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The Utility of Common Surgical Instruments for Pediatric Adenotonsillectomy

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Objectives/Hypothesis: To evaluate the correlation between surgical instrumentation and intraoperative surgical time, postoperative hemorrhage, and associated healthcare cost for pediatric adenotonsillectomy.

Study Design: Retrospective chart analysis.

Methods: Chart data were collected from pediatric patients who underwent adenotonsillectomy from 2011 to 2013. Monopolar electrocautery, radiofrequency ablation, and PlasmaBlade instruments were compared for intraoperative surgical time and postoperative hemorrhage rate. Univariate analysis of variance (ANOVA) and χ^2 analysis was utilized to evaluate differences between instrumentation and variables. Cost analysis examining instrumentation and intraoperative anesthesia was also reviewed.

Results: A total of 1,280 patients who underwent adenotonsillectomy were evaluated. There was no significant overall difference in age, sex, or preoperative diagnosis identified between the three instrumentation groups. When examining the various instruments' effect on procedure time in minutes, univariate ANOVA demonstrated a significant difference overall among the three groups ($F = 8.79$; $P < .001$). Post-hoc pairwise comparisons identified significantly faster surgical times for monopolar cautery than either PlasmaBlade ($P = .03$) or radiofrequency ablation ($P < .001$). The difference in the number of patients who experienced a postoperative bleed by instrument was not statistically significant ($\chi^2 = 2.36$; $P = .31$). After instrumentation expenses were added to anesthesia cost, the overall average costs by instrument and surgical time were estimated to be $30.04 for monopolar cautery, $246.95 for PlasmaBlade, and $244.32 for radiofrequency ablation.

Conclusions: The ideal surgical instrumentation should be cost and time efficient with a low complication rate. Monopolar cautery was associated with a statistically significant lower intraoperative surgical time, similar postoperative hemorrhage rates, and lower operative costs when compared to radiofrequency ablation and PlasmaBlade.

Key Words: Pediatric, adenotonsillectomy, adenoidectomy, coblation, cost analysis, electrocautery, health policy, obstructive sleep apnea, PlasmaBlade, radiofrequency ablation, tonsillitis, tonsillectomy.

Level of Evidence: 4

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INTRODUCTION

Tonsillectomy and adenoidectomy continues to be among the most common operations performed by otolaryngologists in the pediatric population. An estimated 530,000 children undergo tonsillectomy (with or without adenoidectomy) and another 132,000 undergo adenoidectomy in the United States annually.[1] Predominantly performed due to recurrent adenotonsillitis in the past, the most common indication for adenotonsillectomy in the pediatric population is for the treatment of sleep-disordered breathing (SDB).[2] Due to technological advances, there currently exists a myriad of surgical tools from which the otolaryngologist can choose. Despite the commonality and frequency of adenotonsillectomy, there is no consensus regarding optimal surgical technique or instrument selection. In general, adenotonsillectomy carries considerable morbidity, including risk of intraoperative hemorrhage, postoperative hemorrhage, postoperative pain, and limitation of diet. Additionally, with the concern for increasing healthcare costs and emerging healthcare consumerism, cost-efficiency is paramount for sustainable practices. Therefore, operative time and surgical equipment expenses must be considered.

Traditionally, tonsillectomy was performed using "cold techniques" including guillotine, tonsil snare, or scalpel. Despite decreased operative time, a low rate of postoperative bleeding, and cost-efficiency associated with these methods, the use of cold dissection has been abandoned at many institutions due to high intraoperative blood loss and perceived perioperative risk when compared to other methods.[3] As a result, monopolar electrocautery gained popularity due to a reported decrease in intraoperative hemorrhage rate and ease of use.[4] However, one study suggested increased

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TABLE I.
Surgical Instrumentation and Cost.

Instruments	Cost (US$)
Monopolar needle cautery ($5.42) and suction coagulator ($7.88)	$13.30
ProCise XP plasma wand	$225.00
PEAK PlasmaBlade TnA dissection device	$228.77

PEAK = pulsed-electron avalanche knife.

postoperative pain secondary to the high continuous thermal energy (400°C to 600°C) used for dissection.[4] Regarding the rate of postoperative hemorrhage, studies are largely contradictory without clear consensus.[5] Furthermore, some suggest monopolar cautery dissection increases operative time when compared to cold dissection.[3]

Alternatively, bipolar radiofrequency ablation (coblation) significantly limits thermal heat to 40°C to 70°C through the use of irrigating saline and its bipolar component, providing a theoretical decrease in collateral tissue damage. Although several studies suggest a decreased need for postoperative analgesia with intracapsular coblation techniques, a recent Cochrane review concluded the evidence supporting decreased postoperative pain with radiofrequency ablation to be inadequate.[6,7] Other reports examining radiofrequency ablation have cited an increase in postoperative hemorrhage and surgical costs.[8,9] Moreover, inconsistent studies have been published when examining surgical time and insufficient evidence exists to determine whether radiofrequency ablation is superior, in regard to intraoperative efficiency and speed of recovery, when compared to other methods.[6,10]

Pulsed-electron avalanche knife (PEAK) PlasmaBlade technology was recently developed and is reported to cause less collateral tissue damage than both radiofrequency ablation and electrocautery by utilizing low thermal temperatures, pulsed radiofrequency, and plasma mediated electroconduction.[11] Despite this theoretical advantage, studies have yet to demonstrate significant difference in postoperative pain when compared to other methods.[12] A limited number of preliminary studies have reported decreased operative time and hemorrhage using plasma knife technology, but analysis regarding surgical cost and resource efficiency has not been studied.[13]

The goal of this study was to evaluate and compare the most commonly used surgical methods at our institution (monopolar diathermy, coblation, and PlasmaBlade), with the intent of elucidating the most efficient method for extracapsular adenotonsillectomy. Outcomes evaluated included intraoperative time, postoperative hemorrhage rate, and resource analysis of associated surgical anesthesia and instrument costs.

MATERIALS AND METHODS

Study Design

This retrospective cohort study evaluated children who received care at Children's Hospital of Michigan from 2011 to 2013. The cohort included three groups who underwent adenotonsillectomy, with the utilization of one of three different instruments (monopolar cautery, radiofrequency ablation, and PlasmaBlade). Group comparisons were performed evaluating intraoperative surgical time and postoperative bleed rate. Cost analysis was performed for each technique by evaluating instrument cost and surgical anesthesia time.

Subjects

Patient and surgical information of all children (mean age, 7.01 years; standard deviation [SD], 3.74; range, 6 months to 20 years) who underwent extracapsular adenotonsillectomy for the treatment of SDB, recurrent tonsillitis, or both from the years 2011 to 2013 were collected. Prior to the procedure, all children met criteria for adenotonsillectomy as defined by the American Academy of Otolaryngology–Head and Neck Surgery Clinical Practice Guidelines on Tonsillectomy in Children.[14] Demographic data, including age, gender, and medical history were recorded. All subjects with known bleeding disorders, developmental delay, craniofacial abnormalities, and history of peritonsillar abscesses were excluded from this study. Furthermore, all surgeons (including supervised residents and fellows) participating in this study had performed more than 50 adenotonsillectomies with each instrument before their operative data were recorded.

Intraoperative records on all patients were reviewed. Instrumentation type and operative time were recorded. Four fellowship-trained pediatric otolaryngologist directed all surgical procedures. No intraoperative support was utilized in regard to assistance with suctioning or retraction. The instruments examined in this study were monopolar cautery, radiofrequency ablation, and PlasmaBlade. Monopolar needle point cautery (Covidien, Dublin, Ireland) was used with the setting of 15 W to excise the tonsils, and a standard St. Clair Thompson's adenoid curette was used to excise the adenoids with hemostasis achieved via suction cautery (Covidien) at a coagulation setting of 25 W. Radiofrequency ablation was performed using the ProCise XP plasma wand (ArthroCare Corp., Sunnydale, CA) using an ablation setting of 7 W and coagulation setting of 3 W for the tonsils, with an ablation setting of 9 W and a coagulation setting of 5 W for the adenoids. The PEAK PlasmaBlade TnA Dissection Device (Medtronic, Minneapolis, MN) was utilized using the surgical settings of 1 W for cutting and 3 W for coagulation for both tonsillectomy and adenoidectomy. Intraoperative surgical time was calculated from incision start time to removal of McIver mouth gag.

To objectively examine the efficiency of each surgical instrument, postoperative information was reviewed for reports of bleeding. All reports of postoperative hemorrhage were examined and recorded. These data were then further evaluated for onset of bleeding <24 hours (primary hemorrhage) or >24 hours (secondary hemorrhage) postprocedure. Patients were classified as having a postoperative hemorrhage if any physician on physical exam noted active bleeding or the presence of fresh blood clots, and/or if the patient required bedside or further operative intervention. Last, a cost analysis was performed examining surgical instrument type and postinduction anesthesia cost to assess cost-effectiveness of the various instruments and associated surgical techniques in regard to time and outcome. Instrument cost was determined by manufacture-set prices that were currently paid by our institution (Table I). Postinduction anesthesia cost is primarily reimbursed in 15-minute increments converting to 1 unit. For this particular study, anesthesia cost was estimated using 2012 Medicaid reimbursement rates (US Department of Health and Human Services, Center for Medicare and Medicaid Services, 2012 Reimbursement Schedule).

TABLE II.
Preoperative Patient Characteristics.

Variable	Monopolar Cautery, N = 231, Mean (SD) or %	Radiofrequency Ablation, N = 505, Mean (SD) or %	PlasmaBlade, N = 544, Mean (SD) or %	F or χ^2	P
Age	7.09 (3.89)	6.90 (3.71)	7.09 (3.71)	0.38	.69
Sex (% female)	46.8%	52.7%	50.0%	2.31	.32
Preoperative diagnosis*				3.58	.47
OSA	17.2%	38.7%	44.1%		
Recurrent tonsillitis	19.3%	42.1%	38.6%		
OSA and recurrent tonsillitis	20.5%	40.4%	39.2%		

*Seven children with "other" diagnoses were removed from this analysis.
OSA = obstructive sleep apnea; SD = standard deviation.

Medicaid reimbursement rates are considered to more accurately reflect true economic costs in a pediatric institution. American Society of Anesthesiologists code 00170 was used for anesthesia units reimbursed for all associated procedures. The Medicaid reimbursement rate for 1 unit in 2012 was $9.64, averaging $0.64 per minute.

To ensure data reliability, two data collectors not involved in the procedures conducted all chart reviews independently. To demonstrate intrarater reliability, the same data collector reanalyzed 10% of the charts 1 month later. Inter-rater reliability was accounted for by reanalyzing 10% of the charts by the other data collector.

Data Analysis

Descriptive statistics including frequency distributions, measures of central tendency (mean, median, mode), and dispersion were conducted on all study variables. Univariate analysis of variance (ANOVA) was performed to evaluate differences in surgical length and child age by instrument. Pearson correlation examined the relationship between procedure length and child age. χ^2 analysis was used to examine differential rates of postoperative hemorrhage by both instrument and gender. χ^2 was also used to evaluate the relationship between gender and instrumentation. A cost analysis was performed using both postinduction anesthesia expense and instrument price. Intraoperative anesthesia expense was determined by calculating the cost of postinduction anesthesia per minute and multiplying by the total intraoperative surgical time. This was then added to the individual instrumentation cost used in each procedure to determine the total expense of resources utilized by the surgeon.

The protocol summary was reviewed by both Detroit Medical Center and Wayne State University institutional review boards. Full approval was granted for the collection and reporting of data in this study.

RESULTS

Of the 1,568 patients initially identified as potential study participants, 24 (1.5%) underwent tonsillectomy alone and 264 (16.8%) underwent adenoidectomy alone; these independent tonsillectomy and adenoidectomy patients were excluded. This left a sample population of 1,280 patients who underwent both tonsillectomy and adenoidectomy. The procedure was performed using monopolar cautery in 231 (18.0%) cases, radiofrequency ablation in 505 (39.5%) cases, and PlasmaBlade in 544 (42.5%) cases.

The ages of all subjects ranged from 6 months to 20 years (mean, 7.01; SD, 3.74), with only two individuals identified as older than 18 years (0.2%). When examining sex, 50.5% of all patients were female. Overall, 66.3% of patients underwent adenotonsillectomy for the diagnosis of obstructive sleep apnea alone, 19.8% for recurrent tonsillitis, and 13.4% for both. The remaining 0.5% (n = 7) had other diagnoses that required adenotonsillectomy. There was no significant overall difference in age, sex, or preoperative diagnosis identified among the three instrumentation groups (Table II).

The overall average surgical time regardless of instrumentation was 28.72 minutes (SD, 13.49). Individually, monopolar cautery demonstrated an average surgical time of 26.23 minutes (SD, 13.58), PlasmaBlade averaged 28.42 minutes (SD, 13.41), and radiofrequency ablation averaged 30.19 minutes (SD, 13.38) per procedure. When examining the various instruments' effect on procedure time in minutes, univariate ANOVA demonstrated a significant difference among the three groups ($F = 8.79$; $P < .001$). Post-hoc pairwise comparisons identified significantly faster surgical times for monopolar cautery than either both PlasmaBlade ($P = .03$) or radiofrequency ablation ($P < .001$). PlasmaBlade demonstrated significantly faster procedure times when compared to radiofrequency ablation ($P = .01$). Increasing age was also determined to result in longer surgical time regardless of instrumentation ($F = 129.26$; $P < .001$).

The total number of individuals with reported postoperative bleeds for the entire cohort was 26 (2.0%). Fourteen (1.1%) underwent surgery by radiofrequency ablation, eight (0.6%) by PEAK PlasmaBlade, and four (0.3%) by monopolar cautery. The difference in the number of patients who experienced a postoperative bleed by instrument was not statistically significant ($\chi^2 = 2.36$; $P = .31$). Similarly, there were no differences in the number of patients who reported a postoperative primary (n = 5; $\chi^2 = 5.77$; $P = .16$) or secondary (n = 21; $\chi^2 = 2.84$; $P = .24$) hemorrhage. Of the 21 patients with secondary bleeding, 12 (0.9%) underwent surgery by radiofrequency ablation, eight (0.5%) by PlasmaBlade, and four (0.2%) by

monopolar cautery. Patients who underwent adenotonsillectomy for recurrent infections demonstrated a statistically significant higher rate of postoperative hemorrhage regardless of instrumentation ($P = .016$).

An evaluation of the cost difference by instrument as reported by our institution's group purchasing organization was also examined and is listed in Table I. The average intraoperative anesthesia cost was \$16.74 for monopolar cautery, \$18.18 for PEAK PlasmaBlade, and \$19.32 for radiofrequency ablation. After instrumentation expenses were added to anesthesia cost, the overall average costs for instrument and time were estimated as \$30.04 for monopolar cautery, \$246.95 for PlasmaBlade, and \$244.32 for radiofrequency ablation.

DISCUSSION

Adenotonsillectomy is one of the most common surgical procedure throughout the world and in the United States.[15] Currently, various techniques and instruments exist for the removal of tonsils and adenoids, with very little consensus among surgeons as to which is optimal. With such a large volume of cases and the current focus on healthcare cost, improvements in adenotonsillectomy efficiency, safety, and resource management should be examined.

Throughout the evolution of surgical instrumentation and adenotonsillectomy, many studies have focused on postoperative hemorrhage rates and pain, but few have examined operative surgical time among various surgical instruments. Bhattacharyya examined 429,000 cases of nonspecific instrument adenotonsillectomy and discovered a relationship between increasing age and prolonged surgical time.[16] Similar findings were seen in this study, as a significant relationship was demonstrated between increasing patient age and intraoperative surgical time prolongation. Another report of 214 children retrospectively compared coblation, electrocautery, and intracapsular microdebridement procedure times and determined radiofrequency ablation to be faster than monopolar cautery, with an average time of 21.6 minutes compared to 26.1 minutes.[9] In this study, we utilized a much larger patient population, performed only extracapsular procedures, and noted a significantly shorter surgical time when monopolar cautery was used compared to radiofrequency ablation and PlasmaBlade ($P < .001$).

Postoperative adenotonsillectomy hemorrhage is a feared complication and has a reported occurrence ranging from 2.7% to 15.9%.[17] Postoperative hemorrhage has also been examined in many studies comparing monopolar cautery and radiofrequency ablation, but few to none have included PlasmaBlade analysis.[3,5,7,8,12,15,17,18] Hong and colleagues compared monopolar cautery to radiofrequency ablation regarding primary and secondary hemorrhage rates and reported no significant difference.[5] Another group examined monopolar cautery and PlasmaKnife for adenotonsillectomy and reported no significant difference in intraoperative blood loss.[12] This current study demonstrates a similar overall postoperative hemorrhage rate of 2.0% with no significant difference stratified between monopolar cautery, radiofrequency ablation, and PlasmaBlade.

In 2011, the Department of Health and Human Services published the National Quality Strategy Report seeking to improve healthcare efficiency through cost containment while maintaining quality treatment.[19] With this in mind, we examined surgeon-related costs in relation to surgical time and instrument use. Our findings demonstrated that monopolar cautery was less expensive and resulted in slightly less estimated anesthesia cost based on time. Adenotonsillectomy is performed approximately 600,000 times per year, and an estimated 70% of these are done with electrocautery or cold steel instrumentation.[15,20] Using this information, the estimated annual surgeon-related costs of the remaining 30% (180,000) of adenotonsillectomies can be calculated for each instrument evaluated in this study. The cost of using PlasmaBlade and radiofrequency ablation in this remaining group is \$44,451,000 and \$43,977,600 annually, respectively, whereas monopolar cautery was estimated to cost a total of \$5,407,200 for the same population annually. Consequently, we estimated an average savings of surgeon-related healthcare expense at \$38,807,100 per year by utilizing monopolar cautery en lieu of more costly surgical techniques for traditional adenotonsillectomy.

There were some limitations to this study. This study was retrospective, and therefore it was impossible to control for all intraoperative decision making and findings. The utilization of residents and fellows in a teaching institution also may add limitations in procedure time and technique. However, the same residents and fellows assisted all operations for all three instrumentation groups, thus decreasing confounding variables. In this study, fewer patients underwent adenotonsillectomy with monopolar cautery than both radiofrequency ablation and PlasmaBlade. Nonetheless, with the large number of subjects investigated and significant differences identified between the various instrument types, there was no concern regarding power and type II error in our analysis. Cost analysis was utilized to estimate surgeon-related costs and only examined the instrument cost as paid by our institution and postinduction Medicaid anesthesia expense. Product price and anesthetic billing varies based on an individual institution's group purchasing organization and anesthesia department. Also, there are many other institutional, nursing, and anesthetic cost factors that could be added to this analysis. Last, evaluation of postoperative pain was not performed, as these findings are largely subjective and current studies on this topic are inconclusive.[6,7,12] With the above in mind, this was a large population study that evaluated objective data findings to examine instrument-related efficiency, hemorrhage rate, and surgeon-associated cost.

CONCLUSION

There are many options for surgical instrumentation when performing adenotonsillectomy. An ideal product would be efficient, have a low complication rate, and

be relatively inexpensive. In this study, we examined a large group of subjects and identified use of monopolar cautery to be associated with a statistically significant lower intraoperative surgical time and similar postoperative hemorrhage rate when compared to radiofrequency ablation and PlasmaBlade. Furthermore, monopolar cautery use was associated with lower surgeon-related healthcare costs.

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