Prediction Model for the Need of Postoperative Organ Support in an Adult Population Undergoing Elective Major General Surgery - Utilizing the American College of Surgeons - National Quality Improvement Project (ACS-NSQIP) Surgical Risk Calculator

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An accepted model for predicting the need for postoperative organ support and intensive care, in patients undergoing elective surgery, is lacking worldwide. A reliable tool that could predict the need for postoperative organ support would facilitate the efficient utilisation of ICU beds while ensuring patient safety. The American College of Surgeons - National Quality Improvement Project (ACS-NSQIP) surgical risk calculator is validated for the prediction of the risk of serious complications in the postoperative period. We aimed to validate this calculator to predict the need for post-operative organ support. We obtained perioperative data from 126 patients who underwent elective major general surgery. We calculated the percentage risk of serious complications for each patient using the ACS-NSQIP calculator and correlated it with the level of postoperative organ support needed. The mean predicted percentage risk of serious complications, for the group that did not require any organ support was 10.5% and the group requiring 1 or more organ support was 18.1%. The standard error was 0.49 (p = 0.001). A receiver-operating characteristic (ROC) curve gave an area under the curve of 0.71. We chose a cutoff for the percentage risk of serious complications for needing postoperative organ support and 10.8% was chosen as a fair value as it had a sensitivity of 71.4% and a specificity of 66%. The percentage risk of serious complications calculated by the ACS-NSQIP surgical risk calculator has a strong positive correlation with the need for postoperative organ support. Multi-center data is needed to determine definite cut-offs.

Keywords: postoperative organ support, elective major general surgery, ACS-NSQIP surgical risk calculator

Introduction

The need for intensive care after surgery depends on various factors such as organ support, monitoring, and nurse-to-patient ratios. In the UK, the allocation of ICU beds is influenced by 30-day mortality [1], but this decision-making process lacks a clear and validated system, leading to unplanned ICU admissions [2,3]. Efficient utilization of intensive care beds is crucial due to their high cost and impact on healthcare budgets.

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https://orcid.org/0000-0002-9045-2013
Received: 06/07/2023
Accepted: 27/08/2023
DOI: http://doi.org/10.4038/slja.v31i2.9243

Different countries allocate a varying number of ICU beds per hospital bed, ranging from 20-50 beds per 1000 hospital beds in most countries, to as high as 100 in the United States [4]. In Sri Lanka, there is a significant shortage of intensive care beds, with around 10 beds for a teaching hospital [5]. Allocating ICU beds for post-operative patients is a challenging task, requiring a balance between the level of care needed and the timing of major elective surgeries.

When allocating ICU beds, two broad categories of pre-operative parameters are considered: the type and complexity of the planned surgery and the patient's co-morbid status. However, the decision-making process for elective major general surgical patients in many units relies on a combination of 30-day mortality calculations and individual clinician judgment, lacking a clear evidence-based system.

Developing a validated pre-operative tool that can predict the real-time need for intensive care in the post-operative period would greatly aid in efficient resource utilization, including theatre time and ICU beds. However, creating such a tool is challenging due to the multiple and diverse pre-operative patient and surgical variables that are difficult to quantify and correlate with the actual need for postoperative intensive care. Risk assessment models have been developed for specific patient groups, such as lung resections and pediatric surgical patients [6,7], and we found a lot of interest on developing risk assessment models for unplanned ICU admissions [2,9-11]. There is a lack of validated models for adults undergoing elective major general surgery. This is likely due to the high variability of general surgical procedures and the multitude of patient variables that are challenging to analyse as a combined model.

The ACS-NSQIP surgical risk calculator (quoted “the calculator”) is a tool that supports surgical decision-making by estimating the risks of multiple surgeries based on reliable multi-institutional clinical data [12]. Although the calculator has been validated for accuracy in predicting outcomes in different patient groups undergoing specialist surgeries [13-19], there is a lack of studies testing its validity for post-operative organ support. The calculator incorporates 21 pre-operative variables and provides information on eight 30-day postoperative outcomes, including the percentage risk of serious complications and the risk of death. Due to the calculator's high volume, accuracy, transparency, and international acceptance, it was chosen as the primary risk prediction tool for the study [20].

The aim of the study was to correlate the predicted outcomes of the calculator with the actual need for organ support and identify a reliable cut-off point to determine which patients require post-operative organ support.

Methodology

This was a longitudinal study, for which ethical clearance was obtained from the ethics review committee of the Colombo South Teaching Hospital and informed written consent was obtained pre-operatively from each patient.

The percentage of patients needing support in an ICU in Sri Lanka was considered to be 25% [21]. We estimated the sample size to be 124 adults at a margin of error of 5% and a precision of 0.08. Peri-operative data of 126 adult patients who underwent elective major general surgery at the Colombo South Teaching Hospital over a period of 14 months from May 2019 to June 2020 was obtained.

We excluded patients undergoing specialized surgeries (ex: cardiac, cranial, spinal, orthopaedic, etc.), pregnant women, children (<18 years) and patients undergoing emergency and/or expedited surgery. We used the British United Provident Association (BUPA) schedule of procedure codes to define "major surgery" and included procedures categorized as BUPA surgeon's MAJOR 3 or above.

We created a pro-forma to gather pre-operative data related to the calculator and post-operative data related to organ support. Each surgical procedure was standardized using the Current Procedural Terminology (CPT) code from the ACS-NSQIP website. If a patient had multiple procedures or if a procedure didn't fit into a CPT code, they were excluded from the study.

The patients received post-operative care in surgical wards, High Dependency Units (HDU), or Intensive Care Units (ICU). We collected data on the level of organ support received by each patient during the first 48 hours post-operation, regardless of the care setting. Our goal was to determine which patients actually needed organ support during this initial post-operative period. We calculated the percentage risk of serious complications (will be referred to as “serious risk”) and the percentage risk of death for each patient and compared it with the post-operative data.

The patients were divided into two groups: those who did not require any organ support (group 1) and those who needed one or more organ support (group 2). We performed a retrospective cross-sectional analysis to examine the relationship between the serious risk score and the actual need for organ support in the first 48 hours. We used IBM SPSS statistics software to analyse the data and calculated various statistical measures such as mean, median, and receiver operating characteristic (ROC) curves. We determined the optimal cut-off values using the Youden Index method and validated the results using the cut-off scores.

Results

65.6% of the study population were female, 67.4% were less than 65 years in age and 25.39% were 65-74 years in age while 7.14% were 75 years or more in age.

The level of post-operative organ support received by each patient was analysed and the results are as per table 1.

Table 1: *Level of organ support needed Vs the age category and sex*

	Level of organ support			
	Organ support not needed (%) (n=84)	**One or more organ support needed (%) (n=42)**	**Total**	**Chi Square test; df; p**
Age				
65 years or less	55 (64.7)	30 (35.3)	85 (100.0)	0.71; 2; **0.70**
65-74 years	22 (68.8)	10 (31.2)	32 (100.0)	
75-84 years	7 (77.8)	2 (22.2)	8 (100.0)	
Sex				
Male	30 (53.6)	26 (46.4)	55 (100.0)	7.7; 1; **0.0052**
Female	54 (77.1)	16 (22.9)	70 (100.0)	

Of those who needed organ support, a greater proportion were 65 or under. However, a significant association was not found between the level of organ support and age categories (p=0.70). Females were found to need organ support less frequently and this was found to be a statistically significant correlation (p=0.005).

The level of organ support needed was associated with serious risk and the percentage risk of death calculated (table 2).

Table 2: *Level of organ support needed vs. the mean serious risk and the percentage risk of death.*

	Level of organ support		
	Organ support not needed (n=84) **(Group 1)**	**One or more organ support needed (n=42)** **(Group 2)**	**t test; df; p**
Serious risk			
Mean (95% CI)	10.5 (8.8 – 12.09)	18.1 (14.6 – 21.4)	4.5; 124; **0.001**
Median (IQR)	9.4 (11.3)	16.2 (18.0)	
Percentage risk of death			
Mean (95% CI)	0.95 (0.4 – 1.5)	1.7 (0.9 – 2.5)	1.5; 124; 0.13
Median (IQR)	0.23 (0.8)	0.65 (2.1)	

A significant association was found between level of organ support and serious risk (p=0.001) while the level of organ support and percentage risk of death derived from the NSQIP surgical risk calculator was not statistically significant (p=0.13).

An ROC curve was made to predict the need for organ support, using the serious risk. (Figure 1).

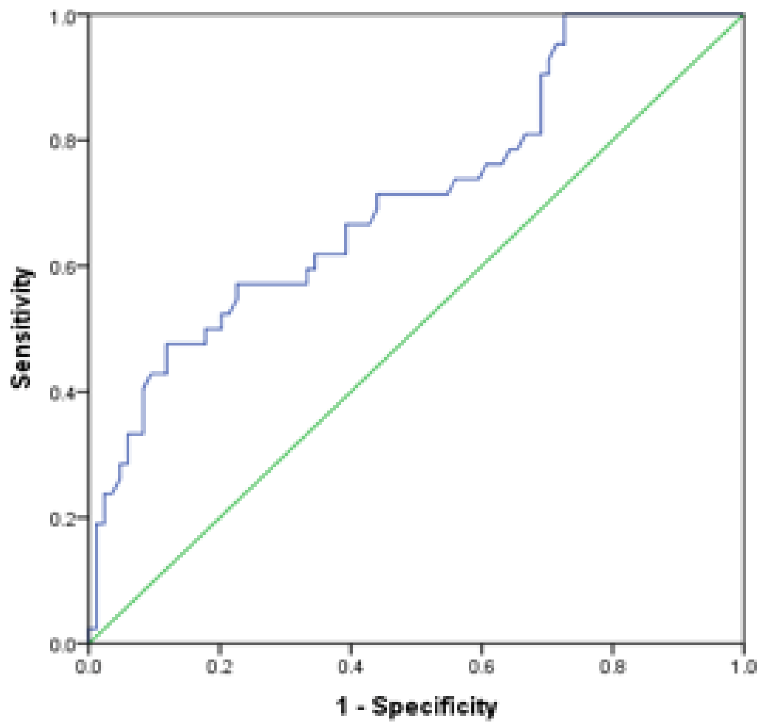

Figure 1: *ROC of the Percentage risk of serious complications*

The area under the curve obtained was 0.71 (SE 0.49) which shows that the model will help distinguish if a patient will or not be needing organ support in the ICU.

An optimal cut-off value of 10.8%, was brought to light for serious risk. With this cut-off, the sensitivity was found to be
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71.4% and 1-specifcty or the false positive rate was found to be 44.0%. This exhibited the best balance of sensitivity and specificity. The indicators of diagnostic accuracy of the serious risk scores based on the validated cut-off values for the need for organ support are shown on Table 3.

Table 3: *Indicators of diagnostic accuracy of the percentage risk of serious complications based on validated cut-off value of 10.8 for organ support.*

	Serious risk - cut-off value of 10.8 (95%CI)
Sensitivity	71.43% (55.42% to 84.28%)
Specificity	55.95% (44.70% to 66.78%)
Positive Predictive value	79.66% (70.07% to 86.76%)
Negative Predictive value	44.78% (37.35% to 52.45%)
Positive Likelihood Ratio	1.96 (1.17 to 3.28)
Negative Likelihood Ratio	0.62 (0.45 to 0.84)
Accuracy	48.41% (39.42% to 57.48%)

At a cut-off score of 10.8, the number of false positives is reduced with a minimum loss of sensitivity. Above this cut-off value, sensitivity decreased significantly without any further gain in specificity.

Discussion

The study found that the serious risk, calculated using the ACS-NSQIP surgical risk calculator, was statistically significant in determining the need for post-operative organ support (p = 0.001). However, the percentage risk of death did not show a significant correlation with the need for organ support (p = 0.13). This suggests that the serious risk has the ability to distinguish between patients who require organ support and those who do not.

To determine a fair cut-off point for the serious risk, we considered the coordinates of the curve. The area under the ROC curve for the serious risk was 0.71, with a standard error of 0.49, indicating fair cut-offs for the test. A serious risk score of 4.3 was found to eliminate the need for organ support with 100% sensitivity. However, to strike a reasonable compromise between sensitivity and specificity, a cut-off score of 10.8 was chosen. This cut-off value provided the best balance between sensitivity and specificity, although a higher cut-off could be chosen if more false positives are acceptable. Overall, the test demonstrated good discrimination ability, making it a reliable and valid tool.

Previous studies have focused on correlating patient and surgical variables with the level of post-operative care required, but most of them were conducted on specific patient groups and lacked a validated risk score. The current study aimed to test the suitability of the ACS-NSQIP calculator for predicting the need for advanced post-operative care instead of developing a new predictive model, which would require a larger sample size and complex analysis.

We observed that younger patients (65 years or less) required organ support more frequently, although this finding was not statistically significant (p = 0.70). This contradicted the common belief that older patients undergoing surgery are more likely to require post-operative ICU care. Future studies aim to stratify the ages to achieve balanced samples from all age groups based on these results.

In the study setting, any organ support, excluding peripheral vasopressor therapy, required an intensive care bed due to the absence of a level 2 High Dependency Unit (HDU). Therefore, it was appropriate to correlate the serious risk with the need for organ support. Invasive monitoring data collected in the post-operative period, which would indicate the need for level 3 ICU care, was not included in the analysis as it did not provide useful inferences.

The conclusions of the study were promising, showing a definite positive correlation between the serious risk and the need for organ support. A serious risk below 4.3 effectively ruled out the need for post-operative organ support, which is a critical clinical value for planning care. The cut-off value of 10.8% struck a reasonable balance between sensitivity and specificity. Although it was slightly higher than the mean and median values of the group that did not require organ support, it remained closer in number to both.

The cut-off value of 10.8% can be used as a tool to aid clinical judgment and decision-making when allocating intensive care beds prior to surgery. The study's results provide a preliminary foundation for a larger multi-center study conducted over a longer duration. Such a study would yield statistically superior and more practical cut-off values for each level of post-operative care required. Importantly, this study demonstrated the applicability of the ACS-NSQIP surgical risk calculator in predicting the need for ICU care following elective major general surgery.

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