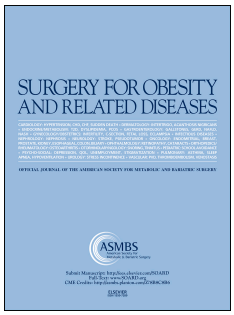
Journal Pre-proof



Remote patient monitoring to facilitate same-day discharge following laparoscopic sleeve gastrectomy: a pilot evaluation.

Timothy J. Schaffner, MD, FACS, FASMBS, Matt Wilkes, MBChB, PhD, FRCA, Robert Laverty, MD, Stephen D. Schwab, PhD, Nicole Zahradka, PhD, Juliana Pugmire, PhD, Dan Yourk, MSN, MHA, FACHE, Pamela C. Masella, MD, FACS, FASMBS, Robert Walter, MD, DHCE, FACP, FCCP, FAASM

PII: S1550-7289(23)00122-3

DOI: https://doi.org/10.1016/j.soard.2023.02.028

Reference: SOARD 5133

To appear in: *Surgery for Obesity and Related Diseases*

Received Date: 29 September 2022

Revised Date: 10 January 2023

Accepted Date: 24 February 2023

Please cite this article as: Schaffner TJ, Wilkes M, Laverty R, Schwab SD, Zahradka N, Pugmire J, Yourk D, Masella PC, Walter R, Remote patient monitoring to facilitate same-day discharge following laparoscopic sleeve gastrectomy: a pilot evaluation., *Surgery for Obesity and Related Diseases* (2023), doi: https://doi.org/10.1016/j.soard.2023.02.028.

Remote patient monitoring to facilitate same-day discharge following laparoscopic sleeve gastrectomy: a pilot evaluation.

Running title: Remote monitoring for sleeve gastrectomy

Timothy J. Schaffner, MD, FACS, FASMBS [(a) (d)]

Matt Wilkes MBChB, PhD, FRCA [(b)]

Robert Laverty, MD [(a)]

Stephen D. Schwab, PhD [(a) (c)]

Nicole Zahradka PhD [(b)]

Juliana Pugmire PhD [(b)]

Dan Yourk MSN, MHA, FACHE [(b)]

Pamela C. Masella MD, FACS, FASMBS [(a)]

Robert Walter MD, DHCE, FACP, FCCP, FAASM [(a)]

Affiliations

a. Brooke Army Medical Center, San Antonio, Texas, USA
b. Current Health Inc., Boston, MA, USA
c. Baylor University, Waco, Texas, USA
d. Bon Secours Mercy Health, Portsmouth, VA, USA

Corresponding Author

Timothy Schaffner

tjschaffner@gmail.com

Brooke Army Medical Center

3551 Roger Brooke Dr, San Antonio, TX 78234

Abstract

Background

Limited hospital inpatient capacity, exacerbated by SARS-CoV-2 (COVID-19) and associated staffing shortages, has driven interest in converting surgeries historically done as inpatient procedures to same-day surgeries (SDS). Remote patient monitoring (RPM) has the potential increase safety and confidence in SDS but has had mixed success in a bariatric population.

Objective

Assess the feasibility of, and adherence to, a protocol offering patients same-day laparoscopic sleeve gastrectomy (SG) supported by RPM with an updated wearable device. Secondary outcomes were readmissions, costs, adherence, and clinical alarm rates.

Setting

Academic, military tertiary referral center (United States)

Methods

A single center, retrospective case control study of patients undergoing laparoscopic sleeve gastrectomy, comparing SDS with RPM to patients admitted to the hospital for SG during this time. Patients for SDS were selected by set inclusion/exclusion criteria and patient/surgeon preference, and perioperative management was standardized.

Results

Twenty patients were enrolled into the SDS group, then compared to 53 inpatients. Inpatients were older (46 vs 39, p=0.006), but with no significant differences in sex, pre-operative BMI or comorbidities. RPM wearable and blood pressure adherence was found to be 97 and 80 %, respectively. Readmission rates were similar (10 vs 7.5 %, p > 0.05). RPM alarm rates were 0.5 (0 – 1.3) per patient for each 24-hour home monitoring period. SDS patients also demonstrated the potential for cost savings over inpatient SG, depending on the number of patients monitored per day, as well as the healthcare setting.

Conclusion

SG as SDS with RPM was a feasible approach. It should be evaluated in other surgical procedures and higher risk patient populations.

Highlights

- Same-day SG can be feasibly augmented with remote patient monitoring.
- Adding RPM can broaden access, increase capacity and save money.
- RPM should be selected mindful of accuracy, connectivity and adherence.
- Inclusion/exclusion and escalation criteria should be protocolized.

Introduction

The SARS-CoV-2 (COVID-19) pandemic placed an enormous strain on hospital systems worldwide. Cancellations of elective surgery resulted in a tremendous backlog of cases that require inpatient admission, including many bariatric surgeries [1]. The typical length of stay following laparoscopic sleeve gastrectomy (SG) has fallen to one night in hospital in recent years. Consequently, there is interest in performing these surgeries as outpatient cases, in order to minimize the impact on hospital infrastructure [2]. The safety of this approach has been debated, but ultimately demonstrated in the literature [3,4]. One retrospective study of 2,534 patients from a free-standing ambulatory surgery center reported readmission, reoperation, and mortality rates at 30 days of 2.5%, 1.3%, and 0.1%, respectively, comparable to those of inpatient admissions [5]. These patients were carefully selected, and as the inclusion criteria for outpatient SG widen, both patients and surgeons may benefit from enhanced in-home monitoring during the post-operative period to increase margin of safety, broaden access for higher risk patients and increase surgeon and patient confidence.

Remote Patient Monitoring (RPM) technology is now widely available. However, previous authors struggled to apply this technology to postoperative management of bariatric patients [6]. Nijland et al. found patients to be poorly adherent with the intermittent monitoring requirements (56 % adherence overall), while facing language barriers and lack of connectivity in their population [6]. Sixteen percent of their patients presented to the Emergency Room following surgery, and half of these were admitted. The authors suggested future work should focus on how to refine home monitoring to increase

compliance. Even with a cohort of adherent patients, deployment of any remote patient monitoring intervention requires changes to hospital workflows. Protocols need to be established, staff made available to watch the monitors, and escalation pathways (or emergency action plans) agreed for when deterioration is detected.

In this pilot study, we built on the work of Nijland et al., by using continuous in-home monitoring with imbedded cellular transmission of patient data and the ability to provide educational material, surveys and prompts in multiple languages. Patients were not required to actively engage with the continuous monitoring devices or have a home WiFi connection for vital sign transmission. We also built-in automated prompts and surveys to increase patient engagement and adherence. The primary objective was to determine the feasibility of this protocol compared to Nijland et al., in particular, whether improved technology led to higher patient adherence to monitoring. We report on our protocol, patient selection and monitoring workflow. We included a case-control analysis of patients who received bariatric surgery concurrently as inpatients, which generated several secondary outcomes, including readmissions, costs, and clinical alarm rates. These were there to contextualize the pilot study, but were not statistically powered.

Materials and Methods

Clinical protocol

Patients were eligible if they met the 1991 NIH consensus criteria for bariatric surgery of a BMI 40 $kg.m^{-2}$ or a BMI of 35.0-39.9 $kg.m^{-2}$ in the presence of severe comorbidities, and then the criteria in **Table 1.** All patients were enrolled from a single military, tertiary referral center, and consisted entirely of military retirees and beneficiaries. SG as the bariatric procedure of choice was made on an individualized basis based on comorbidities, patient preference, and surgeon input. All patients were screened with STOP-BANG sleep apnea questionnaire during pre-operative assessment [7]. Those with a score greater than 3 were referred for a sleep study and commenced on continuous positive airway pressure (CPAP) ventilation prior to surgery if they were diagnosed with obstructive sleep apnea (OSA). Premedication included scopolamine transdermal patch (placed at home 24 hours before surgery), enoxaparin, acetaminophen, aprepitant and cefazolin. Patients were also educated on the remote patient monitoring devices, the discharge process and the remote nursing support.

Patients were anesthetized with short-acting volatile agents. Opioid analgesia was minimized. Ketamine was given at induction, along with lidocaine infusion intraoperatively at the anesthesiologist's discretion. Transverse abdominis plane block using a mixture of 1.3% bupivacaine liposomal injectable solution and 0.25% bupivacaine was performed by the operating surgeon after port placement. Ketorolac was administered at closing unless contraindicated. The fluid therapy target was 2-3 L of intravenous crystalloid (PlasmaLyte) during the perioperative period. Surgical technique was a standard

laparoscopic sleeve gastrectomy with staple line reinforcement, with the option of a postoperative drain. Hiatal hernia repair was performed where indicated. Operative times were targeted to be under two hours.

Patients were discharged with ondansetron, oxycodone, acetaminophen, and omeprazole. Ursodeoxycholic acid was given to all patients unless they had a history of cholecystectomy. They were considered fit for discharge to remote monitoring if their pain was controlled, they were ambulating, tolerating oral fluids, afebrile, and had a heart rate < 100 bpm, blood pressure > 90/60 mmHg and oxygen saturation > 93% on room air, while awake. At the time of discharge, they were issued with the remote patient monitoring kit, refreshed on its use and admitted to the monitoring platform. They were evaluated in the clinic by the operating surgeon or the surgical physician assistant the following day and received additional intravenous fluids if required. Follow up was at two weeks with the nutritionist and three weeks with the surgeon.

Remote patient monitoring

The Current Health platform (Current Health Inc., Boston, USA) consisted of a remote monitoring kit given to patients, and a web dashboard for the surgical and monitoring teams to view the patients' vital signs and reported outcomes. The kit included a wearable armband providing continuous, FDA 510(k) cleared, clinical-grade measures of oxygen saturation, respiratory rate, pulse, motion, and skin temperature. The wearable integrated with a tablet for video visits and as a means for patients to report symptoms, a blood pressure cuff and an axillary temperature patch. The kit also included a 'home hub' which connected the wearable, tablet and peripherals to the cloud via a home internet

connection, or a 4G network sim card for those without home internet access. The wearable was worn at all times except when the patient was bathing, and the patients were prompted to input their oral intake every two hours, along with their blood pressure twice daily.

The web dashboard displayed the patients' observations in a format similar to the familiar hospital observation chart. Alarms were set **(Table 2)**, so that when a patient's vital signs exceeded a preset threshold, alerts were sent to a nurse observation team via push notifications, and also displayed on the web dashboard. Progress of the cohort was also tracked via downloadable aggregated reports.

Once connected to the Current Health platform, patients were monitored at all times by an in-house team of nurses. The nurses conducted "dashboard rounds" at the start of each shift, and then responded to any health alarms, technical concerns, or lack of data transmission. If an alarm triggered, the nurse reviewed the patient's history and vital signs, contacted the patient if appropriate and then escalated to the surgical team if required.

Patients were discharged from monitoring at 48 hours post-operatively, using the same vital sign criteria as for discharge from hospital. If these discharge criteria were not met, monitoring was continued beyond 48 hours at the discretion of the operating surgeon. After discharge, the kits were collected by prepaid courier, and returned to the hospital for reprocessing.

Evaluation methods

The pilot study aimed to enroll 20 SDS patients, as it was felt to be an appropriate number to determine feasibility. Vital signs, and measures of wearable, blood pressure and survey adherence, length of monitoring, and frequency of clinical alarms were assessed using data downloaded from the Current Health platform. To provide additional context, all patients who had their sleeve gastrectomy as inpatients during the SDS pilot (n=53; between March 2021 to May 2022) were included as a comparator. These patients were either ineligible for SDS (n=11), remained as inpatients from patient or provider preference (n=35), or had their planned SDS converted to an inpatient stay postoperatively (n=7). They received the same perioperative management as the SDS group except for fluid management: SDS patients had a 2-3L perioperative fluid target, to ensure adequate hydration in the absence of an overnight postoperative fluid infusion. In the hospital group, fluid replacement was at the discretion of the anesthesiologist, with patients given an infusion of 125 ml per hour crystalloid overnight. Comparative data was collected from the hospital electronic medical record (EMR). The variables collected for both groups from the EMR included length of stay, age, sex, ethnicity, pre-operative BMI and obesity-related comorbidities.

Cost data for the surgical procedure was based on the difference in facility payments for inpatient SG and a similar outpatient procedure plus the variable cost of remote monitoring. TRICARE does not cover SG in an outpatient setting so laparoscopic adjustable band placement (CPT 43770) was used as a comparator. As the surgeon's professional fees and anesthesia were likely to cost the same regardless of setting, these costs were excluded from the analysis. The facility payments for an inpatient SG was

calculated as the average Diagnosis Related Group (DRG) payment for MS-DRG 620 and 621 “O.R. Procedures for Obesity”. This payment is based on a base DRG weight that is first adjusted for a wage index for the area where the hospital is located. If the hospital is an academic medical center, additional compensation is added on to the payment based on the ratio of medical residents to total inpatient beds. Both a generic hospital with no adjustments and an Academic Medical Center like the study location were considered. These were compared to the Ambulatory Payment Classification (APC) for an outpatient laparoscopic adjustable band placement in a hospital as well as in an Ambulatory Surgical Center (ASC). The variable cost of the RPM intervention was calculated per day, based on the capital expenditure and ongoing monitoring contract, costs of nursing labor, and program management support. Note that the daily cost per patient varied depending on the total number of patients with all conditions, being monitored across the entire DHA program.

The data were collated and imported into R (R Foundation for Statistical Computing, Vienna, Austria). Quantitative results were assessed for normality (visualization, Shapiro-Wilk test), and presented as mean (SD) or median (IQR). Parametric comparisons were with Welch’s two-sample t test, and non-parametric with Wilcoxon’s Rank Sum test. Categorical comparisons were made with Pearson’s Chi-squared test. Significance was set at $p > 0.05$.

The study complied with the Declaration of Helsinki. An exemption for retrospective analysis was granted by the BAMC Institutional Review Board [C.2021.103e.]. There was no external funding for this study

Results

20 patients in the SDS group were monitored with the Current Health platform compared with 53 patients in the inpatient group **(Table 3)**. The inpatient group was significantly older (mean (SD): 46 (12.8) vs. 39 (7.5) years, p = 0.006), but there were no differences in sex, pre-operative BMI or other comorbidities (including identical rates of OSA). Patients typically remained on remote monitoring for a day longer than they stayed in hospital **(Figure 1).** Wearable adherence, the amount of time the monitoring device was worn, as a percentage of the amount of the time the patient was in the monitoring program was a median (IQR) of 97 (87-99) % **(Figure 2)**. Blood pressure adherence, the number of readings submitted as a percentage of the number of readings requested, was 80 (71-100) %. Survey adherence, the number of hydration surveys completed as a percentage of the number requested was 58 (32-67) %. The number of clinical alarms triggered per patient was 0.5 (0-1.3, range 0-5) for every 24 hours of their home monitoring period. In other words, a patient would typically trigger a clinical alarm once every two days.

There were two readmissions in the RPM group: one for post-operative bleeding, detected while on monitoring and the other for low oral intake after being discharged from the platform, but there was no significant difference in readmission rates between the two groups.

The average TRICARE MS-DRG payment for inpatient SG was approximately $13,611 in a generic hospital and $17,445 in a San Antonio Academic Medical Center. The APC payment for the comparator outpatient surgery was $9,096 in a hospital and $1,154 in an ASC. The cost of equipping, establishing and staffing the RPM program was

estimated at $3,816 per day for all patients monitored. While a monitoring service, once established, can be potentially used for surgeries beyond SG, for purposes of this analysis patients were assumed to stay in the monitoring program for 2.3 days on average. Because the cost of the RPM program is fixed per day, the actual cost savings from the program have large returns to scale based on the number of patients being monitored at a time. At one patient being monitored per day the ASC saved $3,860 per surgery, while both the generic hospital (-$4,262) and a San Antonio Academic Medical Center (-$428) lost money. When at least two patients were monitored each day, all three settings saved money. At a conservative estimate of 10 patients monitored per day savings varied from $3,637 per patient in a generic hospital to $7,471 in the San Antonio Academic Medical Center and $11,579 in an ASC (**Figure 3)**.

It is important to note that these cost savings were achieved by shifting patients from the inpatient to outpatient setting. During the study period, DHA only allowed outpatient SG if it also included remote patient monitoring, therefore any cost savings is directly attributable to the program. In other settings, cost savings is dependent on enrolling patients in the program who would otherwise have an inpatient procedure in the absence of a remote monitoring program. This study was not designed and is not powered to state whether enrolling patients who would have had an outpatient procedure without RPM have better outcomes.

Discussion

SG is the most performed bariatric procedure in the United States, since eclipsing the gastric bypass in 2013. It accounts for 59.4% of all bariatric procedures (estimated to be 256,000) in 2019 [8]. Despite being performed in high numbers, and the cost savings and safety profile associated with outpatient surgery, the vast majority of SG continue to be performed in an inpatient setting [5,9–11]. As RPM technology has advanced alongside a desire to avoid inpatient treatment during the COVID-19 pandemic, there has been increased interest in use cases beyond post-acute medical care. Our pilot study demonstrated a workable protocol for RPM in SDS-SG that achieved high adherence to monitoring, even in patients traditionally considered higher risk, such as those with obstructive sleep apnea (OSA).

There are a number of published examples of bariatric SDS [5,10]. However, inclusion criteria in these studies were variable, and clinical practice has remained focused on in-patient care [4,9,11]. Outcomes for SDS-SG have typically been published in single-institution case series [4,5,9,10]. Those studies suggested that SDS-SG was safe, with comparable outcomes to inpatient SG, improved patient satisfaction and cost savings. However, a recent retrospective analysis of the MBSAQIP database comparing SDS-SG with discharge on postoperative day 1 (POD1) suggested the opposite [11]. The authors found a higher overall morbidity (1.31 vs. 0.84 %), readmission rate (2.14 vs. 1.64 %), and reoperation rate in SDS-SG compared to POD1 discharge. Inclusion criteria for SDS-SG in this analysis were not standardized, and POD≥1 were not included in the analysis, which may have biased the inpatient cohort to relatively more straightforward

patients. Similarly, Fortin et al. conducted a retrospective study comparing SDS and inpatient SG and found no association between either setting and 30-day hospital readmission, morbidity, reoperation, or mortality [12]. In a sensitivity analysis comparing SDS-SG and POD ≤1 discharge, they found increased odds of 30-day bleeding (1.6 vs. 9 %) and hospital readmission (2.6 vs. 1.6 %) in outpatient SG. However, they also noted a shorter length of stay in the SDS LSG patients who were readmitted (2.48 vs. 4.63 days). Indeed, in our study, one patient was referred back to the emergency department on POD2 with abdominal pain and tachycardia on RPM and found to have postoperative hemorrhage that was managed conservatively. In our protocol, the operating surgeon was given the option to leave a drain at the conclusion of the case. Though our study was not designed or powered to detect elevated postoperative hemorrhage risk, leaving drains along the staple line for early detection of bleeding for outpatient SG may be prudent. However, RPM may obviate the need for drains, as early changes in vital signs or subjective complaints, as in this patient, may also alert the provider to a potential complication. SDS surgery also has the potential to relieve pressure on physical infrastructure. This was particularly important during the COVID pandemic, when limited hospital bed availability meant that elective bariatric surgery was frequently cancelled, delays which have consequences for patients' long-term metabolic health [13].

We sought to build on the work of Nijland, to build a protocol for RPM that would allow safe, accurate monitoring of the outpatient postoperative bariatric patient with high adherence and reproducibility [6]. Our pilot study demonstrated improvements in adherence and reliability from previously published data on RPM in this population. In our study, the median wearable adherence (pulse rate, respiratory rate, temperature, oxygen

saturation, movement) was 97% (87-99%). Patients were also asked to use a blood pressure cuff periodically, the adherence to which was 80% (71-100%). Comparatively, Nijland reported the percentages of patients completing all their vital sign measurements on POD1, 2, and 3 as 62, 58 and 75 %, respectively. Adherence to prompted surveys in our study was 58 (32-67) %, which were primarily to log oral intake. These prompts were made every two hours, and consequently that response rate was expected. Nijland reported higher adherence with video consultations, while our protocol allowed for video consultations with on-call providers as needed. All patients in our study were seen for a face-to-face visit with the surgeon or surgical physicians' assistant on POD1, with 100% attendance. Based on the experience of the pilot, this visit could likely be conducted remotely in future. An additional drawback noted by Nijland in their study was the reliance on patients' home WiFi capability and ownership of an Apple device for video consultations. The Current Health platform did not require a third-party device and had built-in cellular as well as WiFi capability. We were unable to confirm what percentage of the monitored time was via WiFi versus cellular, but this provision was felt important for patients vulnerable to the 'digital divide' [(14)].

Alarm parameters for monitored patients are outlined in Table 2. The median clinical alarms triggered per patient per 24 hours of monitoring was 0.5 (0-1.3). Each clinical alarm required a response from the in-house nurse monitoring the patient, who could have been responsible for a widely variable number of other patients at any point in time. The number of clinical alarms per patient in this study was low, helping to minimizing risk of alarm fatigue and unnecessary patient disturbance. Non-actionable alarms leading to alarm fatigue has been identified as a dangerous phenomenon and the

Joint Commission has prioritized their reduction, as they lengthen response time to genuine alarms [15,16]. The most appropriate alarm settings for RPM will balance sensitivity and specificity, while considering the potential for activities of daily living in the home to transiently affect vital signs, and the options for patient contact and emergency response.

Our study had several limitations. First, as a pilot study, it was inadequately powered to determine the safety of outpatient SG or the effect of RPM on readmission rates: the primary objective was to measure feasibility and adherence to RPM in the SDS-SG population. The cost savings were broad estimates based on the information available but gave an idea of the magnitude of potential savings. Additionally, our study was not randomized, and patients were able to opt for an inpatient stay if they, or their provider, wished. Thus, there was likely some selection bias toward patients who were highly motivated to have SDS surgery and comfortable using the Current Health platform (we note the younger age of the RPM group). The comparison to an inpatient cohort was not to provide a formal control, but rather to ground our study in current practice. We were nonetheless conscious to ensure similar proportions of “riskier” patients, such as those with OSA, and equivalence in BMI in each group. Whether this protocol would still demonstrate high adherence in the bariatric population at large should be explored. Future directions might include a larger, randomized study or exploring the potential for RPM to safely extend outpatient SG to patients at greater risk of operative complications and readmission. It has been demonstrated previously that carefully selected higher-risk patients can safely have outpatient SG [17]. RPM could expand that scope further, especially in OSA (a common exclusionary criterion for outpatient bariatric surgery) providing reassurance to surgeon and patient alike.

Conclusion

This non-randomized pilot study evaluated a novel remote patient monitoring protocol in SDS-SG patients. The protocol was a success, demonstrating high levels of adherence and reliability, and the potential for significant cost savings. The Current Health wearable proved advantageous in providing continuous vital sign transmission and monitoring, with integrated peripheral devices and patient reported outcomes, even in patients without home internet. Our goal will be to use the RPM platform as an additional safety measure to expand utilization and to broaden the inclusion criteria for SDS-SG.

Disclosures

M.W., N.Z., J.P. and D.Y. are employed by Current Health, Inc.

Keywords

Bariatric surgery, Telehealth, Cost Savings, Delivery of Health Care, Digital Divide

Legend

(APC) Ambulatory Payment Classifications; (BAMC) Brooke Army Medical Center; (BMI) Body Mass Index; (CHAMPUS) Civilian Health and Medical Program of the Uniformed Services; (CMAC) CHAMPUS Maximum Allowable Charge; (DHA) Defense Health Agency; (DRG) Diagnosis Related Group; (CPAP) Continuous Positive Airway Pressure; (FDA) Federal Drug Administration; (IQR) Interquartile Range; (MBSAQIP) Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program; (OSA) Obstructive Sleep Apnea; (POD) Postoperative Day; (RPM) Remote Patient Monitoring; (RVU) Relative Value Unit; (SD) Standard Deviation (SDS) Same Day Surgery; (SG) Laparoscopic Sleeve Gastrectomy

References

1. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans: Elective surgery during the SARS-CoV-2 pandemic. Br J Surg [Internet]. 2020 Jun 13 [cited 2022 Jul 19]; Available from: https://academic.oup.com/bjs/article/107/11/1440-1449/6139510

2. Blanchet MC, Gignoux B, Matussière Y, et al. Experience with an Enhanced Recovery After Surgery (ERAS) Program for Bariatric Surgery: Comparison of MGB and LSG in 374 Patients. OBES SURG. 2017 Jul;27(7):1896–900.

3. Aryaie AH, Reddy V, Dattilo Z, Janik MR. Safety of same-day discharge after laparoscopic sleeve gastrectomy: propensity score–matched analysis of the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program Registry. Surgery for Obesity and Related Diseases. 2021 Jan;17(1):46–53.

4. Billing PS, Crouthamel MR, Oling S, Landerholm RW. Outpatient laparoscopic sleeve gastrectomy in a free-standing ambulatory surgery center: First 250 cases. Surgery for Obesity and Related Diseases. 2014 Jan;10(1):101–5.

5. Billing P, Billing J, Harris E, Kaufman J, Landerholm R, Stewart K. Safety and efficacy of outpatient sleeve gastrectomy: 2534 cases performed in a single free-standing ambulatory surgical center. Surgery for Obesity and Related Diseases. 2019 Jun;15(6):832–6.

6. Nijland LMG, van Veen RN, Ruys AT, van Veldhuisen CL, Geerdink TH, de Castro SMM. Feasibility of Postoperative Home Monitoring Using Video Consultation and Vital Sign Monitoring of Bariatric Patients. OBES SURG. 2020 Jun;30(6):2369–74.

7. Chung F, Abdullah HR, Liao P. STOP-Bang Questionnaire. Chest. 2016 Mar;149(3):631–8.

8. American Society for Metabolic and Bariatric Surgery. Estimate of Bariatric Surgery Numbers, 2011-2019 [Internet]. [cited 2022 Jul 19]. Available from: https://asmbs.org/resources/estimate-of-bariatric-surgery-numbers

9. Rebibo L, Dhahri A, Badaoui R, Hubert V, Lorne E, Regimbeau JM. Laparoscopic sleeve gastrectomy as day-case surgery: a case-matched study. Surgery for Obesity and Related Diseases. 2019 Apr;15(4):534–45.

10. Lalezari S, Musielak MC, Broun LA, Curry TW. Laparoscopic sleeve gastrectomy as a viable option for an ambulatory surgical procedure: our 52-month experience. Surgery for Obesity and Related Diseases. 2018 Jun;14(6):748–50.

11. Inaba CS, Koh CY, Sujatha-Bhaskar S, Pejcinovska M, Nguyen NT. How safe is same-day discharge after laparoscopic sleeve gastrectomy? Surgery for Obesity and Related Diseases. 2018 Oct;14(10):1448–53.

12. Fortin SP, Kalsekar I, Johnston S, Akincigil A. Comparison of safety and utilization outcomes in inpatient versus outpatient laparoscopic sleeve gastrectomy: a retrospective, cohort study. Surgery for Obesity and Related Diseases. 2020 Nov;16(11):1661–71.

13. Ahmed B, Altarawni M, Ellison J, Alkhaffaf BH. Serious Impacts of Postponing Bariatric Surgery as a Result of the COVID-19 Pandemic: The Patient Perspective. Journal of Patient Experience. 2021 Jan 1;8:237437352110082.

14. Lawrence K. Digital Health Equity. In: UCR Health and UCR School of Medicine, Riverside, CA, USA, Linwood SL, editors. Digital Health [Internet]. Exon Publications; 2022 [cited 2022 Jul 19]. p. 121–30. Available from: https://exonpublications.com/index.php/exon/article/view/health-equity

15. The Joint Commission. National Patient Safety Goals Effective January 2022 for the Hospital Program. Illinois, USA; 2021 Oct.

16. Sendelbach S, Funk M. Alarm Fatigue. AACN Advanced Critical Care. 2013 Oct 1;24(4):378–86.

17. Billing P, Billing J, Kaufman J, Stewart K, Harris E, Landerholm R. High acuity sleeve gastrectomy patients in a free-standing ambulatory surgical center. Surgery for Obesity and Related Diseases. 2017 Jul;13(7):1117–21.

Table 1. Inclusion criteria for same-day sleeve gastrectomy

Inclusion	Exclusion
Age > 18	History of splenectomy, dialysis, or pacemaker
Weight < 204 kg (450 lb)	History of other bariatric procedures
Expected operative time < 2 hours	Severe obstructive sleep apnea
Ambulatory and reliable escort for 48 hours	
Low cardiac risk (1)	
Mild-moderate obstructive sleep apnea (2)	

(1) A risk for major adverse cardiac event (MACE) of < 1% would be considered low risk. This could be based on Revised Cardiac Risk Index of score of < 1, ACS NSQIP calculator, or Gupta Perioperative Risk.

(2) Patients screened with STOP-BANG during the surgical assessment for surgery. If score > 3 then referred for sleep study. Those found to have sleep apnea were optimized on CPAP prior to surgery. Those with mild or moderate OSA could be considered for outpatient sleeve gastrectomy.

(3) All patients being screened for SDS sleeve gastrectomy were previously screened for bariatric surgery as per NIH consensus guidelines and found to be appropriate candidates (Gastrointestinal Surgery for Severe Obesity. NIH Consens Statement 1991 Mar 25-27;9(1):1-20.).

Table 2. Alarm settings

Alarm	Setting
Brady/tachycardia	Pulse rate <= 40 or >= 120 for 30 mins
Hypoxia	SpO2 <= 85 for 30 min
Tachycardia/tachypnea	Pulse rate >= 110 and resp rate >= 25 for 30 mins
Hypoxia/tachypnea	SpO2 <= 88 and resp rate >= 25 for 30 mins
Hypoxia/bradypnea	SpO2 <= 88 and resp rate <= 7 for 30 mins
Pyrexia	Axillary temp >= 38 C for 60 mins
Hypertension	SBP >= 180 or DBP >= 100
Hypotension	SBP <= 70 or DBP <=30
Deviation in blood pressure	SBP >= 25 % deviation from baseline
Spirometry	FVC >= 15% deviation from baseline FEV1 >= 15% deviation from baseline PEF >= 20% change from baseline

Table 3. Demographics, length of stay and readmission rates

Group		Outpatient	In Hospital
Number of patients		20	53
Age (mean, sd)	Years	39 (7.5) 25-51	46 (12.9)* 19-72
Sex (n, %)	Female Male	17 (85) 3 (15)	36 (68) 17 (32)
Ethnicity	Black Hispanic Other Unknown White	4 (20) 3 (15) 5 (25) 5 (25) 3 (15)	15 (28) 0 (0) 14 (26) 4 (7.5) 20 (38)
Comorbidities (n, %)	DM GERD HLD HTN Infertility NASH OA OSA PCOS Pre-DM T2DM	2 (10) 1 (5) 5 (25) 4 (20) 0 (0) 1 (5) 0 (0) 11 (55) 1 (5) 3 (15) 0 (0)	4 (8) 0 (0) 17 (32) 25 (47) 2 (4) 6 (11) 4 (8) 29 (55) 4 (8) 5 (9) 7 (13)
Length of in-patient stay (mean (sd), range) *	Days (“midnights”)	N/A	1.3 (0.8) 0-3
Length of remote (mean (sd), range) *	Days (“midnights”)	2.3 (1.2) 0.6-5.9	N/A
Preoperative BMI (mean (sd) range)		42 (5.2) 36-57	41 (5.0) 35-57
Readmissions (n, %)		2 (10)	4 (7.5)

** There was a significant difference in age between the groups (p = 0.006) and in days monitored/length of inpatient stay (p < 0.0001), but not in sex, pre-operative BMI or readmission rate (p > 0.05).*

Figure 1. Length of stay (“midnights”) for hospital (light grey) and outpatient RPM (dark grey) cohorts

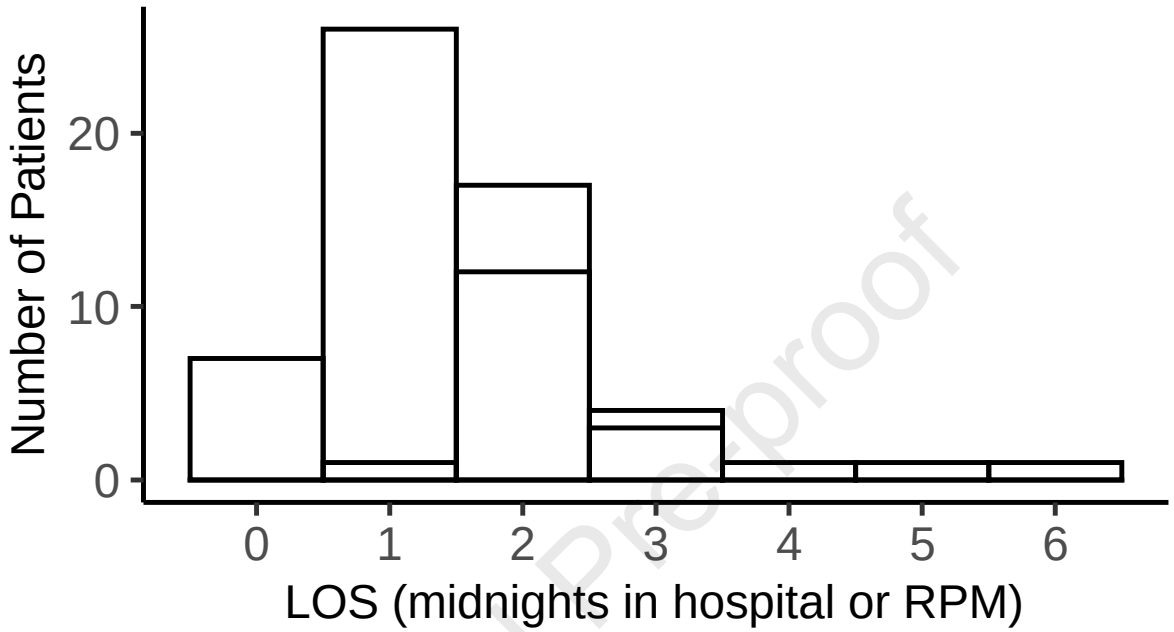


Figure 2. Kernel density plot of wearable adherence (%) for the outpatient RPM cohort.

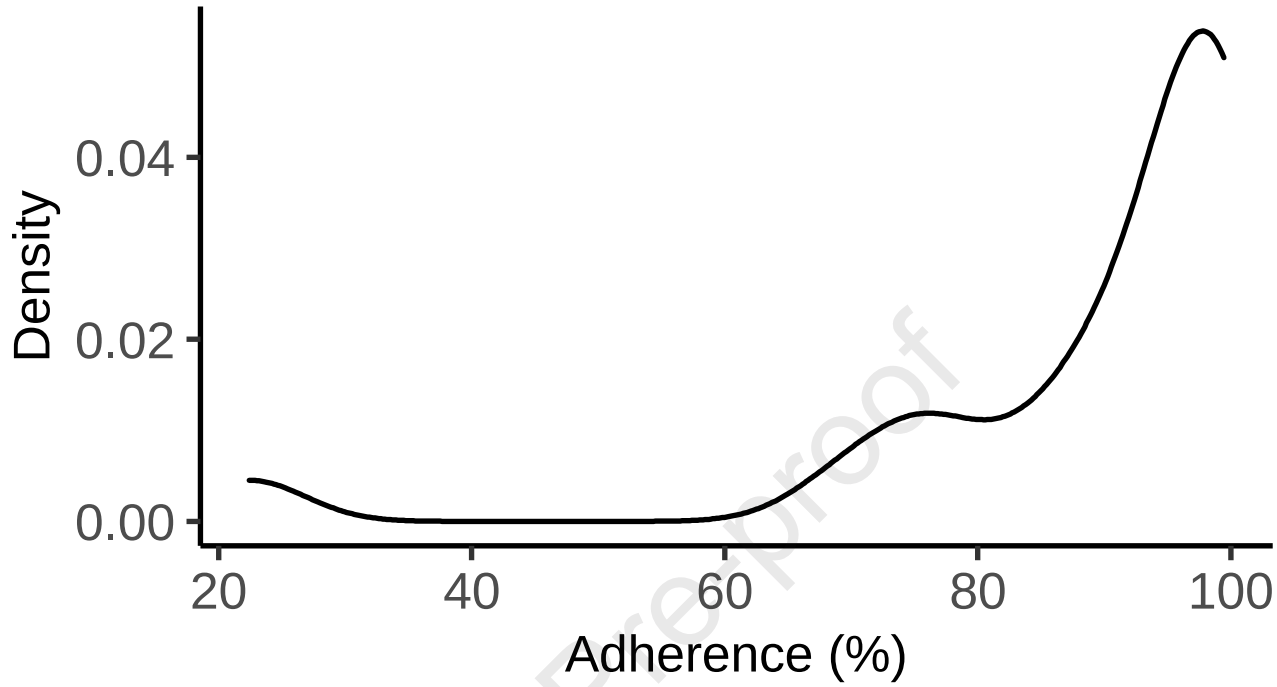


Figure 3. Comparison of cost savings per patient when inpatient SG performed as SDS. Cost savings are presented as a function of the number of patients on RPM per day as well as the healthcare setting the procedure was performed in.