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Early Experience with the Senhance Surgical System in Bariatric Surgery

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ABSTRACT

Background and Objectives: Robotic-assisted surgery advancements have paralleled growing bariatric surgery demands. The Senhance robotic platform offers an alternative to the da Vinci surgical system but there are limited studies evaluating the Senhance system in bariatric surgery. This study aims to review a single surgeon's experience comparing outcomes between traditional laparoscopic and Senhance-assisted sleeve gastrectomy.

Materials and Methods: All sleeve gastrectomies performed laparoscopically, Senhance-assisted, or da Vinci-assisted by a single surgeon at an academic center from January 2019 to July 2021 were retrospectively reviewed. Primary outcomes and quality measures were 30-day complications, operative times and length of stay.

Results: A total of 268 patients, including 162 laparoscopic, 92 Senhance, and 14 da Vinci cases, were included. Operative times were significantly longer with Senhance (115.7 min) and da Vinci (122.7 min), compared to laparoscopic (94.8 min, $P < .0001$). Length of stay (measured in days) was significantly longer in the Senhance (1.8) and da Vinci (2.2) groups compared to laparoscopic cases (1.5, $P < .0001$). These differences remained significant after controlling for age, sex and body mass index. 30-day complication rates were 8.7% (n = 8) in the Senhance group, 7.1% (n = 1) in the da Vinci group and 2.5% (n = 4) in the laparoscopic group ($P = .0567$).

Conclusion: Senhance-assisted sleeve gastrectomy is safe in bariatric surgery and comparable to laparoscopic sleeve gastrectomy with respect to 30-day complications.

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Conflict of interest: Consulting/honoraria for Asensus Surgical (Senhance) and Intuitive Surgical. (Da Vinci)

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INTRODUCTION

The focus of surgical innovations in minimally invasive surgery has been to reduce the invasiveness of procedures while preserving the efficacy and safety of standard laparoscopy.[1] The advantages of minimally invasive surgery have been well documented and include shorter hospital stays, reduced postoperative pain, and quicker recovery time.[2] Laparoscopic surgeries have become the gold standard in many surgical procedures. However, some limitations include reduced dexterity, sensory feedback, and visualization. Robotic surgery is the latest advancement in minimally invasive surgery which seeks to address some of these issues and may correlate with a more rapid learning curve.[3] The da Vinci system (Intuitive Surgical, Sunnyvale, CA) is the most prevalent robotic system and its use has been established in colorectal, gynecologic, hernia, as well as bariatric surgeries.[4] While the outcomes of robotic surgery are similar to laparoscopic surgery,[5,6] the increased cost and operating times can be barriers to widespread use of the technology.[7] The Senhance robotic system (Asensus Surgical, Durham, NC) was introduced as an alternative robotic system.

The configuration as approved in the United States consists of three mobile arms utilizing predominantly reusable instruments.[8] The system also includes: eye tracking, haptic sensing, and 3-dimensional visualization among other features of the system.[9,10] The Transenterix European patient registry for robotic-assisted laparoscopic procedures in urology, abdominal, thoracic, and gynecologic surgery (TRUST Registry) is a large multicenter study evaluating the Senhance system. The study involved 871 patients across 5 centers in Europe and demonstrated Senhance-assisted procedures across these specialties were both safe and reproducible.[11] There is literature predominantly in gynecologic surgery that reports the Senhance system is comparable to

laparoscopic surgery and the da Vinci system in terms of perioperative outcome.[10,12]

Bariatric surgery plays an increasing role in the treatment of obesity and improves long-term outcomes for weight loss, mortality, glycemic and blood pressure control. The use of minimally invasive surgery including robotic assistance is well established in bariatric surgery and is associated with reduced post operative complications.[5,6,13] At our institution we have extensive experience with laparoscopic sleeve gastrectomy and more recently have incorporated the use of the Senhance and da Vinci robotic systems in bariatric surgery. The Senhance platform is more readily available as fewer surgeons are utilizing this device. Access to the da Vinci is more limited as 18 surgeons are competing to access one robot therefore these cases were intentionally reserved for high body mass index (BMI) individuals (>55) where the articulating instruments allow more maneuverability in a smaller space. Our goal with this study is to review our experience with sleeve gastrectomies performed at our facility. We aim to compare outcomes between the traditional laparoscopic approach and the Senhance robotic platform. Although we have limited data on high BMI patients (>55) with respect to the da Vinci platform we will include these for secondary analysis. To our knowledge, this will be the largest series of bariatric patients who underwent Senhance-assisted bariatric procedures.

MATERIALS AND METHODS

This is early data for the Senhance system as there are not many centers performing bariatric cases using this device therefore, we performed a single-center retrospective review. This study was reviewed and approved by the Institutional Review Board. The requirement for informed consent was waived because of the retrospective nature of the study.

The study cohort comprised all patients who underwent minimally invasive sleeve gastrectomy at our institution from January 2019 through July 2021. Patients were placed into three groups: Laparoscopic, Senhance (R1), or da Vinci (R2). Laparoscopic represents the traditional approach to sleeve gastrectomy without robotic assistance. R1 represents sleeve gastrectomies performed using the Senhance system which has haptic feedback. R2 represents sleeve gastrectomies performed using the da Vinci.

The primary surgeon in this study began performing robot-assisted sleeve gastrectomy after our institution acquired both robotic platforms at the start of the study. We selectively used the da Vinci system on patients with BMI > 55 as the articulating instruments allow for more maneuverability in a smaller space. The Senhance system utilizes reusable instruments and our hospital had access to two trays for the device. During our surgery block time we would typically perform 3–4 sleeve gastrectomies and would alternate between Senhance-assisted and traditional laparoscopic sleeve gastrectomy. If the patient had a BMI > 60 and there was da Vinci block time, then they would preferentially be booked on that system. Otherwise, patients were added on sequentially to our regular block time. This allocation was irrelevant to other patient characteristics or BMI and the cases alternated between Senhance-assisted and traditional laparoscopy.

With respect to the surgical technique the laparoscopic and Senhance-assisted approaches were essentially the same. The patient was positioned supine with a split leg table and arms extended. Pneumoperitoneum was established with a Veress needle and an 11-mm optical trocar was placed 15 cm to 18 cm from the xiphoid process just to the left of midline. Additional 5-mm ports were placed in the left upper and right upper quadrants. An additional 15-mm trocar was placed in the left upper abdomen to the left of midline. A subxiphoid Nathanson retractor was placed. The pylorus was identified, and 6 cm was measured proximal to the pylorus. In this area, the gastrocolic ligament was divided, gaining access to the lesser sac. A laparoscopic linear stapler was then used to divide the stomach and the stapler was repositioned against a bougie and fired. Sequential staple loads were fired dividing the stomach right next to the bougie in a vertical fashion. The bougie was removed and esophagogastroduodenoscopy (EGD) was performed to confirm no significant bleeding, twisting, or kinking. A leak test was performed. At this point in the laparoscopic cases the gastrocolic ligament and short gastrics were divided with a laparoscopic energy device, the stomach was removed through the 15 mm port and the fascia at this port site was closed with a Vicryl suture. The Senhance system utilizes the same ports as the laparoscopic case but does not have a stapler. Therefore, for Senhance-assisted cases the procedure was started with a laparoscopic approach. Once the stomach was divided the robot was docked and the short gastrics were taken with the Senhance vessel sealer. For the da Vinci cases the approach was similar in the sense that we utilized the same sized bougie and stapling technique then

performed an EGD with leak test and proceeded to take the short gastrics. For the da Vinci, we utilized their proprietary vessel sealer and stapler.

We collected demographic characteristics, preoperative comorbidities, survival outcomes, length of operation, length of stay, 30-day complications, and 90-day complications from the medical record. Preoperative characteristics included age, sex, race, and BMI. Preoperative comorbidities identified included congestive heart failure, hypertension, diabetes, end stage renal disease, gastroesophageal reflux disease, obstructive sleep apnea, and arthritis.

Group comparisons were conducted via Fisher's exact tests and analysis of variance. Covariate adjusted comparisons of complications were conducted via logistic regression. Propensity score matching was performed to balance baseline characteristics of patients in the treatment groups. Patients with R1 or R2 robotic-assisted procedures were matched with laparoscopic patients separately. Propensity score models included patient age, sex, race, BMI, hypertension, and congestive heart failure. Greedy nearest neighbor matching with a caliper of 0.1 was executed in the propensity score matching procedure in statistical analysis software (SAS), version 9.4. The primary outcome, 30-day complication, in the matched sample was compared via conditional logistic regression.

RESULTS

We identified 268 patients who had undergone sleeve gastrectomy during the study period including 162 laparoscopic cases, 92 using Senhance (R1), and 14 using da Vinci (R2). Preoperative patient characteristics for the entire sample are shown in **Table 1**. Baseline demographic and comorbid conditions were similar between groups except for the R2 group having significantly greater BMI ($P < .0001$), greater rates of congestive heart failure ($P < .0001$) and hypertension ($P = .0299$).

Time variability between groups is shown in **Table 2**. In our analysis of postoperative adverse events (**Table 3**), the rate of surgical complications at 30 days was greater in the robotic surgery groups. The rates were 8.7% (n = 8) among R1 cases and 7.1% (n = 1) among R2 cases and 2.5% (n = 4) among laparoscopic cases ($P = .0567$). No additional patient developed surgical complications between 30 and 90 days. However, two patients in the R1 group that had 30-day complications also had an additional complication in the 90-day period. One patient with a surgical site infection also had stenosis within the sleeve. The second patient with a surgical site infection developed a persistent subcutaneous sinus tract.

The docking time was available for 89/92 Senhance-assisted cases with a mean time of 8 minutes. The docking time was not available for the da Vinci-assisted cases as it was not documented in the records. In the analysis the robot-assisted operative times include the docking time in the total. Operative times were longer in robotic cases, R1 (115.7 min) and R2 (122.7 min), compared to laparoscopic cases (94.8 min, $P < .0001$). Similarly, there was a greater average length of stay in robotic cases, R1 (1.8 days) and R2 (2.2 days), compared to laparoscopic cases (1.5 days, $P < .0001$). These differences remained significant after controlling for patient age, sex, and BMI. Between the laparoscopic and R1 groups, the rate of reoperation (3.1% vs 7.6%) and readmission (5.6% vs 7.6%) were not statistically significant ($P = .22$ and $P = .66$). When we further analyzed the data, postoperative EGDs were included in the category of reoperation. Most of the reoperations in the Senhance group were EGDs for stent placement secondary to sleeve stenosis which was also true for the laparoscopic group's reoperation data.

Propensity score matching was performed between the laparoscopic group and each of the R1 and R2 groups. For the R1 group, 84 of 92 (91.3%) patients were matched with a laparoscopic patient. The odds ratio for 30-day complication in the R1 group compared to the laparoscopic group was 6.0 (0.72, 49.8) ($P = .0971$). For the R2 group, 8 of 14 (57%) patients were matched with a laparoscopic patient. However, there were no complications in the matched sample, so no comparison was performed.

DISCUSSION

A study published in 2017 reported 10 obese patients with endometrial cancer who underwent Senhance-assisted robotic hysterectomy. While the sample size was small, this was the first evidence that the Senhance system can be used safely in obese patients.[14] Although the efficacy of this system has been proven in other surgical fields there is minimal literature on its use in bariatric surgery.

At our facility, the primary surgeon involved in this study has extensive experience with the laparoscopic gastric sleeve procedure. After our facility acquired both the Senhance and da Vinci robotic systems, the surgeon began utilizing both platforms for sleeve gastrectomy. At our facility, the Senhance is more readily available as few surgeons utilize this device. However, access to the da Vinci system is very limited as 18 surgeons compete for

Table 1.
Patient Characteristics

	All (n = 268)		Laparoscopic (n = 162)		R1 (n = 92)		R2 (n = 14)		*P*-value
Age in years, mean (std)	40.1	10.2	39.9	9.9	39.7	10.3	44.4	12.8	0.2542
Age, % (n)									0.9429
18–29	16.8	45	17.3	28	16.3	15	14.3	2	
30–39	33.6	90	33.3	54	35.9	33	21.4	3	
40–49	30.6	82	30.9	50	29.4	27	35.7	5	
50 and older	19.0	51	18.5	30	18.5	17	28.6	4	
Sex, % (n)									0.1058
Female	93.3	250	93.8	152	94.6	87	78.6	11	
Male	6.7	18	6.2	10	5.4	5	21.4	3	
Race, % (n)									0.1873
Black	73.1	196	74.7	121	69.6	64	78.6	11	
White	23.9	64	23.5	38	26.1	24	14.3	2	
Hispanic	2.2	6	1.2	2	4.4	4	.	.	
Unknown	0.8	2	0.6	1	.	.	7.1	1	
BMI, mean (std)	49.7	8.4	48.9	7.4	49.0	8.1	64.6	7.4	**<0.0001**
BMI, % (n)									**<0.0001**
Less than 45	33.6	90	35.2	57	35.9	33	.	.	
45–49.9	23.9	64	25.9	42	22.8	21	7.1	1	
50–54.9	15.7	42	16.7	27	16.3	15	.	.	
55 or greater	26.9	72	22.2	36	25.0	23	92.9	13	
Congestive heart failure, % (n)									**0.0247**
No	97.8	262	98.8	160	97.8	90	85.7	12	
Yes	2.2	6	1.2	2	2.2	2	14.3	2	
Hypertension, % (n)									**0.0299**
No	42.5	114	40.7	66	50.0	46	14.3	2	
Yes	57.5	154	59.3	96	50.0	46	85.7	12	
Diabetes, % (n)									0.6881
No	73.9	198	74.7	121	73.9	68	64.3	9	
Yes	26.1	70	25.3	41	26.1	24	35.7	5	
End stage renal disease, % (n)									0.2189
No	99.3	266	100.0	162	97.8	90	100.0	14	
Yes	0.8	2	.	.	2.2	2	.	.	
Gastroesophageal reflux disease, % (n)									0.2382
No	69.0	185	70.4	114	64.1	59	85.7	12	
Yes	31.0	83	29.6	48	35.9	33	14.3	2	
Obstructive sleep apnea, % (n)									0.0873
No	46.3	124	45.1	73	52.2	48	21.4	3	
Yes	53.7	144	54.9	89	47.8	44	78.6	11	

Table 1. Continued

	All (n = 268)		Laparoscopic (n = 162)		R1 (n = 92)		R2 (n = 14)		*P*-value
Arthritis, % (n)									0.2453
No	76.1	204	77.2	125	77.2	71	57.1	8	
Yes	23.9	64	22.8	37	22.8	21	42.9	6	
Prior Surgery, % (n)									0.3513
No	28.4	76	27.2	44	28.3	26	42.9	6	
Yes	71.3	191	72.8	118	70.7	65	57.1	8	
Unknown	0.4	1	.	.	1.1	1	.	.	

one robot. Secondary to this we primarily alternate cases between the Senhance system and traditional laparoscopy during regular block time. We preferentially reserve high BMI cases (>55) for the da Vinci platform as the articulating instruments allow better maneuverability in smaller working space. The primary goal of this study was to review our experience with sleeve gastrectomy and compare outcomes between traditional laparoscopic and Senhance-assisted sleeve gastrectomy. We included the da Vinci-assisted cases although limited in number and restricted to high BMI individuals as an additional target for secondary analysis. Our primary finding was that 30-day complication rates were not significantly higher in Senhance-assisted sleeve gastrectomy when compared to traditional laparoscopic sleeve gastrectomy. In addition, there were similar rates of readmission and reoperation compared to the laparoscopic group. Most of the reoperations were endoscopies for stent placement secondary to sleeve stenosis and many of the stenoses were diagnosed after the 90-day complication period. From the eight 30-day complications in the Senhance group, 3 were surgical site infections and 2 from stenosis within the sleeve. In this study laparoscopic staplers were being used as there were no available staplers for the Senhance system. We believe stenosis of the sleeve is more representative of issues with technique as opposed to an issue with the Senhance system. Operating time was significantly higher for both robotic groups versus traditional laparoscopic sleeve gastrectomy. We collected docking time for 89/92 patients in the Senhance-assisted group with a mean time of 8 minutes. We did not have docking time for the da Vinci-assisted group but the total operative time for both groups does include docking which plays a factor into the longer OR time. The robotic-assisted cases included in this study include the first cases performed in both robotic arms by the primary surgeon in this study and experience likely plays a role in the longer operating room time for robotic arms. Our institution is a teaching hospital, and with new residents each month, it can be difficult to differentiate between learning curve of the attending and the learning curve of the trainees. Previous studies have shown that da Vinci operative times improve with increased experience of surgeons and operative teams.[15] Thus, it is reasonable to conclude that a similar difference will be seen using the Senhance system.

Length of stay was significantly longer for both robotic arms versus traditional laparoscopic sleeve gastrectomy. Most patients in both laparoscopic and Senhance-assisted groups leave within 0–1 day (61.1% vs 46.7%) while most patients in the da Vinci group leave on post operative day 2 (42.9%). With respect to both robotic groups, a longer length of stay may be attributed to inexperience of

Table 2.
Time Variability Amongst Groups

		All	Laparoscopic	R1	R2
Op time	N	268	162	92	14
	Mean	103.48	94.9	115.67	122.71
	Std	26.81	26.93	20.86	19.27
Length of stay	N	268	162	92	14
	Mean	1.61	1.47	1.76	2.21
	Std	0.85	0.65	1.03	1.19
Dock time	N	89	0	89	0
	Mean	8.11	.	8.11	.
	Std	2.87	.	2.87	.
Console time	N	90	0	89	1
	Mean	17.5	.	16.79	81
	Std	11.86	.	9.79	.

Table 3.
Complication Rates

	All (n = 268)		Laparoscopic (n = 162)		Senhance, R1 (n = 92)		da Vinci, R2 (n = 14)		*P*-value
Operation time, mean (std), minutes	103.5	26.8	94.9	26.9	115.7	20.9	122.7	19.3	**<0.0001**
Length of stay, mean (std), days	1.6	0.9	1.5	0.7	1.8	1.0	2.2	1.2	**0.0007**
Length of stay, % (n)									**0.0171**
0–1 day	54.5	146	61.1	99	46.7	43	28.6	4	
2 days	35.5	95	31.5	51	41.3	38	42.9	6	
3 or more days	10.1	27	7.4	12	12.0	11	28.6	4	
Complication 30 d, % (n)									0.0560
No	95.2	255	97.5	158	91.3	84	92.9	13	
Yes	4.9	13	2.5	4	8.7	8	7.1	1	
Complication 30 d and 90 d, % (n)									0.0560
No	95.2	255	97.5	158	91.3	84	92.9	13	
Yes	4.9	13	2.5	4	8.7	8	7.1	1	
Emergency department visit, % (n)									0.6934
No	81.0	217	79.0	128	83.7	77	85.7	12	
Yes	19.0	51	21.0	34	16.3	15	14.3	2	
Gastric leak, % (n)									–
No	100.0	268	100.0	162	100.0	92	100.0	14	
Port site hernia, % (n)									1.0000
No	99.3	266	99.4	161	98.9	91	100.0	14	
Yes	0.8	2	0.6	1	1.1	1	.	.	
Reoperation, % (n)									0.2268
No	95.5	256	96.9	157	92.4	85	100.0	14	
Yes	4.5	12	3.1	5	7.6	7	.	.	
Readmission, % (n)									0.6619
No	93.7	251	94.4	153	92.4	85	92.9	13	
Yes	6.0	16	5.6	9	7.6	7	.	.	
Unknown	0.4	1	.	.	.	.	7.1	1	
Mortality, % (n)									–
No	99.6	267	99.4	161	100.0	92	100.0	14	
Unknown	0.4	1	0.6	1	.	.	.	.	
Anti-emetic use, % (n)									0.3721
No	20.2	54	17.9	29	25.0	23	14.3	2	
Yes	79.9	214	82.1	133	75.0	69	85.7	12	
Narcotic use, % (n)									0.7445
No	4.1	11	3.7	6	5.4	5	.	.	
Yes	95.9	257	96.3	156	94.6	87	100.0	14	
Transfusion, % (n)									**0.0259**
No	98.9	265	100.0	162	97.8	90	92.9	13	
Yes	1.1	3	.	.	2.2	2	7.1	1	

the primary surgeon and early experience with these new approaches motivating the surgeon to observe the patient for longer than if it was performed in the traditional manner. This would be difficult to analyze with the current data but could be better elaborated with a future larger study involving multiple surgeons in multiple centers. With respect to the da Vinci arm these procedures were performed on higher BMI individuals with more comorbid conditions. In addition, da Vinci procedures were typically performed on Fri and the patients were often discharged over the weekend by a cross-covering surgeon that could explain a delay in discharge.

In addition to providing tactile feedback to the surgeon, the method by which the Senhance uses haptic feedback is also used to detect a point of minimum pressure on the abdominal wall. This is used to create a virtual fulcrum around which the instrument moves. This has the potential to reduce pressure on the abdominal wall and decrease postoperative pain as well as decreasing opioid use. Although not statistically significant, we did see lower narcotic and antiemetic use in the Senhance group.

To our knowledge, this is the largest reported series of bariatric patients to have undergone Senhance-assisted sleeve gastrectomy. At the time of this study, few surgeons were utilizing the Senhance system and even fewer were utilizing this platform for bariatric surgery which leads to a major limitation of this study as the data is collected from a single surgeon at a single institution. Another limitation is the retrospective nature of the study. The primary surgeon has extensive experience with laparoscopic sleeve gastrectomy but has limited experience with robot-assisted sleeve gastrectomy, and in a teaching institution, it is difficult to differentiate between the learning curve of the attending and the residents which rotate monthly. Another limitation of the study is the low number of da Vinci cases which is attributed to limited access as 18 surgeons compete for one robot. Another limitation is that the da Vinci is selectively used for higher BMI patients (>55) as the articulating instruments facilitate working in a smaller space. For this reason, the primary objective of this study was to report the experience with Senhance-assisted cases by comparing this approach to standard laparoscopy. We included the da Vinci data as it was available, and some comparisons were made controlling for BMI but these results should be interpreted with caution. In terms of booking cases, the high BMI patients >55 were preferentially booked on the da Vinci when available. With respect to the other cases, they were booked sequentially and the cases were performed alternating between Senhance-assisted and traditional laparoscopic approaches. The case order was not adjusted for the approach but the patients were not randomized or matched preoperatively therefore this also represents a limitation of the study.

In conclusion, our study reveals that the Senhance robotic platform is a safe alternative to traditional laparoscopic sleeve gastrectomy and can be an alternative to other robotic platforms utilized in bariatric surgery. There are opportunities for future multisurgeon, multicenter randomized studies evaluating long term outcomes and cost analysis between the Senhance and da Vinci platforms.

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