

Introduction of an enhanced recovery program for young adults undergoing posterior spinal fusion surgery for idiopathic scoliosis: a single-centre pilot study evaluating short term outcomes

L. VAN HOORICK¹, C. SPAAS², M. BREEBAART¹, V. SALDIEN¹, J. MICHIELSEN³, G. HANS⁴, D. WILDEMEERSCH⁴

¹Department of Anesthesiology, University Hospital Antwerp, Edegem Belgium; ²Department of Pain Medicine, KLINA, Brasschaat, Belgium; ³Department of Orthopaedic Surgery, University Hospital Antwerp, Edegem, Belgium; ⁴Department of Pain Medicine, University Hospital Antwerp, Edegem, Belgium.

Corresponding author: L. Van Hoorick, University Hospital Antwerp, Drie Eikenstraat 655, 2650 Edegem, Belgium.
E-mail: Lana.vanhoorick@uza.be

Background: The large surgical incision and extensive tissue trauma in posterior spinal fusion for adolescent idiopathic scoliosis causes severe acute postoperative pain. Furthermore, posterior spinal fusion is associated with a risk of persistent postsurgical pain. Six months after posterior spinal fusion, the incidence of persistent postsurgical pain is as high as 22% of the patients. Optimizing pain management therefore remains crucial, but challenging.

Objective: The study objective is to design and implement an enhanced recovery pathway for patients with adolescent idiopathic scoliosis undergoing posterior spinal fusion integrating all aspects of biopsychosocial care. Its outcomes are assessed, including its effect on postoperative pain and early mobilization.

Design and settings: A prospective cohort study was performed at the Antwerp University Hospital.

Methods: In December 2019, a prospective cohort study was set up in which an enhanced recovery pathway substitutes more than the patient controlled intravenous analgesia containing morphine postoperatively. This pathway consists of m/eHealth based psychological screening questionnaires, patient education, early mobilization, and a multimodal analgesia protocol consisting of preemptive gabapentin, an intraoperatively given single dose of methadone (0.2 mg kg⁻¹), non-steroidal anti-inflammatory drugs, and acetaminophen.

Results: We treated 25 adolescents (10 males and 15 females) with the developed enhanced recovery pathway with a mean age of 16.5 years (range 12-22). The mean number of spinal levels fused was 10 (range 6-13). Mean numerical rating scale scores were 4.17 at postoperative day 1, 4.46 at postoperative day 2, and 3.74 at postoperative day 3 in enhanced recovery pathway treated patients. Mean bladder catheterization duration was 3.04 days and enhanced recovery pathway patients stayed in the hospital for an average of 7.4 days.

Conclusions: Using an enhanced recovery pathway for patients undergoing posterior spinal fusion could not only reduce the acute and chronic opioid consumption and its side effects, but could also result in less postoperative pain, shorter hospital stay and higher patient satisfaction. Further reevaluation and improvement focused on these variables will likely further improve the effectiveness of enhanced recovery pathways.

Trial registration: ClinicalTrials.gov NCT04038229.

Keywords: Scoliosis, spinal fusion, pain management.

Introduction

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformation of the spine affecting 1-3% of adolescents with a female predominance (8:1)^{1,2}. AIS is a benign condition, but is frequently associated with back pain and psychosocial difficulties. A Cobb angle greater than 45° is an indication for surgery³. Posterior

spinal fusion (PSF) is characterized by a risk of severe blood loss, extensive tissue trauma, and inflammation resulting in central and peripheral nerve sensitization and ensuing severe acute postoperative pain. Inadequate pain management not only causes a delay in rehabilitation and patient dissatisfaction, but is also an important risk factor of persistent postsurgical pain (PPSP)⁴. The incidence of PPSP after PSF is 22% at 6 months

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postoperatively and 11-15% after 1 to 5 years. Next to severe acute pain, other predicting factors for PPSP include preoperative pain intensity, patient anxiety, patient pain coping efficacy, and parental pain catastrophizing⁵.

Postoperative pain protocols play an important role in enhanced recovery and improved prognosis and are an important area for (re)evaluation and improvement⁶. Traditional analgetic management after PSF consists of intravenous opioids, despite significant adverse effects⁴. In recent years, multimodal analgesia (MMA) has been introduced to decrease postoperative opioid consumption, diminishing postoperative gastrointestinal concerns (mainly nausea and ileus) postponing hospital stay and recovery. Moreover, optimizing preoperative pain management protocols should include PPSP prevention strategies. MMA contributes to enhanced recovery programs (ERP), which allow a more holistic approach, improving many patient-related outcome measurements⁷.

Objective

In this study, we aimed to design and implement an ERP for patients with AIS undergoing PSF integrating all aspects of biopsychosocial care and evaluate its outcomes in comparison with the conventional pain management strategies.

Methods

Study design

A prospective cohort study was conducted with the approval of the Ethics Committee of the Antwerp University Hospital, Belgium (study identifier EC19/14/183, chair P Cras, May 2019) after trial registration (ClinicalTrials.gov NCT04038229). Based on the postoperative treatment protocol received, two cohort groups were compared.

Patients of one cohort were operated between August 2018 and October 2019 and received the standard of care pain management protocol at our institution with patient controlled intravenous analgesia (PCIA) without ERP. On the other hand, patients of the other cohort were operated between December 2019 and July 2021 and treated with the newly designed ERP. All surgeries were performed by a single orthopedic surgeon.

All patients were recruited by the Department of Orthopedics and selected for this study by the Anesthesiology Department, Antwerp University Hospital, Belgium. Inclusion criteria included AIS patients under 26 years of age, scheduled for elective PSF. Patients with non-idiopathic scoliosis, preoperative chronic opioid use (> 3 months), and known unstable psychiatric history with the use of psychotropic drugs were excluded. This manuscript adheres to the applicable CONSORT guidelines.

This study which contains a descriptive analysis of the early rehabilitation process after spinal surgery according to a specifically developed and implemented enhanced recovery care path is part of a comprehensive biopsychosocial trajectory including pre and postoperative psychosocial screening and long term follow up to evaluate persistent postsurgical pain in adolescents after spinal fusion surgery. Results of the entire holistic path can be expected in the near future.

Control group

Figure 1 shows the standard of care in the control group. Patients were scheduled by the department of Orthopedics and since they received standard of care. They consulted an anesthesiologist for a standard preoperative assessment. Intraoperative neuromonitoring involved performing a wake-up test, which is why a short-acting volatile anesthetic (desflurane) in combination with remifentanyl was

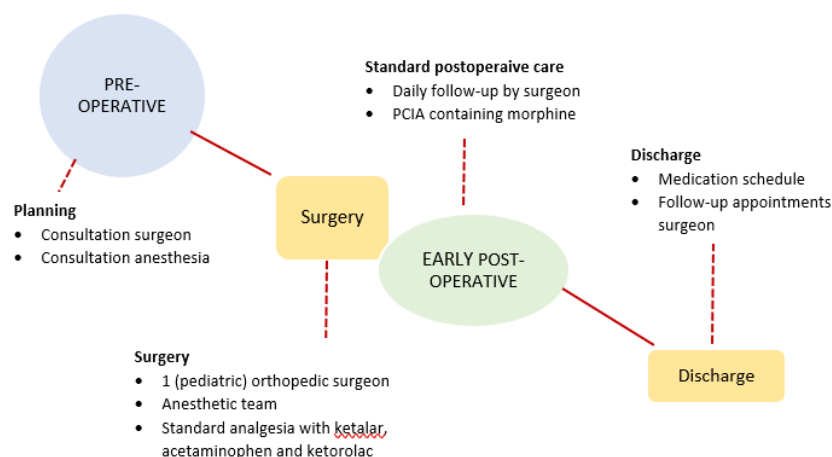


Fig. 1 — Standard of care in control group.

used for maintenance of anesthesia. The traditional analgetic management consisted of intravenous ketamine (loading dose of 0.5 mg kg⁻¹ at induction and 0.2 mg kg⁻¹ h⁻¹ after wake up procedure), ketorolac and acetaminophen. Postoperatively, PCIA containing morphine was started, next to continuation of the intravenous ketorolac and acetaminophen.

Enhanced recovery pathway

Figure 2 presents the designed multidisciplinary ERP.

Preoperative study phase

Once patients with AIS were scheduled for PSF by the department of Orthopedics, they were invited for a clinical study interview 1 to 2 weeks prior to surgery. The ERP was explained and informed consent obtained. A key component of this interview was patient education regarding the anticipated surgical trajectory. The online patient platform *uza@home* was activated and patients replied to an online preoperative screening psychological inventory. This inventory consisted of different screening tools for anxiety and depression (State-Trait Anxiety Inventory or STAI), pain and psychosocial aspects (Multidimensional Pain Inventory or MPI and Child and Adolescent Social and Adaptive Functioning Scale or CASAFS), depression (Childhood Depression Inventory or CDI) and coping mechanisms (Pain Response Inventory or PRI).

After negative screening for QT-prolongation on 5 lead electrocardiography before preoperative methadone administration, ERP was started and oral pre-emptive gabapentin was started 7 days prior to

surgery and increased over time up to a dose of 5mg kg⁻¹ 3 times a day.

Intraoperative study phase

Intraoperative multimodal analgesia consisted of a single dose of methadone (0,2mg kg⁻¹) at induction, in addition to clonidine, ketorolac, and acetaminophen based on patient weight. To prevent postoperative nausea and vomiting (PONV), dexamethasone and dehydrobenzperidol were administered, next to maintenance of anesthesia with TCI/TIVA propofol Marsh model.

Early postoperative study phase

Immediately postoperative, patients were admitted to the post-anesthesia care unit (PACU). When PACU discharge criteria (Aldrete) were fulfilled, they were transferred to the ward, usually on postoperative day (POD) 1. Standard MMA included intravenous acetaminophen every 6 hours and nonsteroidal anti-inflammatory drugs (NSAIDs) every 8 hours, next to the continuation of oral gabapentin three times a day. The conversion of intravenous to orally administration of medication took place on POD 3. Pantoprazole and macrogol to enhance bowel movements were also part of the ERP. If necessary, escape analgesia for breakthrough pain and antiemetic rescue were available. Urinary catheters were removed as soon as possible.

During hospital admission, patients were evaluated multidisciplinary on a daily basis. Pain, nutrition status, nausea and vomiting were scored 3 times a day by ward nurses. Additionally, daily follow-up by specialised pain nurses was provided and physiotherapists evaluated patients' rehabilitation.

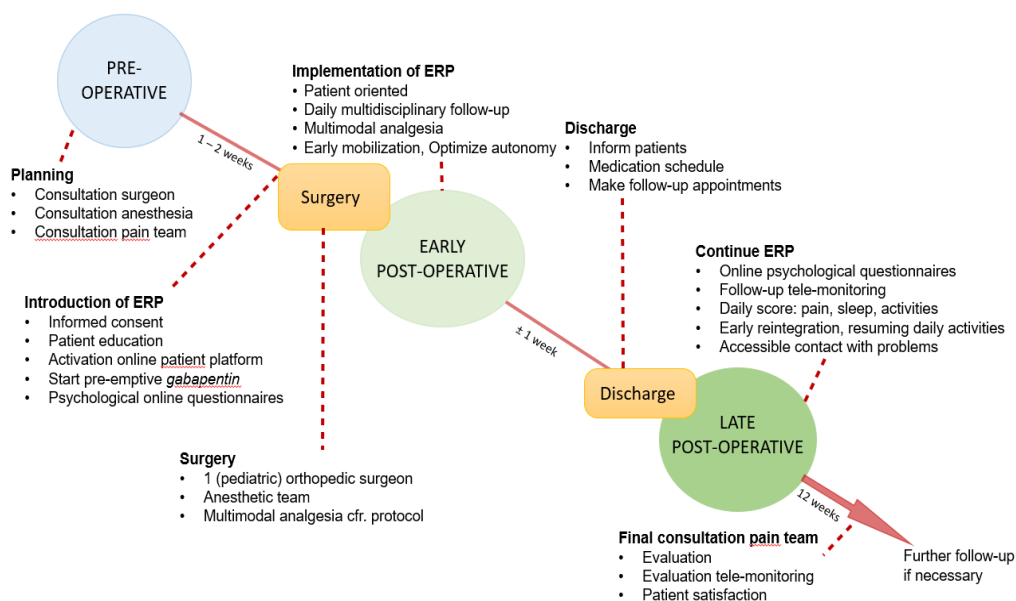


Fig. 2 — Design multidisciplinary ERP.

Patients were discharged on acetaminophen, NSAIDs, and gabapentin. A reduction scheme of gabapentin within 2 weeks after discharge was provided.

Late postoperative study phase

To get a picture of a patients pain sensation as well as its psychosocial aspects, the above mentioned questionnaires (MPI, STAI, CDI, PRI and CASAFS) were provided again after 4 and 12 weeks post-surgery. Patients were asked to fill in a daily online questionnaire up to 3 months postoperatively containing subjective revalidation characteristics including pain, sleep quality and activity progress. The study was completed after a final study interview 12 weeks postoperatively.

Statistical analysis

11 level Numerical Rating Scale (NRS) scores for pain between 0 (no pain) and 10 (worst imaginable pain), subjective sleep scores between 0 (worst possible sleep) and 10 (best possible sleep), and presence of nausea were described by ward nurses in a specific designed registration tool (ScolioseBoek). This tool was also used by specialized pain nurses for an additional NRS and by physiotherapist to describe rehabilitation, including mobility and flow-oriented spirometry⁷.

Patient characteristics and values for hospital length of stay (LOS) and urinary catheterisation

Table I. — Patient characteristics.

	ERP-treated patients (n=25) Mean (SD)	Controls (n=23) Mean (SD)
Gender, n (%)		
Male	10 (40)	2 (9)
Female	15 (60)	21 (91)
Age (years)		
Mean ± SD	16.52 ± 2.82	14.48 ± 1.78
Range	12-22	11-18
Body mass index (kg/m ²)		
Mean ± SD	20.40 ± 4.97	21.36 ± 4.97
Range	13.70-37.40	16.30-35.90
Fused levels (n)		
Mean ± SD	9.60 ± 2.14	10.00 ± 2.13
Range	7-15	6-13

were extracted from the electronic patient record (C-medical record, Cegeka, Vienna, Austria and Millennium, Cerner, North Kansas City, MO, United States)

SPSS Statistics software version 28.0 for Windows (IBM Corp, Armonk, NY, United States) was used for statistical analysis. After normality control, independent sample t-test and chi-square were used where appropriate. Due to the novelty of the design and implementation correct data for power analysis are lacking.

Patient characteristics

Table I summarises the patient characteristics. Overall, 23 AIS patients (2 males and 21 females) who had undergone PSF were included in the conventional group and 25 patients (10 males and 15 females) were treated according to the ERP. Figure 3 shows the process of inclusion and exclusion of patients in the intervention group. Mean age of the conventional group was 14.5 years (range 11-18) at the time of surgery and 16.5 years (range 12-22) in the ERP group. Mean body mass index in the conventional and ERP group were 21.4 (range 16.3-35.9) and 20.4 (range 13.7-37.4) respectively. The mean number of spinal levels fused was 10 (range 6-13) in the conventional group and 9.6 (range 7-15) in the ERP group.

Early recovery

PNRS scores for pain and sleep are summarised in Table II. On POD 1, NRS score for sleep was significantly better in the control group than in the ERP group (7.2 vs 4.9, p=0.003). During the remaining time of hospitalisation, NRS score for sleeping was similar between both groups.

Time to removal of urinary catheter was significantly shorter in the ERP group with a

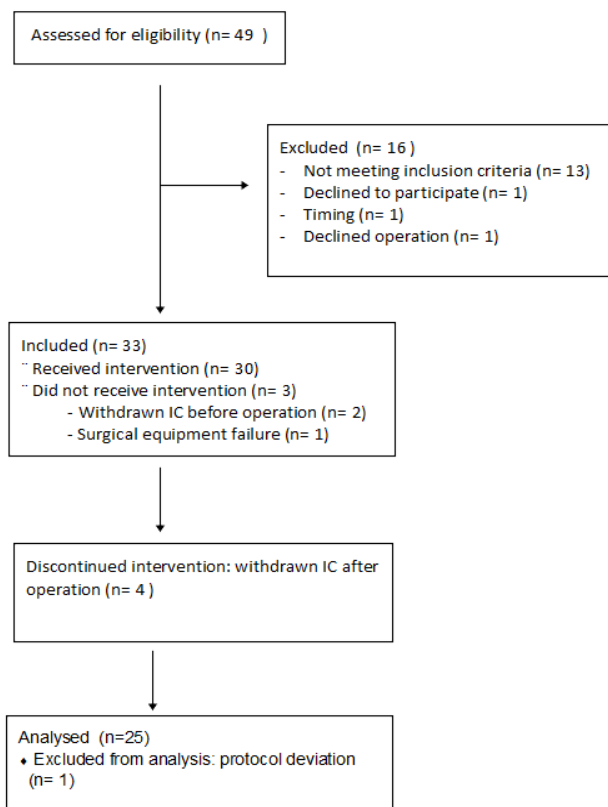


Fig. 3 — CONSORT flow diagram showing patient selection process.

Table II. — Mean NRS scores for pain and sleep by ward nurses.

	ERP-treated patients (n=25) Mean (SD)	Controls (n=23) Mean (SD)	P-value
NRS pain			
POD 1	4.17 (1.28)	3.87 (1.33)	0.23
POD 2	4.46 (1.56)	3.44 (1.53)	0.01 ^a
POD 3	3.74 (1.50)	3.41 (1.37)	0.22
POD 4	2.78 (1.11)	3.11 (1.44)	0.20
POD 5	2.40 (1.09)	2.89 (1.57)	0.36
NRS sleep			
POD 1	4.88 (2.55)	7.20 (1.26)	0.003 ^a
POD 2	5.45 (2.18)	5.41 (2.11)	0.94
POD 3	5.56 (1.98)	6.00 (2.07)	0.47
POD 4	6.20 (2.17)	6.11 (1.78)	0.73
POD 5	7.21 (1.58)	6.45 (1.99)	0.25

difference of 2.14 days (5.18 days vs 3.04 days, $p < 0.001$). LOS on the other hand did not differ between the both cohorts (7.5 days in the control group vs 7.4 days in the ERP group).

Of all patients in the ERP group, 24% were able to execute physical exercises while standing upright on POD 2. This number increased the following days to 67% at POD 3, 92% at POD 4 and 100% at POD 5. This in contrast to the control group where only 5% of patients were able to do these exercises at POD 2, 39% at POD 3, 65% at POD 4 and 93% at POD 5. Moreover, 12% of all ERP participants were able to walk at POD 2, 39% at POD 3, 70% at POD 4 and 87% at POD 5 compared with none of the patients in the control group at POD 2, 17% at POD 3, 18% at POD 4 and 50% at POD 5. Those differences were statistically significant for POD 1 and POD 4 ($p = 0.004$ and $p = 0.003$).

Concerning respiratory rehabilitation, 75% of ERP patients were able to maximally execute flow-oriented incentive spirometry at POD 1 and 94% at POD 2. In the control group, this was only possible for 67% of the patients at POD 1 and 80% at POD 2.

Discussion

PSF for AIS is an extensive operation, presenting several perioperative challenges including effective pain control, management of opioid related side effects, and delay in mobilization⁸. We present a possible ERP including biopsychosocial care and its results on outcome.

Average LOS after PSF was 5-6 days^{9,10}. Gauger et al¹¹ identified postoperative pain scores of 5.3, 5.1, and 4.6 in the first 3 POD in patients treated with PCIA. Walker et al⁵ described an incidence of PPSP of 22 % 6 months after PSF and 11-15% at

1 to 5 years. With acute postoperative pain being one of the risk factors for PPSP, this emphasises the importance of MMA with pre-emptive medication, blocking central sensitisation mechanisms. Other risk factors included preoperative pain intensity, patient anxiety, patient pain coping efficacy, and parental pain catastrophizing revealing the need for a biopsychosocial approach. In recent years, the use of ERP, integrating biopsychosocial care with MMA and early mobilization, has gained extensive attention. Fletcher et al¹² was the first to implement and evaluate an accelerated discharge pathway in paediatric spinal surgery following the example of colorectal surgery and joint arthroplasty. Potential benefits of early mobilization and early discontinuation of (intravenous) opioids were shown as reduced LOS and costs without increasing number of complications. Sanders et al¹³ assessed the effect of ERP on postoperative pain scores, which were 3.40, 4.08, and 3.57 in the first 3 POD. With the implementation of an ERP, some caregivers succeeded in reducing LOS to only 2.2 days¹⁴. Our data show an earlier mobilization defined by standing upright and walking being achieved after implementation of the ERP, although this did not result in shorter LOS. Furthermore, Foley catheters were removed as soon as possible to reduce the risk of potential urinary infections and delayed rehabilitation. Postoperative pain scores were slightly higher in the ERP group for POD 1 to 3 compared with the control group with a statistical significant difference for POD 2. This may possibly be related to early ambulation. Moreover, a trend toward slightly lower NRS scores on POD 4 and 5 were seen, but these were not statistically significant.

We acknowledge that our implementation study has some limitations. First limitation of this study encompasses that the type of surgery (including peroperative neuromonitoring) differed between the historical control group and the intervention group. In the control group, patients underwent a wake-up procedure with associated possible recall and psychological trauma. Fortunately, this was not reported by any patient in this study protocol. In the intervention group however, neuromonitoring consisted of somatosensory and motor evoked potentials. According to the literature, intraoperative awareness is not associated with sleep disturbances or higher postoperative pain scores in children, but results are conflicting¹⁵⁻¹⁷. Second, the COVID-19 pandemic made implementing an ERP very challenging. Patients under the age of 16 years are normally admitted to the paediatric ward. However, due to shortage of hospital beds, patients of the intervention group were occasionally admitted to different surgical wards. These teams were not

familiar with this surgery, nor with the ERP, causing suboptimal implementation and unsatisfactorily late for hospital discharge communication. Third, patients with non-idiopathic scoliosis, known unstable psychiatric disease and preoperative chronic opioid use were excluded from this study. Considering patients diagnosed with mental illnesses could benefit the most from standardized care, they should ideally be included in further pragmatic ERP evaluation research.

Conclusion

Implementing an ERP for patients undergoing PSF leads to earlier mobilization as shown in this prospective study. Further reevaluation and improvement could not only reduce the acute and chronic opioid consumption and its side effects, but could also result in less postoperative pain, shorter hospital stay, faster recovery, and higher patient satisfaction.

Conflicts of interests: The authors have indicated they have no conflicts of interest to disclose.

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Abbreviations:

AIS	Adolescent idiopathic scoliosis
PSF	Posterior spinal fusion
PPSP	Persistent postsurgical pain
MMA	Multimodal analgesia
ERP	Enhanced recovery pathway
PCIA	Patient controlled intravenous analgesia
STAI	State-Trait Anxiety Inventory
MPI	Multidimensional Pain Inventory
CASAFS	Child and Adolescent Social and Adaptive Functioning Scale
CDI	Childhood Depression Inventory
PRI	Pain Response Index
PONV	Postoperative nausea and vomiting
PACU	Post-anesthesia care unit
POD	Postoperative day
NSAIDs	Nonsteroidal anti-inflammatory drugs
OBAS	Overall benefit of analgesia score
NRS	Numeric rating scale
LOS	Length of stay

Addendum 1: ERP – medication component.

Preoperative:

Preemptive oral gabapentin started 7 days preoperatively and gradually increased:

Day -7: 1x 5mg kg-1

Day -6: 2x 5mg kg-1

Day -5: 3x 5mg kg-1

Day -4 until day of surgery: 3x 5mg kg-1, and continued afterwards

Peroperative:

- *Induction with propofol 1% 2-3 mg kg⁻¹ IV, rocuronium 0.6mg kg⁻¹ IV and fentanyl 2 mcg kg⁻¹ IV*
- *Maintenance of anesthesia with propofol IV according to MARSH model*
- *Cefazolin 30mg kg⁻¹ IV at induction, repeat after 4 hours or with major blood loss*
- *Tranexamic acid 20mg kg⁻¹ IV*
- *Methadone 0.2mg kg⁻¹ IV (at induction, after ECG screening for QT prolongation)*
- *Acetaminophen 20mg kg⁻¹ IV*
- *Ketorolac 0.5mg kg⁻¹ IV, max 30mg*
- *PONV prophylaxis: dexamethasone 0.1mg kg⁻¹ iV (at induction) dehydrobenzperidol 0.02 mg kg⁻¹ IV (standard dose 0.625mg)*
- *Clonidine 1 mcg kg⁻¹ IV*

Postoperative

- *Acetaminophen 15mg kg⁻¹ 4x/day IV. If oral nutrition was resumed, switch to oral acetaminophen 60 mg kg⁻¹ day⁻¹ over 3-4 gifts*
- *Ketorolac 0.5mg kg⁻¹ 3x/day IV. If oral nutrition was resumed, switch to oral ibuprofen 10mg kg⁻¹ 3x/day*
- *Rescue pain: 1st night stay at PACU: piritramide 0.02 mg kg⁻¹ IV (or 1-2 mg bolus) ward: buprenorphine 0.1- 0,2mg sublingual , max 6x/day*
- *Rescue PONV: first choice: ondansetron 0.1 mg kg⁻¹ IV up to 3x/day second choice: alizapride 1mg kg⁻¹ IV up to 4x/day third choice: dehydrobenzperidol 0.02 mg kg⁻¹ IV up to 3x/day*
- *Continue oral gabapentin (same dose as preoperatively until 12 days postoperatively, then reduce over 3 consecutive days and completely stopped 14 days after hospital discharge)*
- *Cefazolin 30mg kg⁻¹ 3x/day IV during the first 24 hours postoperatively. The first dose is given 8 hours after the initial dose, regardless of any repeat doses*
- *Macrogol 1 bag 2x/day in constipation prevention*
- *Remove urethral catheter on POD1 and monitor spontaneous miction*

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