures; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

Table 2: Comparison with Previous Literature.

Characteristic	*Open*[A] (N = 233[A] N = 9009[B])	*Laparoscopic*[A] (N = 127[A] N = 3360[B])	*Robotic* (*FG*, N = 145)	*Robotic* (*SG*, N = 99)	P Value
Conversion Rate, %		4.0[A]	1.4	1.0	0.23
Inpatient Admission, %	28.0[A]	16.0[A]	23.4	19.2	0.051
30 Day Readmission, %	9.2[B]	6.9[B]	3.4	1.0	<0.001
Length of Stay, Mean (d)	1.4[A]	0.9[A]	0.7	0.7	0.01

[A]Complications and Other Metrics from Bingener J et al [17].
[B]Thirty-Day Readmission Data from Celio A et al [18].

Discussion

Patient outcomes and surgery optimization has been and should continue to be at the forefront of the discussion pertaining to which surgical method is best suited for ventral hernia repairs. There has been a number of studies that have identified robotic hernia repairs and their outcomes [6,8,10,13]. No studies to the best of our knowledge have been complete on overall metrics of robotic ventral hernia repairs and compared to laparoscopic and open procedures. One retrospective study showed an increase in length of stay and complication rates in robotic ventral hernia repairs compared to laparoscopic repairs. Robotic length of stay was increased at 4.32 days compared to laparoscopic data of 2.19 days (p=0.0023). Robotic thirty-day readmission was increased at 5.62% compared to 3.01% in laparoscopic data (p<0.0001) [19].

In comparison to previous studies, this study compares all four metrics of conversion rate, inpatient admission, thirty-day readmission rate, and length of stay of robotic ventral hernia repairs. Previous publications, to the best of our knowledge, may show certain parts of these variables, unfortunately they do not include all four and, due to robotic procedures being newer, are typically low powered studies.

This study has several limitations. First, it is a retrospective chart review; and therefore, is dependent upon nursing and provider documentation. Second, demographics of the studies used for comparison are statistically significant in some categories along with age being skewed. Third, all thirty-day readmissions and inpatient admissions were accounted for regardless if they were dependent or independent of the surgical hernia repair. Lastly, continual follow-up was unavailable due to the recent surgeries being performed.

Conclusion

Robotic surgeries showed a decreasing trend in conversion rate, length of stay, and thirty-day readmission with thirty-day readmissions and length of stay being statistically significant. Inpatient admissions was not statistically significant and did not trend down. More collect of data and more studies will be needed for further follow-up to truly show if robotic surgery styles are greater than the more common open and laparoscopic styles that many surgeons are using now.

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