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Perioperative risk factors for postoperative respiratory failure

Ahmed F. Attaallah¹, Manuel C. Vallejo², Osama M. Elzamzamy³, Michael G. Mueller⁴, and Warren S. Eller⁴

¹Department of Anesthesiology, Florida Hospital, Tampa, FL

²Departments of Medical Education and Anesthesiology, School of Medicine, West Virginia University, Morgantown, WV

³Clinical and Translational Sciences Institute, West Virginia University, Morgantown, WV

⁴Department of Health Policy, School of Public Health, West Virginia University, Management, and Leadership, Morgantown, WV

Abstract

The study aimed to identify the risk factors for respiratory failure after surgery. Postoperative respiratory failure (PRF) was defined as prolonged intubation after surgery or reintubation after unsuccessful extubation. We conducted a retrospective analysis of the following risk factors: age, obesity as reflected by body mass index (BMI), gender, patient admitted to hospital (in-patient status) vs. outpatient surgery, smoking, hypertension, chronic obstructive pulmonary disease (COPD), diabetes, abnormal liver function, anaemia, respiratory infection, physical condition as reflected by ASA class, case type (elective or emergency), anaesthesia type, and surgical duration. The incidence of PRF was found to be 2.4%. Independent risk factors were older age, inpatient status, hypertension, COPD, elective procedure, surgical duration > 2 hours, and ASA class 3. The study concludes that PRF results in significant postoperative complications. Minimising these risks is essential in improving PRF and subsequently surgical outcomes.

Keywords

Reintubation; Prolonged intubation; Postoperative respiratory failure; Risk factors

Introduction

Postoperative respiratory failure (PRF) is one of the most serious postoperative complications and can lead to poor outcomes (Ebell 2007, Smetana 2009). Unplanned tracheal reintubation and prolonged intubation after surgery may result in significant postoperative pulmonary complications which include a longer duration of mechanical ventilation, tracheotomy, longer intensive care unit (ICU) hospital stay, higher costs and increased mortality (Vidotto et al 2011, Thille et al 2011).

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Corresponding author: Ahmed F. Attaallah, Department of Anesthesiology, West Virginia University, School of Medicine, 16412 Burniston Dr, Tampa, FL 33647. ahmedfikry@hotmail.com.

The purpose of this study is to identify perioperative risk factors for postoperative respiratory failure (PRF) in an academic medical centre.

Background

Patient safety has always been the focus of clinical care. Merging patient safety with business management principles resulted in the development of healthcare quality improvement (Gawande 2008). Quality improvement programs have grown rapidly in response to the public and government demands for more accountability to improve patient care, in order for this to occur, quality guidelines need to be established using accurate data and scientific evidence to measure performance (Ko 2009).

Literature review

Several previous studies have looked at PRF and reported its incidence to range from 2.7% to 3.4%. Rujirojindakul reported chronic pulmonary disease, an operative time of greater than three hours, and ASA physical status 3 as significant factors for reintubation (Rujirojindakul et al 2012). In a two part systematic review, the American College of Physicians determined that chronic obstructive lung disease, older age (> 60 years), ASA class > II, poor activity tolerance, and congestive heart failure increase the risk for PRF. In that same study it was also shown that longer surgery, abdominal, thoracic, neurosurgical, and head and neck surgeries, and emergent status were also associated with increased risk (Qaseen et al 2006). Gupta used multivariate logistic regression analysis and was able to identify preoperative predictors of PRF which included type of surgery, emergency status, functional activity level, sepsis and higher American Society of Anesthesiologists (ASA) class (Gupta et al 2011).

Materials and methods

After local institutional review board approval, a retrospective time-matched controlled, quality assurance electronic medical record data base analysis was performed. The study was not registered as a clinical trial because the medical record and data base analysis did not involve direct patient care contact. From 1st September 2010 through to 31st December 2013, 98 patients were identified from our hospital quality assurance surveillance system as having had a postoperative respiratory failure (PRF) defined as an unplanned postoperative reintubation and (or) prolonged postoperative intubation after surgery. PRF is commonly understood as failure to wean from mechanical ventilation within 48 hours of surgery, or unplanned intubation/reintubation postoperatively (Gupta 2011). For the purpose of this study, prolonged intubation was defined as remaining intubated postoperatively for at least 96 hours after surgery, and postoperative reintubation was defined as reintubation within 24 hours after extubation (AHRQ 2015). Patients in the postoperative respiratory failure group were identified by their International Classification of Disease (ICD) ninth revision codes, ICD code 9604 for postoperative reintubation and ICD code 9672 for prolonged postoperative intubation with mechanical ventilation for 96 consecutive hours or more.

A chart review was conducted on each of the 98 identified patients to identify specific risk factors. Risk factors for PRF were identified from a recent review of the scientific literature and recorded for each case. Potential risk factors for postoperative respiratory failure were classified as:

- Patient-specific
- Preoperative or
- Operation-specific

Patient-specific factors

Patient specific factors included: age, BMI, gender, and in-patient status.

Preoperative risk factors

Preoperative risk factors included: smoking status, history of hypertension, chronic obstructive pulmonary disease (COPD), diabetes, abnormal liver function tests, anaemia, and acute respiratory infection.

Operation-specific factors

Operation-specific factors included: ASA physical status, ASA physical status 3, case type (elective or emergency), anaesthesia type (general or other), total surgical duration, surgical duration 2 hours, and reason for respiratory failure (reintubation or prolonged intubation) (Qaseem et al 2006, Smetana 2009, Gupta 2011, Ramachandran et al 2011, Rujirojindakulet al 2012).

Patients who required multiple operations within this same time period were excluded from study analysis.

All 98 patients with a PRF complication were compared to all eligible patients from a control data source of 4,055 patients from the West Virginia Clinical and Translational Science Institute (WVCTSI) Integrated Data Repository (IDR) quality assurance medical record database over that same time period (1st September 2010 through to 31st December 2013). All patients were matched to the same hospital having a surgical procedure within the same time period. The control group was matched based on the same *patient*-, *preoperative*-, or *operation-specific* risk factors identified in the 98 patients positive for a postoperative respiratory failure complication.

Statistical analysis

Normally distributed data were analysed using the *t*-test using a Welch-Satterthwaite calculation for pooled degrees of freedom (Satterthwaite 1946), or analysis of variance; non-normally distributed data were analysed using the appropriate non-parametric equivalent (Mann-Whitney U or Kruskal-Wallis test). Univariate associations among categorical variables were explored using Chi-square or Fisher exact test for variables. Where appropriate, all results are reported in odds ratios (OR) with 95% confidence intervals (CI). Multivariate analysis was performed using logistic regression. All tests were 2-tailed, and a

P value <0.05 was considered significant. The statistical analyses were performed using Stata 14 (StataCorp, College Station, TX).

Results

The overall incidence of PRF was 2.4%.

Regarding patient-specific risk factors, differences occurred with age, and in-patient status.

Concerning preoperative specific risk factors, differences occurred with respect to hypertension, COPD, anaemia, and acute respiratory infection (see Table 1).

As for operative-specific risk factors: significant differences occurred in ASA physical status, elective case, surgical duration, and reason for respiratory failure (see Table 2).

Multivariate regression analysis of significant variables found patient age, body mass index (BMI), surgical duration, elective case, in-patient status, and the preoperative diagnosis of COPD to be significant risk factors for PRF.

Abdominal surgical procedures were significant compared to all other operative classification sites Figure 1.

Discussion

The primary aim of this study was to identify risk factors for PRF in an academic medical centre.

Several studies have reported PRF to range from 2.7% to 3.4% which is comparable to our reported rate of 2.4% (Arozullah et al 2000, Johnson et al 2007, Gupta et al 2011).

Our analysis found COPD, age older than 60 years, ASA class II or higher, prolonged surgery, and abdominal surgery to be significant. In contrast to Gupta's findings that showed mainly operative-specific PRF risks using multivariate regression analysis (Gupta 2011), the risks we identified using the same method were mostly patient-specific or preoperative such as: patient age, BMI, surgical duration, elective case, in-patient status, and the preoperative diagnosis of COPD.

In contrast to previous studies, we did not find that emergency surgery was a risk factor. This could be due to the fact that almost 98% of the cases in the PRF group and 83% of the cases in the control group in our study were elective. Also, because general anaesthesia typically requires endotracheal intubation, our study showed that intubation was a significant risk factor where 99% of the patients in our PRF group had a general anaesthetic (Table 2).

POSSUM

In comparing PRF risk factors (age > 70 years, COPD, major operation, and elective surgical procedure) with the POSSUM and P-POSSUM risk calculator (VASGBI 2013), the results give a physiology severity score of 18, an operative severity score of 13, a POSSUM predicted morbidity of 36.4%, a POSSUM predicted mortality of 6.8%, and a P-POSSUM

predicted mortality of 1.8% respectively. POSSUM stands for the Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity and was developed as a tool to compare morbidity and mortality for a broad range of surgical procedures (Copeland et al 1991). POSSUM has been shown to be an accurate and reliable risk calculator for estimating in-hospital mortality across all international healthcare systems. POSSUM has been subsequently modified and has become known as the Portsmouth POSSUM or P-POSSUM (Prytherch et al 1998). As in our PRF risk factors, both POSSUM and P-POSSUM is best applied at the time of operation.

Study limitations and strengths

A study limitation is that some confounding factors identified from the literature review and selected for our study were not available in our database. While we examined many possible risk factors, the effects of unknown or unmeasured confounders on the results cannot be excluded. PRF is a Patient Safety Indicator (PSI) from the Agency for Healthcare Research and Quality (AHRQ). The indicators developed by AHRQ are hospital data driven and evidence-based to identify variations in the quality of care. The AHRQ PSIs are risk-adjusted quality indicators that utilise secondary diagnosis ICD-9-CM codes to provide a perspective on patient safety and specifically identify potentially preventable complication. The AHRQ quality indicators are also used for public performance reporting and pay for performance (P4P) initiatives (Farquhar 2008).

A major strength of our study is that we had a control group of well over 4,000 patients that allowed for a large comparison group that had the same patient characteristics as the PRF group. Both the PRF group and controls had the same quality of data because they were selected from the same source. In addition, the database had a wide variety of operative procedures allowing our findings to be applied to the general population. Furthermore, we also used multivariate analysis to adjust for potential confounding factors.

Conclusion

Few studies have been able to differentiate risk factors for PRF. We found that patient-specific and preoperative risk factors including: old age, in-patient status, hypertension, COPD, elective procedure, surgical duration >2 hours, and higher ASA status were independent risk factors for PRF. Minimising these risks is essential in improving PRF and its related complications.

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Figure 1.
Postoperative respiratory failure group operative classification.

Table 1.

Patient-specific and preoperative specific risk factors.

	PRF (n = 98)	95% CI	Control (n = 4055)	95% CI	P value	Odds Ratio (OR)
Patient Specific						
Age (years)	61.6 ± 14.3	(58.8–64.5)	54.0 ± 1 T4	(53.5–54.6)	0.001	-
BMI (kg/m ²)	32.2 ± 9.4	(30.3–34.1)	30.8 ± 9.5	(30.5–31.3)	0.14	-
Gender (%)					0.58	0.9 (0.6–1.3)
Women	59.2%		56.4%			-
Men	40.8%		43.6%			
In-patient Status (%)	97.9%		65.4%		<0.001	253 (6.2–102.1)
Pre-Operative Specific						
Smoker (%)	29.9%		43.3%		0.6	0.9 (0.6–1.4)
Hypertension (%)	69.8%		52.0%		<0.001	23 (1.4–3.3)
COPD (%)	30.9%		10.6%		<0.001	3.8 (2.4–5.9)
Diabetes Mellitus (%)	17.7%		20.4%		0.51	0.8 (0.5–1.4)
Abnormal LFTs (%)	15.1%		21.7%		0.13	0.6 (0.4–1.1)
Anaemia (%)	19.0%		37.2%		0.003	0.5 (0.3–0.8)
Acute Respiratory Infection (%)	8.4%		3.6%		0.02	2.5 (1.2–5.2)

PRF = Postoperative respiratory failure, LFTs = liver function tests.

Table 2.

Operative-specific risk factors.

	PRF (n = 98)	95% CI	Control (n=4055)	95% CI	P value	Odds Ratio (OR)
Operative Specific						
ASA Status	3 (2–4)		3 (1–1)		<0.001	-
ASA Status 3 (%)	78.1%		57.6%		<0.001	2.6 (1.6–4.3)
Case type					0.001	
Elective (%)	97.9%		82.7%		-	10.0 (2.5–40.5)
Emergency (%)	2.1%		17.3%		-	0.10 (0.03–0.41)
Anaesthesia type					0.16	-
General (%)	99.0%		95.8%		-	4.2 (0.6–30.1)
Other (%)	1.0%		4.2%		-	0.2 (0.03–1.7)
Surgical Duration (min)	405.5 ± 237.6	(358.0–453.0)	143.0 ± 717.0	(120.9–165.1)	<0.001	-
Surgical Duration > 2 hr (%)	90.7%		38.7%		<0.001	15.5 (7.8–30.9)

PRF = Postoperative respiratory failure, Other = regional anaesthesia with or without local anaesthesia/monitored anaesthesia care (MAC).