



Impact of Coblation Versus Electrocautery on Acute Post-Operative Outcomes in Pediatric Tonsillectomy

Chen Lin, MD ; Arlyne K. Thung, MD; Kris R. Jatana, MD ; Jennifer N. Cooper, MS, PhD;
L. Christine Barron, BA; Charles A. Elmaraghy, MD

Objective: Based on previous studies in the pediatric population, it remains unclear whether there is a difference in post-operative pain between two widely used tonsillectomy techniques: coblation and bovie electrocautery. This large prospective study investigates whether postoperative pain scores differ between these two surgical techniques for tonsillectomy.

Methods: Prospective, non-randomized study of children aged 2–8 enrolled in a randomized controlled trial of single-dose intravenous acetaminophen for pain associated with adenotonsillectomy. Included procedures occurred between October 2012 and June 2015 at a tertiary referral center. Only patients whose operations exclusively used coblation or electrocautery and who required postoperative admission for extended observation were included. Follow-up period was the length of inpatient stay. Patients and nurses who recorded the pain scores were blinded to the tonsillectomy technique.

Results: A total of 183 patients were included: 117 coblation cases and 66 electrocautery cases. Pain scores in the surgical recovery unit and pain scores after admission to the floor unit were not significantly different between coblation and electrocautery, either before or after adjustment for patient age, body mass index, intravenous acetaminophen use, and surgeon. There was also no difference in length of stay, readmission rate, or post-tonsillectomy hemorrhage.

Conclusions: Coblation and electrocautery tonsillectomy are associated with similar post-operative pain scores in the recovery and inpatient units in the pediatric population. As coblation is costlier, the results of this study may affect which tool is used by otolaryngologists from a cost–benefit perspective.

Key Words: tonsillectomy, pediatric, coblation, electrocautery.

Level of evidence: III

INTRODUCTION

Tonsillectomy is one of the most common pediatric surgical procedures performed by otolaryngologists. It is estimated that 530,000 tonsillectomies are performed each year in children under 15 years of age.¹ A variety of surgical methods for performing tonsillectomy are available to surgeons, with coblation and electrocautery being two of the most commonly used methods.

Coblation (radiofrequency ablation) is a relatively new method of performing tonsillectomy that utilizes bipolar radiofrequency to create current through a saline medium. When saline particles are ionized, this energy is

transferred to the molecular bonds that make up tissue, resulting in ablation. From a technical standpoint, the benefit of coblation over electrocautery lies in the significant temperature reduction that allows tissue ablation to be achieved at temperatures between 40°–70 °C, while electrocautery reaches more than 400 °C.² Due to the lower temperatures of coblation and thus less heat dissipation into surrounding tissue, patients operated on with this technique have been reported to have reduced pain.^{3–7}

Pain control is one of the most important factors considered in tonsillectomy. Post-operative pain can continue for up to 2 weeks and can lead to decreased oral intake and dehydration requiring hospital readmission.⁸ There have been several studies comparing pain outcomes with coblation versus conventional methods of tonsillectomy, particularly electrocautery. Results within pediatric populations have varied greatly, with some studies reporting better pain control after coblation as compared to electrocautery,^{4–7} while other studies, including Cochrane reviews, have found no significant difference.^{9–13} Additionally, Jones et al. found a small but statistically significant difference in pain scores, but suggested that the difference was not clinically significant and that neither method is superior with regard to postoperative pain.¹⁰

As the literature remains unclear on whether coblation results in significantly improved postoperative pain control in the pediatric population, additional large prospective studies are necessary. We aimed to compare

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

From the Department of Otolaryngology-Head and Neck Surgery (C.L., K.R.J., C.A.E.), Nationwide Children's Hospital and The Ohio State University Wexner Medical Center, Columbus, Ohio; Department of Anesthesiology and Pain Medicine (A.K.T.), Nationwide Children's Hospital, Columbus, Ohio; Center for Surgical Outcomes Research (J.N.C.), The Research Institute at Nationwide Children's Hospital, Columbus, Ohio; and the The Ohio State University College of Medicine (L.C.B.), Columbus, Ohio.

Editor's Note: This Manuscript was accepted for publication 00 Month 2018.

Send correspondence to Chen Lin, MD, Department of Otolaryngology-Head and Neck Surgery, Nationwide Children's Hospital and The Ohio State University Wexner Medical Center, 4000 Eye and Ear Institute, 915 Olentangy River Road, Columbus, OH 43212, Phone: 540-588-4368, Fax: 614-293-1923. Email: chen.lin@osumc.edu

DOI: 10.1002/liv.2.212

postoperative pain after coblation versus electrocautery tonsillectomy in a large prospective cohort of children.

METHODS

Design

This was a prospective, single-blind, non-randomized study of participants enrolled in a randomized controlled trial investigating the analgesic effect of single dose intravenous acetaminophen in pediatric patients undergoing adenotonsillectomy.¹⁴ The study protocol and consent form were approved by Nationwide Children's Hospital Institutional Review Board. Children aged 2 to 8 years of age were recruited for the study from October 2012 to June 2015. Patients with the diagnosis of sleep disordered breathing or obstructive sleep apnea were included in the study and were required to have at least 6–8 hours of continuous pulse oximetry monitoring in the postoperative period. The exclusion criteria of the primary randomized controlled trial were: American Society of Anesthesiologists (ASA) physical status classification ≥ 4 , known allergy to acetaminophen or opioids, chronic opioid usage, comorbid renal or hepatic disease. In addition, for the present analysis, patients whose surgeons used a technique other than coblation or electrocautery or used more than one surgical technique were excluded.

Anesthetic Regimen

All patients received a standardized weight based anesthetic regimen that is outlined in the parent study.¹³

Surgical Procedure

All surgeries were performed by 1 of 7 pediatric fellowship trained board-certified otolaryngologists, all of whom used only coblation or electrocautery during the study period, except for one surgeon who used both methods. All surgeons had substantial experience with their method of choice. Total, or extracapsular, tonsillectomy was performed by standard technique for both coblation (Evac 70 Plasma Wand, Smith & Nephew, Cordova, Tennessee) and electrocautery. For coblation settings, "ablate" was set to 7 and "coagulate" was set to 3. For electrocautery, coagulation was set to 20 W. Postoperative pain medication in the form of fentanyl 0.5 mcg/kg was given in the post anesthesia care unit (PACU).

Outcome Measures

Pain in the post-anesthesia care unit (PACU) was assessed by the Faces, Legs, Activity, Cry, Consolability Scale (FLACC) scale that rates pain on a numeric scale from 0 to 10.¹⁵ Pain was assessed at time points 0, 5, 15, 30, and 60 minutes in the PACU. Patients with FLACC scores less than 4 did not receive pain medication. Poor pain control was defined as a pain score greater than or equal to 4. Therefore, patients with FLACC scores of at least 4 received fentanyl 0.5 mcg/kg every 10 minutes as needed. Pain scores were further assessed at the time of

arrival to the inpatient floor unit and at additional time points throughout the inpatient stay, which ranged from 1–3 days. Pain on the inpatient floor unit was assessed by either the FLACC scale or Wong-Baker FACES scale, which also ranges from 0 to 10.¹⁶ Pain control medications used on the inpatient floor unit included Tylenol (acetaminophen), Motrin (ibuprofen), Lortab (hydrocodone/acetaminophen), and Oxycodone. Total pain medication used on the floor unit was also recorded.

Statistical Analyses

All statistical analyses were performed with Statistical Analysis System (SAS) version 9.4 (SAS Institute Inc., Cary, NC). Pain scores were compared between surgical technique groups using Mann Whitney U tests. Other patient characteristics were compared between treatment groups using chi square or Fisher exact tests as appropriate for categorical variables and Mann Whitney U tests for continuous variables. Finally, multivariable models for numerical pain scores over time, postoperative pain medication use, and extended length of stay (>1 night) were fit. Numerical pain scores were analyzed using a negative binomial mixed effects regression model with patient-level intercepts. Quantities of postoperative pain medications used were analyzed using median regression models. Extended length of stay was analyzed using an Firth penalized logistic regression model due to the small number of patients with this outcome, P-values <0.05 were considered statistically significant.

RESULTS

Patient population

A total of 185 patients in the primary randomized controlled trial met inclusion criteria; however, 2 patients from the electrocautery group withdrew from the trial prior to study completion and so were also excluded from this analysis. Of the 183 remaining patients, 66 were in the electrocautery group and 117 in the coblation group. Patients ranged in age from 2 to 8 years, with median ages of electrocautery and coblation patients of 4.3 and 4.8 years, respectively (Table I). This small age difference was statistically significant ($P = 0.03$). Female patients composed 52% and 46% of the electrocautery and coblation groups respectively ($P = 0.49$). BMI percentile did not differ between groups ($P = 0.84$).

Other indications for tonsillectomy including chronic tonsillitis and tonsillar hypertrophy did not differ between the two surgical methods. Total surgical time for procedures using electrocautery averaged 15 minutes, while procedures using coblation took an average of 14 minutes (Table I). This difference was not statistically significant ($P = 0.30$).

When pre-operative and intra-operative medication usage was compared between groups, no significant differences were found in the amounts of midazolam, morphine, dexamethasone, or propofol used (Table I). Patients in the coblation group, however, did tend to receive more ondansetron.

TABLE I.
Characteristics of patients by tonsillectomy surgical technique.

	Electrocautery (N = 66)		Coblation (N = 117)		P
Age (years)	4.3	(3.5–5.6)	4.8	(3.9–6.0)	0.03
Female gender	34	(51.5%)	54	(46.2%)	0.49
BMI percentile	39.7	(19.3–71.5)	48.4	(13.0–73.7)	0.84
Race					0.56
Caucasian	42	(63.6%)	82	(70.1%)	
African American	14	(21.2%)	23	(19.7%)	
Other race or multi-racial	10	(15.2%)	12	(10.3%)	
Surgical indication (other than SDB/OSA)					
Chronic tonsillitis ± adenoiditis	11	(16.7%)	30	(25.6%)	0.16
Tonsillar/adenotonsillar hypertrophy	54	(81.8%)	89	(76.1%)	0.37
Duration of operation (minutes)	15	(12–19)	14	(12–18)	0.30

Medians and interquartile ranges are shown as appropriate. P values are from Mann Whitney U tests, chi square tests, or Fisher exact tests as appropriate. BMI percentiles for age were calculated using year 2000 CDC growth curves.

Pain Scores

There was no statistically significant difference in pain scores at any time point in the PACU. Mean pain scores for the electrocautery group at 0, 5, 15, 30, and 60 minutes in the recovery unit were 0.09, 0.33, 1.92, 2.85, and 1.74. Mean pain scores for the coblation group at the same time points were 0.03, 0.51, 1.60, 2.27, and 1.32. Median pain scores were zero at all time points in both groups. Differences in pain scores between electrocautery and coblation groups were not statistically significant at any time point in the PACU (Table II).

Poor pain control in the PACU, defined as FLACC score greater than or equal to 4, was used to determine whether patients received pain medication in the recovery unit (Table III). Poor pain control occurred in 36 of 66 patients (55%) in the electrocautery group and 62 of 117 patients (53%) in the coblation group. This outcome was not statistically significant (P = 0.84).

First pain scores upon arrival to the inpatient unit were not statistically significantly different between the

two groups. Pain scores were collected during the inpatient stay, which ranged from 6 hours to 3 days, with all but 5 patients admitted overnight. When each patient's maximum pain score across all time points was calculated, no significant difference was found between groups, with the median of the maximum pain scores being 5 in both groups (Table II). In both groups, 83% of patients experienced poor pain control at some point during their postoperative hospital stay (P = 0.94) (Table III). When all pain scores were examined together in a single longitudinal multivariable model, we found no difference in average pain scores throughout the course of hospitalization between groups (Table IV).

Pain Medication Use

There was no significant difference in the amount of fentanyl given in the PACU to either group (P = 0.07). However, we did find significant differences in the amount of pain medication taken on the floor unit (Table III). Total Tylenol or Motrin taken on the unit was significantly higher in the electrocautery group (P < 0.001), while total Loratab was significantly higher in the coblation group (P = 0.008). The choice of pain medication prescribed varied significantly according to the surgeon who performed the procedure. When these differences in medication use between groups were adjusted for the surgeon in median regression models, they became non-significant (P > 0.75).

Length of Stay

The average time spent in the PACU after coblation or electrocautery tonsillectomy was 30 and 35 minutes respectively (P = 0.52) (Table III). Total length of time spent in the hospital ranged from 6 hours to 3 days, with no significant difference between the two groups (p = 1.00). When length of stay was evaluated as a dichotomous outcome (>1 night vs ≤1 night), there was also no difference between groups either before or after adjustment for age, BMI, intravenous Tylenol use, and surgeon (Tables III and V).

TABLE II.
Pain scores by group in the post-anesthesia care unit (PACU) and inpatient unit.

	Electrocautery (N = 66)	Coblation (N = 117)	P
Time in PACU			
0 min	0 (0–0)	0 (0–0)	0.68
5 min	0 (0–0)	0 (0–0)	0.43
15 min	0 (0–5)	0 (0–2)	0.34
30 min	0 (1.5–5)	0 (0–5)	0.13
60 min	0 (0–3)	0 (0–2)	0.17
At time of arrival to inpatient unit (N = 172)*	0 (0–0)	0 (0, 0)	0.71
Maximum pain score across all time points	5 (6–8)	5 (6–8)	0.55

*Only 172 out of 183 patients had pain scores reported at the time of arrival to the inpatient unit.

Medians and interquartile ranges are shown. P values are from Mann Whitney U tests.

TABLE III.
Outcomes by tonsillectomy surgical technique.

	Electrocautery (N = 66)	Coblation (N = 117)	P
Poor pain control	55 (83.3%)	97 (82.9%)	0.94
Total postoperative Fentanyl in PACU (mcg)	0 (0-0)	0 (0-0)	0.07
Tylenol or Motrin taken on unit (mg)	160 (0-480)	0 (0-0)	<0.001
Total hydrocodone-acetaminophen taken on unit (mg)	5.1 (3.2-6.9)	5.7 (4.8-7.5)	0.008
Time spent in PACU (minutes)	35 (12-49)	30 (10-50)	0.52
Stayed in hospital >1 night	5 (7.6)	11 (9.4)	0.79
Readmissions	3 (4.5%)	6 (5.1%)	0.94
Post-tonsillectomy hemorrhage	2 (3.0%)	4 (3.4%)	0.95

Poor pain control was defined as any post-op pain score $\geq 4/10$. P values are from a Fisher exact test for LOS, a chi square test for pain control and Tylenol taken on unit, and Mann Whitney U tests for total postoperative opioids and time spent in the PACU. Readmission data was retrospectively collected over a period of 14 days following surgery.

Readmissions

Data on readmissions to the hospital within 14 days of surgery were retrospectively collected. There was no significant difference in readmission rates between the groups (P = 0.94) (Table III). Additionally, we examined reasons for readmission. We found that 2 out of 66 patients (3.0%) who underwent coblation tonsillectomy had post-tonsillectomy hemorrhage (PTH) versus 4 out of 117 (3.4%) patients who underwent electrocautery tonsillectomy (P = 0.95). The remaining causes for readmissions were related to dehydration.

DISCUSSION

Coblation and electrocautery are two of the most commonly used methods of tonsillectomy. Otolaryngologists consider many factors when choosing a surgical technique for tonsillectomy, but the patient's postoperative pain is a primary concern. Post-operative pain can continue for up to 2 weeks and can lead to decreased oral

intake and dehydration requiring hospital readmission.⁸ Despite many prospective studies comparing these methods to determine which one causes less post-operative pain, there is not a clear consensus.^{4-7,9-13}

Temple and Timms authored a commonly cited study that showed a significant reduction in pediatric pain scores with coblation especially as time progressed after surgery.⁷ Since that study, there have been many studies comparing coblation versus conventional methods of tonsillectomy. Noordzij and Affleck showed a small but statically significant average difference in pain scores over a 2 week post-operative follow-up period in adult tonsillectomy patients who received coblation vs. electrocautery. However, when individual postoperative days were examined, differences were significant only up to postoperative day 3.³ Parsons et al. showed a significant difference in pain scores in children across a 10-day period but did not compare daily scores.⁵ Jones et al. reported statistically significantly lower pain scores in coblation patients only on postoperative day 0, but the authors suggested that the small difference they detected was not clinically significant.¹⁰ Shah et al. reported similar pain scores, morphine consumption, and time to return to normal

TABLE IV.
Multivariable model for pain scores over time.

Variable	Percentage difference in average pain score during hospitalization (95% CI)	P
Age (1 year increase)	6.0 (-1.2, 13.7)	0.10
BMI percentile (10% increase)	1.9 (-1.4, 5.2)	0.26
Surgeon		0.45
1	71.7 (-33.0, 340.0)	
2	36.5 (-46.9, 250.9)	
3	25.0 (-39.7, 158.9)	
4	17.8 (-42.8, 142.3)	
5	-12.8 (-60.2, 91.3)	
6	2.7 (-53.3, 126.1)	
7	ref	
IV Tylenol	-8.6 (-25.6, 12.2)	0.39
Electrocautery	-21.9 (-57.2, 42.4)	0.42

Numerical pain scores were analyzed using a negative binomial mixed effects regression model with patient-level intercepts. Independent variables included age, BMI, surgeon, technique, and IV Tylenol.

TABLE V.
Multivariable model for length of stay >1 night.

Variable	Odds ratio (95% CI)	P
Age (1 year increase)	1.4 (1.0, 2.1)	0.07
BMI percentile (10% increase)	1.1 (1.0, 1.4)	0.11
Surgeon		0.74
1	2.5 (0.0, 333.4)	
2	1.1 (0.0, 127.0)	
3	2.4 (0.1, 80.5)	
4	1.2 (0.0, 35.3)	
5	2.8 (0.1, 122.9)	
6	8.8 (0.1, 727.5)	
7	ref	
IV Tylenol	2.1 (0.8, 5.8)	0.16
Electrocautery	1.6 (0.1, 46.5)	0.77

Extended length of stay (> 1 night) was analyzed as a dichotomous variable using a Firth penalized logistic regression model.

function with coblation and electrocautery in pediatric tonsillectomy patients.⁹

Due to varied findings in these previous studies, we sought to determine whether coblation was associated with lower post-operative pain scores compared to electrocautery at our institution. In the parent RCT study, the main objective of that study was to determine whether intravenous acetaminophen affected postoperative outcomes which included PACU pain scores, PACU opioid consumption, length of PACU stay, and time to first analgesic on the inpatient ward. None of these post-operative outcomes were affected by the single dose of IV acetaminophen.¹⁴

Despite not showing a significant difference in pain scores while children were recovering from tonsillectomy in the hospital, we did show differences in the amount of pain medication used on the inpatient floor only. However, our results do not clearly point to one method requiring more pain medication than the other. While opioid usage was significantly greater in the coblation group, non-opioid medication usage was greater in the electrocautery group. These results are difficult to interpret because the choice of pain medication prescribed varied significantly according to the surgeon who performed the procedure. Pain medication given on the inpatient unit was based on surgeon preference and experience with specific pain medications. Despite these preferences, the rater was blinded to both the surgeon and tonsillectomy technique in each case.

An alignment between the surgeon's surgical technique preference and pain medication preference strongly confounded this finding. Of note, when the differences in medication use between groups were adjusted for the surgeon in median regression models, they became non-significant.

Since this study was conducted, our institution has implemented a standardized inpatient pain regimen consisting of scheduled weight-based ibuprofen and acetaminophen in alternating doses. Opioids are now only given for inadequate pain control after patients have failed first line therapy.

Given the findings of our study and other studies that have shown no significant difference in pain between these techniques, we ask the question of whether the cost of coblation can be justified.⁹⁻¹³ As health care costs shift from insurance companies to hospitals and physicians, physicians must become more accountable for the costs of their decisions, including equipment.¹⁷ Meier et al. revealed that OR costs and supplies were responsible for the greatest variation in total costs for tonsillectomy, accounting for 31.9% and 15.6% of total costs, respectively.^{18,19} The variation in supply costs ranged from \$4 to \$491 and was directly related to the instrument used. Instrument prices range from a few dollars for electrocautery to over two hundred dollars for coblation.^{12,19,20} The total cost of tonsillectomy ranged from \$1150 to over \$1800, and tonsillectomies using electrocautery consistently cost less than average while those using coblation cost more.¹⁸

In addition to supply costs, OR costs, which are driven by procedure time, are a significant contributor to total tonsillectomy costs.¹⁸ Some studies have shown that coblation takes significantly more time to complete.^{3,5,9} However, Meier et al. did not find a correlation between shorter

operative times and lower total costs, concluding that shorter operative times do not overcome differences in supply costs.^{18,19} Additionally, our study showed similar lengths of operative time between electrocautery and coblation, taking on average 15 and 14 minutes, respectively.

It is becoming more imperative that physicians be aware of the financial costs of their decision-making. Their clinical and surgical decisions have significant impacts on growing health care costs. Excess costs are increasingly identified and scrutinized in the current era of health care reform, with changes in the reimbursement system rapidly occurring. Reimbursements have begun shifting from a fee-for-service system to a bundled payment system, in which hospitals are reimbursed for a single episode of care rather than individual visits and procedures. In a bundled payment system, a single episode of care would include the surgery as well as all post-operative care, including consultations and treatment for complications.^{20,21} While this payment system does not currently include pediatric tonsillectomy, common surgical procedures in orthopedic, cardiac, and bariatric fields have fallen under a bundled payment system adopted by the Centers for Medicare and Medicare Services (CMS).^{16,21-23} Additionally, insurance companies have shown interest in moving to this type of system.²² Considering that tonsillectomy is the second most common pediatric surgery and ninth costliest procedure with one of the greatest levels of cost variation across institutions, it is feasible to assume that the costs of tonsillectomy surgery will be evaluated with greater scrutiny in the future and may soon become part of a bundled payment system used by Medicaid and other health care insurers.^{1,24} Additionally, our institution's Accountable Care Organization provides additional financial incentive to reducing the costs of procedures for Medicaid insured children.

There were notable limitations to this study. One limitation was the confounding effect of surgeon on the relationship between tonsillectomy technique and postoperative inpatient pain medication use. At the time of this study, there were differences in pain medication preference depending on the surgeon. However, our institution has since adopted a uniform protocol. Another limitation of this study was the length of time over which pain scores were collected post-operatively. Because we collected pain scores only during the patients' hospital stay, we do not know whether coblation or electrocautery significantly affected pain scores beyond the acute post-operative period. However, we were most interested in studying this acute post-operative period because poor pain control may result in delays in moving patients from the PACU to the inpatient unit or discharging the patient from the inpatient unit to home. These delays in care take up additional time and resources, ultimately leading to an increase in costs. Our study showed no significant difference in total time spent in the post-anesthesia or inpatient units between coblation and electrocautery.

CONCLUSIONS

Coblation and electrocautery for pediatric tonsillectomy were associated with similar post-operative pain

scores in the post-anesthesia recovery and inpatient units.

AUTHORSHIP

All authors contributed to the research proposal, literature review, and manuscript writing/editing. Dr. Jennifer Cooper additionally contributed to all statistical analyses. Drs. Arlyne Thung, Kris Jatana, and Charles Elmaraghy additionally contributed to data collection. All authors were in final approval of the manuscript submitted.

ACKNOWLEDGEMENTS

none.

CONFLICT OF INTEREST/FINANCIAL DISCLOSURE

Dr. Charles A. Elmaraghy – consultant for Smith & Nephew, Inc. as of September, 2015.

PREVIOUS PRESENTATION

Preliminary data from this work was presented at the Triological Society Combined Sections Meeting; January 22, 2016; Miami, FL.

SUBMISSION DECLARATION

This manuscript has not been published and is not under consideration for publication elsewhere.

FUNDING

This work was supported by departmental funding.

TRIAL REGISTRATION

IRB12-00097.

BIBLIOGRAPHY

1. Cullen KA, Hall MJ, Golosinskiy A. Ambulatory surgery in the United States. *Natl Health Stat Report* 2009;(11):1–25

2. Friedman M, LoSavio P, Ibrahim H, Ramakrishnan V. Radiofrequency tonsil reduction: safety, morbidity, and efficacy. *Laryngoscope* 2003;113(5):882–887.
3. Noordzij JP, Affleck BD. Coblation versus unipolar electrocautery tonsillectomy: a prospective, randomized, single-blind study in adult patients. *Laryngoscope* 2006;116(8):1303–1309.
4. Stoker KE, Don DM, Kang DR, Haupt MS, Magit A, Madgy DN. Pediatric tonsillectomy using coblation compared to conventional electrosurgery: a prospective, controlled single-blind study. *Otolaryngol Head Neck Surg* 2004;130(6):666–673.
5. Parsons SP, Cordes SR, Comer B. Comparison of posttonsillectomy pain using the ultrasonic scalpel, coblator, and electrocautery. *Otolaryngol Head Neck Surg* 2006;134(1):106–113.
6. Chang KW. Randomized controlled trial of coblation versus electrocautery tonsillectomy. *Otolaryngol Head Neck Surg* 2005;132(2):273–280.
7. Temple RH, Timms MS. Paediatric coblation tonsillectomy. *Int J Pediatr Otorhinolaryngol* 2001;61(3):195–198.
8. Stewart DW, Ragg RG, Sheppard S, Chaikiadis 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.
9. Shah UK, Galinkin J, Chiavacci R. Tonsillectomy by means of plasma-mediated ablation: prospective, randomized, blinded comparison with monopolar electrosurgery. *Arch Otolaryngol Head Neck Surg* 2002;128(6):672–676.
10. Jones DT, Kenna MA, Guidi J, Huang L, Johnston PR, Licameli GR. Comparison of postoperative pain in pediatric patients undergoing coblation tonsillectomy versus cautery tonsillectomy. *Otolaryngol Head Neck Surg* 2001;144(6):972–977.
11. Burton MJ, Doree C. Coblation versus other surgical techniques for tonsillectomy. *Cochrane Database Syst Rev* 2007;(3):CD004619.
12. Pynnonen M, Brinkmeier JV, Thorne MC, Chong LY, Burton MJ. Coblation versus other surgical techniques for tonsillectomy. *Cochrane Database Syst Rev* 2017;(8):CD004619.
13. Wilson YL, Merer DM, Moscatello AL. Comparison of three common tonsillectomy techniques: a prospective randomized, double-blinded clinical study. *Laryngoscope* 2009;119(1):162–170.
14. Thung AK, Elmaraghy CA, Barry N, et al. Double-blind randomized placebo-controlled trial of single-dose intravenous acetaminophen for pain associated with adenotonsillectomy in pediatric patients with sleep-disordered breathing. *J Pediatr Pharmacol Ther* 2017;22(5):344–351.
15. Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S. The FLACC: a behavioral scale for scoring postoperative pain in young children. *Pediatr Nurs* 1997;23(3):293–297.
16. Wong DL, Baker CM. Pain in children: comparison of assessment scales. *Pediatr Nurs* 1988;14(1):9–17.
17. Grenda TR, Pradarelli JC, Thumma JR, Dimick JB. Variation in hospital episode costs with bariatric surgery. *JAMA Surg* 2015;doi:10.1001/jamasurg.2015.2394 (Epub ahead of print).
18. Meier JD, Duval M, Wilkes J, Andrews S, Korgenski EK, Park AH, Srivastava R. Surgeon dependent variation in adenotonsillectomy costs in children. *Otolaryngol Head Neck Surg* 2014;150(5):887–892.
19. Meier JD, Zhang Y, Greene TH, Curtis JL, Srivastava R. Variation in pediatric outpatient adenotonsillectomy costs in a multihospital network. *Laryngoscope* 2015;125(5):1215–1220.
20. Prasad JT, Christenson JR, Cohen DS, Metz CM, Saraiya, SS, Haupt MS. The utility of common surgical instruments for pediatric adenotonsillectomy. *Laryngoscope* 2015;125(2):475–479.
21. Cutler DM, Ghosh K. The potential for cost savings through bundled episode payments. *N Engl J Med* 2012;366(12):1075–1077.
22. Miller DC, Gust C, Dimick JB, Birkmeyer N, Skinner J, Birkmeyer JD. Large variations in Medicare payments for surgery highlight savings potential from bundled payment programs. *Health Aff (Millwood)* 2011;30(11):2107–2115.
23. Mechanic RE. Mandatory Medicare bundled payment-is it ready for prime time? *N Engl J Med* 2015;373(14):1291–1293.
24. Keren R, Luan X, Localio R, Hall M., McLeod L., Dai D., Srivastava R., Pediatric Research in Inpatient Settings (PRIS) Network. Prioritization of comparative effectiveness research topics in hospital pediatrics. *Arch Pediatr Adolesc Med* 2012;166(12):1155–1164.