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ORIGINAL CONTRIBUTIONS

Enhanced Recovery after Bariatric Surgery in the Severely Obese, Morbidly Obese, Super-Morbidly Obese and Super-Super Morbidly Obese Using Evidence-Based Clinical Pathways: a Comparative Study

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Abstract
Background We discuss the anesthetic outcome in morbidly obese patients under the enhanced recovery after surgery (ERAS) protocol. Our evidence-based clinical pathways focused on prehabilitation and included interventions like aggressive preoperative optimization of medical comorbidities, familiarizing with perioperative protocols, thromboprophylaxis, opioid free multimodal analgesia, and early ambulation.
Methods We did a retrospective analysis of prospectively collected data of 823 patients who underwent laparoscopic bariatric surgery. Our goal was to assess the effects of BMI on the recovery and anesthetic outcome parameters, under the categories of severely obese (SeO: BMI <39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO: BMI >60 kg/m^2). Time to ambulate (TA) was the primary variable.
Results Requirement for non-invasive ventilation (NIV) was the only significant predictor of TA and discharge readiness (DR); the DR was further affected by functional capacity and presence of chest pain. Our analysis indicated that each unit increase in BMI (kg/m^2) contributes to increase in ambulation time by 1.24 min (95 % CI: 0.648 to 1.832 min; $P < 0.001$) and DR by 0.52 h (95 % CI: 0.435 to 0.606 h; $P < 0.001$). The odds ratio for requirement for NIV (per unit change in BMI) was 1.163 (CI: 1.127/1.197; $P < 0.001$).
Conclusions Aggressive preoperative optimization can avert effects of BMI on anesthetic outcome. Practice of prehabilitation and preoperative optimization of comorbidities using evidence-based clinical pathways can complement the principles of ERAS in patients undergoing bariatric surgery to facilitate their discharge readiness.

Keywords ERAS · Bariatric · Super obesity · Super-super obesity · Enhanced · Recovery · Anesthetic · Outcomes · Prehabilitation

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Background

Enhanced recovery after surgery/anesthesia (ERAS) protocols have caused a paradigm shift in surgical care by attenuating perioperative stress, resulting in safer outcome. However, extension of the benefits of these protocols to the morbidly obese patients will require their evidence-based modification.

The existing literature focuses on surgical outcome parameters, with gross scarcity of anesthetic outcome data for the obese, particularly for super-morbidly obese and super-super morbidly obese, whose number is also fast increasing [1–5]. Here, we discuss the anesthetic outcome data following evidence-based clinical pathways focused on prehabilitation, preoperative optimization, and ERAS.

Early ambulation after surgery is a significant part of enhanced recovery after surgery program [6, 7]. However, there is paucity of literature to support its relevance in the obese.

Our goal was to assess the effects of BMI on the recovery and anesthetic outcome parameters. Patients were categorized into severely obese (SeO: BMI <39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO: BMI >60 kg/m^2).

The primary objective was to assess the effect of BMI on time to ambulate (TA) and the secondary objective was to assess and compare the outcome parameters between the BMI groups.

The primary variable was time to ambulate and the secondary variables were discharge readiness (DR), occurrence of arrhythmias, hypoxia, dyspnea, hypotension, persistent tachycardia, neuropathy/neuropraxia, postoperative nausea and vomiting (PONV), chest pain, backache, pneumonitis, stroke, delayed emergence, re-intubation, and unplanned intensive care unit (ICU) admission.

Methods

With Institutional Ethics Committee approval (CTRI/2016/04/006887), we retrospectively analyzed prospectively collected outcome data from consecutive adult patients who underwent laparoscopic bariatric surgery at our center between August 2013 and March 2015.

All patients of either gender, more than 18 years of age and body mass index (BMI) >35 kg/m^2 who underwent laparoscopic bariatric surgery were included in the study. Patients undergoing revision and metabolic surgery were excluded.

Complete electronic record system for obese patients was initiated in August 2013 at our institute. A total of 823 consecutive patients met the eligibility criteria in the given period and were included in the study. For this given number of patients, the power for detecting a difference of 35 min in mean ambulation time in six pairwise comparisons was found to be 96 %.

The perioperative protocol was standardized and all patients underwent preoperative assessment by an anesthesiologist 10 to 15 days preoperatively. The same clinical team of five surgeons and three anesthesiologists provided the perioperative care to all patients. Most patients attended a preoperative support group meeting and were counseled by the dietician, psychiatrist, and physician wherever appropriate.

Data was collected on age, gender, BMI, pre-existing comorbidities, and prevalence of obstructive sleep apnoea (OSA), based on the STOPBANG scoring system [7], preoperative (non-invasive ventilation) NIV requirement, and functional capacity (walking with support, WS) from the electronic records.

Patients were counseled to practice deep breathing and strengthening exercises of upto 20 to 40 min per day. They were familiarized about early ambulation in the postoperative period [6, 7]. The time lapse between reaching the post anesthesia care unit (PACU) and the beginning of unsupported ambulation upto 20 m in the PACU or with walker (WS) was documented as Time to Ambulate (TA) [8–10].

Anesthesia protocol was as per Fig. 1. Patients were extubated at BIS >70, after return of jaw tone and airway reflexes. No sugammadex was used in any patient. Presence of arrhythmias, hypoxia, dyspnea, neuropathy/neuropraxia, PONV, chest pain, backache, delayed emergence, re-intubation, unplanned intensive care unit (ICU) admission, and any hemodynamic instability were addressed as complications and collated.

In the postoperative period, the SpO_2 was maintained around preoperative or baseline levels using oxygen supplementation or NIV as appropriate desaturations below baseline, and non responsive to oxygen therapy/NIV was defined as hypoxemia. Patients were allowed to suck ice cubes and start clear liquids within 6 h. Patients, who could tolerate feeds had no postoperative nausea vomiting, were hemodynamically stable, had stable hematocrit, could walk without support, and did not have any signs of hypoxemia were defined discharge ready (DR).

Statistical Analysis

The analysis was done in two different ways. The first analysis considered BMI as such with no grouping to indicate how post-op recovery is affected by per unit rise in BMI. Logistic regression was run for qualitative dependents such as requirement for tramazac hydrochloride (TMZ), to give odds ratio (OR) per unit of BMI with its *P*-value, and 95 % confidence interval (CI). For quantitative dependents such as ambulation time, least square regression was run, limiting linear form with its statistical significance.

The second analysis considered BMI in groups, namely, <40, 40.00–49.99, 50.00–59.99, and 60+, respectively, called severely obese, morbidly obese, super-morbidly obese, and super-super morbidly obese. In this analysis, the statistical significance of the relation between BMI group and qualitative outcome such as TMZ requirement, were investigated by cross-tabulation and chi-square test. For quantitative outcome such as ambulation time, analysis of variance (ANOVA) was done to find statistical significance of the difference in mean levels in different BMI groups. For all quantitative outcomes, mean, SD, and 95 % CI for mean were calculated. A further

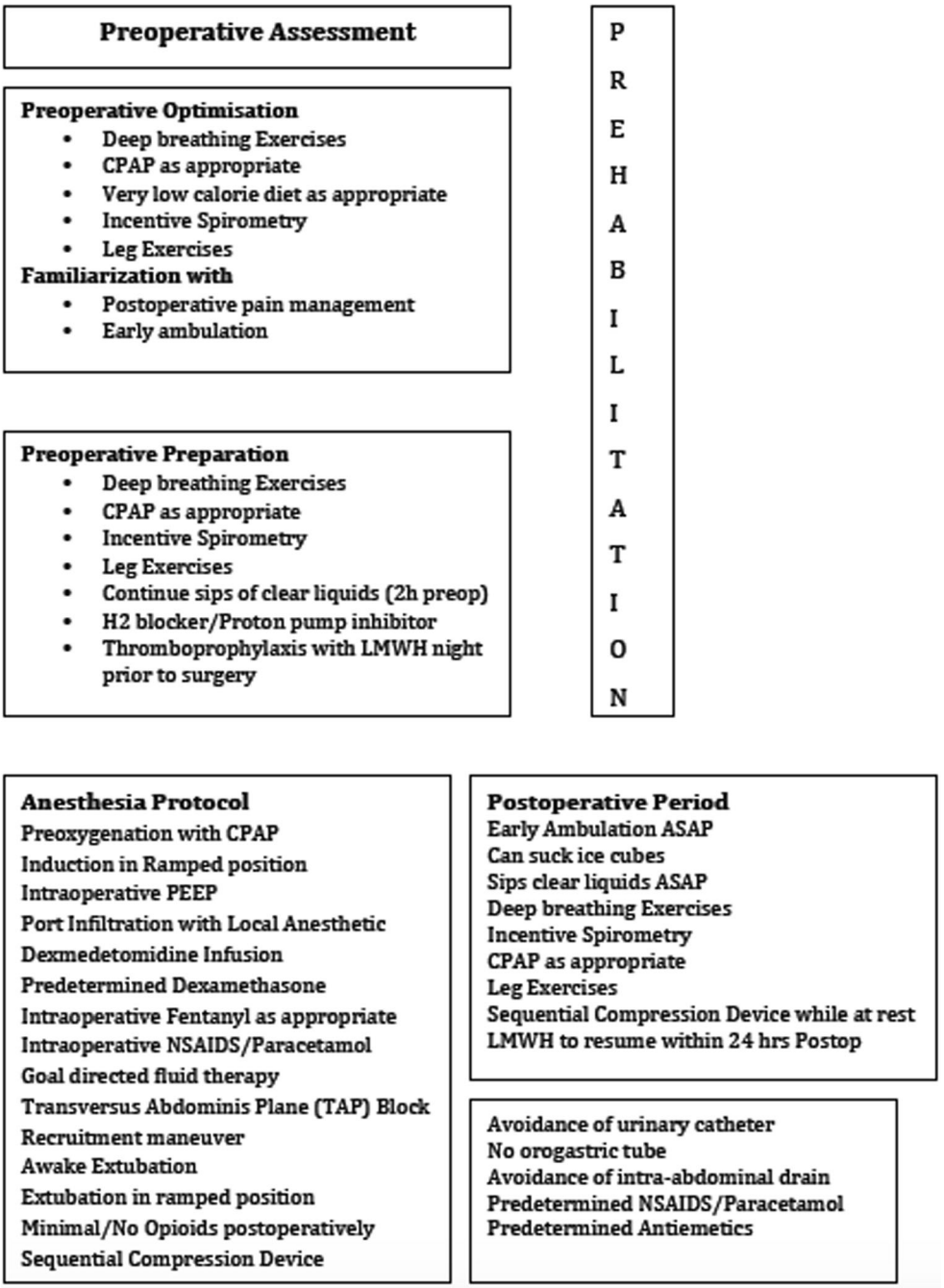

Fig. 1 Evidence-Based Clinical pathways applied for enhanced recovery after surgery in the bariatric patients in this study

post-hoc analysis was done by Tukey test to find if any particular BMI group had a different outcome.

All statistical tests were carried out at two-tailed 5 % level of significance, although exact values have been reported. SPSS 16.0 was used for analysis.

Results and Observations

Our study included 823 patients who underwent laparoscopic bariatric surgery. There was a preponderance of female patients in all BMI groups except the SSMO group where 58.8 % of the patients were male ($P = 0.04$) (Table 1). The groups were not significantly different for incidence of hypertension, diabetes mellitus, and osteoarthritis. Cardiomyopathy, coronary artery disease, preexisting arrhythmia, and nephropathy also did not differ ($P > 0.05$) across the BMI groups (Table 2). However, there was significant difference in the prevalence of OSA (as per STOPBANG >5) viz. SeO: 10.7 %; MO: 36.7 %; SMO: 76.8 %; SSMO: 92.6 %; ($P < 0.001$).

Table 1 Patient characteristics

BMI group	SeO	MO	SMO	SSMO	Overall	*P* value
n	28	442	285	68	823	
BMI kg/m^2 (mean ± SD)	39.6 ± 0.4	45 ± 3	54 ± 3	65 ± 4	49.7 ± 7	
Mean age (years) (mean ± SD)	43 ± 13	41 ± 12	43 ± 12	42 ± 11	42 ± 12	
Male/female (%)	28.6	44.6	45.6	58.8	45.6	0.041*
Bypass *n* (%)	19(67.9)	360(81.4)	220(77.2)	24 (35.3)	623(75.8)	<0. 001*
Sleeve gastrectomy *n* (%)	6(21.4)	69(15.6)	62(21.8)	38(55.9)	175(21.1)	
Others *n* (%)	3(10.7)	13(2.9)	3(1.1)	6(8.8)	25(3.0)	
Anesthesia duration (Minutes) (Mean ± SD)	158 ± 36.5	183 ± 37	180 ± 46	159 ± 41	179 ± 41	<0.001*

Values are expressed as *n* (%). Severely obese (SeO BMI < 39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO: BMI >60 kg/m^2)

SD standard deviation

*$P < 0.05$ considered statistically significant

Table 2 Preoperative comorbid conditions

BMI group	SeO	MO	SMO	SSMO	Overall	*P* value
Number	28	442	285	68	823	
Hypertension *n* (%)	16(57.1)	241(45.5)	161(56.5)	46(67.6)	464(56.4)	0.247
Diabetes mellitus *n* (%)	13(46.4)	208(47.1)	112(39.3)	29(42.6)	362(44.0)	0.226
Severe OSA (STOPBANG >5)	3(10.7)	162(36.7)	219(76.8)	63(92.6)	447(54.3)	<0.001*
NIV *n* (%)	0(0.0)	25(5.7)	42(14.7)	40(58.8)	107(13.0)	<0.001*
RVSP 30–40 *n* (%)	0(0.0)	2(0.5)	7(2.5)	4(5.9)	13(1.6)	0.012*
Nephropathy *n* (%)	0(0.0)	15(3.4)	8(2.8)	3(4.4)	26(3.2)	.721
CMP *n* (%)	2(7.1)	15(3.4)	12(4.2)	3(4.4)	32(3.9)	0.750
Arrythmias *n* (%)	0(0.0)	2(0.5)	2(0.7)	2(2.9)	6(0.7)	0.150
CAD *n* (%)	2(7.1)	6(1.4)	3(1.1)	0(0.0)	11(1.3)	0.051
Neuropathy *n* (%)	2(7.1)	3(0.7)	3(1.1)	2(2.9)	10(1.2)	0.012*
Osteoarthritis *n* (%)	14(50)	218(49.3)	149(52.3)	38(55.9)	419(50.9)	0.719
Walks with support (WS) *n* (%)	2(7.1)	10(2.3)	32(11.2)	7(10.3)	51(6.2)	.001*
Hypothyroid *n* (%)	1(3.6)	12(2.7)	40(14.0)	0(0.0)	53(6.4)	0.000*

Values are expressed as *n* (%). Severely obese (SeO BMI < 39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO): BMI >60 kg/m^2

SD standard deviation, *OSA* obstructive sleep apnea, *NIV* non invasive ventilation, *RVSP* right ventricular systolic pressure, *CMP* cardiomyopathy, *CAD* coronary artery disease

*$P < 0.05$ considered statistically significant

There was also significant difference in the frequency of OSA patients requiring NIV in the preoperative period across the BMI groups, viz. SeO:0 %; MO: 5.7 %; SO: 14.7 %; SSO: 58.8 %; ($P < 0.001$). The overall prevalence of OSA in the study groups was 54 % with maximum in SSMO group, (Table 2).

There was a distinctive difference in prevalence of patients walking with support (WS), preoperative neuropathy, hypothyroid, and patients having (right ventricular systolic pressure) RVSP in the range of 30–40 across the BMI groups (Table 2). The number of preoperative comorbid conditions was also different across the BMI groups, with the number increasing significantly with increasing BMI, (Fig. 2).

Ten patients had preoperative neuropathy of which 2 were in SeO, 3 in MO, 3 in SMO, and 2 were SSMO ($P = 0.012$).

Two patients had ankylosing spondylitis, 2 had paraparesis and 1 patient had a preoperative correction of meningomyelocele with paraparesis. However, none of these patients had any aggravation of neuropathic symptoms in the postoperative period. Some developed postoperative neuropraxia (1 in SeO, 14 in MO, 17 in SMO, and 3 in SSMO: $P = 0.325$) that resolved uneventfully within 24 h. Others developed intractable backache in the first 6 h of surgery, which resolved within 24 h on conservative management.

Some patients (2 in SeO, 15 in MO, 12 in SMO, and 3 in SSMO; $P = 0.75$) had preexisting cardiomyopathy (CMP), of which two were TMT positive and six had coronary stent in-situ and two had persistent atrial fibrillation. None of them showed any aggravation of symptoms in the perioperative period. One patient of the MO group had sudden onset of dyspnea on the first postoperative day, associated with right ventricular pressure of 80 mmHg but no hypoxemia. This patient was further managed in the intensive care unit. All other patients were electively monitored in the high dependency unit (HDU), for 24 h postoperatively.

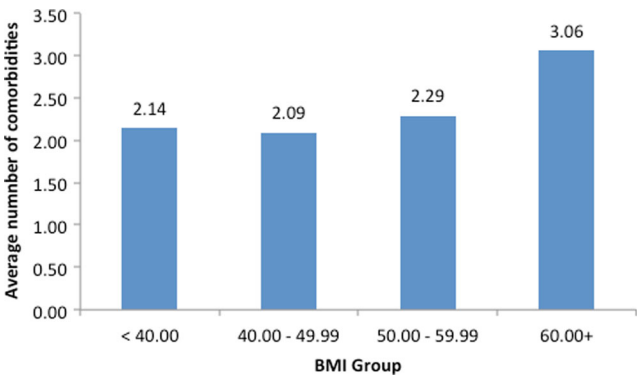

Fig. 2 This figure represents average number of comorbidities (Y axis) across the BMI groups expressed in kg/m^2 (X axis) and clearly depicts higher number of comorbidities in high BMI segments

There was significant difference in the anesthesia duration across the groups, with maximum duration in the SSMO group; (SeO: 158 ± 36.5; MO: 183 ± 37; SMO: 180 ± 46; SSMO: 159 ± 41; $P < 0.001$: overall duration = 179 ± 41 in minutes). Owing to technical constraints, most patients in the SSMO underwent laparoscopic sleeve gastrectomy, which is a briefer procedure. This is performed as a bridging surgery for SSMO, in our center.

TAP block under ultrasound guidance was attempted in all patients. Wound infiltration (bupivacaine 0.25 %) was administered when muscle planes could not be identified for the TAP block. There was a significant difference in the success of the TAP block across the groups with a significantly higher number of patients requiring wound infiltration in the SSMO group: (Odds Ratio = 1.095; CI 1.038/1.056;$P = 0.001$). However, the requirement of rescue analgesic, i.e., tramazac hydrochloride (TMZ) in the PACU, was negligible and did not differ between the BMI groups: Odds Ratio = 0.999; CI (0.957/1.043;$P = 0.97$).

Extubation could be accomplished in 100 % of the patients across all groups and none of the patients required reintubation. (Table 3).

Our results showed that TA and DR are significantly different across BMI groups (Table 4). Pairwise multiple comparisons by Tukey test showed that this was mostly due to higher mean TA in the SSMO group, but mean DR was significantly different in almost every group. (Table 4).

As per least square regression, each unit increase in BMI (kg/m^2) contributes to increase in ambulation time by 1.24 min (95 % CI: 0.648 to 1.832 min; $P < 0.001$) and DR by 0.52 h (95 % CI: 0.435 to 0.606 h; $P < 0.001$) Table 4. This could be attributed to greater prevalence of patients walking with support in the higher BMI (SMO and SSMO) groups (SeO: 7 %, MO: 2.3 %, 32 in SMO: 11.2 %, and SSMO: 10.3 %; $P = 0.000$).

It was remarkable to note that there was statistically significant difference in the number of desaturation episodes requiring NIV support across the BMI groups (SEO:0 %, MO: 9.5 %, SMO: 19.3 %, and SSMO: 77.9 %; $P < 0.001$); however, all these episodes could be managed uneventfully, (Tables 3 and 5). There was significant difference in intraoperative ventilatory adjustments, chest pain, persistent tachycardia, and postoperative neuropraxia across the BMI groups (Table 3, Fig. 3). Overall, number of adverse events was more in the higher BMI groups.

Table 3 Postoperative events

BMI group	SeO	MO	SMO	SSMO	Overall	*P* value
N	28	437	284	65	823	
TAP block *n* (%)	28(100)	406(92.9)	163(57.4)	61(93.8)	658(80.8)	<0.001*
Hypoxemia below baseline (requiring NIV) *n* (%)	0(0.0)	42(9.5)	55(19.3)	53(77.9)	150(18.2)	<0.001*
Persistent tachycardia *n* (%)	2(7.1)	2(0.5)	6(2.1)	2(2.9)	12(1.5)	0.018*
Chest pain *n* (%)	0(0.0)	14(3.2)	26(9.1)	12(17.6)	52(6.3)	<0.001*
Postop arrythmias *n* (%)	0(0.0)	2(0.5)	0(0.0)	0(0.0)	2(0.2)	0.628
Paraesthesias/neuropraxia	1(3.6)	14(3.2)	17(6.0)	3(4.4)	35(4.3)	0.325
Postop nephropathy (*n*)%	0(0.0)	4(0.9)	1(0.4)	0(0.0)	5(0.6)	0.638
Backache	0(0.0)	14(3.2)	9(3.2)	5(7.4)	28(3.4)	0.212
Re-intubation	0	0	0	0	0	
Failure to extubate on OT Table	0	0	0	0	0	
Unplanned ICU admission	0	0	0	1	1	
Dyspnea or suspected Pulmonary embolism	0	1	0	0	1	

Values are expressed as *n* (%). Severely obese (SeO BMI < 39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO): BMI >60 kg/m^2

SD standard deviation, *TAP* Transversus Abdominis Plane Block, *NIV* non-invasive ventilation

*$P < 0.05$ considered statistically significant

On multivariable logistic regression analysis of preoperative variables, we found that requirement of NIV was the only significant predictor of TA and DR, the latter was also affected by requirement for support for walking, WS. The DR was also significantly prolonged in patients who walked with support WS, and had chest pain. The odds ratio for requirement of NIV (per unit change in BMI) was 1.163 (CI: 1.127/1.197; $P < 0.001$), Table 6.

Table 4 Tukey's test

Time to ambulate (minutes)					
	Over-all	SeO	MO	SMO	SSMO
	823	28	437	284	65
Mean ± SD	158.9 ± 60.9	155.2 ± 65.9	156 ± 56	156.2 ± 64.1	191.6 ± 67.3
95 % Confidence interval	154.8, 163.1	132.8, 177.5	150.4, 161.6	149.2, 163.2	177.3, 205.9
	SeO	–	$P > 0.05$	$P > 0.05$	$P = 0.036$
	MO	$P > 0.05$	–	$P > 0.05$	$P < 0.001$*
	SMO	$P > 0.05$`	$P > 0.05$	–	$P < 0.001$*
	SSMO	$P = 0.036$	$P < 0.001$*	$P < 0.001$*	–
Discharge Readiness (hours)					
	Over-all	SeO	MO	SMO	SSMO
Mean ± SD	30.5 ± 9.3	27.4 ± 6.4	28.1 ± 6.7	31.5 ± 8.7	43.3 ± 15.7
95 % Confidence Interval	29.9, 31.14	24.3, 30.6	27.3, 28.9	30.5, 32.5	41.2, 45.2
	SeO	–	$P = 0.975$	$P = 0.069$	$P < 0.001$*
	MO	$P = 0.975$	–	$P < 0.001$*	$P < 0.001$*
	SMO	$P = 0.069$	$P < 0.001$*	–	$P < 0.001$*
	SSMO	$P < 0.001$*	$P < 0.001$*	$P < 0.001$*	–

Values are expressed as *n* (%). Severely obese (SeO BMI < 39.9 kg/m^2), morbidly obese (MO: BMI 40–49.9 kg/m^2), super-morbidly obese (SMO: BMI 50–59.9 kg/m^2), and super-super morbidly obese (SSMO): BMI >60 kg/m^2

SD standard deviation

*$P < 0.05$ considered statistically significant

Table 5 Effect of BMI on primary outcomes (Univariate analysis)

Postoperative outcome	Regression coefficient	95 % Confidence interval	*P* value
Time to ambulate (minutes)	1.24	(0.648–1.832)	<0.001*
Discharge readiness (hours)	.521	(0.435–0.606)	<0.001*

*$P < 0.05$ is statistically significant

Discussion

Though some studies have assessed the feasibility of fast track surgery in patients undergoing bariatric surgery [1–5], the main finding of our study is that the degree of obesity (as assessed by BMI) influences the postoperative course and the anesthetic outcome of the patients. Though the frequency of comorbid conditions and postoperative adverse outcomes vary significantly across the BMI groups, with prehabilitation and aggressive preoperative optimization of each comorbidity, it is possible to avert their influence on anesthetic outcome.

Though there was no difference in the anesthetic management in the patients, there was significant difference in some anesthetic outcomes across the BMI groups.

Though some studies have reported that there is no additional risk with increasing BMIs, our study clearly indicates that several comorbid conditions may show significantly higher prevalence with increasing BMI (Figs. 2 and 3).

This could be attributed to greater prevalence of OSA, with higher BMI. Most notably, it is the presence of OSA and requirement for NIV that is likely to affect the time to ambulate and discharge readiness. Some recent studies have demonstrated high incidence of postoperative cardio-pulmonary events in patients with OSA; none of the patients in our study had any evidence of any such event [8].

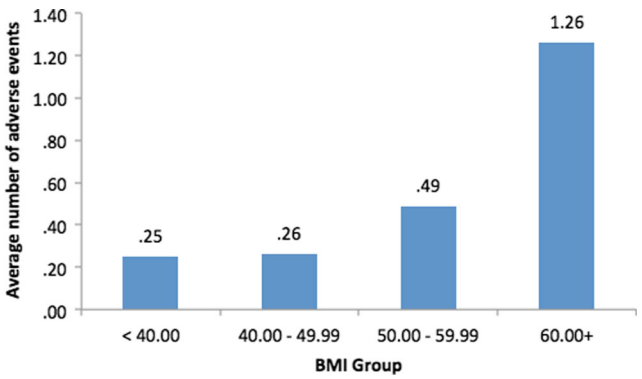

Fig. 3 This figure represents average number of adverse events (Y axis) across the BMI groups expressed in kg/m^2 (X axis) and clearly depicts higher number of adverse events s in high BMI segments

Early ambulation can be considered to be the single most important determinant of patient safety and reflection of enhanced recovery programs. Though there is limited evidence to support exact mechanisms by which it acts, it is the most significant prophylactic measure following surgery. Besides promoting early gut motility, it contributes by improving diaphragmatic excursions, subsequent decrease in pulmonary atelectasis, and also preventing the development of deep venous thrombosis. However, there is lack of consensus about the exact definition of early ambulation. Our results clearly demonstrate that BMI significantly influences the TA and DR; presence of OSA and NIV requirement are strong predictors of them. Though the desaturation events differed widely across the groups, no patient had intractable hypoxemia. This could be attributed to opioid free analgesia and aggressive preoperative optimization [11–14].

Laparoscopic bariatric surgery can be associated with moderate to severe pain, and effective opioid free analgesia is essential to facilitate and expedite postoperative recovery and prevent opioid related misadventures. TAP block has proven to be efficacious as a part of multimodal analgesia. This was attempted in all patients and helped in reducing the requirement for postoperative opioids, promoting early ambulation, and preventing opioid related nausea and vomiting. However, in some patients, it was a technical challenge to execute the block. In these patients, the surgical ports were infiltrated with local anesthetics [15].

Thromboembolic complications continue to be the most dreaded cause of postoperative morbidity and mortality in morbidly obese patients. Immediate postoperative ambulation has proven to be a significant step to prevent this [5, 6].

All patients received low molecular weight heparin the evening prior to surgery, which continued into the postoperative period for 10 days. Sequential compression device was an additional measure during periods of immobility. All patients followed frequent leg exercises or walks. Above knee TED stockings were provided an evening prior to surgery and continued upto 10 days postoperatively [16–18].

The focus of our clinical pathways was to optimize the oxygen reserves, provide thromboprophylaxis, and prevent any possible regurgitation and aspiration.

Table 6 Multivariable regression of preoperative variables

Dependent	Significant predictor in the model	Regression coefficient	95 % Confidence interval	*P* value
Time to ambulate (minutes)	Requiring preop NIV	17.801	5.462–30.139	0.005*
Discharge readiness (hours)	Requiring preop NIV	6.189	4.328–8.050	<0.001*
	With support	3.767	1.171–6.363	0.005*
Multivariable regression of postoperative variables				
Dependent	Significant predictor in the model	Regression coefficient	95 % Confidence interval	*P* value
Time to ambulate (minutes)	Requiring multiple ventilatory Adjustments	50.373	17.001–83.745	0.003*
	Requiring NIV	12.737	1.959–23.516	0.021*
Discharge readiness (hours)	Requiring NIV	4.891	3.282–6.501	<0.001*
	Chest pain	5.896	3.359–8.433	<0.001*
	Requiring multiple ventilatory adjustments	9.330	4.347–14.313	<0.001*

NIV non-invasive ventilation

*$P < 0.05$ is statistically significant

Our preparations started with counseling the patient at the time of preoperative assessment and familiarizing them with the issues of their limited oxygen reserves.

There was stress on deep breathing exercises, spirometry, leg exercises, frequent ambulation, sleeping in propped up position, etc [19, 20]. This further helps in improving pulmonary functions by mobilization of mucous secretions. Optimizing the oxygen reserves continued into the induction, intraoperative, and postoperative period.

Patients were positioned on ramp on the operation theater tables [21–23]. All pressure points were well taken care of. Preoxygenation was with FiO_2 1.0 with CPAP of 5 to 10 mmHg. PEEP of 5 mmHg was administered throughout the intraoperative period.

Recruitment maneuver was performed prior to extubation, and all patients underwent extubation after return of airway reflexes, swallowing, and jaw tone [24–27]. Anesthesia was titrated to maintain a BIS of 40–60 in the intraoperative period and extubation was performed at a BIS of >70.

Care was taken to prevent rhabdomyolysis. All the pressure points were well padded, and in case the surgery extended more than 4 h, surgeon was requested to deflate the carboperitoneum for at least 10 min to allow circulation in compressed areas [28–31]. Fluids were administered as per goal directed therapy [32].

Faster emergence, opioid free pain management, and early ambulation are closely knit and would extend greater benefit to this sub-population. Research shows that morbidity and mortality of obese is markedly higher and different from the non obese [33, 34]. However, in our patients by rigidly following our clinical pathways and adequately optimizing all comorbidities, we could obviate the adverse events.

Evidence on ERAS suggests a multimodal approach to minimize surgery and anesthesia related stress and a close collaboration between caregivers on perioperative protocols.

Though cost benefits have been the driving force behind this concept, the obese will clearly draw greater clinical benefits. Practice of prehabilitation and preoperative optimization of comorbidities using evidence-based clinical pathways can complement the principles of ERAS in patients undergoing bariatric surgery and contribute to improvement in the anesthetic outcomes, minimize the short-term morbidities, and facilitate discharge readiness.

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Attestation: Lakshmi Jayaraman has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is responsible for archiving the study files.

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Compliance with Ethical Standards This study was conducted in compliance with Good Clinical Practice (GCP) and in accordance with the ethical principles that have their origin in the Declaration of Helsinki Guidelines for Ethics in Research.

Informed Consent Informed consent was obtained from all participants in the study.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Kariv Y, Delaney CP, Senagore AJ, et al. Clinical outcomes and cost analysis of a "fast track" postoperative care pathway for ileal pouch-anal anastomosis: a case control study. Dis *Colon rectum*. 2007;50(2):137–46.
2. Varadhan KK, Lobo DN, Ljungqvist O. Enhanced recovery after surgery: the future of improving surgical care. Crit Care Clin. 2010;26:527–47.
3. Bamgbade OA, Adeogun BO, Abbas K. Fast-track laparoscopic gastric bypass surgery: outcomes and lessons from a bariatric surgery Service in the United Kingdom. Obes Surg. 2012;22:398–02.
4. Chaar M, Claros L, Ejeji G, et al. Improving outcome of bariatric surgery: best practices in an accredited surgical center. Obes Surg. 2014;24:1057–63.
5. Barreca M, Renzi C, Tankel J, et al. Is there a role for enhanced recovery after laparoscopic bariatric surgery? Preliminary results from a specialist obesity treatment center. Surg Obes Relat Dis. 2016;12(1):119–26.
6. Waldhausen JH, Schirmer BD. The effect of ambulation on recovery from postoperative ileus. Ann Surg. 1990;212(6):671–7.
7. Delaney CP, Zutshi M, Senagore AJ, et al. Prospective, randomized, controlled trial between a pathway of controlled rehabilitation with early ambulation and diet and traditional postoperative care after laparotomy and intestinal resection. Dis *Colon rectum*. 2003;46(7):851–9.
8. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. Anesthesiology. 2008;108:812–21.
9. Mokhlesi B, Margaret D, Vekhter H, et al. Sleep-disordered breathing and postoperative outcomes after bariatric surgery: analysis of the nationwide inpatient sample. Obes Surg. 2013;23(11):1842–51.
10. Barbalho-Moulim MC, Miguel GP, Forti EM, et al. Effects of preoperative inspiratory muscle training in obese women undergoing open bariatric surgery: respiratory muscle strength, lung volumes, and diaphragmatic excursion. Clinics (Sao Paulo). 2011;66:1721–7.
11. Lemanu DP, Srinivasa S, Singh PP, et al. Optimizing perioperative care in bariatric surgery patients. Obes Surj. 2012;22:979–90.
12. Krenk L, Jennum P, Kehlet H. Sleep disturbances after fast-track hip and knee arthroplasty. Br J Anaesth. 2012;109(5):769–75.
13. Yue HJ, Guilleminault C. Opioid medication and sleep-disordered breathing. Med Clin North Am. 2010;94:435–46.
14. Casati A, Putzu M. Anesthesia in the obese patient: pharmacokinetic considerations. J Clin Anesth. 2005;17:134–45.
15. Bernards CM, Knowlton SL, Schmidt DF, et al. Respiratory and sleep effects of remifentanil in volunteers with moderate obstructive sleep apnea. Anesthesiology. 2009;110:41–9.
16. Sinha A, Jayaraman Punhani D. Efficacy of ultrasound guided TAP block for pain management after laparoscopic gastric bypass. Obes Surg. 2013;23:548–53.
17. Geerts WH, Bergqvist D, Pineo GF, et al. Prevention of venous thromboembolism: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2008;133:381S–53S.
18. Magee CJ, Barry J, Javed S, et al. Extended thromboprophylaxis reduces incidence of postoperative venous thromboembolism in laparoscopic bariatric surgery. Surg Obes Relat Dis. 2010;6:322–5.
19. Raftopoulos I, Martindale C, Cronin A, et al. The effect of extended post-discharge chemical thromboprophylaxis on venous thromboembolism rates after bariatric surgery: a prospective comparison trial. Surg Endosc. 2008;22:2384–91.
20. Jense HG, Dubin SA, Siverstein PI, et al. Effect of obesity on safe duration of apnea in anesthetized humans. Anesth Analg. 1991;72:89–93.
21. Eichenberger A, Proietti S, Wicky S, et al. Morbid obesity and postoperative pulmonary atelectasis: an underestimated problem. Anesth Analg. 2002;95:1788–92.
22. Juvin P, Lavaut E, Dupont H, et al. Difficult tracheal intubation is more common in obese than in lean patients. Anesth Analg. 2003;97:595–600.
23. Brodsky JB, Lemmens HJ, Brock-Utne JG, et al. Morbid obesity and tracheal intubation. Anesth Analg. 2002;94:732–6.
24. Gonzalez H, Minville V, Delanoue K, et al. The importance of increased neck circumference to intubation difficulties in obese patients. Anesth Analg. 2008;106:1132–6.
25. Coursa M, Proeitti S, Schnyder P, et al. Prevention of atelectasis formation during the induction of anesthesia in morbidly obese patients. Anesth Analg. 2004;98:1491–5.
26. Talab HF, Zabani IA, Abdelrahman HA, et al. Intraoperative ventilatory strategies for prevention of pulmonary atelectasis in obese patients undergoing laparoscopic bariatric surgery. Anesth Analg. 2009;109:1511–6.
27. Herriger A, Frascarolo P, Spahn DR, et al. The effect of positive airway pressure during pre-oxygenation and induction of anaesthesia upon duration of non-hypoxic apnoea. Anaesthesia. 2004;59:243–7.
28. Gander S, Frascarolo P, Suter M, et al. Positive end-expiratory pressure during induction of general anesthesia increases duration of nonhypoxic apnea in morbidly obese patients. Anesth Analg. 2005;100:580–4.
29. Bostanjian D, Anthone GJ, Hamoui N, et al. Rhabdomyolysis of gluteal muscles leading to renal failure: a potentially fatal complication of surgery in the morbidly obese. Obes Surg. 2003;13:302–5.
30. Szewczyk D, Ovadia P, Abdullah F, et al. Pressure induced rhabdomyolysis and acute renal failure. J Trauma. 1998;44:384–8.
31. Mognol P, Vignes SM, Chosidow D, et al. Rhabdomyolysis after laparoscopic bariatric surgery. Obes Surg. 2004;14:91–4.
32. Youssef T, Abd-Elaal I, Zakaria G, et al. Bariatric surgery: rhabdomyolysis after open roux-en-Y gastric bypass: a prospective study. Int J Surg. 2010;8:484–8.
33. Wool DB, Lemmens HJ, Brodsky JB, et al. Intraoperative fluid replacement and postoperative creatine phosphokinase levels in laparoscopic bariatric patients. Obes Surg. 2010;20:698–01.
34. Flegal KM, Graubard BI, Williamson DF, et al. Excess deaths associated with underweight, overweight, and obesity. JAMA. 2005;293:1861–7.