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Suprazygomatic Maxillary Nerve Blocks and Opioid Requirements in Pediatric Adenotonsillectomy
A Randomized Clinical Trial

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IMPORTANCE Pain management following pediatric adenotonsillectomies is opioid-inclusive, leading to potential complications.

OBJECTIVE To investigate the use of suprazygomatic maxillary nerve (SZMN) blocks to reduce pain and opioid use after pediatric intracapsular adenotonsillectomy and to measure recovery duration and incidence of complications.

DESIGN, SETTING, AND PARTICIPANTS This was a randomized, blinded, prospective single-center tertiary pediatric hospital that included 60 pediatric patients (2-14 years old) scheduled for intracapsular adenotonsillectomy from November 2021 to March 2023. Patients were excluded for having combined surgical procedures, developmental delay, coagulopathy, chronic pain history, known or predicted difficult airway, or unrepaired congenital heart disease. Participants were randomized to receive bilateral SZMN blocks (block group) or not (control group).

INTERVENTION SZMN block administered bilaterally under general anesthesia for intracapsular adenotonsillectomy.

PRIMARY OUTCOMES AND MEASURES Opioid consumption, FLACC (Face, Legs, Activity, Cry, Consolability) scores, and rates of opioid-free postanesthesia care unit (PACU) stay. Secondary outcomes were recovery duration and incidence of adverse effects, ie, nausea, vomiting, block site bleeding, and emergency delirium.

RESULTS The study population included 53 pediatric patients (mean [SD] age, 6.5 [3.6] years; 29 [55%] females; 24 [45%] males); 26 were randomly assigned to the SZMN block group and 27 to the control group. The mean (SD) opioid morphine equivalent consumption during PACU stay was 0.15 (0.14) mg/kg for the 27 patients in the control group compared with 0.07 (0.11) mg/kg for the 26 patients in the block group (mean difference, 0.08; 95% CI, 0.01-0.15; Cohen *d*, 0.64). The block group had a higher incidence of opioid-free PACU stays (n = 7 patients; 58%) compared with the control group (n = 15 patients; 26%) (mean difference, 32%; 95% CI, 5%-53%). Patients in the block group experienced lower FLACC scores (0.7 vs 1.6; mean difference, 0.9; 95% CI, 0.2-1.6; Cohen *d*, 0.7). The overall occurrence of adverse events was similar in the 2 groups, with no reported nerve block-related complications.

CONCLUSIONS AND RELEVANCE The results of the randomized clinical trial indicate that SZMN blocks are a useful adjunct tool for managing postoperative pain in pediatric intracapsular adenotonsillectomy. Use of these blocks during adenotonsillectomy provided clinically meaningful reductions of postoperative opioid consumption with a low risk of complications.

TRIAL REGISTRATION ClinicalTrials.gov Identifier: NCT04797559

Visual Abstract

Supplemental content

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Adenotonsillectomies are a prevalent outpatient pediatric surgical procedure; as many as 10.5 million pediatric tonsillectomy procedures were completed globally from 1993 through 2014.[1,2] Effective postoperative pain management is challenging[3] with more than 75% of pediatric patients experiencing severe pain.[4] Pain medication is underdosed on the first 2 postoperative days.[5-7] Inadequate pain control can be associated with poor oral intake and dehydration, increasing health care costs through emergency visits and hospital admissions.[8-10] Obstructive sleep-disordered breathing is among the leading indications for pediatric tonsillectomy.[11] Patients with obstructive sleep apnea are vulnerable to opioid-induced respiratory depression.[12,13] Adequate postoperative pain management with opioids may raise the risk of respiratory complications, nausea, vomiting, and drowsiness, which may delay oral intake and hospital discharge.[9,14] Nonopioid multimodal agents—eg, acetaminophen, dexamethasone, dexmedetomidine, and ketorolac—offer varying efficacy and adverse effects such as sedation and increased postoperative bleeding.[15-18] Topical and local infiltration methods, including surgical peritonsillar injection, have limited use due to inconsistent pain relief and risks of complications such as post-tonsillectomy hemorrhage, intravascular injection, vocal cord paralysis, brain stem stroke, and upper airway obstruction.[19-21] With the ongoing opioid epidemic,[22] health care professionals are acutely aware of the risks associated with opioid use.[23-27]

The adenotonsillar tissues receive innervation from both the glossopharyngeal nerve and the lesser palatine branch of the maxillary nerve, creating a complex neural network.[28] Thus, regional anesthesia had seldom been used in this surgical population until recently.[29-32] The suprazygomatic maxillary nerve block (also known as maxillary nerve, pterygopalatine, and infratemporal fossa block) can be administered as a local anesthetic to block the maxillary nerves[33-35] and decrease sensation to various oral structures, including the tonsils, uvula, adenoids, and soft palate.[36] This technique selectively anesthetizes the posterior pharynx while preserving vital protective airway reflexes, such as coughing and swallowing, by sparing the glossopharyngeal nerve.[37]

The SZMN block has been a regional technique for providing postoperative pain relief in cleft lip and palate repair in infants 3 to 6 months of age.[38-42] The literature has shown that the SZMN block effectively decreases pain, decreases opioid exposure, enhances recovery, and decreases complications.[28,34-38,41,42] The objective of this trial was to explore the potential of use SZMN as a regional anesthesia technique and opioid-sparing adjuvant for managing postoperative pain after pediatric intracapsular adenotonsillectomy.

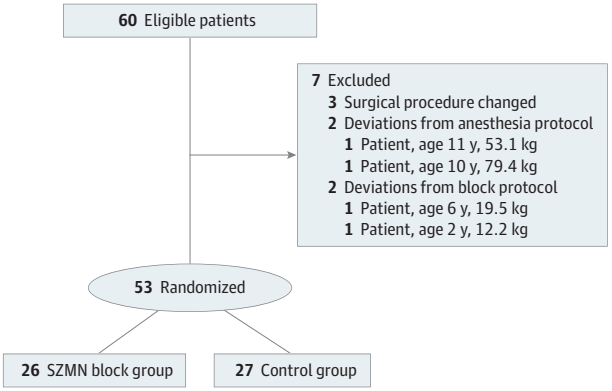
Key Points

Question Does the suprazygomatic maxillary nerve block decrease opioid requirements and improve postoperative outcomes in pediatric intracapsular adenotonsillectomy?

Findings This randomized clinical trial including 60 patients aged 2 to 14 years found that suprazygomatic nerve blocks reduced opioid consumption during postanesthesia care unit (PACU) stay time and increased the incidence of opioid-free PACU recovery. No clinically meaningful differences between the block and control groups were observed in postoperative nausea, vomiting, and emergence or delirium.

Meaning These results indicate that suprazygomatic nerve blocks provide an effective pain management tool for pediatric intracapsular adenotonsillectomy by decreasing opioid use during PACU stay.

Figure 1. Participant CONSORT Flow Diagram



SZMN indicates suprazygomatic maxillary nerve.

Methods

This prospective, blinded, randomized clinical trial was conducted at a single tertiary pediatric specialty hospital. The Stanford University Institutional Review Board reviewed and approved trial protocol (available in Supplement 1). Written informed consent was obtained from a legal guardian for all patients. In addition, informed assent was obtained for children 7 years and older. The study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guideline.

Study Design and Patient Randomization

Patients from 2 to 14 years old with sleep-disordered breathing or who were otherwise healthy and undergoing intracapsular adenotonsillectomy were recruited. Exclusion criteria included combined surgical procedures outside the maxillary nerve distribution, external capsular adenotonsillectomies, coagulopathy, chronic pain history, pain medication use, difficult airway, or unrepaired congenital heart disease (**Figure 1**). Of the 60 pediatric patients enrolled, 7 were withdrawn from the study analysis: 3 due to alterations in the surgical procedure and 4 due to deviations from the study protocol for anesthesia medication or block procedures. In 2 of the excluded patients, the primary anesthetic maintenance was sevoflurane instead of intravenous propofol with low-dose sevoflurane. Two others were excluded from the technical aspect of the block procedure: in 1 patient the needle was unable to be inserted into the desirable deep fossa depth, and another the block was done with hydrodissection using local anesthetic that was associated with transient facial paralysis. The remaining

53 patients were randomized to the 2 groups, 26 to the SZMN block group and 27 to the control group (Figure 1). The research anesthesiologist randomized patients using REDCap, version 14.0.1,[43] on the day of surgery.

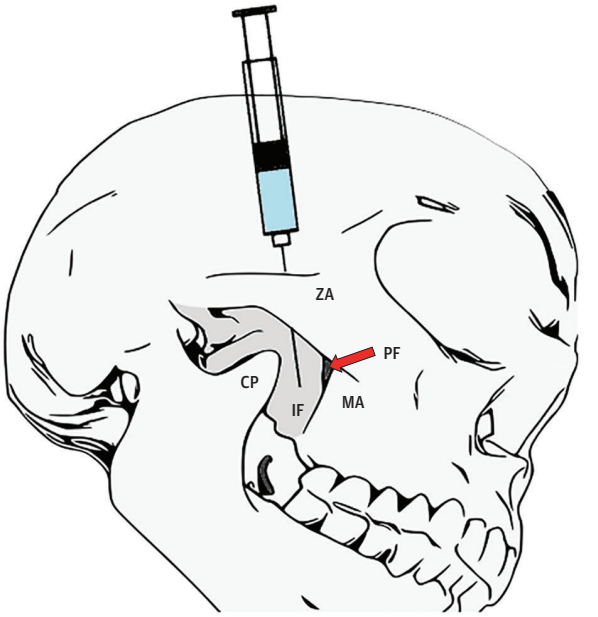
Blinding

Patients, nurses, research assistants, and family members were blinded. The surgeon, primary room anesthesiologist, and regional anesthesiologist placing the nerve block were not blinded for practicality and safety. The front zygomatic angle site was covered with a small bandage on all children, and no sham block was performed. All families received the exact instructions regardless of the study group.

Description of the SZMN Block

We used the SZMN method described by Mesnil et al[41,70] to insert the needle through the frontozygomatic angle (**Figure 2**): the needle was advanced to the greater sphenoid bone wing until contact is made; then, advancement of the needle tip into the pterygopalatine fossa is made by repositioning the alignment obliquely forward and caudal. Local anesthetic was injected on the maxillary bone surface after negative aspiration. When needed, we diluted from 1 mg per kg (mg/kg) of ropivacaine, 0.5%, per side to 5 mL (maximum volume, 5 mL). Ultrasonography imaging confirmed local anesthetic deposition beneath the temporalis muscle.

Figure 2. Key Landmark for Needle Insertion When Performing Suprazygomatic Approach to the Maxillary Nerve



The red arrow indicates the pterygopalatine fossa. CP indicates coronoid process; IF, infratemporal fossa; MA, maxilla; PF, pterygopalatine fossa; and ZA, zygomatic arch.

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Anesthesia Management and Intervention

All patients were examined per the American Society of Anesthesiologists physical status classification scale (ASA score), premedicated, and maintained under general anesthesia according to our institutional standards and titrated by the room anesthesiologist. Premedication included oral midazolam, 0.5 mg/kg. Induction consisted of a mixture of sevoflurane inhalation, 1- to 2-µg/kg fentanyl and 1- to 2-mg/kg propofol. Intraoperative anesthesia maintenance was 200-µg/kg propofol per minute with an inhalational agent maintained at less than 0.5 minimum alveolar concentration, 1- to 2-µg/kg fentanyl, 0.5- to 1.0-µg/kg dexmedetomidine, 15-mg/kg acetaminophen, and 0.5-mg/kg dexamethasone (maximum dose, ≤10.0 mg/kg). Pediatric regional anesthesiologists performed ultrasonography-guided bilateral SZMN blocks after intubation and before surgery in the block group. These anesthesiologists were part of a highly experienced team that routinely administers and places these blocks as part of our enhanced recovery protocol for cleft palate repairs and other procedures involving pediatric patients at our institution. The intraoperative anesthesia team was not blinded for patient safety reasons, but both groups used the same anesthetic protocol to ensure consistency. Bandages covered all patients' temples to blind the postoperative team.

After the SZMN blocks were performed, residents and attending surgeons performed the intracapsular adenotonsillectomy using the attending surgeon's choice of instrumentation (coblation, suction cautery, or microdebrider). All patients were deep extubated and transported to the postanesthesia care unit (PACU) with oxygen. Blinded PACU nurses titrated opioids based on patient needs and the institutional postanesthesia order set (fentanyl intravenously [IV], 0.25-0.50 µg/kg, every 5 minutes as needed, up to 3 doses; morphine IV, 0.025 mg/kg, every 10 minutes as needed, up to 4 doses; or hydromorphone, 0.005 mg/kg, every 10 minutes as needed, up to 4 doses for moderate pain with a Face, Legs, Activity, Cry, and Consolability [FLACC] score[44-47] of 4 to 6). Oral acetaminophen and ibuprofen were prescribed as discharge medications per the American Society for Pediatric Otolaryngologists' postoperative pain management guidelines.[48]

Data Collection and Outcome Assessment

The primary outcome was the total morphine equivalents administered during the PACU stay. Secondary outcomes included awake pain score based on FLACC score.[44-47] The FLACC scores were recorded every 15 minutes by the blinded recovery nurse as per institutional practice. The FLACC score is a widely accepted and validated tool for assessing pain in pediatric patients. It quantifies pain by observing specific behaviors and physiological responses, with each component scored on a scale of 0 to 2, producing a total score ranging from 0 to 10. Prior research studies,[44-47] have shown that a clinically meaningful change in FLACC score after an intervention is typically 2 points. Nurses in the PACU followed institutional guidelines and clinical experience for opioid dosages.

Postoperative emergence agitation, nausea, and vomiting were recorded by blinded PACU nurses and research assistants. Emergence delirium, as observed in our study, is characterized by psychomotor agitation and delirium, typically

Table 1. Demographic Characteristics of Pediatric Participants, by Study Group

Characteristic	Study group, No. (%)		
	Control	SZMN block	Mean difference (95% CI)
Participants	27	26	NA
Age, mean (SD), y	6.5 (3.6)	6.4 (3.1)	0.1 (−2.2 to 1.5)
Female	17 (63)	12 (46)	0.2 (−0.1 to 0.4)
Male	10 (37)	14 (54)	0.2 (−0.1 to 0.4)
BMI, mean (SD)	19.3 (6.0)	19.6 (4.8)	−0.3 (−2.7 to 3.3)
Patients with obesity,[a] %	10 (37)	10 (38)	−0.05 (−0.3 to 0.2)
ASA score, mean (SD)	1.8 (0.37)	1.8 (0.47)	0
Patient ASA score, %			
1	4 (14.8)	3 (11.5)	NA
2	23 (85.1)	22 (84.6)	NA
3	0	1 (3.8)	NA

Abbreviations: ASA, American Society of Anesthesiologists physical status classification scale; NA, not applicable; BMI, body mass index calculated as weight in kilograms divided by height in meters squared; SZMN, suprazygomatic maxillary nerve block.

[a] Weight in the 95 percentile or greater.

occurring within 45 minutes from the emergence of anesthesia. Patients who experienced retching were deemed to have nausea. Our PACU policy allows for discharge from the recovery area in 30 minutes if the patient meets the institutional postprocedure score. Postoperative adverse events after discharge, including nausea, vomiting, block site bleeding, tonsillar hemorrhage, and dehydration were assessed prospectively through surveys emailed to families daily for 1 week postoperatively.

Statistical Analysis

We hypothesize that the SZMN group can improve clinically over the control group by a 40% reduction in opioid consumption. Given a type 1 error rate of 0.05 and a power of 0.90, a sample size of 26 participants is necessary to discern a significant difference in opioid consumption (mean [SD] morphine equivalents, 0.19 [0.083] mg/kg) between the SZMN and control groups. This calculation is based on findings from a study investigating multimodal pain adjuncts in pediatric intracapsular adenotonsillectomy surgery.[49] We allocated 30 individuals to each study group to account for 10% of dropouts and incomplete data. Continuous variables were represented as means (SDs) for statistical analysis. Categorical variables were given as counts and percentages. Between-group differences in continuous variables were tested using *t* test or the Wilcoxon rank sum test, while categorical variables were tested using the χ^2 or Fisher exact test, as appropriate. Variables were reported as mean difference or risk reduction with 95% CIs, and an effect size was calculated. Using Cohen *d* and *h* approach, we defined an effect size of 0.2 as small, 0.5 as medium, and 0.8 as large.[50] All analyses were conducted in R, version 4.0.1 (The R Foundation for Statistical Computing).

Results

The study analysis included 53 patients (mean [SD] age, 6.5 [3.6] years; 29 [55%] females; 24 [45%] males); 26 were randomized to the SZMN block group and 27, to the control group. No meaningful differences were seen in the demographic characteristics of patients in either group (**Table 1**). The study was not structured to identify patient subgroups such as high apnea-hypopnea index (AHI). The study results were associated with a moderate and clinically meaningful reduction in mean (SD) opioid morphine equivalent consumption during PACU stay of 0.15 (0.14) mg/kg for the control group compared with 0.07 (0.11) mg/kg for the block group (mean difference, 0.08 mg/kg; 95% CI, 0.01 to 0.15; Cohen *d*, 0.64). Additionally, 15 patients (58%) in the block group required no opiates compared with 7 patients (26%) in the control (mean difference, 32%; 95% CI, 6.6%-56.9%). While patients in the block group experienced lower FLACC scores (0.7 vs 1.6; difference 0.9; 95% CI, 0.18 to 1.62; Cohen *d*, 0.72), the difference was small and likely not clinically important.

Patients in the block group spent a mean of 82.4 minutes in the operating room compared with 65.5 minutes in the control group (mean difference, 16.8; 95% CI, 6.3 to 27.3; Cohen *d*, −0.32). In the PACU, patients in the block group spent a mean of 117 minutes compared with 111 minutes in the control group (difference, 6 min; 95% CI, −15 to 27; Cohen *d*, −0.17). The incidence of nausea or vomiting and the emergence of delirium were similar in the 2 groups (**Table 2**) in the PACU. Four of the 27 control group patients (14.8%) were readmitted for rehydration and pain management after same-day discharge. These readmissions occurred on the following postoperative days (POD): POD1 (dehydration), POD2 (dehydration), POD4 (dehydration and bleeding), and POD6 (dehydration). Although there was no readmission for pain or dehydration management for patients in the block group, 1 patient did return to the hospital 4 days after surgery for observation of potential tonsillar hemorrhage. The overall response rate for each POD survey over 7 days was satisfactory: 50 (94%) on POD1, 46 (86.8%) on POD2, 46 (86.8%) on POD3, 44 (83%) on POD4, 43 (81.1%) on POD5, 44 (83%) on POD6, and 41 (77.3%) on POD7.

Discussion

This randomized clinical trial of the effectiveness of using maxillary nerve blocks for intracapsular adenotonsillectomy demonstrate that this regional anesthesia technique is an effective way to decrease immediate postoperative pain in children

Table 2. Clinical Outcomes Among the SZMN Block Group Compared With Control Group

Outcome	Control group (n = 27)	SZMN block group (n = 26)	Mean difference, % (95% CI)	Effect size
PACU				
Morphine milligram equivalent per kg, mean (SD)	0.15 (0.14)	0.07 (0.11)	0.08 (0.01 to 0.15)	0.64
FLACC pain score, mean (SD)	1.6 (1.6)	0.7 (0.9)	0.9 (0.2 to 1.6)	0.72
Incidence of opioid-free PACU stay, No. (%)	7 (25.9)	15 (57.7)	−31.8 (−56.9 to −6.6)	0.49
Time in OR, mean (SD), min	65.6 (21.3	82.4 (16.5	−16.8 (−27.3 to −6.3)	0.34
Time in PACU, mean (SD), min	111 (38	117 (35	−6 (−26.2 to 14.2)	0.17
Postdischarge				
Patient-reported pain scores, mean (SD) [% response]				
POD1	3.5 (2.8) [100]	3.0 (2.5) [88.5]	0.5 (−0.9 to 1.9)	0.18
POD2	3.0 (2.9) [92.5]	3.7 (2.5) [80.7]	−0.7 (−2.2 to 0.8)	−0.26
POD3	3.3 (2.9) [92.5]	4.0 (2.9) [80.7]	−0.7 (−2.3 to 0.9)	−0.24
Readmission incidence (rehydration/pain), No. (%)	4 (14.8)	0	14.8 (1.4 to 28.2)	1.06
Patients with ≥1 adverse events, No. (%)	6 (22)	3 (11.5)	10.5 (−0.1 to 0.3)	0.26
Adverse event type, No. (%)				
Hematoma	0	0	NA	NA
Emergence delirium	3 (11)	2 (8)	NA	NA
Nausea	3 (11)	1 (4)	NA	NA
Vomiting	0	2 (8)	NA	NA

Abbreviations: FLACC, Face, Legs, Activity, Cry, and Consolability score; PACU, postanesthesia care unit; OR, operating room; POD, postoperative days; SZMN, suprazygomatic maxillary nerve.

Clinical outcome effect size: 0.2 small, 0.5 medium, 0.8 large.

being treated for sleep-disordered breathing at a tertiary children's hospital. The maxillary nerve block can increase operating time and does not affect pain and recovery after the first postoperative day.

Opioids are sometimes recommended for postoperative pain control after adenotonsillectomy.[3,51,52] However, opioids influence respiration by raising the CO_2 threshold for breathing regulation through their action on the brain stem. This effect becomes particularly pronounced in patients with obstructive sleep apnea, with reduced CO_2 sensitivity at baseline.[53-56] When combined with potential mechanical obstructions arising from postoperative edema or anatomical factors, children undergoing adenotonsillectomies face an elevated risk of life-threatening hypoxemia during the postoperative period.[8] In the block cohort, the implementation of SZMN blocks reduced the need for postoperative opioids as well as increased the incidence of patients who did not need any opioids (32%). Studies for cleft palate repair, oral surgery, and orthognathic surgery have also demonstrated a comparable reduction in postoperative opioids and pain scores.[42,57,58] We hypothesize that in our study, the SZMN block improved pain control, which led to fewer opioid doses required because of a moderate decrease in average opioid morphine equivalents and a higher percentage of patients in the block who required no opioids compared with control group patients in the PACU.[41,42,58]

Data regarding local infiltration have failed to show consistent and significant improvement over the control group.[59-61] Moreover, local infiltration has been associated with seizures, deep cervical abscesses, upper airway obstruction, and stroke.[19] A recent meta-analysis[62] did not note any difference between pain scores as assessed by visual analogue scale in either the control or local infiltration of the tonsillar pillar group. The ultrasonography-guided for maxillary nerve block technique may avoid these complications due to direct visualization of the internal maxillary artery and spread of local anesthetic, thereby potentially minimizing the risk of iatrogenic vessel or nerve damage. Using suprazygomatic approach, it is possible to administer local anesthesia to only the palatine branch of the maxillary nerve while preserving the glossopharyngeal nerve to maintain airway reflexes. The needle trajectory points away, instead of toward, the skull base, which strategically directs the needle away from potential penetration sites of skull base structures (Figure 2), further enhancing safety protocols.[41]

Moreover, as documented in previous studies,[42,63-65] the suprazygomatic approach reduces the likelihood of ocular injury, a risk associated with infrazygomatic and infraorbital blocks. Complications associated with maxillary nerve block infiltration encompass various issues such as local anesthesia toxic effects, allergies, pain at the injection site, infection, swelling, sensory deficits, and hematoma, and have a reported rate of 3% for facial blocks.[66] Our study encountered 1 complication that required exclusion. Specifically, hydrodissection with a local anesthetic during needle advancement inadvertently deposited the local anesthetic superficially, resulting in blockage of a buccal branch of the facial nerve, causing mild asymmetrical smiling, which resolved within 5 hours.

In assessing SZMN block efficacy, we expected the block onset to be within 20 minutes of injection. For this reason, we did not expect a difference in anesthetic requirements intraoperatively given that the incision was made immediately before block onset. Drawing from insights in the literature on cleft

palates and SZMN blocks,[40,67-70] it becomes evident that the block's effects on pain typically dissipate within the initial postoperative day. Although it is known that pediatric posttonsillectomy pain can be substantial for up to 7 days postoperatively, our study could not draw any conclusions from pain scores after discharge. Patients had similar pain scores in the first 3 postoperative days (Table 2). Patients who received the block were highly satisfied with the surgical pain control they experienced. We believe that it contributed to early hydration and decreased readmission rates.[51,71-73]

To contextualize our study findings, our PACU uses several perioperative quality surrogates. Emergence delirium is used to evaluate perioperative PACU care. Psychomotor agitation within 30 minutes of anesthesia indicates delirium. PACU nurses also assessed nausea (younger pediatric patients may retch while older ones may only show discomfort). We found no significant differences between the control and block groups in delirium, nausea or vomiting, or PACU discharge times. Our hospital standardizes aggressive nausea prophylaxis with at least 3 agents, which may mask the block group's benefit. PACU discharge times varied and were also often unrelated to patient factors. Patients who met discharge criteria were frequently delayed due to lack of transportation, hospital beds, and other nonmedical factors.

Limitations

This pilot study had a number of limitations. A variable factor is the absence of standardization in instrumentation and the involvement of resident physicians, which can produce variations in pain levels associated with different surgical techniques and experiences. Because intracapsular tonsillectomy was the most frequently performed surgical technique at our institution, it was the focus of our investigation. Both study groups exhibited low FLACC scores, and a change of less than 1 point may lack clinical significance. These findings may be due to intracapsular tonsillectomy, which has been shown to reduce pain compared with extracapsular tonsillectomy. Future studies may include patient-reported pain scores, which may differ. As our study was not adequately powered to discern the specific patient demographic characteristics most responsive to nerve blocks, our univariate analysis did not reveal any significant associations between age, weight, body mass index (calculated as weight in kilograms divided by height in meters squared), or other patient characteristics and opiate requirements or pain scores. However, considering that patients with high AHI are particularly susceptible to opioid-related effects, we anticipate future investigations will elucidate the most important benefits within this subgroup. The confidence intervals are broad due to the sample size, and the trial results should be interpreted cautiously because the estimate for the actual value of the difference derived from this study may need to be revised in future studies.

Another limitation to consider is that although this nerve block technicque can be easily learned, there may be a learning curve during broader implementation such as there is when learning any new procedure. Our institution is a tertiary medical center with anesthesiologists trained in regional anesthesia who perform this nerve block routinely as part of an enhanced recovery pathway. Anesthesiologists can be trained through structured programs covering anatomy, ultrasonography techniques, and supervised clinical practice. There are also a plethora of online resources and tutorials for self-taught learners.

Likewise, risks and benefits must be assessed before any procedure. We acknowledge the need to balance the increase in operating room time against the modest reduction in pain scores, particularly beyond the PACU recovery period. Although we did not record the time required to place a nerve block, patients receiving the SZMN block experienced longer operating room times: a modest 17-minute increase for patients receiving the block. This delay can be attributed to educational efforts, additional time for procedural timeouts, and coordination between teams before and after the procedure. While the ultrasonography approach may only need minimal readily available equipment in pediatric operating rooms and can be done within 10 minutes, the alternative landmark SZMN block uses less than 2 minutes.[9,41,74] Increases in operating room time may mean reserving this technique for subsets of patients that will have maximal benefit.

Conclusions

This randomized clinical trial serves as a pilot study and provides evidence that supports integrating SZMN blocks in the perioperative pain management protocol for pediatric intracapsular adenotonsillectomy. Although these findings suggest potential advantages such as pain reduction and opioid sparing,[29] future research is necessary to validate these outcomes and identify specific patient populations likely to derive the most benefit from this procedure. Therefore, further investigation is warranted to further validate our outcomes and elucidate which patients are the best candidates for this nerve block.

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Concept and design: Lin, Sidell, Balakrishnan, Tsui.
Acquisition, analysis, or interpretation of data: Lin, Abboud, Zoghbi, Kasimova, Thein, Meister, Sidell, Tsui.
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REFERENCES

1. Hall MJ, Schwartzman A, Zhang J, Liu X. Ambulatory surgery data from hospitals and ambulatory surgery centers: United States, 2010. *Natl Health Stat Report*. 2017;2017(102):1-15.

2. Crowson MG, Ryan MA, Rocke DJ, Raynor EM, Puscas L. Variation in tonsillectomy rates by health care system type. *Int J Pediatr Otorhinolaryngol*. 2017;94:40-44. doi:10.1016/j.ijporl.2017.01.014

3. Jensen DR. Pharmacologic management of post-tonsillectomy pain in children. *World J Otorhinolaryngol Head Neck Surg*. 2021;7(3):186-193. doi:10.1016/j.wjorl.2021.03.004

4. Dorkham MC, Chalkiadis GA, von Ungern Sternberg BS, Davidson AJ. Effective postoperative pain management in children after ambulatory surgery, with a focus on tonsillectomy: barriers and possible solutions. *Paediatr Anaesth*. 2014;24(3):239-248. doi:10.1111/pan.12327

5. Tan L, Carachi P, Anderson BJ. The time course of pain after tonsillectomy. *Paediatr Anaesth*. 2020;30(9):1051-1053. doi:10.1111/pan.13970

6. Fortier MA, MacLaren JE, Martin SR, Perret-Karimi D, Kain ZN. Pediatric pain after ambulatory surgery: where's the medication? *Pediatrics*. 2009;124(4):e588-e595. doi:10.1542/peds.2008-3529

7. Stewart DW, Ragg PG, Sheppard S, Chalkiadis GA. The severity and duration of postoperative pain and analgesia requirements in children after tonsillectomy, orchidopexy, or inguinal hernia repair. *Paediatr Anaesth*. 2012;22(2):136-143. doi:10.1111/j.1460-9592.2011.03713.x

8. Katz SL, Monsour A, Barrowman N, et al. Predictors of postoperative respiratory complications in children undergoing adenotonsillectomy. *J Clin Sleep Med*. 2020;16(1):41-48. doi:10.5664/jcsm.8118

9. Stanko D, Bergesio R, Davies K, Hegarty M, von Ungern-Sternberg BS. Postoperative pain, nausea and vomiting following adeno-tonsillectomy: a long-term follow-up. *Paediatr Anaesth*. 2013;23(8):690-696. doi:10.1111/pan.12170

10. Curtis JL, Harvey DB, Willie S, et al. *Causes and costs for ED visits after pediatric adenotonsillectomy*. Vol 152. Otolaryngology - Head and Neck Surgery; 2015,

11. Parker NP, Walner DL. Trends in the indications for pediatric tonsillectomy or adenotonsillectomy. *Int J Pediatr Otorhinolaryngol*. 2011;75(2):282-285. doi:10.1016/j.ijporl.2010.11.019

12. Waters KA, McBrien F, Stewart P, Hinder M, Wharton S. Effects of OSA, inhalational anesthesia, and fentanyl on the airway and ventilation of children. *J Appl Physiol (1985)*. 2002;92(5):1987-1994. doi:10.1152/japplphysiol.00619.2001

13. Brown KA, Laferrière A, Lakheeram I, Moss IR. Recurrent hypoxemia in children is associated with increased analgesic sensitivity to opiates. *Anesthesiology*. 2006;105(4):665-669. doi:10.1097/00000542-200610000-00009

14. McColley SA, April MM, Carroll JL, Naclerio RM, Loughlin GM. Respiratory compromise after adenotonsillectomy in children with obstructive sleep apnea. *Arch Otolaryngol Head Neck Surg*. 1992;118(9):940-943. doi:10.1001/archotol.1992.01880090056017

15. Pinto JM, Salvador R, Naclerio RM. Choice of analgesics after adenotonsillectomy: are we between a rock and a hard place? *JAMA Otolaryngol Head Neck Surg*. 2016;142(11):1041-1042. doi:10.1001/jamaoto.2016.3216

16. Kelly LE, Sommer DD, Ramakrishna J, et al. Morphine or Ibuprofen for post-tonsillectomy analgesia: a randomized trial. *Pediatrics*. 2015;135(2):307-313. doi:10.1542/peds.2014-1906

17. Diercks GR, Comins J, Bennett K, et al. Comparison of ibuprofen vs acetaminophen and severe bleeding risk after pediatric tonsillectomy: a noninferiority randomized clinical trial. *JAMA Otolaryngol Head Neck Surg*. 2019;145(6):494-500. doi:10.1001/jamaoto.2019.0269

18. Tsaousi GG, Chatzistravou A, Papazisis G, Grosomanidis V, Kouvelas D, Pourzitaki C. Analgesic efficacy and safety of local infiltration of tramadol in pediatric tonsillectomy pain: a systematic review and meta-analysis. *Pain Pract*. 2020;20(5):550-563. doi:10.1111/papr.12874

19. Ohlms LA. Injection of local anesthetic in tonsillectomy. *Arch Otolaryngol Head Neck Surg*. 2001;127(10):1276-1278. doi:10.1001/archotol.127.10.1276

20. Alsarraf R, Sie KCY. Brain stem stroke associated with bupivacaine injection for adenotonsillectomy. *Otolaryngol Head Neck Surg*. 2000;122(4):572-573.

21. Bean-Lijewski JD. Glossopharyngeal nerve block for pain relief after pediatric tonsillectomy: retrospective analysis and two cases of life-threatening upper airway obstruction from an interrupted trial. *Anesth Analg*. 1997;84(6):1232-1238. doi:10.1213/00000539-199706000-00011

22. Qian ZJ, Alyono JC, Jin MC, Cooperman SP, Cheng AG, Balakrishnan K. Opioid prescribing patterns following pediatric tonsillectomy in the United States, 2009-2017. *Laryngoscope*. 2021;131(5):E1722-E1729. doi:10.1002/lary.29159

23. Lauder G, Emmott A. Confronting the challenges of effective pain management in children following tonsillectomy. *Int J Pediatr Otorhinolaryngol*. 2014;78(11):1813-1827. doi:10.1016/j.ijporl.2014.08.011

24. Harbaugh CM, Lee JS, Hu HM, et al. Persistent opioid use among pediatric patients after surgery. *Pediatrics*. 2018;141(1):e20172439. doi:10.1542/peds.2017-2439

25. Franz AM, Martin LD, Liston DE, Latham GJ, Richards MJ, Low DK. In pursuit of an opioid-free pediatric ambulatory surgery center: a quality improvement initiative. *Anesth Analg*. 2021;132(3):788-797. doi:10.1213/ANE.0000000000004774

26. Lee BH, Kumar KK, Wu EC, Wu CL. Role of regional anesthesia and analgesia in the opioid epidemic. *Reg Anesth Pain Med*. 2019;44(4):rapm-2018-100102. doi:10.1136/rapm-2018-100102

27. Anne S, Mims JW, Tunkel DE, et al. Clinical practice guideline: opioid prescribing for analgesia after common otolaryngology operations. *Otolaryngol Head Neck Surg*. 2021;164(S2):S1-S42. doi:10.1177/0194599821996297

28. Bičanić I, Hladnik A, Džaja D, Petanjek Z. The anatomy of orofacial innervation. *Acta Clin Croat*. 2019;58(suppl 1):35-42.

29. Lin C, Pan S, Barros VR, Meister K, Tsui BCH. Opioid-free postoperative pain management after adenotonsillectomy with nasal turbinate reduction using bilateral suprazygomatic infratemporal-pterygopalatine fossa injections: a case report. *A A Pract*. 2021;15(8):e01502. doi:10.1213/XAA.0000000000001502

30. Smith L, Balakrishnan K, Pan S, Tsui BCH. Suprazygomatic maxillary (SZM) nerve blocks for perioperative pain control in pediatric tonsillectomy and adenoidectomy. *J Clin Anesth*. 2021;71:110240. doi:10.1016/j.jclinane.2021.110240

31. Tsui BCH, Pan S, Smith L, Lin C, Balakrishnan K. Opioid-free tonsillectomy with and without adenoidectomy: the role of regional anesthesia in the "new era". *Anesth Analg*. 2021;133(1):e7-e9. doi:10.1213/ANE.0000000000005567

32. Zoghbi V, Okonski F, Pan S, Lin C, Balakrishnan K, Tsui BCH. Suprazygomatic infratemporal pterygopalatine fossa block with adjuvant low-dose dexmedetomidine for adenotonsillectomy. *Can J Anaesth*. 2022;69(4):555-557. doi:10.1007/s12630-022-02190-8

33. Anugerah A, Nguyen K, Nader A. Technical considerations for approaches to the ultrasound-guided maxillary nerve block via the pterygopalatine fossa: a literature review. *Reg Anesth Pain Med*. 2020;45(4):301-305. doi:10.1136/rapm-2019-100569

34. Sola C, Raux O, Savath L, Macq C, Capdevila X, Dadure C. Ultrasound guidance characteristics and efficiency of suprazygomatic maxillary nerve blocks in infants: a descriptive prospective study. *Paediatr Anaesth*. 2012;22(9):841-846. doi:10.1111/j.1460-9592.2012.03861.x

35. Prigge L, van Schoor AN, Bosman MC, Bosenberg AT. Clinical anatomy of the maxillary nerve block in pediatric patients. *Paediatr Anaesth*. 2014;24(11):1120-1126. doi:10.1111/pan.12480

36. Echaniz G, Chan V, Maynes JT, Jozaghi Y, Agur A. Ultrasound-guided maxillary nerve block: an anatomical study using the suprazygomatic approach. *Can J Anaesth*. 2020;67(2):186-193. doi:10.1007/s12630-019-01481-x

37. Pani N, Kumar Rath S. Regional & topical anaesthesia of upper airways. *Indian J Anaesth*. 2009;53(6):641-648.

38. Oberhofer HM, Breslin N, Heindel H, Ching J. Analgesic efficacy of intraoperative nerve blocks for primary palatoplasty. *J Craniofac Surg*. 2021;32(2):594-596. doi:10.1097/SCS.0000000000006829

39. Mostafa MF, Herdan R, Elshazly M. Comparative study of levobupivacaine and bupivacaine for bilateral maxillary nerve block during pediatric primary cleft palate surgery:

a randomized double-blind controlled study. *Korean J Anesthesiol*. 2018;71(2):135-140. doi:10.4097/kjae.2018.71.2.135

40. Mostafa MF, Aal FAA, Ali IH, Ibrahim AK, Herdan R. Dexmedetomidine during suprazygomatic maxillary nerve block for pediatric cleft palate repair, randomized double-blind controlled study. *Korean J Pain*. 2020;33(1):81-89. doi:10.3344/kjp.2020.33.1.81

41. Mesnil M, Dadure C, Captier G, et al. A new approach for peri-operative analgesia of cleft palate repair in infants: the bilateral suprazygomatic maxillary nerve block. *Paediatr Anaesth*. 2010;20(4):343-349. doi:10.1111/j.1460-9592.2010.03262.x

42. Chiono J, Raux O, Bringuier S, et al. Bilateral suprazygomatic maxillary nerve block for cleft palate repair in children: a prospective, randomized, double-blind study versus placebo. *Anesthesiology*. 2014;120(6):1362-1369. doi:10.1097/ALN.0000000000000171

43. Harris PA, Taylor R, Minor BL, et al; REDCap Consortium. The REDCap consortium: building an international community of software partners. *J Biomed Inform*. doi:10.1016/j.jbi.2019.103208

44. Crellin D, Harrison D, Santamaria N, Babl FE. Comparison of the psychometric properties of the FLACC scale, the MBPS and the observer applied visual analogue scale used to assess procedural pain. *J Pain Res*. 2021;14:881-892. doi:10.2147/JPR.S267839

45. Redmann AJ, Wang Y, Furstein J, Myer CM III, de Alarcón A. The use of the FLACC pain scale in pediatric patients undergoing adenotonsillectomy. *Int J Pediatr Otorhinolaryngol*. 2017;92:115-118. doi:10.1016/j.ijporl.2016.11.016

46. Nilsson S, Finnström B, Kokinsky E. The FLACC behavioral scale for procedural pain assessment in children aged 5-16 years. *Paediatr Anaesth*. 2008;18(8):767-774. doi:10.1111/j.1460-9592.2008.02655.x

47. Malviya S, Voepel-Lewis T, Burke C, Merkel S, Tait AR. The revised FLACC observational pain tool: improved reliability and validity for pain assessment in children with cognitive impairment. *Paediatr Anaesth*. 2006;16(3):258-265. doi:10.1111/j.1460-9592.2005.01773.x

48. Mitchell RB, Archer SM, Ishman SL, et al. Clinical Practice Guideline: tonsillectomy in children (update)—executive summary. *Otolaryngol Head Neck Surg*. 2019;160(2):187-205. doi:10.1177/0194599818807917

49. Batra YK, Shamsah M, Al-Khasti MJ, Rawdhan HJF, Al-Qattan AR, Belani KG. Intraoperative small-dose ketamine does not reduce pain or analgesic consumption during perioperative opioid analgesia in children after tonsillectomy. *Int J Clin Pharmacol Ther*. 2007;45(3):155-160. doi:10.5414/CPP45155

50. Sullivan GM, Feinn R. Using effect size-or why the P value is not enough. *J Grad Med Educ*. 2012;4(3):279-282. doi:10.4300/JGME-D-12-00156.1

51. Kim M, Kacker A, Kutler DI, et al. Pain and opioid analgesic use after otorhinolaryngologic surgery. *Otolaryngol Head Neck Surg*. 2020;163(6):1178-1185. doi:10.1177/0194599820933223

52. Levy B, Paulozzi L, Mack KA, Jones CM. Trends in opioid analgesic-prescribing rates by specialty, US, 2007-2012. *Am J Prev Med*. 2015;49(3):409-413. doi:10.1016/j.amepre.2015.02.020

53. Sanders JC, King MA, Mitchell RB, Kelly JP. Perioperative complications of adenotonsillectomy in children with obstructive sleep apnea syndrome. *Anesth Analg*. 2006;103(5):1115-1121. doi:10.1213/01.ane.0000244318.77377.67

54. Brinkman JE, Toro F, Sharma S. Physiology Respiratory Drive. StatPearls. 2021. Accessed April 19, 2024. https://www.ncbi.nlm.nih.gov/books/NBK482414/

55. Baldo BA, Rose MA. Mechanisms of opioid-induced respiratory depression. *Arch Toxicol*. 2022;96(8):2247-2260. doi:10.1007/s00204-022-03300-7

56. Boom M, Niesters M, Sarton E, Aarts L, Smith TW, Dahan A. Non-analgesic effects of opioids: opioid-induced respiratory depression. *Curr Pharm Des*. 2012;18(37):5994-6004. doi:10.2174/138161212803582469

57. Radder K, Shah A, Fatima S, Kothari C, Zakaullah S, Siddiqua A. Efficacy and feasibility of frontozygomatic angle approach for extra oral maxillary nerve block in oral surgery: a descriptive clinical trial. *J Maxillofac Oral Surg*. 2014;13(3):231-237. doi:10.1007/s12663-013-0514-7

58. Nores GDG, Cuzzone DA, Hush SE, et al. The impact of bilateral suprazygomatic maxillary nerve blocks on postoperative pain control in patients undergoing orthognathic surgery. *FACE*. 2020;1(1):58-65. doi:10.1177/2732501620949188

59. Basuni AS, Ezz HAA, Albirmawy OA. Preoperative peritonsillar infiltration of dexamethasone and levobupivacaine reduces pediatric post-tonsillectomy pain: a double-blind prospective randomized clinical trial. *J Anesth*. 2013;27(6):844-849. doi:10.1007/s00540-013-1638-0

60. Gemma M, Piccioni LO, Gioia L, Beretta L, Bussi M. Ropivacaine peritonsillar infiltration for analgesia after adenotonsillectomy in children: a randomized, double-blind, placebo-controlled study. *Ann Otol Rhinol Laryngol*. 2009;118(3):227-231. doi:10.1177/000348940911800311

61. Sun J, Wu X, Zhao X, Chen F, Wang W. Pre-emptive peritonsillar infiltration of magnesium sulphate and ropivacaine vs. ropivacaine or magnesium alone for relief of post-adenotonsillectomy pain in children. *Int J Pediatr Otorhinolaryngol*. 2015;79(4):499-503. doi:10.1016/j.ijporl.2015.01.009

62. Grainger J, Saravanappa N. Local anaesthetic for post-tonsillectomy pain: a systematic review and meta-analysis. *Clin Otolaryngol*. 2008;33(5):411-419. doi:10.1111/j.1749-4486.2008.01815.x

63. Echaniz G, Chan V, Maynes JT, Jozaghi Y, Agur A. Ultrasound-guided maxillary nerve block: an anatomical study using the suprazygomatic approach. *Can J Anaesth*. 2020;67(2):186-193. doi:10.1007/s12630-019-01481-x

64. Jerman A, Umek N, Cvetko E, et al. Comparison of the feasibility and safety of infrazygomatic and suprazygomatic approaches to pterygopalatine fossa using virtual reality. *Reg Anesth Pain Med*. 2023;48:359-364. doi:10.1136/rapm-2022-104068

65. Radder K, Shah A, Kothari C, Giraddi G, Sharma D, Nayak R. Comparison of frontozygomatic versus sigmoid notch approach for extraoral maxillary nerve block anesthesia: a prospective clinical trial. *J Maxillofac Oral Surg*. 2018;17(3):301-307. doi:10.1007/s12663-017-1045-4

66. Malamed SF. *Handbook of Local Anesthesia*. Elsevier Health Sciences; 2012.

67. Barbero GE, de Miguel M, Sierra P, et al. Clonidine as an adjuvant to bupivacaine for suprazygomatic maxillary nerve blocks in cleft lip and palate repair: a randomized, prospective, double-blind study. *Cleft Palate Craniofac J*. 2021;58(6):755-762. doi:10.1177/1055665620964141

68. Mansour RF, Abdelghany MS. Ultrasound-guided suprazygomatic maxillary nerve block in cleft palate surgery: the efficacy of adding dexmedetomidine to bupivacaine. *Egypt J Anaesth*. 2021;37(1). doi:10.1080/11101849.2021.1953832

69. Esfahanian M, Marcott SC, Hopkins E, et al. Enhanced recovery after cleft palate repair: a quality improvement project. *Paediatr Anaesth*. 2022;32(10):1104-1112. doi:10.1111/pan.14541

70. Mesnil M, Dadure C, Captier G, et al. A new approach for peri-operative analgesia of cleft palate repair in infants: the bilateral suprazygomatic maxillary nerve block. *Paediatr Anaesth*. 2010;20(4):343-349. doi:10.1111/j.1460-9592.2010.03262.x

71. Postier AC, Chambers C, Watson D, Schulz C, Friedrichsdorf SJ. A descriptive analysis of pediatric post-tonsillectomy pain and recovery outcomes over a 10-day recovery period from 2 randomized, controlled trials. *Pain Rep*. 2020;5(2):e819. doi:10.1097/PR9.0000000000000819

72. Hession-Laband E, Melvin P, Shermont H, Murphy JM, Bukoye B, Amin M. Reducing readmissions post-tonsillectomy: a quality improvement study on intravenous hydration. *J Healthc Qual*. 2018;40(4):217-227. doi:10.1097/JHQ.0000000000000143

73. Shelton FR, Ishii H, Mella S, et al. Implementing a standardised discharge analgesia guideline to reduce paediatric post tonsillectomy pain. *Int J Pediatr Otorhinolaryngol*. 2018;111:54-58. doi:10.1016/j.ijporl.2018.05.020

74. Smith CR, Dickinson KJ, Carrazana G, et al. Ultrasound-guided suprazygomatic nerve blocks to the pterygopalatine fossa: a safe procedure. *Pain Med*. 2022;23(8):1366-1375. doi:10.1093/pm/pnac007