ORIGINAL RESEARCH

Multimodal Analgesia for Paediatric Patients Undergoing Lower Limb Reconstruction with External Fixators: A Prospective Case Series of Post-operative Pain and Functional Goals

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Abstract

Aim: Limb reconstruction with external fixators requires appropriate pain management to promote effective analgesia and healing while minimising adverse events of the analgesic technique used. The objective of this prospective case series was to evaluate a multimodal analgesia regimen designed to reduce opioid requirements and hence reduce the opioid-related side effect profile.

Materials and methods: A prospective cohort of patients undergoing lower limb reconstruction surgery (LRS) were managed through an evidence-informed multimodal analgesia guideline (MMAG), including acetaminophen, pregabalin, dexmedetomidine, IV lidocaine, and opioids. Outcome measures included intraoperative and post-operative opioid administration, post-operative pain scores, time to achieve mobilisation milestones, and post-operative complications. Surveys were conducted to obtain patient reported experiences.

Results: 26 patients were included in this prospective case series. 110.59 (84.29, 162.13) (median, interquartile range) µg/kg/hr intraoperative IV morphine equivalent opioids were administered. In the first 48 hours post-operatively, patients received 11.49 (6.41, 19.35) µg/kg/hr of IV morphine equivalent dose. Median level of pain (0–10) in the first 48 post-operative hours was 2 (1, 2). Patients achieved mobilisation. And 19/20 patients surveyed reported 'yes' to having effective pain management; 17/20 patients had no unwanted side effects associated with analgesia medications. There were no cases of compartment syndrome.

Conclusion: This multimodal analgesia regime applied to patients undergoing lower LRS with external fixators demonstrates the feasibility of this analgesic regimen which revealed effective pain control, early mobilisation, with minimal side effects, but warrants further study.

Clinical significance: This study provides valuable evidence that this standardised multimodal anaesthesia and analgesia regimen is feasible, offers adequate post-operative comfort and encourages early mobilization while minimising opioid use and adverse events in a paediatric LRS population at our institution.

Keywords: Analgesia, External fixation, Lower limb, Pain, Paediatric, Post-operative.

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Introduction

Limb lengthening and reconstruction surgery with external fixation is a mainstay of treatment for paediatric limb deformity and leg length discrepancy. Limb reconstruction surgery (LRS) with external fixators in the paediatric population may be associated with significant acute pain, especially in the first 24–48 hours of the post-operative period.[1–3] It is important to manage pain effectively and promote early mobilisation, achieving effective post-operative rehabilitation, avoiding the risk of pressure sores, and reducing the small risk of deep vein thrombosis in this population.[4] Effective pain management should not potentially mask the signs and symptoms of compartment syndrome. Unrecognised compartment syndrome can cause intense acute pain, contractures, toe deformities, paralysis, sensory neuropathy, chronic pain, and may even necessitate amputation.[5] Minimising acute post-operative pain will also help prevent complications, including infections, anxiety, depression, persistent post-operative pain, and subsequent chronic pain.[4]

Perioperative anaesthesia and analgesia for LRS may not be standardised across institutions. Regional nerve blocks and epidural analgesia may potentially delay early mobility,

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mask signs and symptoms of, or delay decision-making around compartment syndrome.[5,6] While opioids are effective for LRS, they are associated with dose-dependent side effects, such as somnolence, respiratory depression, urinary retention, nausea, vomiting, ileus, constipation, pruritis, and hypotension which all negatively affect post-operative mobilisation and achievement of post-operative functional goals.[7] Central nervous system depression by opioids may increase the risk of falls and fractures that could hinder bone healing. Potential long-term effects of opioids include long-term use, opioid use disorder or even opioid overdose.[8] Long-term opioid use is actually the most common complication after elective surgery in adults.[9,10]

To reduce opioid requirements, we implemented an institutional evidence-informed standardised anaesthetic and post-operative analgesia strategy specifically for our LRS paediatric population. This multimodal analgesia guideline (MMAG) utilises drugs acting through different mechanisms: acetaminophen, pregabalin, dexmedetomidine, IV lidocaine therapy (IVLT), and opioids (Appendix 1). The purpose of MMAG is to use analgesia agents that work on different receptors to optimise the post-operative comfort, reduce opioid requirement and hence opioid side effects. Multimodal analgesia guideline is designed primarily to reduce the potential barriers to quick recognition and management of compartment syndrome which can be a risk with regional techniques and to maximise early mobilisation, through adequate pain relief.

The primary outcomes of this study were intra- and post-operative opioid utilisation, pain scores, and patient reported experiences with pain management. Secondary outcomes included time to achieve mobilisation milestones. We also documented adverse events, such as compartment syndrome.

Materials and Methods

We conducted a prospective case series of participants undergoing lower LRS at a single tertiary academic paediatric hospital from September 2016 to November 2021 to assess the MMAG. This study was conducted in accordance with the Declaration of Helsinki. Ethics approval was obtained from the Institutional Research Ethics Board (ethics number H15-03419). The inclusion criteria included participants between ages 5 and 25 years undergoing external fixation for deformity correction with or without lengthening. Any participants who were unable to report pain verbally were excluded. Families of participants were approached for potential inclusion in this study in the orthopaedics clinic during preoperative consultation. Research staff had obtained written informed consent from parents/guardians of children between ages 5 and 18 years, assent from children between ages 7 and 18 years, and consent from participants over 18 years old. This manuscript was prepared according to the STROBE checklist.

Between September 2016 and November 2021, 29 consecutive patients undergoing elective lower LRS with external fixators were approached to be included in this study. 3 patients were excluded; 1 patient was excluded as they were not willing to accept medication and had challenges when participating in outcome measures and only received 2/5 of the MMAG drug regimen, and 2 patients declined participation. Therefore, 26 patients were included in this study, representing 90% of elective LRS conducted at the institution over the enrollment time period (Table 1). The C-1 and C-2 STAIC scores were 33.0 (29.0, 38.0) and 32.0 (30.0, 37.0), respectively, where 20 corresponds to no anxiety and 80 corresponds to high anxiety.

Conflict of interest: None

Research involving human participants: This study involved human participants.

Patient consent statement: The author(s) have obtained written informed consent from the patient for publication of the details and related images.

Table 1: Baseline characteristics of study cohort

Age	14.0 (10.3, 17.0)
Gender (% male)	69.2
ASA score (1–5)	1 (1,2)
Length of stay post-op (days)	4 (3,5)
C-1 STAIC score	33.0 (29.0, 38.0)
C-2 STAIC score	32.0 (30.0, 37.0)
Blount's disease	6
LLD secondary to trauma	4
Fibular hemimelia	5
Other	11
Additional procedures	
Femoral osteotomy	5
Bilateral LRS with frame application	2
Gastrocnemius release/resection	3

ASA, American Society of Anaesthesiologists; Age, ASA, Length of stay, STAIC score reported as median (Q1, Q3); LLD, limb length discrepancy; LRS, limb reconstruction surgery; $n = 26$

20/26 patients participated in telephone surveys at 24 hours post-discharge and first clinic follow-up surveys.

The State-Trait Anxiety Inventory for Children (STAIC) was completed by participants prior to surgery for assessment of baseline anxiety, as increased anxiety is associated with increased post-operative pain and need for increased post-operative analgesia.[11]

The MMAG was implemented for patients undergoing LRS as described in Appendix 1 and the five components included preoperative: (1) acetaminophen, (2) pregabalin, intraoperative, (3) dexmedetomidine, IVLT with (4) bolus followed by (5) continuous infusion.

Patient charts were reviewed for the following: intraoperative and post-operative opioid administration, pain scores in post-anaesthesia care unit (PACU) and during first 48 hours post-operatively at 4 hour intervals, time to achieve mobilisation milestones, and post-operative complications, including nausea, pruritis, and compartment syndrome. Age-appropriate pain scores (Numeric Pain Score and FACES Pain Scale Revised)[12] were reported on a scale of 0–10 where 1–3 is mild pain, 4–6 is moderate pain, and 7–10 is severe pain. Patient surveys were conducted by research staff through phone interviews 24 hours post-discharge and at the first post-operative clinic visit, typically at 1 week post-surgery. Phone interviews were conducted with patients when able, with parents contributing to responses. Responses at clinic were collected from patients and parents collectively when applicable. Questions consist of yes/no answers to statements regarding pain management and side effects experienced. Patient reported experiences of post-operative analgesia at their phone and clinic follow-ups were evaluated on a 5-point Likert scale. A sample of the

24 hour phone follow-up script and 1st clinic follow-up questions can be found in Appendix 2. In the instance where a data point was missing for a patient, they were excluded in the median calculation. For patients lost to follow-up after hospital discharge, they were excluded in the analysis for those respective outcomes.

Median and interquartile ranges were used to report the dosage of opioids administered intra- and post-operatively. Opioid dosage was converted to IV morphine equivalents using online opioid equianalgesic calculator https://clincalc.com/Opioids/. A sample calculation can be found in Appendix 3. Patients who received at least 4/5 of the components of MMAG drug regimen (as long as the four included IVLT and pregabalin) were included in data analysis. 4/5 was chosen as a cutoff because some patients did not receive dexmedetomidine based on discretion of the anesthesiologist.

Results

Opioid Dosage and Pain Scores

The median amount of opioids administered intra-operatively for patients receiving MMAG was 110.59 (84.29, 162.13) µg/kg/hr IV morphine equivalents (Table 2). The median duration of surgery was 3.13 (2.65, 3.98) hours. In the first 48 hours post-operatively, patients were given 11.49 (6.41, 19.35) µg/kg/hr of IV morphine equivalents, including continuous morphine infusion as well as oral morphine or hydromorphine as titrated by the nursing staff according to institutional guidelines. In the PACU, the median level of pain was 4 (1, 5) while the pain level throughout the first 48 hours post-operatively, measured at 4-hour intervals was 2 (2, 3) (Table 2). In addition, pain levels remained at 2 (0, 3) and 2 (0, 3) at 24 hours post-discharge and at first clinic follow-up, increasing to 4 (1, 5) with movement.

Table 2: IV morphine equivalents administered and pain scores

Length of surgery (hr)	3.13 (2.65, 3.98)
Intra-op IV morphine equivalents per hour (µg/kg/hr)	110.59 (84.29, 162.13)
IV morphine equivalents 1st 48 hours post-op (µg/kg/hr)	11.49 (6.41, 19.35)
Median pain score PACU	4 (1, 5)
Peak pain score PACU	6 (2, 8)
Pain score 1st 48 hours post-op Q4 hours	2 (2, 3)
Pain score 24 hours post-discharge	2 (0, 3)
Pain score at 1st clinic follow-up (at rest)	2 (0, 3)
Pain score at 1st clinic follow-up (with movement)	4 (1, 5)

PACU, post-anaesthesia care unit; Doses and pain scores on scale of 0–10 reported as median (Q1, Q3), $n = 26$

Adverse Effects

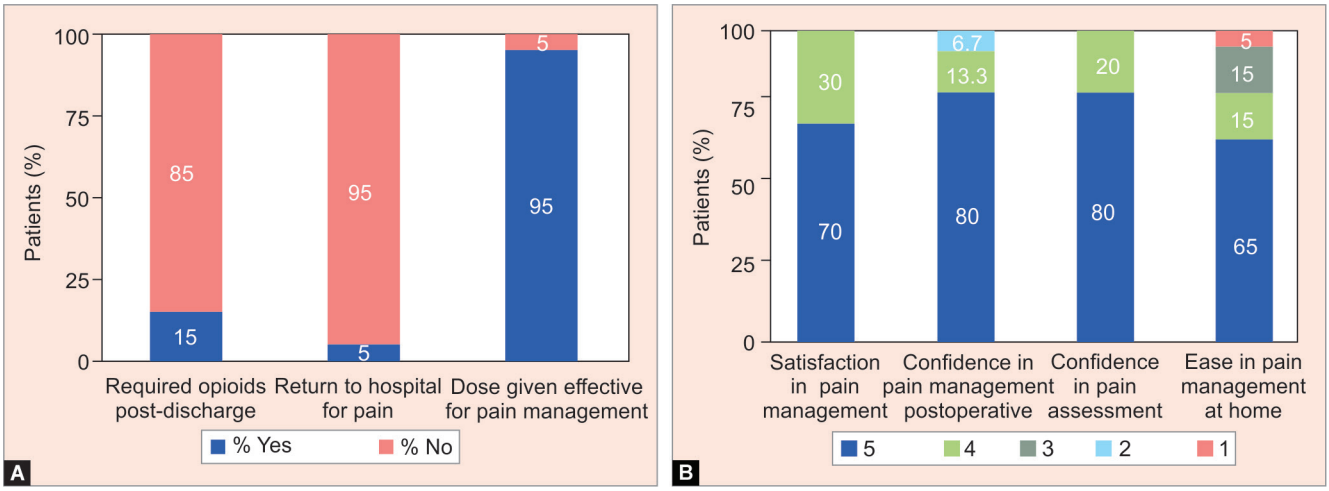
Adverse effects associated with opioids post-operatively were found to be minimal in patients who received the multimodal analgesia regimen. Patients remained alert with a median arousal score of 1 post-operatively. 12/26 patients (46.2%) required antiemetics; of those requiring antiemetics a median of 1 dose of antiemetic was given. 4/26 patients (15.3%) required antipruritics; of those receiving antipruritics, a median of 1.5 doses were given. No patients experienced or were suspected of developing compartment syndrome.

Mobilisation Milestones

Eighteen out of 26 patients had documented mobilisation milestones by the physiotherapy team. It was found that patients who received the MMAG drug regimen reached their mobilisation milestones as follows: patients were first able to dangle in less than a day, stand (of 17 recorded), and demonstrate a measure of muscle control (of 11 recorded) at 1 day. By 2 days, they were able to weight bear through their involved lower extremity (of 12 recorded), ambulate with appropriate walking aids, and utilise the stairs (of 10 recorded).

Patient Reported Experiences on Pain Management

Twenty out of 26 patients participated in surveys through telephone interviews at 24 hours post-discharge and at their first clinic follow-up. The first clinic follow-up occurred at 8 (7, 11) days post-discharge. Only 3/20 patients (15%) required opioids post-discharge (Fig. 1A). The remaining patients either did not require any analgesia or were provided pregabalin with a tapering schedule and acetaminophen as needed. The majority



Figs 1A and B: Patient survey responses on pain management. (A) Patient responses to yes/no questions; (B) Patient responses to statements on a 5-point Likert scale. 1, strongly disagree; 2, disagree; 3, neither; 4, agree; 5, strongly agree. $n = 20$

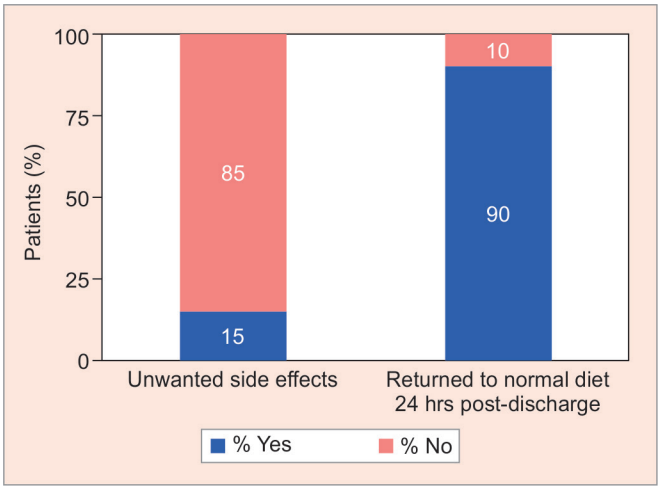


Fig. 2: Patient survey responses to yes/no questions with respect to adverse events. $n = 20$

of the patients (95%) agreed with the statement that the dose of pain medications given was effective for pain management. 1/20 patients (5%) returned to the hospital post-discharge for pain. In addition, patients were satisfied with their pain management (Fig. 1B). Patients found that pain management was not difficult at home, were confident in their ability to assess pain, and were confident in their pain management post-operatively.

When asked about their post-operative experience, 17/20 patients (85%) reported no unwanted side effects related to their pain medications such as nausea and constipation (Fig. 2). 18/20 patients (90%) were able to return to their normal diet at 24 hours post-discharge.

Conclusion

We demonstrated in this case series that implementing a preventative multimodal analgesia regimen for our paediatric population in our institution undergoing elective lower LRS provided good pain management and appropriate functional outcomes with a minimal opioid-related side effect profile. By evaluating objective measures including intraoperative and post-operative opioid administration, time to reach mobilisation milestones, and incorporating patient reported experiences, we are able to assess a more holistic post-operative course.

As the MMAG was designed through an evidence-informed approach with the goal of improving post-operative pain while reducing opioid usage, we sought to assess these parameters in our study. It has been shown that perioperative pregabalin significantly decreases the total post-operative consumption of opioids.[13] Similarly, dexmedetomidine administered intra-operatively has been shown to decrease post-operative opioid consumption.[14] Reduction in both intra- and post-operative use of opioids has also been shown for IVLT in various studies.[15–21] While we acknowledge the off-label use of IVLT, pregabalin, and dexmedetomidine in this study, we also note that off-label drugs are commonly used in the paediatric population based on clinical evidence and judgement, given the lack of clinical trials.[22] Although we do not have control comparison in this study, it can be seen that the amount of morphine equivalents administered intra-operatively and in the first 48 hours post-op was modest in patients who received MMAG. Importantly, very few of the patients required opioids on discharge.

In addition to reducing opioid usage, intraoperative administration of dexmedetomidine has been shown to reduce pain intensity over the first 48 hours post-operatively.[14] A 2015 Cochrane review also reported that IVLT decreased early post-operative pain (24 h).[23] In our current study, patients reported a moderate level of pain in the PACU, as expected for the extensive involvement of LRS. Over the course of the first 48 hours post-operatively, the median level of pain reported was mild, and this continued at 24 hours after discharge from hospital, as well as at patients' first clinic visits. Appropriate analgesia was confirmed through surveys conducted with patients, where the overall experience with pain management was reported positively. While the first 24–48 hours post-operatively is the focus of analgesic targets, it is important to note that the MMAG regimen provided adequate analgesia beyond this time period, which may further promote optimal recovery and bone healing for our patient population. It is appropriate to note that our past clinical experience indicates that missing one or two components of this multimodal regimen resulted in a cumulative increase in opioid requirements. Since the completion of this study, we have added non-steroidal anti-inflammatory drugs (NSAIDs) to the regimen as new data have supported their safe use in this population.[24]

With the global opioid crisis arising since the early 2000s, opioid overdose has become a leading cause of death.[25] Non-fatal opioid overdose events has also increased significantly.[26] It has been shown that the duration of postsurgical opioid prescription is strongly associated with opioid misuse.[27] Therefore, excessive opioid prescribing related to surgery has been an important public health concern, particularly in orthopaedics.[28] In this study, we found that with the MMAG regimen, patients did not require high levels or long duration of opioid administration for adequate pain control. Notably, individual patients have unique levels of pain tolerance which would explain the variability. However, most did not go home with a prescription for opioids despite the significant involvement of LRS. This suggests the potential of applying this multimodal approach to other paediatric orthopaedic procedures to minimise the morbidity related to opioid use as well as reducing the prescribing of unnecessary opioids.

Another reason to reduce opioid administration is to minimise their array of side effects. Peri-operative administration of pregabalin has been shown to reduce opioid-related side effects.[13] In a study of paediatric abdominal surgeries involving IVLT, it was found that patients returned to normal bowel function earlier.[1] This was also seen in adult studies where intraoperative IVLT use for various abdominal,[15–17] spinal,[18,19] and brain[20] surgeries was associated with decreased post-operative nausea[24] and earlier return of organ function. In this study, the typical side effects seen with opioids, such as nausea, poor appetite, pruritis, and constipation were minimal. These patients rarely required any antiemetic or antipruritic medications post-operatively. Most had returned to their normal diet post-discharge with appropriate appetite and reported minimal side effects, which is important for their recovery course and well-being. As opioids are associated with CNS depression, it is important to note that patients in this case series remained alert during their post-operative course, allowing them to actively participate in rehabilitation which is essential for LRS recovery.

Studies have also reported that IVLT may be associated with earlier discharge from hospital;[19,29] while this was not specifically found in this study as there are complex rehabilitation needs associated with LRS, the majority of the patients were discharged

home in well within a week. In addition, a study of IVLT in spinal surgeries showed improved short form-12 (SF-12) physical component scores post-operatively compared with placebo, indicating that the use of lidocaine did not negatively affect bone healing.[18] It is encouraging to see that our study population was also able to reach their mobilisation milestones in a timely manner, which is crucial for their recovery. Furthermore, none of the participants experienced compartment syndrome, the symptoms of which could potentially be masked by regional nerve blocks or epidural analgesia.[6]

While we aimed to provide a comprehensive evaluation of the targeted preventative MMAG in this prospective case series, there were some limitations. We had a small sample size due to a small population undergoing a very specific procedure. Based on a successful clinical pilot, the MMAG had been implemented at our institution at the time of our study; we therefore did not enroll patients as controls. As a result, we were not able to perform comparative statistical analysis. Limb reconstruction surgery is technically complex and specific to individual patients due to variability in operative interventions, including additional soft tissue procedures, pin placements and number, osteotomy sites, and techniques. Additionally, hardware removals from previous surgeries may be incorporated to facilitate reduced number of patient procedures. Thus, soft tissue manipulation and surgical field are heterogeneous and an inherent limitation of our study. Some patients were lost to follow-up for mobilisation milestones and post-discharge surveys due to logistical challenges. Finally, at our institution, LRS with external fixation for acute trauma occurs infrequently, and our study does not include this patient population. Therefore, further studies may be necessary to determine the generalisability of this pain regimen for patients undergoing external fixation for acute trauma.

Clinical Significance

This study provides valuable evidence that this standardised multimodal anaesthesia and analgesia regimen is feasible, offers adequate post-operative comfort and encourages early mobilisation while minimising opioid use and adverse events in a paediatric elective LRS population at our institution. This can further guide implementation strategies and future studies in extending the protocol to other orthopaedic procedures for the paediatric population.

Ethics Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethics approval was obtained from the local institutional review board at the senior author's institution.

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Appendix 1

Perioperative Multimodal Analgesia Guideline (MMAG)

Preoperative Premedication Analgesia

Acetaminophen 20 mg/kg po
Pregabalin 1 mg/kg po (to the nearest 25, 50, and 75 mg)

Intraoperative Analgesia/Antiemesis

- Fentanyl/morphine at discretion of attending anaesthesiologist
- Anaesthesia at discretion of attending anesthesiologist
- TIVA recommended to reduce post-operative pain, nausea and vomiting (PONV)
- Lidocaine bolus 1 mg/kg IV followed by lidocaine infusion
- Lidocaine infusion 2 mg/kg/hr throughout the duration of the case
- Lidocaine infusion to be stopped immediately prior to admission to PACU
- Dexmedetomidine 0.5 mg/kg slow IV bolus
- Dexmedetomidine infusion for cases longer than 2 hours (dose at discretion of attending anaesthesiologist)
- Dexamethasone 0.1 mg/kg IV bolus
- Ondansetron 0.1 mg/kg IV bolus

Post-operative Analgesia Orders

- Acetaminophen 12.5 mg/kg po q 4 hourly regular (Max 75 mg/kg/day)
- Pregabalin 1 mg/kg po (to the nearest 25, 50, and 75 mg) po q 12 hourly regular
- Morphine infusion—see pre-printed order sheet
- Consider Naloxone infusion to prevent opioid-induced pruritus

In general, children following external fixator or frame surgery will not be referred to the acute pain service (APS). However, pharmacogenomic, pharmacokinetic, and pharmacodynamic factors play a role in the wide inter-individual variation in response of any individual child to analgesic agents. There is also huge inter-individual variability in pain perception from a standard surgical insult. Therefore, it is important to tailor medications to the needs of individual children based on continual re-assessment.

Some children will need other adjuvant agents in the post-operative period. Therefore, it is recommended that the following patients are referred to APS:

- Patient with BMI >85 percentile
- Patients with significant preoperative pain issues
- Patients with high level anxiety and/or mood disorder preoperatively
- Patients in whom pain becomes difficult to manage in the first 12 hours post-operatively
- Patients with significant comorbidities which will impact choice of analgesia agents (e.g., sleep disordered breathing, airway compromise, significant developmental delay)

Appendix 2

24-hour Telephone Call Script

First follow-up—24 hours after discharge (questions to child or parent, depending on age)

SCRIPT: 'I would like to ask you some questions regarding information you received about how to manage your child's pain'.

Domain 1: Pain Information

- Were there any issues following your LRS (Yes/No)
  - If yes, what were the post-surgical issues (patient report)
- In terms of managing pain after surgery, did you receive:
  Options: Written booklet from a nurse, verbal instructions from a nurse, written instructions from a doctor, verbal instructions from a doctor, Not sure
- Did you seek out additional information or advice after discharge on how to manage pain
  - If yes, how did you seek out this information or advice?
  - Was this information helpful?
- Did you have an unexpected return to hospital for pain control problems?
  - If yes, why?
- Did you have an unexpected return to hospital for any other complications related to the procedure?
  - If yes, why?

SCRIPT: 'Thank you'. 'I would like to ask you some questions regarding pain after surgery'.

Domain 2: Child's Self-report Pain Assessment

- Current pain score at rest
- Current pain score upon movement
- Describe your pain…
  - … at the time of discharge from the hospital
  - … on the trip home
  - … at the moment
  - … during the first 24 hours after discharge
  Options: No pain, Mild pain, Moderate pain, Severe pain, and Not sure
- What is the highest level of pain you experienced?
- When was the highest level of pain experienced?
- How long was your trip home?

SCRIPT: 'Thank you'. 'Now, I would like to ask you some questions regarding how you managed your pain after surgery'.

Domain 3: Pain Management

- Did you take pain medications as prescribed?
  - If yes: Dose, route, time given, beneficial/side effects
  - If no, why not?
- Do you think that the dose of medication given was effective in relieving your pain?
- Did you experience any unwanted or problematic side effects from your pain medications?
  - If so, what?
- Have you returned to a normal diet?
  - If yes, when? If no, why not?

SCRIPT: 'Thank you'. 'I would like to ask you some questions regarding how your pain was managed at the hospital after surgery'.

Domain 4: Satisfaction and Confidence

- How satisfied were you with how your pain was managed while at the hospital?
  Options: Very dissatisfied, Dissatisfied, Neither, Satisfied, and Very satisfied
  - Why?

- Did you feel comfortable asking the doctors or nurses at the hospital questions about pain management?
- How well informed did you feel about the medications prescribed after your operation?
  Options: Not at all informed, 2, 3, 4, Very informed
- How confident…
  - … were you in managing your pain after your operation?
  - … are you in assessing your level of pain?

  Options: Not at all confident 2, 3, 4, Very confident
- Describe how difficult it was to manage your pain at home following discharge?
  Options: Not at all difficult 2, 3, 4, Very difficult
- Why?
- Do you have any other comments or suggestions that may help us in the future to manage pain in children following LRS?

First Clinic Follow-up

Second follow-up—at first post-op clinic visit (*questions to* child *or* parent*, depending on age*)

Domain 1: Pain Information

- Did you have an unexpected return to hospital for pain control problems since we last spoke to you?
- Did you have an unexpected return to hospital for any other complications related to the procedure?

Domain 2: Pain Assessment

- Current pain score at rest
- Current pain score upon movement
- What is the highest level of pain you have experienced?
  Options: No pain, Mild pain, Moderate pain, Severe pain, and Not sure
- When was the highest level of pain experienced?

Domain 3: Pain Management

- Did you take pain medications as prescribed?
  - If yes: Dose, route, time given, beneficial/side effects
  - If no, why not?
- Do you think that the dose of medication given was effective in relieving your pain?
- Did you experience any unwanted or problematic side effects from your pain medications?
  - If so, what?
- Have you returned to a normal diet?
  - If yes, when? If no, why not?
- Have you taken any pain-relieving drugs in the past 2 days?
  - If yes, Dose, route, time given, beneficial/side effects
- What non-medical strategies have worked best to help manage your pain?

Domain 4: Satisfaction

- How satisfied are you with your pain management at home?
  Options: Very dissatisfied, Dissatisfied, Neither, Satisfied, and Very satisfied
- Why?
- Do you have any other comments or suggestions that may help us in the future to manage pain in children following LRS?

Domain 5: Beliefs

- Do you agree with the following statements:
  - Pain medications work best when given regularly
  - Pain medications work best when used as needed
  - Pain medications are addictive
  - Pain medications have dangerous side effects
  - Children have the same amount of pain as adults for the same operation
  - There are benefits to having pain
  - There are benefits to treating pain

  Options*:* Strongly disagree, Disagree, Neither, Agree, and Strongly agree

Appendix 3

Sample Intraoperative IV Morphine Equivalent Calculation

In calculating total intraoperative IV morphine equivalents of opioids, we include the following agents that were used as part of the anaesthetic regimen:

- Morphine
- Hydromorphone
- Fentanyl
- Sufentanil

The choice of agents is at the discretion of the anaesthesiologist. They are all converted into IV morphine equivalents based on an online opioid equianalgesic calculator at https://clincalc.com/Opioids/
Example:
Patient weight: 35 kg
Intra-operative opioids given
Morphine: 3 mg = 3000 μg
Fentanyl: 75 μg → 7,500 μg IV morphine eq
Total intra-op IV morphine equivalents: 10,500 μg IV morphine eq → 300 μg/kg
Length of surgery: 4 hours
Intra-op IV morphine equivalents per hour: 300 μg/kg/4 hours = 75 μg/kg/hr.