Feasibility and Outcome of an Accelerated Recovery Protocol in Asian Adolescent Idiopathic Scoliosis Patients

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The legal regulatory status of the device(s)/drug(s) that is/are the subject of this manuscript is not applicable in my country.

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Study Design: Prospective cohort study

Objective: To determine the feasibility of an accelerated recovery protocol for Asian Adolescent Idiopathic Scoliosis (AIS) patients undergoing posterior spinal fusion (PSF).

Summary of Background Data: There has been successful implementation of an accelerated recovery protocol for AIS patients undergoing PSF in the western population. No similar studies have been reported in the Asian population.

Methods: 74 AIS (65F, 9M) patients scheduled for PSF surgery were recruited. The accelerated protocol encompasses pre-operative regime, pre-operative day of surgery counseling, intra-operative strategies and an accelerated post-operative rehabilitation and pain management regime. All patients were operated using a dual attending surgeon strategy. Outcome measures included pain scores at 5 time intervals, length of stay and detailed recovery milestones. Any complications or readmissions during the first 4 months post-operative period were recorded.

Results: Mean duration of operation was 2.2 ± 0.3 hours with a mean blood loss of 824.3 ± 418.2 mls. No patients received allogeneic blood transfusion. The mean length of stay was 3.6 ± 0.6 days. Surgical wound pain score was 6.4 ± 2.1 at 12 hours which reduced to 5.0 ± 2.0 at 60 hours. Abdominal pain peaked at 36 hours with pain scores 2.4 ± 2.9. First liquid intake was at 5.2 ± 7.5 hours, urinary catheter removal at 18.7 ± 4.8 hours, sitting up at 20.6 ± 9.1 hours, ambulation at 27.2 ± 0.5 hours, consumption of solid food at 32.2 ± 0.5 hours, first flatus at 39.0 ± 0.7 and first bowel movement at 122.1 ± 2.0 hours. The complication rate was 1.4% due to superficial wound infection with 1 patient failed to comply with the accelerated protocol.

Conclusion: An accelerated recovery protocol following PSF for AIS is feasible without increasing the complication or readmission rates. The total length of stay was 3.6 days and this comparable with the outcome in western population.

Key Words: Asian, adolescent idiopathic scoliosis, posterior spinal fusion, accelerated recovery protocol, deformity, surgery

Level of Evidence: 4
Introduction

Posterior spinal fusion (PSF) surgery for Adolescent Idiopathic Scoliosis (AIS) is a major surgery associated with significant post-operative pain. Despite advancement in post-operative pain management that included multimodal strategies such as local anesthetic infusion, patient controlled delivery of opiates, intravenous as well as oral acetaminophen and newer generation anti-inflammatory drugs, the duration of hospital stay following PSF surgery still averaged 5 to 6 days. Increasing healthcare cost over the years have prompted introduction of accelerated recovery protocol following PSF. In 2014, Fletcher et al described their accelerated discharge protocol for AIS patients that expedited mobilization and resulted in shorter length of hospital stay. Sanders et al reported reduction of hospital charges by 22% when an accelerated post-operative regime was introduced with no significant increase in wound complications or readmission rates. In their study, hospital stay was reduced from 5.0 days to 3.7 days.

There is no similar studies on accelerated discharge protocol have been carried out in the Asian AIS population. As pain perception and post-operative rehabilitation could be influenced by ethnic and cultural differences, we would like to explore the feasibility and report the outcome of implementation of an accelerated recovery protocol for AIS patients undergoing PSF in the Asian community.

Methodology

Study Design

We prospectively recruited 74 AIS patients scheduled for PSF surgery from September 2015 to June 2016. Written informed consents were obtained from the parents. This study was approved by our institutional ethical board. Patients with non-idiopathic scoliosis, psychological disorders, metabolic bone disease and undergoing revision surgery were excluded. The anesthesia protocol was standardized for all patients.

Development of the accelerated protocol

Prior to the development of this accelerated protocol, an audit of 33 AIS cases operated using a similar surgical technique between January 2010 to June 2010 was performed. The mean hospital stay in this group of patients was 125.4 ± 58.4 hours. In the traditional pathway, surgery was performed by a single attending surgeon without the use of intra-operative cell salvage. Pain management used was Patient Controlled Analgesia (PCA) or subcutaneous morphine administration. The anesthetist decided when to discontinue...
PCA. All patients were monitored in the Intensive Care Unit for the first 24 hours post-operatively. After PCA was discontinued, ambulation of patient, which included sitting up, standing, and removal of Foleys catheter were carried out. The dressing was changed at day 2 to 3 post-operation and the drain was removed once drainage was less than 50mls per day. Discontinuation of PCA, removal of subfascial drain and removal of Foley catheter was between day 2 to 3 after operation.

The accelerated recovery pathway was the initiative of a multidisciplinary panel which consists of surgeons, anesthetists and rehabilitation physicians. The initial step in the development of the protocol was establishment of the discharge criteria; criteria in which patients need to fulfill before discharge were allowed. We also established methods to improve post-operative pain management, strategies to shorten the operation time and milestones in which the patients had to achieve to enable earlier ambulation. As patient and family cooperation was crucial in the execution of the accelerated pathway, pre-operative counseling and discussion with surgeons and patient support group were emphasized. The details of the accelerated recovery pathway are outlined below.

**Anesthesia Protocol**

Patients were induced with intravenous (IV) propofol 2.5mg/kg, IV target controlled infusion (TCI), (Minto model) of remifentanil 5ng/ml and IV rocuronium 1 mg/kg to facilitate endotracheal intubation. Anesthesia was maintained with desflurane (end-tidal concentration 4.6 - 4.8, minimum alveolar concentration of 0.6 - 0.7) and TCI remifentanil 2 - 8 ng/ml, to maintain BIS value of 40 - 60 during surgery. Patient mean arterial pressure was maintained above 60 mm Hg. The patient was kept normothermic. We used forced air warming device (Bair Hugger) and water bath coaxial fluid and blood warming device (HOTLINE) throughout surgery. All patients received 0.2mg/kg of IV morphine 45 minutes and 1 mcg/kg of IV Fentanyl 10 minutes before the end of surgery. IV dexamethasone 4 mg and IV ondansetron 4 mg were administered as prophylaxis for post-operative nausea and vomiting.

**Accelerated Recovery Protocol**

The Accelerated Recovery Protocol in our institution encompasses pre-operative regime, pre-operative day of surgery counseling, intra-operative strategies to shorten the duration of operation and to minimize blood loss and accelerated post-operative rehabilitation regime and pain management strategies. Figure 1 summarizes the four pillars of the accelerated recovery protocol.
Pre-operative regime

Six weeks prior to operation, patients were instructed to engage in aerobic exercise 3 sessions a week for 30 minutes per session. The intensity and choice of the exercise was as tolerated by the patients. Patients were also started on back extension strengthening and flexibility exercise two sessions daily up to 20 repetitions per session. Patients were asked to take oral Iberet Folic 500 (multivitamins and minerals) 1 tablet once a day 1 month prior to operation. Patients were also introduced and connected with a scoliosis support group to prepare them mentally and emotionally for the surgery. The scoliosis support group consisted of patients who spoke the same language, were of the same age group and who stayed in the vicinity of the patient’s home address. A consent was taken from all members of the support group to allow us to provide patients with their contact number. Communication between patients and members of the support group was via phone communication or face to face meeting.

Pre-operative Day of Surgery

Upon admission, patients were counseled by a physician assistant regarding details on back care as well as correct technique for post-operative mobilization. The surgical and anesthetic teams will counsel the patients on the expected post-operative course which included the expected post-operative pain intensity, the trajectory of post-operative pain and the pain management strategies.

Intra-operative strategy

A dual attending surgeon strategy was practiced in this study to reduce the operative time and the blood loss. IV tranexamic acid 20mg/kg was administered as a bolus dose after induction and prior to skin incision. IV Cefuroxime (1.5g) was administered on induction. Intra-operative cell salvage was used in all cases. Intra-operative neuromonitoring was by Somatosensory Evoked Potential (SSEP). All patients underwent PSF using alternate level pedicle screw configuration. Facetectomies were performed to increase the spinal flexibility as well as to facilitate spinal fusion. No osteotomies were performed in this cohort of patients. Reduction was performed using translation method as well as direct vertebral rotation. Fusion was augmented using autogenous local bone graft obtained from facet joints, spinous processes, transverse processes and decorticated laminae of each instrumented vertebrae. A subfascial drain was inserted in all cases. Prior to skin closure, 2mg/kg Bupivacaine diluted to a volume of 25mL was infiltrated subcutaneously.
Post-operative period

Pain management strategy
In the recovery room, all patients received IV morphine patient-controlled analgesia (PCA) with the following preparation: PCA boluses of 1mg morphine with a 5 minute lock-out interval and 4 hourly dose limit of 20mg morphine. PCA morphine was provided for at least 48 hours after surgery and will be discontinued once consumption was less than 5mg within 24 hours. IV Cefuroxime (750mg) was given for 3 doses on D1 post-operative period. Oral analgesia in the form of celecoxib(Celebrex®) capsule 200mg once or twice daily and acetaminophen tablets 500-1000mg 6 hourly were commenced as soon as patient was able to tolerate oral intake. After the discontinuation of PCA morphine, breakthrough pain was managed with immediate-release oxycodone hydrochloride (OxyNorm®) capsule 5mg.

Oral intake
Clear liquid was allowed as requested and as tolerated from 2 hours post-operatively. From 6 hours after the operation, nourishing liquids were allowed as tolerated. Soft diet was commenced 24 hours to 48 hours as tolerable. Normal diet was allowed only if patient has no nausea and vomiting.

Post-operative recovery milestones
The milestones which were implemented in the accelerated protocol were removal of indwelling catheter by 18-24 hours, removal of subfascial drain by 18-24 hours and change of dressing by 18-24 hours. The subfascial drain was removed after drainage of a maximum of 200mls. Upon removal of catheter and drain, supervised mobilization was allowed within 24 hours. Between 24 to 48 hours, patients are allowed to ambulate as tolerated and post-operative radiograph would be performed. PCA would be discontinued once the consumption was less than 5mg within 24 hours.

Patients would be discharged once they fulfilled all of the following:

1. Patient readiness to be discharged home
2. Tolerable and reducing pain intensity
3. Ambulating independently
4. Afebrile with no staining on the dressing
5. Tolerating oral intake with no nausea and vomiting
Discharge protocol

Upon discharge, patients were prescribed oral celecoxib, acetaminophen and oxycodone hydrochloride tablets to control post-operative pain. Patients were encouraged to increase fluid intake and to consume high fiber diet with oral syrup lactulose for 3 days until the first bowel opening. If no bowel opening occurs within 3 days following discharge, rectal suppositories was used. Dressing was unchanged until the first outpatient clinic visit at 10 to 14 days post-operation.

Outcome measure

Patient demographics, curve characteristics, pre-operative haemoglobin levels, operation duration and intra-operative blood loss were documented. The post-operative data including PCA morphine usage, surgical wound pain score, abdominal pain score, nausea score were assessed at 12 hours, 24 hours, 36 hours, 48 hours and 60 hours post-operatively. Times for first fluid intake, first oral intake, first flatus, sitting up, ambulating and first bowel movement (by phone after discharge) were documented. Times for removal of Foley catheter and surgical wound drain were documented. Surgical complications and readmissions were monitored up to 4 months post-operation.

Power Analysis, Sample Size and Statistical Analysis

The sample size calculation was performed using G*Power software (version 3.1.9.2). All data were stored and analyzed by using the SPSS Inc., Chicago, IL, and (SPSS v 22). Demographic variables were analyzed using descriptive statistic and were represented as means, percentages and plotted in graphs.

Results

There were 65 females and 9 males patients with mean age of 15.8 ± 4.6 years. The demographic, curve characteristics and operative data were illustrated in Table 1. The mean Cobb angle of patients operated were 65.5 ± 15.9 degree. There were 24Lenke type 1, 18 Lenke 2, 3 Lenke 3, 3 Lenke 4, 18 Lenke 5 and 8Lenke 6 curves. Average pre-operative haemoglobin is 13.7 g/dL ± 3.3 and this dropped to 10.3± 3.0 g/dL post-operatively. The mean duration of operation was 2.2 ± 0.3 hours. The mean intra-operative blood loss was 824.3 ± 418.2 mls. None of the patients received allogeneic blood transfusion. The time from completion of operation to discharge averaged 70.8 ± 10.3 hours. The mean length of stay was 86.2 ± 14.4 hours.
Post-operative parameters on surgical wound pain, abdominal pain, nausea score, frequency of vomiting, PCA usage and percentage of PCA discontinuation were demonstrated in Table 2 and Figure 2. Surgical wound pain score demonstrated a decreasing trend over time, with pain score of 6.4 ± 2.1 at 12 hours post-operation, which reduced to 6.4 ± 2.0 at 24 hours, 5.9 ± 2.1 at 36 hours, 5.3 ± 2.1 at 48 hours and 5.0 ± 2.0 at 60 hours. In contrast to the surgical wound pain, abdominal pain peaked at 36 hours with pain scores of 2.4 ± 2.9. Nausea score and frequency of vomiting had a corresponding upward trend whereby the nausea score and frequency of vomiting peaked at 36 hours and reduced subsequently.

PCA morphine usage was the highest at 12 hours (11.2 ± 9.4mg) with 100% of patients on it. 81.1% of patients discontinued their PCA at 36 hours. PCA morphine usage significantly reduces after 36 hours with an increase of mean usage of 1.2mg from 36 to 48 H and 0.1 mg from 36H to 48 H (Table 2).

Table 3 illustrates the recovery milestones of the patient undergoing the accelerated recovery protocol. First liquid intake was at an average of 5.2 ± 7.5 hours, urinary catheter removal at 18.7 ± 4.8 hours, sitting up at 20.6 ± 9.1 hours, ambulation at 27.2 ± 0.5 hours, consumption of solid food at 32.2 ± 0.5 hours and first flatus at 39.0 ± 0.7. Bowel movement was the last milestone parameters to be achieved at a mean duration of 122.1 ± 2.0 hours.

Complications and failure of the accelerated recovery protocol

There were no complications related to opioid consumption such as severe pruritus and respiratory depression. There was one patient who had superficial wound infection which was treated as an outpatient with dressing and oral antibiotics. There were no other surgical complications, patient readmission or revision surgery.

One patient failed to achieve the milestones for the accelerated recovery protocol. This patient had Lenke type 1 with Cobb angle of 68° (T6-T12). The operation duration was 2 hours 20 minutes. Intra-operative blood loss was 1100 ml. The post-operation to discharge time was the longest at 113 hours compared to the mean length of hospital stay (70.8 ± 10.3 hours) in other patients. Pain score at 12H, 24H, 36H, 48H and 60H was 9, 9, 10, 10 and 10 despite the use of PCA Morphine with additional acetaminophen intake for first 4 days post-operation. All recovery milestones for this patient i.e. first fluid intake, solid food intake, ambulation, flatus, bowel opening, were all prolonged.
Discussion

Advancement of spinal instrumentation has led to biomechanically stronger constructs which allowed earlier mobilization without the need for orthotic support post-operatively. This reduced the duration of post-operative hospital stay from weeks to an average of 5 to 6 days in the early 2000s.

From 2001 to 2011, there was a gradual reduction of length of hospital stay from an average of 6.1 days to 5.6 days in 2011. Cho and Egorova also reported a similar length of hospital stay when they compared the patients under Medicaid (medical insurance) versus private patients. Medicaid patients stayed an average of 6.1 days compared to private patients who stayed an average of 5.6 days following surgery for pediatric idiopathic scoliosis.

Rising hospital cost as well advancement in multimodal post-operative pain management has provided the impetus to explore accelerated recovery protocol for patients following scoliosis corrective surgery. Martin et al reported a rise in mean hospital charges for AIS corrective surgery from USD 72,780 in 2001 to USD 155,278 in 2011 (a 113% increase). Multimodal post-operative pain management consisting of epidural infusions, patient controlled analgesia as well as newer generation analgesics has also improved post-operative pain control. In the past 3 years, there have been few studies which reported on the outcome of an accelerated protocol following AIS surgery. The main outcomes of these studies were summarized in Table 4.

To date, all of these accelerated recovery protocol studies were retrospective studies utilizing hospital databases. These studies found that accelerated recovery protocol have led to significantly shorter hospitalization without increasing the rate of complications or readmission. The length of stay ranged from 2.2 to 3.7 days whereas complication rates were 1% to 15.6%. Majority of these studies found that pain scores were not increased by accelerated recovery regime except for one study by Sanders et al who reported a significant higher pain scores at post-operative day 2, 3 and 4. The key features of an accelerated recovery compared to the traditional protocol were multimodal pain management, faster ambulation and earlier removal or discontinuation of Foley catheter, drain and PCA. In the protocol by Gornitzky et al, drains were kept longer and in some cases, patients were discharged home with it and only removed during the outpatient clinic follow up.

Nevertheless, the feasibility of such a regime in the Asian population had never been studied or documented. Morse et al reported that there were significant differences between pain perception between US ethnicities.
and native Korean and Japanese population. Hsieh et al\textsuperscript{28} reported lower pain tolerance among Chinese university aged students compared to European Canadian counterparts. With a different pain perception and family support system in Asians, introducing an accelerated recovery regime may be challenging. Our study was the first prospective study that investigated the feasibility of an accelerated recovery protocol among Asian population. We found that the success rate of our regime was 98.6% with only 1 patient failing to achieve the recovery milestones. There was another patient who developed superficial wound infection which recovered with wound dressing and oral antibiotics. There were no readmissions.

In this study, we found that the total length of stay of 3.6 days was comparable with previous published studies. We noted that the wound pain scores among our patients were higher than previous studies. This could be due to cultural differences in pain reporting or variation in the multimodal pain management regime. However, it did not prevent the implementation of early mobilization or early removal of the drain and Foley catheter. Early mobilization did not result in an increase in post-operative pain but instead the pain trajectory reduced gradually from a pain score of 6.2 at 12H to a score of 5.0 at 60H. Our patients had higher average blood loss compared to previous studies despite shorter operation duration. This may be due to the extensive corticotomies and harvesting of local bone graft resulted in more bleeding from raw bone surface\textsuperscript{29}. However, none of our patients required allogenic blood transfusion.

The main limitation of this study was the lack of a control group for comparison between the traditional protocol and the current regime. This was due to the prospective nature of this study as it was not ethical to subject another group of patients to a slower recovery regime with higher cost incurred by the patients. We also did not have a reliable hospital database which would allow comparison with a historical cohort. Higher pain scores post-operatively compared to other studies may imply suboptimal pain control and can be investigated in our future pain management studies. As pain perception and family support system might vary among different regions in Asia, the results of the current study might not be applicable to other Asian countries. We did not sub-analyzed which specific factors in the protocol contributed significantly or not to the recovery process. Another limitation was the short follow-up duration of the study (4 months) and any delayed infections which may have occurred in this cohort would not be registered.

In conclusion, an accelerated recovery protocol following posterior spinal fusion in AIS is feasible among Asians without increasing the complication or readmission rates. An accelerated regime resulted in a length of stay of 3.6 days which was comparable with the results in the western population.
Acknowledgement:
We would like to acknowledge Siti Mariam Mohamad and Siti Mariam Abd Gani for their contribution in the preparation and compilation of this manuscript.
References


Figure 1: Accelerated Recovery Protocol for Posterior Spinal Fusion in AIS patients

**Pre Op**
- Aerobic exercise Regime
- Oral haematinics
- Back strengthening and flexibility exercise regime
- Scoliosis support group

**Day of Surgery**
- Counselling on expected post-op course and goals
- Counselling of post-op pain trajectory and management
- Counselling on post-op mobilization technique

**Intra Op**
- Dual attending surgeon strategy
- Cell salvage
- Anaesthesia protocol
- Subcutaneous Bupivacaine prior to wound closure
- Single deep subfascial drainage
- Prophylactic IV Cefuroxime

**Post Op**
- D1
  - PCA Morphine
  - Tab Acetaminophen
  - Cap Celecoxib
  - IV Cefuroxime
  - IV Ondansetron
  - Oral fluid intake
  - Removal of subfascial drain
  - Removal of indwelling catheter
  - Change of dressing
  - Supervised mobilization

- D2
  - Check radiograph
  - Discontinuation of PCA Morphine
  - Ambulation as tolerated
  - Soft diet
  - Oral medication

- D3
  - Discharge
Figure 2: Trajectory of surgical wound pain and abdominal pain from 12H to 60H
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<th>Mean</th>
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<tr>
<td>Age (years)</td>
<td>15.8</td>
<td>± 4.6</td>
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<tr>
<td>Cobb angle (degree)</td>
<td>65.5</td>
<td>± 15.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>158.1</td>
<td>± 6.2</td>
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<tr>
<td>Weight (kg)</td>
<td>47.3</td>
<td>± 9.3</td>
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<td>87.8</td>
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<td>32.4</td>
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<tr>
<td>Type 2</td>
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<tr>
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<tr>
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<th>Operative Data</th>
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<tr>
<td>Pre-operative hemoglobin (g/dL)</td>
<td>13.7</td>
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</tr>
<tr>
<td>Post-operative hemoglobin (g/dL)</td>
<td>10.3</td>
<td>± 3.0</td>
</tr>
<tr>
<td>Operation duration (hours)</td>
<td>2.2</td>
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<tr>
<td>Intra-operative blood loss (mls)</td>
<td>824.3</td>
<td>± 418.2</td>
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<tr>
<td>Post-operative drainage (mls)</td>
<td>130.5</td>
<td>± 53.1</td>
</tr>
<tr>
<td>Post-operation to discharge (hours)</td>
<td>70.8</td>
<td>± 10.3</td>
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<tr>
<td>Hospital stay (hours)</td>
<td>86.2</td>
<td>± 14.4</td>
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Table 2: Post-operative pain, nausea, vomiting parameters and PCA morphine usage

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<thead>
<tr>
<th>Time</th>
<th>12H</th>
<th>24H</th>
<th>36H</th>
<th>48H</th>
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<tr>
<td></td>
<td>6.4±2.1</td>
<td>6.4±2.0</td>
<td>5.9±2.1</td>
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<tr>
<td>Surgical wound pain score</td>
<td>1.0 ± 2.1</td>
<td>1.6 ± 2.4</td>
<td>2.4 ± 2.9</td>
<td>2.2 ± 2.5</td>
<td>1.9 ± 2.3</td>
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<td>Abdominal pain score</td>
<td>1.6 ± 2.4</td>
<td>2.0 ± 2.6</td>
<td>2.4 ± 2.7</td>
<td>1.8 ± 2.6</td>
<td>0.7 ± 1.5</td>
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<tr>
<td>Nausea score</td>
<td>0.6 ± 1.1</td>
<td>0.8 ± 1.1</td>
<td>1.2 ± 1.6</td>
<td>0.5 ± 1.2</td>
<td>0.3 ± 0.6</td>
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<tr>
<td>Frequency of vomiting</td>
<td>11.2±9.4</td>
<td>17.7±12.7</td>
<td>23.8±16.5</td>
<td>25.0±19.0</td>
<td>25.1±19.0</td>
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<tr>
<td>Cumulative PCA morphine usage(mg)</td>
<td>0</td>
<td>2.7</td>
<td>81.1</td>
<td>14.9</td>
<td>1.3</td>
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<tr>
<td>Percentage of PCA discontinuation (%)</td>
<td>0</td>
<td>2.7</td>
<td>81.1</td>
<td>14.9</td>
<td>1.3</td>
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Values in Mean ± SD, PCA = Patient controlled anesthesia, H = Hour
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<th>Rapid Recovery Protocol</th>
<th>Mean ± SD (Hours)</th>
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<td>First liquid intake</td>
<td>5.2 ± 7.5</td>
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<td>Foley catheter removal</td>
<td>18.7 ± 4.8</td>
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<td>First time sitting</td>
<td>20.6 ± 9.1</td>
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<tr>
<td>Time taken to ambulate</td>
<td>27.2 ± 0.5</td>
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<tr>
<td>First solid food intake</td>
<td>32.2 ± 0.5</td>
</tr>
<tr>
<td>First flatus</td>
<td>39.0 ± 0.7</td>
</tr>
<tr>
<td>Time to bowel opening</td>
<td>122.1 ± 2.0</td>
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PCA = Patient controlled anesthesia
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<tr>
<th>Author</th>
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<th>Design</th>
<th>N</th>
<th>Protocol</th>
<th>Length of stay (D/H)</th>
<th>Mean pain score</th>
<th>Complication (%)</th>
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<tr>
<td>Fletcher et al</td>
<td>2014</td>
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<td>Convention</td>
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<td>-</td>
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<td></td>
<td>154</td>
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D = Day, H = Hour