Identifying Risk for Postoperative Pneumonia in Thoracic Surgery Patients

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Background

- Postoperative pneumonia (POP) is the third most common postoperative complication among all surgical procedures, with significant negative impact on patient morbidity and mortality.
- The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database is a nationally validated, outcomes-based program used to improve the quality of surgical care across surgical specialties. The NSQIP database houses data sourced directly from patient records in academic and community hospitals.
- Literature regarding patient risk factors for developing pneumonia after thoracic surgery is scarce.
- Current clinical risk scores for POP after thoracic surgery are based on pre-surgical respiratory function tests, which are not routinely ordered for all patients undergoing thoracic surgery.

Purpose

- The aims of this project were to:

  1. Conduct secondary analysis of data extracted from the ACS NSQIP database to develop and validate a predictive model to identify thoracic surgery patients at risk for POP.

  2. Create a risk-based calculator to identify patients at risk for developing POP.

  3. Provide evidence-based practice recommendations for anesthesia management of thoracic surgery patients at high risk for developing POP.

Sample and Methods

- A total of 23 covariates (predictors) were identified, from the literature, to be associated with POP. Data from 9,014 thoracic cases, extracted from the 2018-2022 ACS NSQIP database were analyzed using the three statistical methods described below.
- Method 1: Logistic regression with 23 covariates and POP as the outcome variable Model performance was assessed through 10-fold cross-validation.
- Method 2: Machine learning with eXtreme Gradient Boosting (XGBoost) and hyperparameter optimization. Model performance was assessed through 10-fold cross-validation.
- Method 3: Item Content Validity Index (I-CVI) of the 23 covariates was calculated for relevance based on input from a panel of 12 thoracic surgery experts. Predictors with I-CVI > .78 were identified. Performance was assessed through AUC ROC.

Results

- Method 1 identified nine significant predictors for POP ($p < .05$) with a 10-fold cross-validated AUC ROC = .72 (fair classifier).
- Method 2 had a 10-fold cross-validated AUC ROC = .75 (fair classifier). XGBoost is a gradient boosting framework that constructs an ensemble of decision trees. Therefore, there are no coefficients to report.
- Method 3 identified six predictors for POP (I-CVI > .78) with an AUC ROC = .6 (poor classifier). The six predictors were: functional health status, COPD, congestive heart failure, systemic sepsis, age, and immunosuppressive therapy.

Postoperative Pneumonia Risk-Based Calculator

Predictor (Effect Size)	Point(s) (Effect Size/.05)	Total Point(s) = POP Risk
Sepsis (1.43)	29	
SIRS (1.04)	21	≤ 10 = Low
Male gender (.77)	15	
Bleeding disorder (.57)	11	
Current smoker within one year (.39)	8	11-25 = Moderate
Disseminated cancer (.39)	8	
Hypoalbuminemia (.33)	7	
History of severe COPD (.31)	6	> 25 = High
Anemia (.05)	1	

Recommendations

- Preoperative prehabilitation and optimization of patients with modifiable and non-modifiable predictors.

Conclusions

- To our knowledge, this was the first study to develop a model and a risk-based calculator for identifying patients at risk for developing POP.
- The study found nine significant predictors of POP in thoracic surgery patients and, using effects sizes, developed a risk-based calculator.
- Logistic regression and machine learning models can classify POP patients more accurately than expert opinions.
- Anesthesia practitioners can use the model and risk-based calculator to identify at-risk patients, implement perioperative optimization measures, and prevent POP occurrence.

References

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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