

# General Anesthesia

## Best evidence in anesthetic practice

### Clinical prediction guide: a 14-item index predicts 30-day risk of postoperative pneumonia after non-cardiac surgery

#### Article appraised

Arozullah AM, Khuri SF, Henderson WG, Daley J, for the Participants in the National Veterans Affairs Surgical Quality Improvement Program. Development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. *Ann Intern Med* 2001; 135: 847–57.

#### Structured abstract

**Objective:** How accurate is a 14-item index [postoperative pneumonia risk index (PPRI)] for estimating the 30-day risk of developing pneumonia in patients undergoing non-cardiac surgery?

**Design:** Two cohort studies – one for derivation and one for validation.

**Setting:** One hundred American Veterans Affairs medical centres that perform major surgery.

**Patients:** All non-cardiac operations performed under general, neuraxial, local, or monitored anesthesia at low- volume hospitals (< 140 cases per month) and the first 36 consecutive operations at high-volume hospitals ( $\geq 140$  cases per month) were included. Operations with very low mortality rates, major transplantation procedures, and patients with postoperative respiratory failure or unplanned intubation prior to

diagnosis of postoperative pneumonia were excluded. Data from 160,805 patients (80.3% of all eligible patients; 1 September 1997 to 31 August 1999) were used for index derivation and from 155,266 patients (82.1% of all eligible patients; 1 September 1995 to 31 August 1997) for validation. All patients were followed prospectively for 30 days after the initial operation. Less than 20% of patients were excluded due to missing data.

**Description of prediction guide:** Logistic regression was used to identify preoperative predictors of postoperative pneumonia. The PPRI is a 14-item index (maximum score 84 points) that divides patients into five classes of increasing risk (Table I) for postoperative pneumonia. Points are scored for type of surgery and anesthesia, general patient risk factors, respiratory risk factors, and neurological risk factors (Table II).

**Main outcome measures:** Postoperative pneumonia based on the Centers for Disease Control and Prevention definition.

**Main results:** Postoperative pneumonia developed in 1.5% of patients in the derivation cohort and 1.7% of patients in the validation cohort. The risk of postoperative pneumonia for patients in PPRI class 1, 2, 3, 4, and 5 were similar between the two cohorts.

TABLE I Operating characteristics of the postoperative pneumonia risk index (PPRI)

PPRI score	Risk class	Postoperative pneumonia		Sensitivity (%)	Specificity (%)	Positive likelihood ratio
		Present	Absent			
0 – 15	1	166	69167	100.0	0.0	0.15
16 – 25	2	664	55093	93.2	43.7	0.77
26 – 40	3	1284	30819	66.3	78.5	2.7
41 – 55	4	331	3186	14.1	97.9	6.7
> 55	5	15	80	0.6	99.9	12

All values are calculated from data presented on the PPRI derivation cohort.

TABLE II Postoperative pneumonia risk index (PPRI)

<i>Preoperative risk factor</i>	<i>Point value</i>
<i>Type of surgery</i>	
Abdominal aortic aneurysm repair	15
Thoracic	14
Upper abdominal	10
Neck	8
Neurosurgery	8
Vascular	3
<i>Age</i>	
≥ 80 yr	17
70–79 yr	13
60–69 yr	9
50–59 yr	4
<i>Functional status</i>	
Totally dependent	10
Partially dependent	6
Weight loss > 10% in past six months	7
History of chronic obstructive pulmonary disease	5
General anesthesia	4
Impaired sensorium	4
History of cerebrovascular accident	4
<i>Blood urea nitrogen level</i>	
< 2.86 mmol·L <sup>-1</sup>	4
7.85–10.7 mmol·L <sup>-1</sup>	2
≥ 10.7 mmol·L <sup>-1</sup>	3
Transfusion > 4 units	3
Emergency surgery	3
Steroid use for chronic condition	3
Current smoker within one year	3
Alcohol intake > two drinks/day in past two weeks	2

Table taken from Arozullah AM, et al. Ann Intern Med 2001; 135: 847–57.

**Conclusions:** The PPRI classified patients into five levels of risk for postoperative pneumonia with good discrimination.

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### Commentary by J. Bradley and F.A. McAlister

The identification of patients at high risk for postoperative complications is a key skill for perioperative physicians. This task is difficult but, for some complications (particularly cardiac), is greatly aided by the existence of rigorously developed and well-validated clinical prediction rules. Although pulmonary compli-

cations are more common than cardiac events and are associated with longer hospital stays,<sup>1</sup> the pulmonary risk prediction literature is relatively sparse.

The postoperative pneumonia risk index represents a significant advance in this field. Similar to their earlier publication outlining a risk index for postoperative respiratory failure,<sup>2</sup> Arozullah and colleagues conducted secondary analyses of data from the 100-hospital strong Veterans Affairs National Surgical Quality Improvement Program to derive a multifactorial risk index for predicting pneumonia after non-cardiac surgery. Their study is blessed with large numbers and a heterogeneous collection of patients and surgical procedures in which to evaluate potential predictors. They enrolled over 80% of all eligible patients without loss to follow-up, used appropriate statistical techniques, and validated their index in another cohort of patients drawn from the same quality improvement program. Further, their 14-item index is easy to apply and employs readily available preoperative clinical data.

However, this study has a number of important limitations. First, the results may not be as generalizable as they first appear: the patients were virtually all male veterans with high comorbidity; thus, the performance of the risk index in women or healthier populations is unknown. Similarly, although this index performed well in a broad spectrum of relatively high risk surgeries, its accuracy in individuals undergoing lower-risk surgical procedures (which were excluded) is unknown. Second, as all patients were not subjected to the criterion standard (postoperative radiography or standardized physical examination for pneumonia), the results may have been affected by ascertainment bias (i.e., clinicians may have been more likely to look for pneumonia in those patients they felt were at higher risk).<sup>3</sup> This is particularly concerning in a non-blinded study, such as this one, in which the individuals doing the outcome follow-up are not blinded to the preoperative status of the patients. Third, the investigators chose to exclude 729 patients who were diagnosed with pneumonia after developing respiratory failure or requiring re-intubation. It is difficult to say whether this biased their results (as many of the variables identified in this study were also identified in their index for predicting postoperative respiratory failure),<sup>2</sup> but clinicians may well question the logic of separating these often inter-related outcomes. Finally, and perhaps most importantly, the investigators did not include data (physical examination, pulmonary function tests, or arterial blood gases) commonly employed to assist in risk prediction. A systematic review of this literature identified several elements of the history, physical examination, and

bedside laboratory testing that predict these complications.<sup>4</sup> In a cohort study employing blinded and independent preoperative assessments and postoperative outcome ascertainment, we have demonstrated that a variety of physical exam maneuvers and pulmonary function abnormalities are predictive of pulmonary complications; however, numbers were small in this pilot study and data collection continues.<sup>5</sup>

Thus, although this study is an important advance in this field, particularly for those seeking to perform case-mix adjustment in comparing complication rates between hospitals and surgeons, there are still more questions than answers for the clinician faced with predicting an individual patient's postoperative pulmonary risk. Further studies with prospective and blinded comparison of the preoperative evaluation and postoperative respiratory status are urgently needed.

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## References

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## Commentary by K. McRae and W.S. Beattie

Since the publication of the Goldman index in 1977,<sup>1</sup> prediction of perioperative risk has focused mainly on cardiovascular complications. While up to 50% of postoperative morbid events may be cardiovascular, as many as 25% of postoperative deaths may be secondary to pulmonary infection. Little information exists regarding the prediction of pulmonary complications.

Arozullah *et al.* examined data collected prospectively by a network of research nurses in Veterans Administration (VA) hospitals as part of the National Surgical Quality Improvement Program (NSQIP). The NSQIP was initiated to allow for adjustment of patient preoperative risk when assessing surgical quality of care in VA hospitals. A data set collected from surgical patients from 1997 to 1999 was used for generation of the index; validation was performed with independent data from 1995 to 1997. Using sound statistical methods, and a clinically appropriate definition of pneumonia, the resulting postoperative pneumonia risk index (PPRI) comprises 25 weighted risk factors.

There are a number of limitations in this study. First, the study population is atypical and primarily comprises men with frequent comorbidity. Second, the reported decreased goodness-of-fit in some hospitals suggests data collection was not uniform from institution to institution. Third, the 1.5% incidence of pneumonia is lower than frequencies reported in most reports of pneumonia in selected high-risk patient cohorts. Finally, several surgical risk analyses have been developed from the current database.<sup>2</sup> As the NSQIP database was not designed to primarily to evaluate respiratory risk, it is possible that data on relevant respiratory risk factors were missed.

Currently, the most suitable application of this index is for evaluative research to compare inter-hospital performance parameters, particularly within the VA hospital system. However, the proposed index is lengthy and not easily committed to memory. Simplicity impacts on the use of a scoring system applied for risk assignment in the clinical setting. A notable example is the Apgar score (five variables, each scored as 0, 1, or 2), which is routinely used to direct at-risk patients to high intensity care, whereas the APACHE II score (15 variables with multiple weights) is not. The complexity of the PPRI may achieve optimum accuracy in the VA population but this is at the expense of the ease of use in a broader patient group.

TABLE Simplification of the postoperative pneumonia risk index (PPRI) in a similar fashion to Lee *et al.*'s cardiac risk index

<i>Cardiac risk index</i> <sup>3</sup>	<i>Simplified PPRI</i>
High-risk surgery	High-risk surgery
History of ischemic heart disease	History of chronic obstructive pulmonary disease
History of congestive heart failure	Functional status
History of cerebrovascular disease	History of cerebrovascular accident
Preoperative treatment with insulin	Age
Serum creatinine > 2.0 mg·dL <sup>-1</sup>	Abnormal blood urea nitrogen

Over 20 years after the original analysis by Goldman, Lee *et al.* compared risk stratification for cardiac events in a large non-emergent non-cardiac surgical population using a simplified index.<sup>3</sup> Six independent dichotomous variables were identified as present (0 points) or absent (1 point). The resultant index demonstrated little loss of predictive power compared to Goldman's index (nine risk factors with variable weights)<sup>1</sup> and Detsky's index (13 variables with variable weights)<sup>4</sup> in a large surgical population. We propose that the PPRI be simplified in a similar fashion to Lee *et al.* (Table). If this simplified index has predictive accuracy, it would find wider acceptance and use.

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