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Laparoscopic hiatal hernia repair as same day surgery: Feasibility, short-term outcomes and costs☆

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ABSTRACT

Introduction: Laparoscopic hiatal hernia repair is commonly performed with 1 night hospitalization. The aim was to assess repairs as same-day-surgery (SDS).
Methods: Costs/short-term outcomes of SDS were compared to hospital-stay < 24-h: observation (OBS) and hospital-stay ≥ 24-h: inpatient (INP). Outcomes were assessed by postoperative 30-day ER visits/readmissions.
Results: There were 262 procedures, excluding 50 reoperative repairs, 212 procedures were included: There were 66 SDS, 65 OBS and 81 INP. SDS vs. OBS: OBS were older, had higher ASA, less type I and more type III and IV hernias. Costs were significantly less in the SDS group with no difference in post-operative ER visits/post-discharge readmissions. SDS vs. INP: INP were older, had higher ASA, less type I and more type III and IV hernias. Costs were significantly less in the SDS group with no difference in post-operative ER visits/post-discharge readmissions.
Conclusion: Laparoscopic hiatal hernia repair can be performed as SDS in majority of elective repairs with good short-term outcomes and reduced cost.

Introduction

Laparoscopic hiatal hernia repair is commonly performed with length of stay of 1 day for sliding hiatal hernias, and 2–4 days[1,2,3] for large paraesophageal hiatal hernias. Enhanced Recovery After Surgery (ERAS) protocols have shown to decrease the length of stay in laparoscopic bariatric[4,5] colorectal[6,7] and urologic procedures.[8,9] The use of ERAS protocols may similarly decrease the length of stay and cost of laparoscopic hiatal hernia repair.

We previously reported the feasibility of laparoscopic Heller myotomy and Dor fundoplication in the same surgery setting with implementation of an ERAS protocol[10] and showed that assembling a trained surgical team can result in decreased operative time and costs of laparoscopic hiatal hernia repair.[11]

The aim of the study was to assess the feasibility, short-term outcomes and costs of hiatal hernia repair in the same day surgery (SDS) setting with a trained surgical team and implementation of a simple ERAS protocol, to compare patients' characteristics, costs and outcomes in the SDS group to the observation (OBS) and inpatient (INP) group, and to assess characteristics of patients who were transitioned from SDS to OBS and INP, to identify patterns and causes of failure of SDS hiatal hernia repair.

Methods

A retrospective study of prospectively collected data for patients who underwent laparoscopic hiatal hernia repairs from 10/11/2016 to 08/27/2019 in a single center was conducted. The reoperative procedures were excluded. All consecutive primary laparoscopic repairs were included in the study.

Our hospital is a 320 bed acute care hospital located in Houston, Texas and is one of 17 hospitals in the Memorial Hermann Healthcare System, providing medical, surgical and trauma services to the Southeast Texas region. Over 8,000 inpatient surgeries and 4,500 same day surgeries are annually performed in our hospital. Physicians in private practice and academic physicians affiliated with McGovern medical school at UT Health practice at our hospital.

Patients' characteristics and perioperative data were extracted

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from electronic health records. Financial and procedure coding data were obtained using a cost accounting system by Allscripts Health Solutions, Inc (version 7.2.93.10341) provided by the director of operational effectiveness at Memorial Hermann Southeast hospital. Allscripts Health Solutions system uses charge data to estimate cost. Estimated cost is calculated as a function of patients billed charges such as lab tests, radiology procedures, supplies, OR time and room charges. Cost for each patient's charge or Charge Description Master (CDM) is derived by engineered standard or Relative Value Units (RVUs) that are updated yearly during the budgeting cycle. Relative Value Units (RVUs) are used as a way to allocate direct cost such as direct labor cost (personnel who provide hands on care), and the cost of materials (actual purchase price from vendors). Indirect cost such as capital expense (brick and mortar, equipment) and indirect labor (hospital leadership and administration) is then allocated to each CDM using RVUs. Each month the RVUs are used to calculate the cost of a CDM based upon expenses incurred in a year.

All patients underwent an upper endoscopy and a video esophagram prior to hiatal hernia repair. CT scan was obtained in a selected group of patients and were mostly obtained prior to referral to us. We do not routinely obtain CT scan to assess for hiatal hernia. Esophageal motility study was obtained in patients who had evidence of dysmotility on video esophagram, manifested by a retained column of barium in the upright position and tertiary esophageal contractions, and pH monitoring was obtained in patients with type I hiatal hernia <4 cm and without evidence of esophagitis or Barrett's esophagus on endoscopy.

Same day surgery (SDS) was defined as discharge on the same day the procedure was performed. Observation (OBS) was defined as < 24-h hospital stay (1 night hospitalization) and inpatient was defined as ≥ 24 h hospitalization (≥2 night hospitalization).

SDS was planned for all elective repairs after 04/13/17 in patients with age ≤75 years, with ASA II-III, with type I-III hiatal hernias and with type IV hernias without intrathoracic stomach (ITS), defined as 100% herniation of the stomach into the chest on preoperative esophagram/CT scan. The exclusion criteria included any of the following: admission via ER, patients >75 years, ASA IV and patients with ITS. We believe repair of intrathoracic stomach requires extensive esophageal mobilization and mediastinal dissection, therefore, patients are at risk for esophageal or gastric injury. In addition, because of post-surgical tissue edema and nerve swelling or damage, patients may present with gastric distension after the stomach is reduced into the abdomen. Therefore, patients with ITS were observed and were transitioned to inpatient status if required. A video esophagram was obtained on POD#1 in patients who underwent repair of ITS to assess for leak, for esophageal clearance and gastric emptying/distension. NGT was placed if patients had complaints of abdominal distension and if there was evidence of gastric distension on the video esophagram.

The patient preference to be admitted on the day of surgery vs. getting discharged the same day was communicated preoperatively with all patients who were candidates for SDS hernia repair. Further discussion with patients was made in the recovery room after the patients' clinical condition was assessed by the operating surgeon. We had a low threshold to convert patients' status to observation status as needed. The patients were discharged approximately 4–5 h after the end of the procedure. None of patients were discharged after 7:00 pm.

All procedures were performed by a single surgical and anesthesia team. Our surgical team include 1 surgeon, 2 scrub technicians, 2 nurse circulators, 2 CRNA/anesthesiologists and 2 certified surgical assistants. One scrub technician, 1 nurse circulator, 1 CRNA/anesthesiologist and 2 certified surgical assistants participate in each case. One surgical assistant stands on the patient's right side and holds the camera and 1 assistant stands on the patient's left side and helps with retraction. The patient is in the reverse Trendelenburg position with legs slightly split apart and secured and supported by the operating table. The surgeon stands in between patients' legs.

First year cardiothoracic fellows and general surgery chief residents rotate at our hospital during a 6-week rotation. Approximately 40% of our cases per year are covered either by a first-year cardiothoracic fellow or a chief resident interested in thoracic or minimally invasive surgery, and 60% are performed in the private practice setting, where the surgeon operates with 2 certified surgical assistants. When the cardiothoracic fellow or the chief resident scrubs with us, one of the surgical assistants does not scrub in the case.

We previously described the indications and techniques of laparoscopic Toupet and Nissen fundoplication.[12] All patients underwent a completion upper endoscopy in the operating room to assess the fundoplication and presence of leak. All procedures were performed under general anesthesia with the use of Propofol, Fentanyl and Sevoflurane gas. The laparoscopic insufflation setting included C02 flow of 40 L/min and 15 mm Hg intra-abdominal pressure.

A protocol with a series of measures in the preoperative, intraoperative and postoperative phases was devised and a simple ERAS protocol for control of nausea and pain was implemented. The use of scopolamine patch, dosage of Zofran and Tylenol, and the exact time of delivery of medications in 3 phases were assembled in the ERAS protocol.

In phase 1, preoperatively, patients were instructed to have clear liquid diet the day before surgery. In the preoperative holding area, patients were asked to void, an antiemetic dermal patch (scopolamine patch) was applied behind the ear, 1 dose of IV antiemetic medication (4 mg IV Zofran), 1 dose of IV antibiotics (2 g IV Cefoxitin) and 1 dose of anticoagulation (5000 units S/Q Heparin) were given. In phase 2, intraoperatively, no Foley was inserted, prior to skin incision 1 dose of IV analgesic (1000 mg IV Tylenol) was given. Marcaine 5% local injection was given prior to skin incision and prior to skin closure. Prior to extubation, another dose of antiemetic medication (4 mg IV Zofran) was given. In phase 3, postoperatively in the recovery room, another dose of IV analgesics (1000 mg IV Tylenol) was given. Patients were assessed by a team of trained thoracic nurses. Careful attention was paid to treat postoperative nausea and pain. The dressings were checked for any signs of bleeding. The ability to tolerate clear liquid diet and the ability to void were verified. The three phases of the ERAS protocol are shown in Table 1.

Patients were assessed by the operating surgeon in the post-anesthesia recovery room and the pre-discharge unit. Discharge instructions as previously reported[11] were reviewed with patients by the operating surgeon and were reinforced by thoracic nurses. A copy of the discharge instructions was given to the patients.

Demographics, clinical data, costs and short-term outcomes of patients who had their procedures performed as SDS were compared to patients who had their procedures planned and not performed as SDS, and to the group of patients who had their procedures performed as OBS, and as INP. Short-term outcomes were assessed by number of post-discharge 30-day ER visits and readmissions.

The study was approved by the institutional review board at UT Health and Memorial Hermann system.

Table 1
Measures implemented in three phases for the same day surgery protocol.

1. **Preoperative phase**
   Clear liquid diet the day before surgery
   Preoperative holding area
   a. Scopolamine dermal patch behind the ear
   b. Zofran 4 mg IV
   c. Cefoxitin 2 g IV
   d. Heparin 5000 units S/Q
   e. Patients were asked to void
2. **Intraoperative phase**
   a. No Foley
   b. Tylenol 1000 mg IV prior to skin incision
   c. Marcaine 5% local injection prior to skin incision and prior to skin closure
   d. Zofran 4 mg IV prior to extubation
3. **Postoperative phase**
   a. Tylenol 1000 mg IV
   b. Check dressings
   c. Assess ability to tolerate clear liquid diet
   d. Assess ability to void.

Statistical analysis

Clinical data and outcomes were entered in the Microsoft Office Excel program and then analyzed using Stata (v16; Stata Corp LP, College Station, TX). Continuous data are expressed as medians with interquartile ranges. Independent Student's t-test was performed for continuous variables, and the Chi-square test was performed for categorical variables. Two-sided p values were computed. Differences were considered statistically significant at $P < 0.05$.

Statistical analysis for costs was performed using Minitab Statistical Software (version 18.1, Minitab LLC, Quality Plaza, 1829 Pine Hall Rd, State College, PA 16801–3210). Statistical testing was accomplished using the 2-sample *t*-test for the continuous variables expressed as means with statistical significances measured at a P value < 0.05.

Results

From 11/10/2016 to 08/27/2019 there were 262 laparoscopic hiatal hernia repairs. The reoperative repairs (n = 50) were excluded and 212 procedures in 209 patients (3 reoperative repairs during the same admission) were included in the study. There were 66 SDS, 65 OBS and 81 INP procedures (in 78 patients). SDS was planned in 114 patients and was performed in 66/114 (57.9%) and not performed in 48/114 (42.1%). Demographics, clinical data, costs and short-term outcomes of patients who had their procedures planned and performed as SDS vs. patients who had their procedures planned and not performed as SDS are shown in Table 2. Patients who had their procedures planned and not performed as SDS were older, had higher ASA, less type I and more type III and type IV hiatal hernias. The total, direct, operating room, and room costs were significantly less in the SDS group. There was no difference in post-operative ER visits: 9/66 (13.6%) vs. 8/48 (16.7%), p= 0.080 and post-discharge readmissions 7/66 (10.6%) vs. 4/48 (8.3%), p=0.575, between the 2 groups.

Out of 48/114 (42.1%) patients who had their procedures planned and not performed as SDS: 30/48 (62.5%) were transitioned to OBS and 18/48 (37.5%) were transitioned to INP. The most common reasons for transition from SDS to OBS was patient preference in 9/30 (30.0%) followed by neck and shoulder pain because of CO_2 insufflation in 8/30 (26.7%). Patients who had their procedures planned and performed as SDS had median age of 55 (45–63) and the subgroup of patients who were transitioned to OBS because of patient preference (9/30) had a median age 65 (62–69), $p < 0.015$.

The most common reason for transition from SDS to INP was distension/ileus in 6/18 (33.3%) followed by abdominal pain in 4/18 (22.2%). The reasons for transition from SDS to OBS and SDS to INP are shown in Table 3.

Demographics, clinical data, costs and short-term outcomes of

Table 2
Demographics, clinical information, costs and short-term outcomes of patients who had their surgeries planned and performed as same day surgery, versus patients who had their surgeries planned and not performed as same day surgery.

	Planned and Performed as SDS 66/114 (57.9%)	Planned and Not performed as SDS 48/114 (42.1%)	p value
Age	55 (45–63)	65 (52–69)	0.002
BMI	30.05 (26.9–34.4)	30.52 (26.8–34.4)	0.633
ASA median (IQR)			
ASA II (%)	46 (69.7%)	18 (37.5%)	0.001
ASA III (%)	20 (30.3%)	30 (62.5%)	0.000
Gender	M 24 (36.4%)/F 42 (63.6%)	M 12 (25%)/F 36 (75%)	0.738
Hernia size (cm)	5 (4–5)	5 (4–8.5)	0.050
Type of Hiatal Hernia			
Type I (n=65)	45 (68.2%)	20 (41.7%)	0.038
Type II (n=0)	0	0	1.000
Type III (n=32)	13 (19.7%)	19 (39.6%)	0.000
Type IV (n=17)	8 (12.1%)	9 (18.7%)	0.000
Duration of operation (min)	99.5 (92–116)	107 (92–120)	0.477
Length of stay (days)	0 (0–0)	1 (1–2)	0.000
Cost/procedure			
Total	$6,427	$13,075	0.001
Direct	$5,353	$9,823	0.001
Operating room	$3,110	$3,729	0.001
Hospital room		$2,768	0.001
30-day outcomes			
ER visits post-discharge	9/66 (13.6%)	8/48 (16.7%)	0.080
Readmissions	7/66 (10.6%)	4/48 (8.3%)	0.575

Table 3
Reasons for transition from same day surgery (SDS) to observation (OBS) and inpatient (INP) in 48 patients who had surgeries planned and not performed same day surgery.

30/48 (62.5%) procedures planned and not performed as SDS were transitioned to OBS	
Patient preference	9/30 (30.0%)
Neck and shoulder pain because of CO_2 insufflation	8/30 (26.7%)
Chest pressure/chest pain/SOB	5/30 (16.7%)
Nausea/retching	5/30 (16.7%)
Acute kidney injury	2/30 (6.7%)
Abdominal pain	1/30 (3.3%)
18/48 (37.5%) procedures planned and not performed as SDS were transitioned to INP	
Abdominal distension/ileus	6/18 (33.3%)
Abdominal pain	4/18 (22.2%)
Neck and shoulder pain	3/18 (16.7%)
Nausea/retching	2/18 (11.1%)
Acute kidney injury	1/18 (5.6%)
Dysphagia	1/18 (5.6%)
Chest pressure/chest pain/SOB	1/18 (5.6%)

patients who had their procedures performed as SDS vs. patients who had their procedures performed as OBS are shown in Table 4. Patients in the OBS group were older, had higher ASA, larger hiatal hernia size, less type I and more type III and IV hiatal hernias. The total, direct, operating room, and room costs were significantly less in the SDS group. There was no difference in postoperative ER visits: 9/66 (13.6%) vs. 9/65 (13.8%), p=0.798 and post-discharge readmissions: 7/66 (10.6%) vs. 6/65 (9.2%), p=0.625, between the 2 groups.

Demographics, clinical data, costs and short-term outcomes of patients who had their procedures performed as SDS vs. INP are shown in Table 5. Patients in the INP group were older, had higher ASA, less type I and more type III and IV hiatal hernias. There were 37 patients with ITS in the INP group. The median length of stay in the INP group was 2 nights. The total, direct, operating room, and room costs were significantly less in the SDS group. There was no difference in post-operative ER visits: 9/66 (13.6%) vs. 12/78 (15.4%), p=0.767, and post-discharge readmissions: 7/66 (10.6%) vs. 6/78 (7.7%), p=0.543, between the 2 groups.

Procedures included Toupet fundoplication in 172/212 (81.1%), crural closure with fundopexy in 20/212 (9.4%), Nissen fundoplication in 18/212 (8.5%), Dor fundoplication in 1/212 (0.5%) and crural closure alone in 1/212 (0.5%).

Three patients had recurrent hiatal hernia during the same admission and required reoperation for recurrent hernia repair. Two out of 3 patients were planned and not performed as SDS because of recurrence of hiatal hernia and 1/3 was not planned as SDS as she was admitted via ER. Costs of the second operation was added to costs of each admission. Excluding these 3 patients, the difference in costs of SDS procedures vs. 75 INP procedures in 75 patients remained significantly less: total: $6,427 vs. $17,623, (p<0.001), direct: $ 5,353 vs. $ 12,806, (p<0.001), operating room: $ 3,110 vs. $4,033, (p<0.001) and hospital room: none vs. $4,859, (p<0.001).

There were no conversions and no blood transfusions. There were two 30-day mortalities in 2 patients in INP group who had undergone repair of type IV hiatal hernia with intrathoracic stomach, organoaxial volvulus and herniated omentum: 1 in-hospital mortality on POD#10 in a 92 year old female who died from HIT with diffuse arterial emboli including ischemia of the right upper extremity with digital necrosis and 1 in an 86 year old female who was discharged on POD#4 and was readmitted on POD#5 with MI and died on POD#6.

There were a total of 26 in-hospital complications in 22/209 patients (10.5%). The median length of stay for these 22 patients was 4 days (2–9.5), 6/22 were planned as SDS and were transitioned to INP, and 16/22 were INP. There were none in the OBS group. The complications included NGT placement in 13/209 (6.2%): 12/209 for gastric distension (5.7%) and 1/209 for ileus

Table 4
Demographics, clinical information, costs and short-term outcomes of patients who had their surgeries performed as same day surgery, versus patients who had their surgeries performed as observation.

	Same Day Surgery (SDS) (n = 66)	Observation (OBS) (n = 65)	p value
Age	55 (45–63)	66 (57–71)	0.0001
BMI	30.05 (26.9–34.4)	30.2 (27.3–33.8)	0.624
ASA median (IQR)			
ASA II (%)	46 (69.7%)	22 (33.9%)	0.000
ASA III (%)	20 (30.3%)	40 (61.5%)	0.000
ASA IV (%)	0	3 (4.6%)	0.083
Gender	M 24 (36.4%)/F 42 (63.6%)	M 17 (26.2%)/F 48 (73.8%)	0.672
Hernia size (cm)	5 (4–5)	6 (4–9)	0.007
Type of Hiatal Hernia			
Type I (n=63)	45 (68.2%)	18 (44.7%)	0.027
Type II (n=0)	0	0	1.000
Type III (n=34)	13 (19.7%)	21 (32.3%)	0.000
Type IV (n=34)	8 (12.1%)	26 (40.0%)	0.000
ITS (n=18)	0	18 (27.7%)	0.000
Duration of operation (min)	99.5 (92–116)	113 (93–130)	0.474
Length of stay (days)	0 (0–0)	1 (1–1)	0.000
Cost/procedure			
Total	$6,427	$10,597	0.001
Direct	$5,353	$8,154	0.001
Operating room	$3,110	$3,643	0.001
Hospital Room		$1,578	0.001
30- day outcomes			
ER visits post-discharge	9/66 (13.6%)	9/65 (13.8%)	0.798
Readmissions	7/66 (10.6%)	6/65 (9.2%)	0.625

Table 5
Demographics, clinical information, costs and short-term outcomes of patients who had their surgeries performed as same day surgery, versus patients who had their surgeries performed as inpatient.

	Same Day Surgery (SDS) (n = 66)	Inpatient (INP) (n = 81 procedures in 78 patients)	p value
Age	55 (45–63)	70 (60–76)	0.000
BMI	30.05 (26.9–34.4)	30.52 (26.8–34.4)	0.633
ASA median (IQR)			
ASA II (%)	46 (69.7%)	15 (18.5%)	0.004
ASA III (%)	20 (30.3%)	63 (77.8%)	0.024
ASA IV (%)	0	3 (3.7%)	0.083
Gender	M 24 (36.4%)/F 42 (63.6%)	M 13 (16%)/F 68 (84%)	0.492
Hernia size (cm)	5 (4–5)	8 (4.5–9)	0.000
Type of Hiatal Hernia			
Type I (n=59)	45 (68.2%)	14 (17.3%)	0.004
Type II (n=0)	0	0	1.000
Type III (n=31)	13 (19.7%)	18 (22.2%)	0.000
Type IV (n=57)	8 (12.1%)	49 (60.5%)	0.000
ITS (n=37)	0	37 (45.7%)	0.000
Duration of operation (min)	99.5 (92–116)	114 (99–132)	0.799
Length of stay (days)	0 (0–0)	2 (2–3)	0.000
Cost/procedure			
Total	$6,427	$18,716	0.001
Direct	$5,353	$13,613	0.001
Operation room	$3,110	$4,167	0.001
Hospital room		$5,293	0.001
30-day outcomes			
ER visits post-discharge	9/66 (13.6%)	12/78 (15.4%)	p = 0.767
Readmissions	7/66 (10.6%)	6/78 (7.7%)	p = 0.543

(0.5%), atrial fibrillation in 2/209 (1.0%), pneumonia in 1/209 (0.5%), HIT in 1/209 (0.5%), intubation in 1/209 (0.5%), mediastinal hematoma requiring VATS drainage in 1/209 (0.5%), gastric leak in 1/209 (0.5%), pleural effusion requiring chest tube placement in 2/209 (1.0%), AKA in 2/209 (1.0%), MI in 1/209 (0.5%) and dissection of the esophageal wall in 1/209 (0.5%) The esophageal wall dissection was identified at the time of completion endoscopy in the operating room that possibly had occurred at the time of intubation in a 92 year old patient with an intrathoracic stomach.

There were a total of 30/209 (14.4%) ER visits after discharge: 9 SDS, 9 OBS and 12 INP. Out of 9/66 (13.6%) SDS patients who had postoperative ER visits, 2/66 (3.0%) did not require readmission. The reasons for ER visits for these 2 patients included abdominal pain in 1/66 (1.5%) and palpitation in 1/66 (1.5%). Seven out of 66 (10.6%) SDS patients require readmissions for abdominal pain in 2/66 (3.0%), nausea and vomiting in 1/66 (1.5%), fever in 1/66 (1.5%), dysphagia in 1/66 (1.5%), diarrhea in 1/66 (1.5%) and neck and shoulder pain in 1/66 (1.5%).

Out of 9/65 (13.8%) OBS patients who had postoperative ER visits, 3/65 (4.6%) did not require readmission. The reasons for ER visits for these 3 patients included abdominal pain in 1/65 (1.5%), shortness of breath/chest pain in 1/65 (1.5%), neck and shoulder pain in 1/65 (1.5%). Six out of 65 (9.2%) OBS patients required readmission for abdominal pain in 1/65 (1.5%), shortness of breath/chest pain in 2/65 (3.1%), colitis in 1/65 (1.5%), nausea and vomiting in 1/65 (1.5%) and fever in 1/65 (1.5%).

Out of 12/78 (15.4%) patients in the INP group who had postoperative ER visits, 6/78 (7.7%) did not require readmission. The reasons for ER visits in these 6 patients included dysphagia in 2/78 (2.6%), abdominal pain in 1/78 (1.3%), shortness of breath/chest pain in 2/78 (2.6%) and dehydration in 1/78 (1.3%). Six out of 78 (7.7%) INP group required readmission for dysphagia in 3/78 (3.8%), abdominal pain in 1/78 (1.3%), nausea/vomiting in 1/78 (1.3%) and MI in 1/78 (1.3%).

Discussion

The use of ERAS protocols to achieve SDS is shown in laparoscopic procedures such as sleeve gastrectomy.[13] Our study shows that laparoscopic hiatal hernia repair can be performed in the majority of patients in the SDS setting with the implementation of an ERAS protocol. We believe a protocol should be a simple guideline with clear steps and reproducible pathways that can be easily followed by team members and applied in a systematic manner. The protocol in our study was based on prevention and control of postoperative pain and nausea with a multidisciplinary approach to perioperative care provided by a dedicated and trained surgical team. Medications and steps of our protocol may seem basic but their application in a systematic manner with clear dosage and simple steps that were devised through the ERAS protocol was an important factor that allowed us to perform hiatal hernia repair in the SDS setting.

Neck and shoulder pain were important factors contributing to failure of SDS procedures in our study. The transition from SDS to OBS occurred in 26.7% of patients and transition from SDS to INP in 16.7% of patients because of neck and shoulder pain. After discharge, as CO2 was absorbed, only 1.5% of ER visits in SDS and 1.5% in OBS groups were caused by neck and shoulder pain. None of patients in the INP group had a visit caused by neck and shoulder pain, as CO2 probably had been absorbed by the time they were discharged from the hospital.

The mediastinal dissection during the esophageal mobilization seems to be a contributing factor to neck and shoulder after laparoscopic hiatal hernia repair. We have recently decreased the C02 flow to 20 L/min (down from 40 L/min) and intra-abdominal pressure to 12 mm Hg (from 15 mm Hg) during laparoscopic hiatal hernia repair with the aim to decrease postoperative neck and shoulder pain. The reduction in the CO2 flow and intra-abdominal pressure may result in a partial relief of neck and shoulder pain that remain a considerable problem after our procedures and may not

be completely relieved by any measures other than passage of time. It is crucial to explain to patients that they will probably have shoulder and neck pain following the procedure, caused by C02 insufflation. Patients should be informed that the pain can be severe but it improves with time, is facilitated by early ambulation and most importantly, does not require hospitalization. Clear delineation of expectation about transient postoperative neck and shoulder pain following laparoscopic hiatal hernia repair may facilitate SDS procedures. In addition to a detailed discharge instruction sheet and discharge instructions given to patients by nurses, a surgeon-patient discussion of couple of minutes in the pre-discharge unit to answer questions and to reemphasize expectations is helpful to prevent potential post-discharge visits to the ER that are related to neck and shoulder pain.

Interestingly, the most common reason for transition from SDS to OBS was patient preference in 9/30 (30.0%) patients. The patients who chose to stay overnight had a median age 65 (62–69) compared to 55 (45–63) in the SDS group ($p < 0.015$) which reflects the desire of younger patients to get discharged faster and return to work earlier. The patient preference to be admitted on the day of surgery vs. getting discharged the same day was communicated pre-operatively with all patients who were candidates for SDS hernia repair. Further discussion with patients was made in the recovery room after the patients' clinical condition was assessed by the operating surgeon. We had a low threshold to convert patients' status from SDS to OBS as needed. As more hiatal hernia repairs are performed as SDS, the choice of admission overnight, solely based on patient's preference may not remain an option as insurance companies may not allow overnight stay for SDS procedures.

In our study all procedures were performed by the same surgical team and with participation of a cardiothoracic fellow or a chief resident in about 40% of cases. We believe consistency of the team and repetition of each steps with focus on constant improvement are essential components to achieve SDS. Surgeon's operative experience and technical skills are important factors that should constantly improve but does not seem to be the main factor in achieving laparoscopic hiatal hernia repair in the SDS setting. We have performed 654 hiatal hernia repairs in the last 10 years by a single surgeon and a dedicated surgical team, and only achieved SDS hernia repair in the last 3 years. We believe the change in our practice to SDS hiatal hernia repair was multifactorial and consisted of a progressive improvement in our surgical experience over years with shorter operative time and better surgical outcomes, and successful laparoscopic Heller myotomies performed as SDS in our center. Other factors included a gradual increase in the experience of the entire surgical team in all perioperative phases, implementation of a well-defined and simple ERAS protocol which we think is the pillar of perioperative care, and daily and repetitive reinforcement of the protocol until it became an integral and effortless practice of our team. The fact that approximately 40% of our cases were covered by a cardiothoracic fellow or a chief resident and about 60% of cases were performed in private practice setting, suggests that SDS hiatal hernia repair can be performed in high volume specialized esophageal centers with a trained and experienced surgical team, in both academic and private practice settings. Key points seem to be assembling a trained and dedicated surgical team inside and outside of the operating room, constant and systemic reinforcement of ERAS protocols and clear delineation of expectations for patients.

While the role of a surgical team for implementation of measures in 3 perioperative phases of the SDS protocol is crucial, patient selection is equally important. We believe that not all patients are candidates for SDS, as we excluded patients with age above ≥ 75, ASA IV, intrathoracic stomach and admissions via emergency room. Exclusion criteria seems similar to other outpatient laparoscopic procedures such as laparoscopic cholecystectomy which is routinely preformed in SDS setting but certainly not in a patient with ASA IV or a gangrenous gallbladder. We excluded reoperative procedures from the study as we believe reoperative procedures are more complex, they require extensive lysis of abdominal and mediastinal adhesions, a more elaborate mediastinal dissection, and a longer operative time compared to primary repairs. Patients are at higher risk for leak, perforation and postoperative bloating, and should be observed overnight to assess for potential complications. We believe at least for the time being, the reoperative procedures are not a candidate for SDS. With further improvement in perioperative care, the exclusion criteria for SDS laparoscopic hiatal hernia may change and may allow same day surgery procedures in a larger group of patients, including age > 75, selected admissions via emergency room, and a group of patients with intrathoracic stomach or in patients who undergo reoperative procedures.

Of note, after completion of the present study in the last 4 months, we have performed 38 hernia repairs. Excluding reoperative procedures (n=13), patients with age > 75 and/or intrathoracic stomach (n=6), 19 procedures were planned as SDS and 18/19 (95%) were performed as SDS, compared to 57.9% in the present study. We have made 2 changes in our practice in the last 4 months, 1: we have decreased the C02 flow to 20 L/min (down from 40 L/min) and intra-abdominal pressure to 12 mm Hg (from 15 mm Hg) with the aim to decrease postoperative neck and shoulder pain, 2: since January 10, 2019 we have implemented a new non-narcotic anesthesia protocol without the use of Fentanyl and with the use of only 1/2 dose of Sevoflurane gas. The new anesthesia protocol is based on use of Magnesium in combination with Lidocaine, Precedex, Ketamine, and Esmolol which are aimed to decrease perioperative pain, and at the same time reduce postoperative nausea and ileus created by narcotics. Ileus and abdominal distension were the main reasons for transition from SDS to INP group, seen in 33.3% of patients. Therefore, we believe the new anesthesia protocol may increase the feasibility of hiatal hernia repair in the SDS setting. The outcomes and costs of hiatal hernia repairs with a lower CO2 insufflation rate, a lower intra-abdominal pressure and the new anesthesia protocol will be assessed in a future study.

With the emphasis of health care system on costs and outcomes, and progressive demands for outpatient and minimally invasive procedures, hiatal hernia repair in the SDS setting seems a viable option that may continue to grow in specialized esophageal centers. Education of the surgical team, improvement in measures to decrease perioperative pain and nausea, and better patient education with delineation of clear expectations are important factors that may result in an increased number of SDS procedures.

Conclusion

Elective laparoscopic hiatal hernia repair can be performed in the majority of patients as same day surgery with reduced costs, and short-term outcomes comparable to observation and inpatient settings. Assembling a trained surgical team, implementation of ERAS protocols to reduce postoperative pain and nausea, and patient selection with delineation of clear expectations are crucial.

Limitations

We acknowledge the limitations of our study including lack of randomization and possible ER visits and readmissions to other centers that were unknown to us and would have affected the outcomes of our study. The implementation of same day surgery hiatal hernia repair requires a high volume specialized center with

an experienced and dedicated surgical team focused on esophageal surgery and may not be feasible in all hospitals and surgical centers.

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