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 \( \chi^2 \) 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 \$30.94 for monopolar cautery, \$246.95 for PlasmaBlade, and \$224.52 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, coagulation, 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. 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). 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. As a result, monopolar electrocautery gained popularity due to a reported decrease in intraoperative hemorrhage rate and ease of use. However, one study suggested increased

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TABLE I. Surgical Instrumentation and Cost.

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monopolar needle cautery ($5.42)</td>
<td>$13.30</td>
</tr>
<tr>
<td>and suction coagulator ($7.88)</td>
<td></td>
</tr>
<tr>
<td>ProCise XP plasma wand</td>
<td>$225.00</td>
</tr>
<tr>
<td>PEAK PlasmaBlade TnA dissection device</td>
<td>$228.77</td>
</tr>
</tbody>
</table>

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.9

Alternatively, bipolar radiofrequency ablation (coablation) 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 coablation techniques, a recent Cochrane review concluded the evidence supporting decreased postoperative pain with radiofrequency ablation to be inadequate.4,7 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, coablation, 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.13 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 the 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 otolaryngologists 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., Sunnyvale, CA) using an ablation setting of 7 W and coagulation setting of 3 W for the tonsil, 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 McVay 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 (USD Department of Health and Human Services, Center for Medicare and Medicaid Services, 2012 Reimbursement Schedule).

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Medicaid reimbursement rates are considered to more accurately reflect true economic costs in a pediatric institution. American Society of Anesthetologists 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 inter-rater reliability, the same data collector analyzed 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. Analysis was used to examine differential rates of postoperative hemorrhage by both instrument and gender. 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, 60.3% of patients underwent adenotonsillectomy for the diagnosis of obstructive sleep apnea alone, 19.8% for recurrent tonsillitis, and 13.4% for both. The remaining 5.5% (n = 7) had other diagnoses that included 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 26.93 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 bled was for the entire cohort was 26 (2.0%). Seventeen (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 (χ² = 2.36; P = .11). Similarly, there were no differences in the number of patients who reported a postoperative primary (n = 5, χ² = 5.77; P = .16) or secondary (n = 21, χ² = 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 cauter. Patients who underwent adenotonsillec-
tomy 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 organi-
zation was also examined and is listed in Table I. The
average intraoperative anesthesia cost was $16.74 for
monopolar cauter, $18.18 for PEAK PlasmaBlade, and
$19.32 for radiofrequency ablation. After instrumenta-
tion expenses were added to anesthesia cost, the overall
average costs for instrument and time were estimated as
$30.04 for monopolar cauter, $246.95 for PlasmaBlade,
and $244.32 for radiofrequency ablation.

**DISCUSSION**

Adenotonsillectomy is one of the most common sur-
gical procedure throughout the world and in the United
States.\(^5\) Currently, various techniques and instru-
ments 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 instrumenta-
tion and adenotonsillectomy, many studies have focused
on postoperative hemorrhage rates and pain, but few
have examined operative surgical time among various
surgical instruments. Bhatcharyya examined 429,000
cases of nonselective instrument adenotonsillectomy and
discovered a relationship between increasing age and
prolonged surgical time.\(^6\) Similar findings were seen in
this study, as a significant relationship was demonstra-
ted between increasing patient age and intraopera-
tive surgical time prolongation. Another report of 214
children retrospectively compared clobation, electrocau-
ter, and intracapsular microdebridement procedure
times and determined radiofrequency ablation to be
faster than monopolar cauter, 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 cauter was used
compared to radiofrequency ablation and PlasmaBlade
($P < .001$).

Postoperative adenotonsillectomy hemorrhage is a
fearful complication and has a reported occurrence rang-
ing 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 radiofre-
cyency ablation regarding primary and secondary hemor-
rhage rates and reported no significant difference.\(^5\)
Another group examined monopolar cautery and Plasma-
Knife for adenotonsillectomy and reported no significant
difference in intraoperative blood loss.\(^12\) This current
study demonstrates a similar overall postoperative hem-
orrhage rate of 2.0% with no significant difference strati-
ied between monopolar cauter, 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 find-
ings demonstrated that monopolar cauter was less
expensive and resulted in slightly less estimated anes-
thesia 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 abla-
tion 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 esti-
imated an average savings of surgeon-related healthcare
expense at $38,807,100 per year by utilizing monopolar
cautery on 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 proce-
dure time and technique. However, the same residents
and fellows assisted all operations for all three instru-
mentation groups, thus decreasing confounding vari-
ables. In this study, fewer patients underwent
adenotonsillectomy with monopolar cauter than both
radiofrequency ablation and PlasmaBlade. Nonetheless,
with the large number of subjects investigated and sig-
ificant differences identified between the various
instrument types, there was no concern regarding power
and type II error in our analysis. Cost analysis was util-
ized to estimate surgeon-related costs and only exami-
ned the instrument cost as paid by our institution and
postinduction Medicaid anesthesia expense. Product
price and anesthetic billing varies based on an individ-
ual institution's group purchasing organization and
anesthesia department. Also, there are many other insti-
tutional, nursing, and anesthetic cost factors that could
be added to this analysis. Last, evaluation of postopera-
tive pain was not performed, as these findings are
largely subjective and current studies on this topic are
inconclusive.\(^6,7,15\) With the above in mind, this was a
large population study that evaluated objective data
findings to examine instrument-related efficiency, hem-
orrhage rate, and surgeon-associated cost.

**CONCLUSION**

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

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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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BIBLIOGRAPHY