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Research Article

Development and implementation of a comprehensive Enhanced Recovery After Surgery (ERAS) protocol for lumbar spine fusion- The Singapore Experience

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Abstract

Introduction

Enhanced recovery after surgery (ERAS) protocols have been shown to be effective at reducing perioperative morbidity and costs while improving outcomes. To date spine surgery protocols have been limited in scope especially in the Southeast Asian region due to the unique nature of patient demographics and varied surgical practices.

Methods

The authors describe the creation and implementation of one of the first comprehensive ERAS protocols in lumbar spine fusion (1-2 levels) in Singapore. The protocol is unique in that it has a comprehensive perioperative paradigm encompassing the entire surgical period and is tailored to the unique patient demographics in Singapore. This programme was designed for patients 18 years and older scheduled for 1-2 levels of primary lumbar spine fusion. The authors included all type of lumbar surgical fusion including open and MIS techniques in the programme. The ERAS bundle contained elements such as multimodal analgesia including preoperative acetaminophen and gabapentin, Erector Spinae block/ Thoracolumbar Interfacial Plane (TLIP) block, postoperative analgesia regimen to reduce strong opioid intake and early mobilization. Data collection with regards to compliance with protocol, length of stay and postoperative outcome scores were done.

Results

A total of 24 patients who underwent lumbar fusion surgery 1-2 levels from November 2020 to July 2021 were studied. (The low numbers due to number of closures of elective operation theatres due to covid-19 pandemic) The compliance with preoperative (87.5%) and postoperative (85.06 %) medications were relatively good. Compliance with post-operative elements such as early physiotherapy and mobilization, early removal of urinary catheter (by POD 2-87.5 % POD 3- 100 %) and drain were also excellent (POD 2- 75% POD 3 - 100 %). Post-ERAS patients required less amount of strong opioids and length of stay on an average in the acute hospital was 3.125 days. The compliance with preoperative education (33.3 %) was poor and preoperative physiotherapy (79.16%) was relatively poor.

Conclusion

Implementing the ERAS protocol for lumbar fusion for 1-2 level had significant decrease in use of postoperative opioids and had significant effect on length of stay. There was improved collaboration and communication between spine surgeons, anesthetists, and physiotherapists with improved patient care in mind. Moving forward this project will look into improved pre and post-operative compliance with programme to further improve patient outcomes.

Keywords: ERAS; Lumbar spine fusion; Surgery; Thoracolumbar Interfacial Plane

Introduction

Enhanced Recovery after Surgery (ERAS) proposes a multimodal, evidence-based approach toperioperative care. Thanks to the overall improvement in care protocols and the fluidity of the patient pathway, the first goal of ERAS is the improvement of surgical outcomes and patient experience, with an ultimate impact on a reduction in the length of stay (LOS). ERAS procedures involve the optimization of each pre-, intra-, and postoperative stage, placing thepatient in a central and proactive position in his or her own management [1].

Peer-reviewed ERAS protocols are available for various surgical disciplines and procedures. Despite technical differences in these protocols, a common motif is present: minimization andimprovement of the stress response. The proposed rationale suggests that by maintaining homeostasis, untoward effects such as postoperative Catabolism, pain, and immune dysfunction can be attenuated [2-4]. Given the apparent benefits of ERAS programs in other surgical disciplines, it is not surprisingthat its implementation in spine surgery is becoming increasingly common. Wainwright et al [5] provided an excellent overview for recovery barriers in the postoperative period with regard to spine surgery, citing that spinal procedures are associated with high amounts of pain, slow return of function, and prolonged hospital stays, among other complications.

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Methods

The authors describe the creation and implementation of one of the first comprehensive ERAS protocols in lumbar spine fusion (1-2 levels) at Ng Teng Fong General Hospital (NTFGH) in Singapore. While some of the bundle elements were already common practice for lumbar fusion procedures at our institution and were included in the ERAS protocol, there was no standardized care bundle for all lumbar fusion patients.

The protocol is unique in that it has a comprehensive perioperative paradigm encompassing the entire surgical period and is tailored to the unique patient demographics in Singapore. It is designed for patients 21 years and older undergoing elective primary lumbar fusion surgery up to 2 levels.

The authors included all type of lumbar surgical fusion including open and MIS techniques in the programme ranging from Transformational Lumbar Interbody Fusion (TLIF), Extreme lateral Lumbar Interbody fusion (XLIF), Oblique Lumbar Interbody Fusion (OLIF), Anterior Lumbar Interbody Fusion (ALIF) and Endoscopic Lumbar Interbody Fusion (Endo LIF). The ERAS bundle contained elements which included prehabilitation, patient education, perioperative multimodal analgesia including preoperative acetaminophen and gabapentin, Erector Spinae block/ Thoracolumbar Interfacial Plane (TLIP) block, postoperative analgesia regimen to reduce strong opioid intake and early mobilization.

Data collection with regards to compliance with protocol, length of stay, strong opioid use postoperatively and postoperative outcome scores were done. We compared the data with the cohort of patients who had lumbar fusion surgery 1-2 levels without the ERAS protocol. The primary goal of the NTFGH ERAS program is to improve patient clinical outcomes, reduce hospital LOS, reduce postoperative narcotics use, and decrease the need for blood transfusions. Previous studies have shown that independently controlling for these risk factors improved outcomes after spine surgery [6,7] We identified 3 phases in which the NTFGH protocol aims to optimize patient care in spine surgery: preoperative risk assessment and risk alleviation, protocoled perioperative care, and postoperative recovery and mobilization (Figure 1).

Figure 1: NTFGH ERAS protocol for lumbar fusion surgery.

Pre-operative phase

Risk Assessment and AlleviationInfection Prevention

A major source of morbidity after spine surgery is postoperative wound infection. Our protocol included nasal swabs to assess for *Staphylococcus* colonization and a decolonization when appropriate. I)2% mupirocin ointment smeared to the anterior nares twice a day for 5 days; and ii) 2% chlorhexidine solution or Octenisan used as a body wash during showering or wiped over the body during a sponge bath, daily for 5 days. This workflow is also a hospital policy which we decided to include in the protocol.

Anaemia/Blood Management

All patients undergoing either major or complex elective spine surgery are screened for anaemia. Patients with preoperative anaemia are identified by the Preanesthetic clinic and appropriately referred to haematology for further work up and management. Seicean et al. evaluated the NSQIP database and found that all levels of anaemia were significantly associated with prolonged hospital LOS and poorer outcomes at 30 days in patients undergoing elective spine surgery [8].

Tobacco Use

During the preoperative clinic appointments, patients are screened for tobacco use. Active smokers are actively counselled on the benefits of quitting or decreasing tobacco consumption. This is done at the pre op patient education session as clinic timings are constrained. Chiang et al. studied [6] 48 non-smokers, current smokers, and former smokers. They found that male current smokers required more opioid analgesia during the first 72 hours after surgery than the other 2 groups. [9] In addition, they also reported higher pain intensity scores on postoperative day (POD) 1.

Prehabilitation and patient education

All patients were systematically educated on what to expect during their recovery period. The education session was conducted at clinic setting with PowerPoint presentation during their pre-anaesthetic check-up visit so that they can avoid another visit to hospital. They were educated again about the details of surgery and what to expect postoperatively. This was coordinated by the clinic nurse assistant.

Patients were also referred to prehabilitation with the physiotherapists who also educates the patient regarding the recovery process and pain management and sets the expectations for the patients to start the rehabilitation even as early as Post-Operative Day (POD) 0 or 1. This session is also utilised to record the VAS and ODI (Oswestry Disability Index) scores for these patients.

An aim of multimodal prehabilitation is to work with patients to prepare them metabolically by enhancing cardiorespiratory capacity and physiologic reserves, as well as mentally through antianxiety and coping strategies, to withstand the impending surgical stress response. [10].

Peri-operative phase

Pre-emptive and multimodal analgesia are two new pain management concepts that have been developed on the basis of the pathophysiology of acute pain. Pre-emptive analgesia, which is analgesia before pain onset, is based on central sensitization. The concept of multimodal analgesia was introduced to avoid the high dose requirements and dose dependent adverse events of opioids, as well as to achieve synergistic effects. [11].

The morning of surgery, all patients are given oral acetaminophen 1000 mg and gabapentin 300–650 mg. Acetaminophen and gabapentin have been shown to reduce the need for narcotics postoperatively. [12,13] The combination of acetaminophen and gabapentin is more effective than either drug alone. [14] This concept of protective premedication was introduced to protect the central nervous system from the harmful effects of noxious stimuli to the patient, resulting in hyperalgesia and allodynia. Syal et al. studied the combination of acetaminophen and gabapentin versus either agent alone given the morning of surgery. [15] Patients who consumed the combination regimen had lower visual analogue scale scores at all time intervals postoperatively. In addition, this was found to extend the time to opioid rescue following lower-extremity surgery.

The intraoperative analgesic protocol involves the use of non-steroidal anti-inflammatory drugs, ketamine, long acting narcotic infusion, lidocaine, epidural pain catheters, and local wound infiltration with long-acting analgesic solutions. The surgeon and anaesthesiologists discuss the timing and dose of these medications, taking into account previous doses consumed as an outpatient, goals of the surgery, and postoperative care needs.

Anesthesia Protocol for ERAS Spine

General anesthesia is instituted with target controlled infusions of propofol and remifentanil and a single dose of non- depolarizing muscle relaxant is used for intubation. Ketamine is given after induction but before surgical incision. It has an opioid sparing, dissociative effect and is advantageous in surgical patients in whom high postoperative opioid consumption is anticipated. Laskowski et al., in their systematic review, supported the benefit of ketamine when used in painful procedures, including abdominal, thoracic, and major orthopaedic surgeries. [16] This finding was independent of both the administration time and dose of portions of the proinflammatory system.

Antiemetics in the form of ondansetron is given at 0.1mg/kg given 30 minutes prior to extubation. We also give dexamethasone 0.1mg/kg as it also acts a s an antiemetic and is given after induction. The crux of our anaesthesia protocol is the regional anaesthesia given by anaesthetists priorto incision after the patient has been turned prone in the form of Thoraco-lumbar InterfascialPlane (TLIP) block or Erector Spinae (ESP) block. This is done ultrasound guided and is given for all types of lumbar fusion surgery in the ERAS programme (Figure 2). This does not eat into the procedure time as its done by our expert anaesthetists who are well versed in blocks andis ultrasound guided and is usually done by the time the surgeons have scrubbed for the procedure.

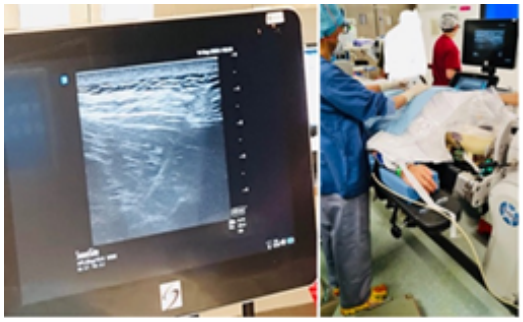

Figure 2: Regional Anaesthesia performed by anaesthetists prior to cleaning and draping in prone position.

Acute postoperative pain relief to conventional multimodal analgesia may effectively prevent the development of postoperative pain syndromes. To discharge patients more quickly after surgery and minimize opioid consumption, multimodal analgesia, including regional blocks, was used to reduce the consumption of other analgesics and their side effects. [17].

Analgesia is given in the form of Fentanyl, Oxycodone or Morphine, dosage as judged by theanaesthetist, half an hour before the termination of Remifentanil infusion. Paracetamol (1 gram if body weight greater than 50kg and 500 mg if body weight 50 kg or less) IV, 30 minutes before the end of surgery.

Monitoring intra op is Standard monitoring plus BIS (Bispectral Index)/Entropy, Invasive monitors if clinically indicated, Temperature monitoring and Fluid Management is Based onclinical judgement and non-invasive parameters.

Post-operative phase

The crux of the ERAS programme is early mobilisation of the patient. Analgesia as per the protocol is built into the postoperative notes unless contraindicated and all patients ,unless specified by surgical team, is seen by the physiotherapists and ambulation initialised . Early mobilization has been shown to reduce perioperative complications and decrease the LOS by 34%. [18] A 2009 Cochrane review found strong evidence supporting an intensive exercise program during the postoperative period to increase return to work and improve functional status. Additionally, patients mobilized early were more likely to be discharged tohome rather than a skilled nursing facility. [19].

Anti-constipation Lactulose / Senna/Bisacodyl is prescribed as appropriate. VAS score is monitored during ambulation and is recorded. Urinary catheter is removed usually as early as POD1 and drain if inserted is removed with drainage less than 100 ml which is usually POD2-POD3.Once cleared by Physiotherapists, patients are discharged home early with follow up by Physiotherapists by telephone consults on pod7. Follow upclinic visits are done in clinic on pod14 for wound inspection and follow up.

VTE prophylaxis

In addition to early mobilization, it is essential to place postoperative patients on VTE prophylaxis. Postoperatively, patients may have prolonged periods of immobilization due to pain, cerebrospinal fluid leakage, or disability secondary to neurogenic compression possibly leading to VTE. Schoenfeld et al. suggested that patients with high risk factors may require additional attention, including those with BMI greater than 40, those older than 80 years, and those with an operative time greater than 261 minutes. [20].

Implementation and Data collection

The pre-ERAS patients (historical control group) were identified through the electronic medical record (EMR) and included patients who underwent 1–2-level lumbar fusion surgerybetween November 2019 to October 2020. A transition phase after the ERAS protocol was started lasted from September 1, 2020, to October 30, 2020. During this transition phase, staff and physicians were educated on the protocol and became familiar with its steps to improve compliance. Regular meetings of all ERAS team leads and members were held. The entire ERAS protocol was made available in the EMR (Electronic Medical Record) to be used as a reference when needed, and reminders in the

form of tip sheets were put up in the clinicsto remind the surgeons. After the transition phase, post-ERAS patients underwent surgery between November1, 2020 to December31 2021. All preoperative, intraoperative, and postoperative data were collected from the EMR for both the pre-ERAS and ERAS groups andentered into a database.

Results

A total of 29 patients who underwent lumbar fusion surgery 1-2 levels with ERAS protocol from November 2020 to December 2021 were studied. This cohort was compared with 25 patients who underwent Lumbar fusion surgery 1-2 levels without eras protocol (non-ERAS) from November 2019 to October 2020. For patients with ERAS protocol programme, the compliance with preoperative (93.1%) and postoperative (86.2 %) medications were relativelygood. Compliance with post-operative elements such as early physiotherapy and mobilization, early removal of urinary catheter (by POD 2-89.6 % POD 3- 100 %) and drain were also excellent (POD 2- 75% POD 3 - 100 %). The compliance with preoperative education(37.9 %) and preoperative physiotherapy (79.31%) was relatively poor. (Tables 1 & 2) shows the distribution of cases with respect to the type of lumbar fusion and the number of levels of lumbar fusion in each group.

ERAS					
NO				yes	Total
surgery_4g p	Open	Count	19	15	34
		% within surgery_4gp	55.9%	44.1%	100.0%
		% within ERAS	76.0%	51.7%	63.0%
	lateral access fusion	Count	5	2	7
		% within surgery_4gp	71.4%	28.6%	100.0%
		% within ERAS	20.0%	6.9%	13.0%
	Endo LIF	Count	1	6	7
		% within surgery_4gp	14.3%	85.7%	100.0%
		% within ERAS	4.0%	20.7%	13.0%
	MIS TLIF	Count	0	6	6
		% within surgery_4gp	0.0%	100.0%	100.0%
		% within ERAS	0.0%	20.7%	11.1%
Total % within surgery_4gp % within ERAS		Count	25	29	54
		46.3%	53.7%	100.0%	
		100.0%	100.0%	100.0%	

Table 1: Types of lumbar fusion in the various groups.

For the purpose of regression analysis, all patients who underwent lateral access fusions, MIS (Minimally Invasive) fusions and Endoscopicfusion (EndoLIF) were grouped together into MIS group. Patients who underwent the ERAS protocol required significantly less amount of strong opioids (as per the WHO pain ladder-e.g.Morphine, Oxycodone etc.) with a 32% drop when compared with non-ERAS. Patients on ERAS would require significantly less OXYNORM/ OXYCONTIN/ PCA compared with patients without (p=0.008, OR=0.099, 95% CI 0.018 – 0.555). There was no significant difference between open surgery and MIS (p=0.613) (Tables 3 & 4)).

ERAS					
NO				yes	Total
LEVELS	1	Count	20	28	48
		% within LEVELS	41.7%	58.3%	100.0%
		% within ERAS	80.0%	96.6%	88.9%
	2	Count	5	1	6
		% within LEVELS	83.3%	16.7%	100.0%
		% within ERAS	20.0%	3.4%	11.1%
Total % within LEVELS % within ERAS		Count	25	29	54
		46.3%	53.7%	100.0%	
		100.0%	100.0%	100.0%	

Table 2 : Number of levels of fusion involved in each groups.

OXYNORM/ OXYCONTIN/ PCA Y/N					
N				Y	Total
ERAS	NO	Count	15	10	25
		% within ERAS	60.0%	40.0%	100.0%
	yes	Count	27	2	29
		% within ERAS	93.1%	6.9%	100.0%
Total % within ERAS		Count	42	12	54
		77.8%	22.2%	100.0%	

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.56.

Value		df	Asymptotic Significance (2- sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	8.512a	1	.004		
Continuity Correction	6.705	1	.010		
Likelihood Ratio	9.002	1	.003		
Fisher's Exact Test				.007	.004
N of Valid Cases	54				

b. Computed only for a 2x2 table.

Table 3: ERAS- Use of strong opioids in both groups- Cross tabulation and chi square tests.

Case Processing Summary

Unweighted Cases		N	Percent
Selected Cases	Included in Analysis	54	100.0
	Missing Cases	0	.0
	Total	54	100.0
Unselected Cases		0	.0
Total		54	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent VariableEncoding

Original Value	Internal Value
N	0
Y	1

Categorical Variables Coding

Parameter coding

Frequency			(1)
ERAS	NO	25	.000
	yes	29	1.000
MIS	Open	34	.000
	MIS	20	1.000

Variables in the Equation

B			S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1a	MIS(1)	.403	.797	.256	1	.613	1.497	.314	7.132
	ERAS(1)	-2.310	.878	6.926	1	.008	.099	.018	.555
	Constant	-.505	.456	1.225	1	.268	.604		

Table 4: Logistic Regression analysis for strong opioids in open surgery group and MIS group.

a. Variable(s) entered on step 1: MIS, ERAS.

ERAS		**Statistic**			**Std. Error**
Length of Stay	NO	Mean		4.24	.474
		95% Confidence Interval for Mean	Lower Bound	3.26	
			Upper Bound	5.22	
		5% Trimmed Mean		4.12	
		Median		4.00	
		Variance		5.607	
		Std. Deviation		2.368	
		Minimum		1	
		Maximum		10	
		Range		9	
		Interquartile Range		4	
		Skewness		.548	.464
		Kurtosis		-.175	.902
	yes	Mean		2.86	.336
		95% Confidence Interval for Mean	Lower Bound	2.17	
			Upper Bound	3.55	
		5% Trimmed Mean		2.70	
		Median		3.00	
		Variance		3.266	
		Std. Deviation		1.807	
		Minimum		1	
		Maximum		8	
		Range		7	
		Interquartile Range		3	
		Skewness		1.234	.434
		Kurtosis		1.605	.845

The length of stay on an average in the acute hospital was 2.7 days when compared with non-ERAS cohort with ALOS of 4.1days. The median length of stay was 4 days for non-ERAS patients and 3 days for ERAS patients. Patients on MIS would have significantly shorter median length of stay compared withpatients took open surgery by 2 days ($p<0.001$, 95% CI 1.00 – 3.00.) Patients on ERAS would have significantly shorter median length of stay compared with patients without by 2 days too ($p<0.001$, 95% CI 1.03 – 2.97) (Tables 5 & 6).

Descriptives

Ranks

ERAS		N	Mean Rank	Sum of Ranks
Length of Stay	NO	25	32.64	816.00
	yes	29	23.07	669.00
	Total	54		

Test Statistics

Length to stay

Mann-Whitney U	234.000
Wilcoxon W	669.000
Z	-2.265
Asymp. Sig. (2-tailed)	.024

Table 5: Descriptive statistics and Test Statistics for Length of Stay for both groups.

a. Grouping Variable: ERAS

Parameter Estimates (q=0.5)[a,b]

Parameter	Coefficient	Std. Error	t	df	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
(Intercept)	1.000	.4098	2.440	51	.018	.177	1.823
[ERAS=1]	2.000	.4833	4.138	51	.000	1.030	2.970
[ERAS=2]	0c	.	.	.	.	.	.
[MIS=0]	2.000	.4990	4.008	51	.000	.998	3.002
[MIS=1]	0c	.	.	.	.	.	.

Table 6: Quantile Regression analysis for mean of Length of Stay.

a. Dependent Variable: Length of Stay

b. Model: (Intercept), ERAS, MIS

c. Set to zero because this parameter is redundant.

Discussion

Our results did show a significant reduction in the usage of stronger opioid medication including, morphine and oxycodone after implementing ERAS. The study also showed a significant reduction in the length of stay for patients under ERAS. The ERAS movement was started to improve efficiency, reduce morbidity, improve patient experience, and decrease cost. Our spine ERAS protocol was implemented to improve post-operative patient care and surgical outcomes similar to what has been done with ERAS in other surgical specialties. Blackburn et al. implemented an ERAS bundle for all elective spine surgeries including some lumbar fusions [21], and the other spinal ERAS projects have investigated endoscopic lumbar fusions and correction of scoliosis [22].

Decreasing LOS helps to reduce costs and is an important outcome measure in many enhanced recovery protocols [23]. There are many factors that affect LOS. Preoperative comorbidities are not the sole contributor to LOS, and the most significant factors that prolong LOS are postoperative events such as bleeding, drains, late mobilization, and delayed discharge to rehabilitation facilities [24]. To get patients mobilised early a chat group was made available between anaesthetists, surgeons and physiotherapists and real time update of the patient progress could be made and doubts and queries cleared faster enabling early mobilisation. The protocol included early removal of catheter. Our compliance to this parameter was good to excellent with 90% of catheters removed on POD 2 and 100% by POD3.Similar compliance was observed for post-operative drain removal with 75% drains being removed on pod2 and 100% by POD 3.

We arranged the patient education in the clinic setting without an additional appointment and trained the clinic staff on educating the patients with help of power point presentations. However, the compliance to the pre-op education was poor (37. 9%).This was attributed to poor compliance by physicians to order the pre-op education programme at the time of listing for surgery and in some cases due to patient non-compliance.

Pre-habilitation was also incorporated into the ERAs protocol. Physiotherapist will go throughwith the patient the expectations post op and start the therapy session if not already undergoing therapy. The compliance with the prehabilitation was 79.3%. We still consider it poor and the reasons for this was the non-compliance with the ordering at the time of listingfor surgery and patient non-compliance.

Some of the limitations of this study include a single institution, and it was a non- randomized, non-blinded project with historical patients identified from a record search of the EMR. Compliance from nursing, surgical, and anaesthesia teams in following the protocol was suboptimal which is reflected in the intervention compliance. There are many barriers to implementing ERAS protocols such as ineffective communication among team members, patient non-compliance, staff turnover with the need for continued education, and physician and staff non-compliance. This is not unique to this ERAS project and has beenshown in other studies as well. [25,26].

Despite the limitations, we were able to successfully implement the spine ERAS protocol at our institution with improvement in some aspects of patient outcomes. The care of the lumbar fusion patients intraoperatively and postoperatively have become more standardized, and perioperative teams have become more familiar with the protocol and compliance has continued to improve. This early data showing decreases in Length of stay and decrease in use of stronger opioid use is also promising as we continue to move forward with this project. This study also demonstrates the areas where implementations are most challenging for ERASprojects. Future studies can focus on these areas for further compliance improvement and patient outcomes.

Conclusion

Implementing the ERAS protocol for lumbar fusion for 1-2 level had significant decrease in use of postoperative opioids and had significant effect on length of stay. There was improved collaboration and communication between spine surgeons, anesthetists, and physiotherapists with improved patient care in mind. Even though the compliance to the programme was relatively poor in the pre-operative

education phase of ERAS, the outcomes were promising. We aim to further improve the pre- and post-operative compliance to the programme by more target specific schooling of various department staff, tip sheets quarterly ERAS team meetings thus improving patient outcome further.

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