Identifying Preoperative Variables and Ultrasound Data to Better Predict Operative Times in Thyroidectomy Surgeries

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Abstract

Predicting operative times is a common tool for structuring surgical schedules and has implications in terms of utilization management, decreasing OR costs, and patient satisfaction; however, it is fraught with inaccuracies. The aim of this study was to evaluate thyroidectomy surgeries across a hospital system to determine the degree of error involved in an established prediction system and identify preoperative variables that correspond to longer operative times. In this retrospective chart review, thyroidectomies within a hospital system were evaluated for demographic data, comorbidities, and ultrasound information (presence of nodules, nodule size, thyroid volume). Analyses were completed to determine preoperative factors with significant correlation ($p<0.05$) to inaccurate operative time predictions. 943 surgeries were evaluated from 1/3/2013 to 12/30/2016. Analysis revealed BMI ($p=0.041$), hypothyroidism ($p=0.048$), multinodular goiter ($p=0.021$), and thyroid volume (0.025) were associated with increased operative times. The current results demonstrate objective, preoperative variables which correlate to longer operative times in thyroidectomy surgeries. Considering these factors can enhance the surgeon's ability to predict operative duration. Further, incorporation of this information into predictive models can ultimately streamline and improve operative time predictions on a larger scale.

Introduction

Now more than ever, hospitals and the healthcare industry demand high-quality, low cost care, delivered with the utmost efficiency. The operating room represents a specific area in which costs are high, and efficient time management translates to improved resource utilization, increasing revenue, and improved patient, surgeon, and perioperative staff satisfaction[1]. OR scheduling is at the crux of establishing an efficient day in the operating room. Measuring and understanding perioperative concerns is a component of improving this process and receives a great deal of attention; however, the intraoperative aspect generates less notoriety in the literature[1]. Current models for predicting the operative time (cut-to-close) revolve strictly around surgeon specific time averaging for a given CPT code. This neglects individual patient and disease specific concerns which necessarily impact the difficulty and eventual time involved in an individual's case. Thyroidectomy surgeries represent an ideal model for assessing objective, preoperative variables that impact case duration due to the standardization of the pre-surgery work up and the relative uniformity of the procedures performed. A paucity of data is available regarding factors impacting the difficulty or duration of thyroid surgery[2,3]. The aim of this study was to evaluate thyroidectomy surgeries across a hospital system to determine the degree of error involved in an established prediction system and identify preoperative variables that correspond to longer operative times.

Methods and Materials

Retrospective chart review was conducted utilizing the Geisinger Health System (GHS) EHR to retrieve data from all thyroidectomies performed from 1/3/2013-12/30/2016.
Initial data focused on direct comparison of scheduled operative times (based on individual surgeon and documented preop CPT code) to the post operatively documented operative time. From this, a mean absolute error was calculated-elucidating the degree of inaccuracy with the current predictive model.
Secondly, data was extracted from the EHR to include patient characteristics (age, gender, BMI, comorbidities) and thyroid related diagnoses (inflammatory thyroid disease, malignancy, multinodularity). Using NLP/text mining on free-form notes from ultrasounds performed prior to surgeries, critical additional discrete elements to calculate total thyroid volume were added to the data set. The association between patient characteristics and surgical duration was assessed using correlation coefficients for continuous or two level variables while ANOVA was used for three or more level variables. Multivariable linear regression was then used to find all factors associated with surgical duration. Variables were selected using a backwards elimination technique where the significance level for removing effects to the model was set at 0.20. Data was represented as β estimates and standard errors. SAS 9.4 (SAS Institute, Cary NC) was used for all the statistical analyses and a p value < 0.05 was considered statistically significant.
A preliminary regression model was generated utilizing this data to leverage the thyroid volume along with general type of thyroidectomy (umbrella groupings included hemithyroidectomy, total thyroidectomy, substernal thyroidectomy, and total thyroidectomy with neck dissection) leading to more accurately scheduled cases.

Figure 1. Mean absolute error for all thyroidectomy cases (x = 15 min, y = number of cases)

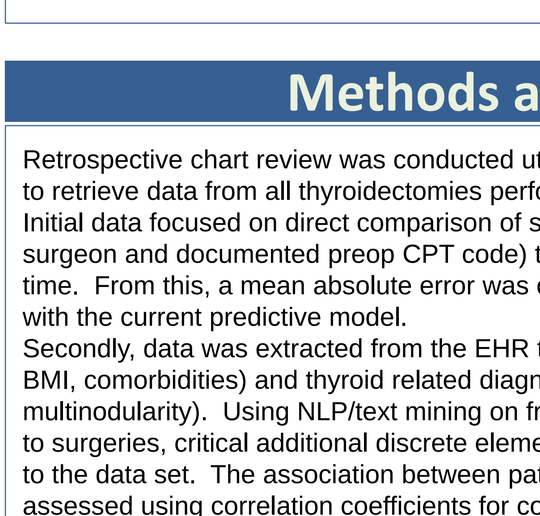
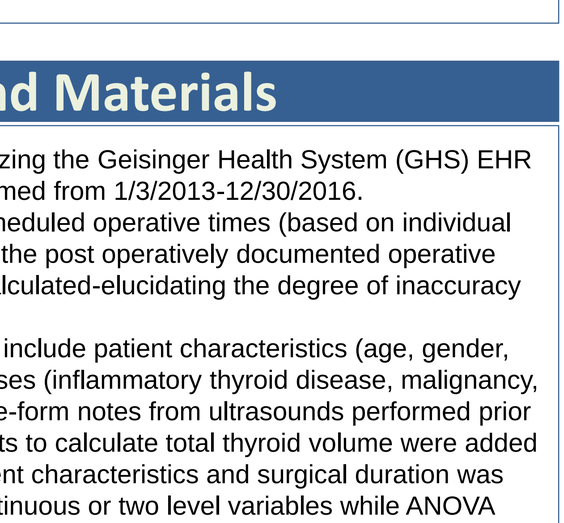


Figure 2. Surgical duration falling within 15 min of predicted using current model



Results

943 discrete thyroidectomy surgeries completed between 1/3/2013 and 12/30/2016 were evaluated across the Geisinger Health System including 5 separate hospitals.

The mean absolute error across all surgeries found 30% were accurately scheduled to within 15 minutes. 22% were within 15-30 minutes, 18% within 30-45 minutes, and 12% within 45-60 minutes. 16% were scheduled incorrectly by >60 minutes. Hemithyroidectomy, either as initial surgery or as a completion procedure, was the most accurately predicted to within 15 minutes; however, this was 35% and 37% respectively. Total thyroidectomy was predicted within 15 minutes 30% of the time. Substernal thyroidectomy and thyroid with radical neck were least accurate to within 15 minutes at 10% and 17%.

Univariate and multivariate analysis found age, gender, nodule size, hyperthyroidism, and thyroid specific diagnosis had no correlation (based on $p < 0.05$) with surgical duration. Univariate analysis found BMI (0.041), hypothyroidism (0.048), multinodular goiter (0.021), and total gland volume (0.036) were significant impactors of duration. Multivariate analysis yielded total thyroid volume as the lone independent predictor of surgical duration (0.025).

Table 1. Relationship of preoperative variables to increased operative times.

Variable	Correlation Coefficient	Univariate p Value	Multivariate p Value
Age	-0.095	0.191	0.804
BMI	0.148	0.041	0.119
Thyroiditis/Graves/ Hashimotos	0.136	0.061	0.421
Hypothyroidism	0.143	0.048	0.149
Multinodular Goiter	-0.166	0.021	0.116
Total Gland Volume	0.151	0.036	0.025

Discussion

Scheduling thyroidectomy surgeries within allotted time blocks is, as yet, an imperfect science. Although much work has gone into improving perioperative timing and efficiency, there is a deficiency of evidence in the literature working towards identifying preoperatively available predictive data directed specifically at the intraoperative portion of the case[1]. The evidence that is available is directed at identifying difficult thyroidectomy cases as opposed to accurate prediction of case duration[3,4]. The current study elucidates obvious inaccuracies with the current model utilized throughout a large hospital system. Surgeries consistently miss their targeted end times, which creates unsatisfactory patient experiences (perceived delays), as well as poor working conditions for operating room staff, and inadequate utilization of hospital resources.
Given that thyroidectomy cases have a standardized preoperative work up and generally fit into a small number of surgical categories (hemithyroidectomy, total thyroidectomy, substernal thyroidectomy, and thyroidectomy with neck dissection), this subset of surgeries is an ideal model to work towards a more targeted, comprehensive predictive model. Working with surgeons in the Geisinger Health System, and using a unique combination of billing and EHR data, a cohort of all patients who had a relevant thyroidectomy surgery performed was created. Additional text mining of free form data from preoperative ultrasounds allowed for thorough evaluation of data available to all planned thyroidectomy operations. Multivariate analysis confirmed total thyroid lobe volume as the single independent predictor of thyroidectomy duration throughout this cohort. This represents a promising finding for future utilization of this preoperative variable as an augmentation to the current predictive model. Currently, the project aims to accomplish this task, and a preliminary regression model is included in Figure 3.

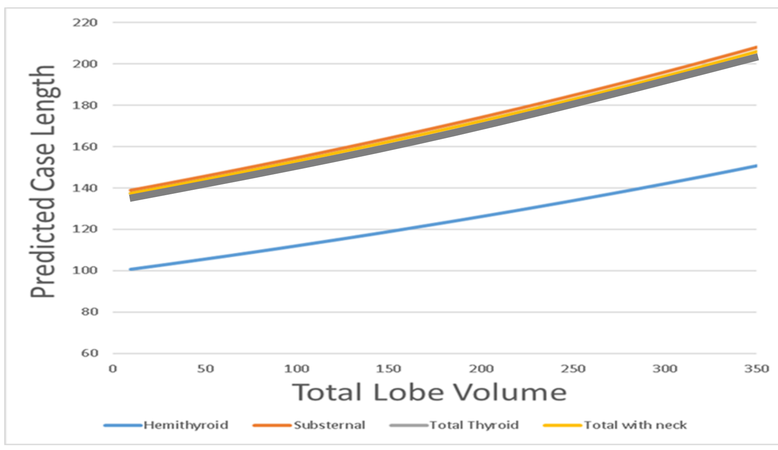


Figure 3. Preliminary predictive model (Thyroid volume in cubic centimeters x time in minutes)

Conclusions

Current methods for predicting operative times center on time averaging based on procedure codes for an individual surgeon and fail to address patient specific, preoperative data. This study elucidates the inadequacy of this process. Thyroidectomy surgeries represent an ideal model for assessing objective, preoperative variables due to the standardization of the pre-surgery work up and the relative uniformity of the procedures performed. Specifically, thyroid lobe volume, extracted from preoperative ultrasounds, represents an independently predictive variable which can be used to enhance prediction of operative time and better streamline OR scheduling.

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References

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