Comparison of Pediatric Intracapsular Tonsillectomy and Extracapsular Tonsillectomy: A Cost and Utility Decision Analysis

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Abstract

Objectives. To use decision analysis modeling to compare utility and cost outcomes of intracapsular tonsillectomy (ICT) and extracapsular tonsillectomy (ECT). To use sensitivity analysis to determine the most important factors influencing outcomes favoring one surgical method versus another.

Study Design. Decision analysis model.

Setting. Hypothetical cohort.

Subjects and Methods. A decision analysis model was created with computer software comparing the results of ICT and ECT. The model featured complications with completion tonsillectomy, such as postsurgical bleed, dehydration, and tonsillar regrowth. Outcomes were quantified with a utility scale ranging from 0.95 (1 surgical procedure without complications) to 0.55 (ICT, regrowth requiring completion ECT, post-ECT bleeding). Costs measured out-of-pocket costs for an insured patient and factored in different recovery times for ECT versus ICT.

Results. Based on baseline parameters, ECT had higher cumulative utility than ICT. Utility model results were highly dependent on the value of having a single uncomplicated surgery, as well as on the tonsillar regrowth rate. Utility was equal at a regrowth rate of 1.64%; rates above this value favored ECT. The base cost model showed that ICT ($4177.92) was less expensive than ECT ($4546.91), although ICT with regrowth had the highest outcome cost ($8393.91). ECT and ICT costs were equal at a tonsil regrowth rate of 17.8% and at a recovery period of 7.4 days.

Conclusion. Utility decision modeling based on best estimates for baseline parameters suggests that ECT may be slightly superior to ICT, but cost analysis suggests the opposite. However, the comparative results are highly dependent on subtle changes in the tonsil regrowth rate and the potential difference in recovery time.

Keywords
tonsillotomy, tonsillectomy, decision analysis, utility measure, cost analysis

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Tonsil removal is one of the most commonly performed otolaryngologic surgical procedures worldwide.1,2 However, it has a known associated morbidity; therefore, there is a constant effort to improve and optimize the procedure to maximize benefits and limit its risks. With this in mind, there has been a recently renewed interest in intracapsular tonsillectomy (ICT; ie, partial tonsillectomy).3,4 Compared with extracapsular tonsillectomy (ECT; ie, complete tonsillectomy), ICT has been associated with diminished postoperative pain and may have lower rates of bleed and dehydration, leading to less analgesic use and quicker return to normal diet.5-7 However, ICT is uniquely associated with a tonsillar regrowth rate, which represents a potential source of recurrent tonsillitis, obstructive symptoms, and ultimate need for repeat surgery.8,9 Previously reported rates of tonsil regrowth vary from <1%10 to as high as 16%,11 and risk of reoperation was found to be greater after ICT than ECT.4

ECT was originally described in 1906,12 but it did not become the mainstream method of tonsil surgery until the introduction and acceptance of general anesthesia. Today, the most common method of ECT utilizes electrocautery.6,13 Inherent to technique, ECT may produce some amount of thermal injury to the surrounding pharyngeal muscles and expose them to the harsh environment of the pharynx during the postoperative healing phase; these factors...
potentially contribute to higher rates of pain and possible increased rates of postoperative bleeding. By leaving the tonsil capsule intact and avoiding exposure of the pharyngeal muscles, ICT may minimize some of the morbidities associated with ECT. However, these potential advantages may be offset by the possibility of tonsillar regrowth and revision ECT surgery, which makes determining the optimal approach elusive.

The technique of decision analysis can help to examine alternatives with competing trade-offs to estimate which option may be best. In decision analysis, a decision tree is plotted, starting from a choice with alternative treatment options (in our case, ECT vs ICT) and their relevant outcomes. The value of each alternate in the decision tree is determined by multiplying the likelihood of that outcome with the value of said outcome.

More important, decision analysis can access which parameters are most important and drive the key model outcomes. This approach is ideal when there exist outcomes data but a direct comparative study is problematic, if not practically impossible, due to ethical and/or practical limitations. The purpose of this study is to employ the published outcomes data for ICT and ECT in a decision analysis model based on comparative outcomes and complication rates to estimate which surgical method provides the best utility and is more cost-effective.

### Methods

This study uses only published data and therefore was exempted from institutional review board review at our institution, Walter Reed National Military Medical Center. A thorough literature review was conducted (MEDLINE, PubMed, Cochrane Databases) to determine initial model parameters and appropriate complication rate ranges for postoperative bleeding and dehydration rates for ICT and ECT, as well as tonsillar regrowth rate (Table 1).

A decision analysis model was created with TreeAge Pro (2008; TreeAge Software, Williamstown, Massachusetts) comparing the outcomes for tonsil removal once meeting criteria for the surgery. In this model, surgical outcomes included full recovery, postoperative tonsil bleed, and postoperative dehydration requiring intravenous hydration (Figure 1). Unique to the ICT arm was the possibility for tonsillar regrowth, with the performance of completion tonsillectomy (with its associated possible complications). For simplicity, several assumptions were made in model development: (1) A pediatric patient population (age, <18 years) met criteria for tonsil removal. (2) Insured patients sought treatment in a Maryland zip code. (3) Interventions were done at an outpatient hospital facility. (4) Tonsillar regrowth was synonymous with the decision to proceed with completion salvage ECT in each case. (5) Patients undergoing surgery only had 1 complication; that is, no patient had multiple bleeds, multiple dehydration episodes, or a combination thereof. However, unique to the ICT arm was the possibility of tonsillar regrowth and the decision to proceed with a definitive ECT, which then could have potential for an additional single complication (eg, bleed, dehydration). (6) Patients who had postoperative bleed or dehydration after ICT did not get subsequent ECT. These parameters were set to model real-life situations as closely as possible while balancing the need to create a generalizable model.

For the purposes of the utility analysis, each end state (ie, surgical outcome) was assigned a relative utility value (Table 2). The utility values assigned to each end state were based on a commonsense approach to what a typical patient/parent would consider reasonable. The possible utility values range from 0 (absolute no benefit from intervention) to 1 (perfect outcome with no morbidity). This approach has been used in previous published studies. These utility values were reviewed for appropriateness by 3 other otolaryngologists not involved in the study. This model’s anchor states ranged from a high of 0.95 (best outcome; 1 surgical procedure without complications) to a low of 0.55 (worst outcome; ICT with completion ECT with postoperative bleeding secondary to ECT). Utility values were discounted for multiple operations to mimic real-life inconveniences for having additional surgery.

For the cost outcome analysis, a monetary cost for each outcome was calculated to allow a direct comparison of total cost for ICT versus ECT (Table 3). Based on a consumer health calculator, the total costs for intervention were tallied for tonsillectomy (Current Procedural Terminology codes 42825, 42826), tonsil bleed requiring surgical intervention (42962), removal of residual tonsilar tissue (42860), and intravenous hydration (96360), including facility and anesthesia costs. Cost of recovery days were calculated by measuring loss of daily household income based on US Census income figures. These costs were factored into our model. For both cost and utility outcome models, 1-way sensitivity analyses were performed on pertinent model parameters to identify those that most influenced model results.

Statistical analysis included only simple descriptive statistics and 1- and 2-way sensitivity analyses with graphical display. Formal hypothesis testing was not performed.

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**Table 1. Key Model Parameters.**

<table>
<thead>
<tr>
<th>Parametera</th>
<th>Starting Value, %</th>
<th>Range Used for Sensitivity Analysis %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-ICT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleed rate6,10,23</td>
<td>1</td>
<td>0.5-6</td>
</tr>
<tr>
<td>Dehydration rate2</td>
<td>2</td>
<td>0.5-3.5</td>
</tr>
<tr>
<td>Tonsillar regrowth rate10,11,21</td>
<td>10</td>
<td>0.6-17</td>
</tr>
<tr>
<td>Post-ECT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bleed rate6,10,23</td>
<td>3</td>
<td>1.5-7</td>
</tr>
<tr>
<td>Dehydration rate2</td>
<td>3</td>
<td>1.5-5</td>
</tr>
</tbody>
</table>

Abbreviations: ECT, extracapsular tonsillectomy; ICT, intracapsular tonsillectomy.

References used to establish parameter starting value and estimated range that was used for sensitivity analysis.
Results

The complete model is shown in Figure 1. Based on the baseline values of all key parameters (Table 1), ECT (0.9410 cumulative utility) was superior to ICT (0.9155) for the overall utility-based analysis. Extensive sensitivity analysis was performed to assess the key parameters driving model results. A tornado diagram plotted the change in total cumulative utility over the specified parameters of interest (Figure 2). Tornado diagrams allow for the comparison of the importance of each variable. While holding all other model parameters equal, the model is rerun with 1 selected variable (eg, utility value for 1 surgical procedure) across a range of values (0.85-0.99). This process is repeated for multiple model parameters (eg, bleed rate, dehydration rate, utility value for tonsil bleed). Afterward, the parameters that have the highest impact on the model results are graphed. The wider the bar, the more important that variable on the model outcome. This revealed that the utility assigned to the endpoint of having a single surgical procedure (eg, no need for completion tonsillectomy) was the most important parameter in determining model results. Tonsil regrowth rate was another key determinant of the model results. The overall cumulative utility for ICT and ECT was equal at a breakeven tonsil regrowth rate of 1.64% (Figure 3). Regrowth rates above this threshold value increasingly favored ECT, with the utility of ECT increasing and that of ICT decreasing.

The cost analysis demonstrated that ICT ($4177.92 total cost) was the overall cheaper option versus ECT ($4546.91). This dollar amount factored in differences in complication rates (bleed, dehydration, regrowth) and average days of recovery between the methods. Of note, ICT with regrowth had the highest individual cost outcomes in the model: ICT with uncomplicated ECT, $8289; ICT with post-ECT bleed, $11,460; and ICT with post-ECT dehydration, $8615. Again, a tornado diagram was created to determine the most influential parameters of the cost model, which were the rate of tonsil regrowth and the days of recovery following surgery (ICT or ECT). The total cumulative cost of ICT and ECT was even at a regrowth rate of 17.8% (Figure 4). Total cumulative cost also had a breakeven point when ICT was modeled to require 7.4 days of postoperative recovery, and the same was true for ECT postoperative recovery length as well.

Discussion

This study utilized decision analysis modeling to compare outcomes between ICT and ECT in terms of overall utility and dollar cost. It attempted to answer the following question: Given the differences in complication rate (bleeding, dehydration, need for completion surgery), which provides
more benefit and value for the patient? Each path in our model represented a unique potential patient result for a child undergoing tonsil removal. ECT had a higher cumulative utility than ICT. Results from the tornado diagram implies that this dominance is largely driven by the assigned utility value in having a single surgical procedure. With ECT, there is minimal chance of repeat surgery, as there is no residual tonsillar with potential for regrowth. However, it has higher rates of postoperative dehydration and bleeding, which can make it a less desirable option. Subsequent sensitivity analysis showed that before the breakeven point of a 1.6% rate of regrowth, ICT is the superior option—likely for the previously mentioned reasons. The finding that the decision between ECT and ICT mostly hinges on the possibility of future surgery is not surprising. A recent study sampling parents of pediatric otolaryngology patients indicated that avoidance of possible future salvage surgery was key factor driving their potential choice of ECT versus ICT. This finding is key especially for younger patients, as age at first procedure was significantly associated with risk of regrowth and repeat operation, with younger patients having higher risk.

ECT also proved to be the overall more expensive option. In our model based on published baseline parameters, ECT required double the recovery period of ICT. The cost associated with such a prolonged recovery time, calculated per averaged income values, was the primary determinant of its higher overall cost. The 2 outcomes became financially equivalent when the tonsillar regrowth rate following ICT equaled 17.8%, as the potential cost of repeat surgery outweighed any benefit of a shorter, thus overall cheaper, recovery time. However, even prior to reaching that 17.8%, those who ended up in the ICT arm requiring revision surgery had the highest cost at $8393.91; this figure is a weighted average of all outcomes of ICT—to include uncomplicated ECT, ECT with dehydration, and ECT with bleed. Though the risk may be low, the total cost to the patient requiring a completion tonsillectomy is nearly double that of the patient undergoing an initial uncomplicated ECT. The patient undergoing completion ECT also faces additional exposure to anesthesia, a second recovery period with its associated discomforts for both patient and parent, and a second period of lost potential income for a parent or caregiver.

The limitations of this model must first be recognized. Model accuracy and validity depend on input parameters, and outcomes can easily be manipulated by changing such inputs. This model reviewed multiple publications to determine inputs, such as differences in bleeding rates, dehydration rates, and tonsillar regrowth rates, to minimize any bias that could occur from utilizing single sources. Secondary sensitivity analysis was also used to verify that findings held true across a range of values, to reflect the range published in literature. Also, inherent to any cost analysis, including this one, are large general assumptions regarding averaged parental income and family arrangements required for appropriate postoperative recovery.

Cost is difficult to assess and truly measure, as individual hospitals and practices have different methods of charging patients, who themselves can see different costs depending on location and insurance status. This model attempted to measure (albeit, imperfectly) the burden of surgery from the

Table 3. Model Cost Values.

<table>
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<th>Condition/Endpoint</th>
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<th>Range Used for Sensitivity Analysis, $</th>
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<tr>
<td>Initial surgery (ICT or ECT)</td>
<td>2892</td>
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<td>Recovery (per day)</td>
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Abbreviations: ECT, extracapsular tonsillectomy; ICT, intracapsular tonsillectomy; IV, intravenous.

**Figure 2.** A tornado diagram depicting the 3 parameters that have the most influence on the overall utility within the model. The utility assigned to having a single procedure (intracapsular vs extracapsular tonsillectomy) was the most influential parameter, as demonstrated by its widest bar and highest placement. PT, partial tonsillectomy.

**Figure 3.** One-way sensitivity analysis for impact of tonsil regrowth rate on overall utility outcomes. Beyond a breakeven regrowth rate at 1.6% (demonstrated at the intersection of the 2 slopes), total tonsillectomy becomes the dominant option. Note partial tonsillectomy’s gradual downward slope vs total tonsillectomy’s utility value remaining stable.

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patient’s point of view by modeling costs in terms of dollars spent on surgery and lost due to recovery. To simplify and remove potential sources of error, we kept assumptions consistent: an insured patient seeking care at an outpatient hospital facility in the same zip code.

Due to these assumptions, this model may not perfectly capture the relative total societal costs of each surgical procedure. This may especially be pronounced when disposable surgical equipment costs are compared. The most common methods of ICT include microdebrider and coblation, which have significantly higher disposable equipment costs ($80-$100 for microdebrider shaver blade, $140-$200 for coblation wand), as opposed to the bovie spatula and handpiece ($10-$20) used for ECT.20 From a patient’s perspective, this 4- to 10-fold increase in equipment cost of ICT over ECT may not be fully represented in the analysis. Despite these differences, the cost of reoperation for tonsil regrowth would be expected to dwarf these more minor cost differences. The price faced by a patient is often not equivalent to the true cost of surgery given different hospital billing methods and insurance reimbursement plans. Based on the relatively higher equipment costs for ICT, ICT might in fact be the more expensive given different hospital billing methods and insurance reimbursement plans. Based on population-level utility modeling, ECT may be superior to ICT on the basis of best estimates for baseline parameters. The key parameter driving this result was the utility that a patient places on having a single uncomplicated operation. The base model cost analysis showed that ICT was an overall less expensive option. However, the sensitivity analysis and comparative results are highly dependent on subtle changes in the tonsil regrowth rate and the potential difference in recovery time. Providers should consider individual needs, preferences, and circumstances when deciding between ICT and ECT and may factor in the results of this study when making that decision.

**Conclusion**

Based on population-level utility modeling, ECT may be superior to ICT on the basis of best estimates for baseline parameters. The key parameter driving this result was the utility that a patient places on having a single uncomplicated operation. The base model cost analysis showed that ICT was an overall less expensive option. However, the sensitivity analysis and comparative results are highly dependent on subtle changes in the tonsil regrowth rate and the potential difference in recovery time. Providers should consider individual needs, preferences, and circumstances when deciding between ICT and ECT and may factor in the results of this study when making that decision.

**Author Contributions**

Grace Baik, substantial contribution to conception, design; manuscript draft, revision; Scott E. Brietzke, substantial contribution to conception, design; manuscript draft, revision;

**Disclosures**

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**References**


