



Unplanned postoperative reintubation following general and vascular surgical procedures: Outcomes and risk factors



Derrick Acheampong, Shanice Guerrier, Valentina Lavarias, David Pechman, Christopher Mills, William Inabnet, I. Michael Leitman*

Icahn School of Medicine at Mount Sinai, USA

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ABSTRACT

Background: Unplanned postoperative reintubation (UPR) is a marker for severe adverse outcomes following general and vascular surgery.

Study design: A retrospective analysis of 8809 adult patients, aged 18 years and older, who underwent major general and vascular surgery at a large single-center urban hospital was conducted from January 2013 to September 2016. Patients were grouped into those who experienced UPR and those who did not. Univariate and multivariate regression analyses were used to identify predictors of UPR, and association of UPR with adverse postoperative outcomes. All regression models had Hosmer-Lemeshow $P > 0.05$, and C-statistic > 0.75 , indicating excellent goodness-of-fit and discrimination.

Results: Of the 8809 patients included, 138 (1.6%) experienced UPR. There was no statistical difference in incidence of UPR between general and vascular surgery patients ($p = 0.53$). Independent predictors of UPR advanced age (OR 5.1, 95%CI 3.5–7.5, $p < 0.01$), higher ASA status (OR 7.9, 95%CI 5.6–11.1, $p < 0.01$), CHF (OR 7.0, 95%CI 3.6–13.9, $p = 0.02$), acute renal failure or dialysis (OR 3.1, 95%CI 1.8–5.7, $p = 0.01$), weight loss (OR 5.2, 95%CI 2.8–9.6, $p = 0.01$), systemic sepsis (OR 4.8, 95%CI 3.4–6.9, $p < 0.01$), elevated preoperative creatinine (OR 4.2, 95%CI 3.0–5.9, $p = 0.01$), hypoalbuminemia (OR 5.3, 95%CI 3.8–7.5, $p = 0.01$), and anemia (OR 4.0, 95%CI 2.8–5.9, $p < 0.01$). Following surgery, UPR was associated with increased mortality (OR 3.8, 95%CI 2.7–5.2, $p < 0.01$), pulmonary complications (OR 1.8, 95%CI 1.7–2.0, $p < 0.01$), renal complications (OR 2.6, 95%CI 1.7–3.5, $p < 0.01$), cardiac complications (OR 4.6, 95%CI 2.0–6.7, $p < 0.01$), postoperative RBC transfusion (OR 5.7, 95%CI 3.8–8.6, $p < 0.01$), and prolonged hospitalization (OR 1.8, 95%CI 1.5–2.4, $p < 0.01$).

Conclusion: UPR is significantly associated with postoperative morbidity and mortality. Perioperative management aimed at decreasing incidences of UPR after noncardiac surgery should target preoperative anemia in addition to previously identified predictors.

1. Introduction

Following surgery, patients are usually extubated once the need for mechanical ventilation or airway protection is no longer necessary. However, in some patients, reintubation following extubation is essential to prevent potentially life-threatening postoperative outcomes. Unplanned postoperative reintubation (UPR) is therefore an unexpected event that indicates an unfavorable postoperative course. It serves as a marker for severe adverse outcome after surgery, and is associated significant morbidity, mortality and healthcare cost [1–6]. Indications

for UPR have ranged from unexpected or failed extubation to clinical deterioration of patients after surgery [5].

Previous studies have identified and provided invaluable insight on predictors of UPR following noncardiac surgery [7–11]; however, these studies have noted inherent limitations that affect their generalizability and application. For example, the most referenced UPR risk index by Arozullah and colleagues [7] had a population of only men, making it difficult to draw any definitive conclusions. Similarly, the risk-index by Johnson and colleagues [8] that sought to improve on previous risk indices was mostly comprised of a population from Veterans Affairs

Abbreviations: UPR, unplanned postoperative reintubation; ASA, American Society of Anesthesiology; CHF, congestive heart failure; RBC, red blood cell; SGOT, aspartate aminotransferase; DLco, diffusing capacity of the lung for carbon monoxide

* Corresponding author. Department of Surgery, Mount Sinai Beth Israel, 10 Union Square East, 2M, New York, NY, 10003, USA.

E-mail address: michael.leitman@mssm.edu (I.M. Leitman).

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(VA) hospitals (90%), making its generalizability questionable. In addition, other published risk indices have focused either on specific surgical subspecialties [9], excluded essential perioperative comorbidities [10], or excluded the effects of preoperative laboratory variables [11] in their analyses.

The present study thus seeks to improve upon previous studies by examining the incidence, impact, and predictors of UPR in adult male and female patients undergoing general and vascular surgery at a large urban hospital. It is the hope of the authors that results published herein will provide a more comprehensive analysis that supports the findings of previous studies, or perhaps identifies novel predictors of UPR, to allow for well-informed decisions among surgeons during the perioperative period.

2. Method

Adult patients, aged 18 years and older, who underwent major general and vascular surgery from January 2013 to September 2016 at a large urban teaching hospital were retrospectively reviewed. The primary outcome was unplanned postoperative reintubation (UPR) within 30 days following general and vascular surgery. UPR was defined as the placement of an endotracheal tube or mechanical or assisted ventilation due to the onset of cardiopulmonary or respiratory failure, as manifested by severe respiratory distress, hypoxia, hypercarbia or respiratory acidosis. Causes of UPR include but are not limited to refractory hypotension, cardiac arrest, inability to protect airways, accidental self extubations requiring reintubations, and emergency tracheostomy in patients who otherwise had no chronic/long-term tracheostomy.

Preoperative and operative variables analyzed included age, gender, body mass index, race, American Society of Anesthesiologists (ASA) status, emergency surgery, diabetes, smoking history, dyspnea, dependent functional status, ventilator dependence, congestive heart failure, chronic obstructive pulmonary disease, hypertension, acute renal failure or dialysis, disseminated cancer, wound infection, steroid use, weight loss, bleeding disorder, preoperative red blood cell (RBC) transfusion, systemic sepsis, serum sodium, blood urea nitrogen, creatinine, albumin, total bilirubin, aspartate aminotransferase (SGOT), alkaline phosphatase, white blood count, hematocrit, platelet count, partial thromboplastin time, international normalized ratio, and operative time.

Thirty-day outcomes analyzed included mortality, pulmonary complications (pneumonia, unplanned reintubation, prolonged mechanical ventilation), cardiac events (cardiac arrest, myocardial infarction), renal failure, neurological complications (stroke or cerebrovascular accidents), thrombotic complications (deep venous thrombosis, pulmonary embolism), wound infection, postoperative RBC transfusion, readmission, and prolonged hospitalization (length of hospital stay > 30 days).

2.1. Statistical analysis

Statistical analyses were performed using SPSS software (Version 22, Chicago, IL, USA). Patients were grouped into those who experienced UPR and those who did not. Univariate analysis was performed on patient demographics, preoperative variables and postoperative outcomes. Baseline characteristics were compared using χ^2 tests for categorical variables and two-tailed *t*-test for continuous variables. Variables with *P* values less than 0.05 in the univariate analysis were included in a stepwise multivariate regression model. The regression model was assessed for goodness-of-fit and discrimination using the Hosmer-Lemeshow test and C statistic.

The study was approved by the Mount Sinai Beth Israel Hospital Institutional Review Board.

Table 1
Effects of UPR on mortality and length of stay (LOS).

	UPR n = 138 (1.6%)	No UPR n = 8671	p-value
Average Hospital LOS (days)	21.5	4.5	<i>P</i> < 0.001
30-day Mortality	33.30%	1.30%	<i>P</i> < 0.001

3. Results

A total of 8809 adult patients who underwent major general or vascular surgery were included, 138 (1.6%) of which experienced UPR. Patients who were reintubated were significantly older and less likely to be female (Table 1). Overall, patients who experienced UPR were more likely to have comorbidities and abnormal preoperative laboratory values than those who did not. There was no significant difference in the incidence of UPR between patients who underwent general or vascular surgery (*p* = 0.53).

Independent predictors of UPR included age > 65 years (OR 5.1, 95%CI 3.5–7.5, *p* < 0.01), ASA > 3 (OR 7.9, 95%CI 5.6–11.1, *p* < 0.01), CHF (OR 7.0, 95%CI 3.6–13.9, *p* = 0.02), acute renal failure or dialysis (OR 3.1, 95%CI 1.8–5.7, *p* = 0.01), weight loss (OR 5.2, 95%CI 2.8–9.6, *p* = 0.01), systemic sepsis (OR 4.8, 95%CI 3.4–6.9, *p* < 0.01), preoperative creatinine > 1.2 mg/dL (OR 4.2, 95%CI 3.0–5.9, *p* = 0.01), albumin < 3.5 g/dL (OR 5.3, 95% CI 3.8–7.5, *p* = 0.01), and hematocrit < 34% (OR 4.0, 95%CI 2.8–5.9, *p* < 0.01) (Table 1).

After surgery, UPR was associated with increased mortality (OR 3.8, 95%CI 2.7–5.2, *p* < 0.01), pulmonary complications (OR 1.8, 95%CI 1.7–2.0, *p* < 0.01), renal complications (OR 2.6, 95%CI 1.7–3.5, *p* < 0.01), cardiac complications (OR 4.6, 95%CI 2.0–6.7, *p* < 0.01), postoperative RBC transfusion (OR 5.7, 95%CI 3.8–8.6, *p* < 0.01), and prolonged hospitalization (OR 1.8, 95%CI 1.5–2.4, *p* < 0.01) (Table 2) (Table 3) (Table 4).

4. Discussion

This study reports a 1.6% incidence of unplanned postoperative reintubation (UPR), which is comparable to the range of 0.4%–4% reported by other studies [3–6,11–15]. Consistent with previous studies [1–6], the present study also identified UPR to be significantly associated with morbidity and mortality. UPR was associated with increased mortality, wound infection, postoperative RBC transfusion, prolonged hospitalization, pulmonary, renal, cardiac and thrombotic complications. Identified predictors of UPR included advanced age, higher ASA status, CHF, acute renal failure or dialysis, weight loss, systemic sepsis, elevated preoperative creatinine, hypoalbuminemia, and anemia.

While previous studies have identified and discussed several predictors of UPR after surgery [7–11], to the best of our knowledge, only one study to date identifies anemia as a predictor of UPR in patients undergoing noncardiac surgery [3]. Still, the fact that anemia was observed as a predictor of UPR in this present study was not surprising. There are numerous studies in the literature that discuss the significant impact of anemia on adverse postoperative outcomes [16–18]. Beattie and colleagues [16] in their retrospective analysis of 7759 adult patients who underwent noncardiac surgery observed anemia to be significantly associated with a more than two-fold increase in mortality within 90 days of surgery. Musallam and colleagues [17] also report that even mild preoperative anemia results in significant postoperative mortality and morbidity. In a large multicenter retrospective study of elderly patients who underwent various major noncardiac surgeries, Wu and colleagues [18] demonstrated that every percentage point decrease in hematocrit from normal range results in a 1.6% increase in

Table 2
Patient characteristics contributing to UPR following general and vascular surgery.

Patient characteristics	UPR n = 138 (1.6%)	No UPR n = 8671	p-value
Age (years)	72.1 ± 12.6	56.5 ± 17.4	P < 0.001
Male	52.20%	46.50%	P = 0.185
Female	47.80%	53.50%	P = 0.185
Admission from nursing home	14.50%	2.00%	P < 0.001
ASA classification			
ASA 3	36.20%	30.20%	P = 0.143
ASA 4	53.60%	14.30%	P < 0.001
ASA 5	3.60%	0.50%	P < 0.001
Emergency Operation	40.60%	19.40%	P < 0.001
Dirty/Infected wound	23.90%	8.80%	P < 0.001
Diabetes			
Non-Insulin dependent	10.90%	11.10%	P = 0.931
Insulin dependent	26.10%	8.50%	P < 0.001
Current Smoker within one year	18.80%	16.30%	P = 0.449
Dyspnea			
Moderate Exertion	3.60%	2.00%	P = 0.309
At Rest	2.20%	0.40%	P = 0.153
Functional Dependence			
Partially-Dependent	21.70%	8.90%	P < 0.001
Totally-Dependent	15.90%	1.60%	P < 0.001
CHF within 30 days prior to surgery	7.20%	1.00%	P = 0.005
Hypertension requiring medication	77.50%	46.30%	P < 0.001
Ascites	6.50%	0.50%	P = 0.004
Dialysis	8.00%	2.50%	P = 0.018
Disseminated Cancer	6.50%	2.30%	P = 0.045
Open wound	14.50%	4.90%	P = 0.001
Steroid use	6.50%	2.90%	P = 0.086
10% loss of body weight within 6 months prior to surgery	8.70%	1.60%	P = 0.003
Bleeding Disorder	16.70%	5.30%	P < 0.001
Preoperative RBC transfusions within 72 h prior to surgery start time	3.60%	1.10%	P = 0.114
SIRS	6.50%	5.20%	P = 0.532
Sepsis	18.10%	2.50%	P < 0.001
Septic shock	5.10%	0.80%	P = 0.022
Multiple preoperative risk factors			
Cases with 2 Risk Factors	21.70%	17.10%	P = 0.185
Cases with 3 Risk Factors	20.30%	8.90%	P = 0.001
Cases with 4 Risk Factors	18.80%	4.50%	P < 0.001
Cases with 5 + Risk Factors	18.10%	3.70%	P < 0.001

Table 3
Preoperative laboratory variables as predictors of UPR following general and vascular surgery.

Preoperative Laboratory Values	UPR n = 138 (1.6%)	No UPR n = 8671	p-value
Total Bilirubin lab value > 1.0 mg/dL	88.40%	78.90%	P = 0.006
Serum Creatinine lab value > 1.2 mg/dL	99.30%	97.50%	P < 0.001
Hematocrit lab value < 38%	99.30%	98.20%	P < 0.001
Platelet Count lab value < 150 × 103/mm ³	99.30%	97.90%	P = 0.012
WBC > 11.0 × 10 ⁹ /L	99.30%	98.10%	P < 0.001
Mean Albumin	3.3 ± 0.9	4 ± 0.7	P < 0.001

adjusted 30-day postoperative mortality.

Though not clearly understood, the impact of anemia on adverse postoperative outcomes can be attributed to the subsequent tissue hypoperfusion and hypoxia that arises from anemia, and its resulting hemodynamic instability and general systemic dysfunction [19]. In

Table 4
Postoperative outcomes contributing to UPR following general and vascular surgery.

Postoperative outcomes	UPR n = 138 (1.6%)	No UPR n = 8671	p-value
Pneumonia	23.20%	1.00%	P < 0.001
On Ventilator > 48 h	44.20%	0.60%	P < 0.001
Acute Renal Failure	10.10%	0.30%	P < 0.001
Progressive Renal Insufficiency	10.10%	0.20%	P < 0.001
Urinary Tract Infection	0.70%	0.60%	P = 0.866
Cerebrovascular accidents	2.90%	0.10%	P < 0.001
Cardiac Arrest	31.20%	0.70%	P < 0.001
Myocardial Infarction	10.10%	0.70%	P < 0.001
Venous Thromboembolism	2.20%	0.40%	P = 0.023
Sepsis	10.10%	1.90%	P < 0.001
Septic Shock	27.50%	0.70%	P < 0.001
URTOR	17.40%	3.70%	P < 0.001
Multiple postoperative complications			
2 postoperative complications	28.30%	2.10%	P < 0.001
3 postoperative complications	19.60%	0.70%	P < 0.001
4 postoperative complications	13.80%	0.20%	P < 0.001
5 + postoperative complications	22.50%	0.10%	P < 0.001

terms of the impact of anemia on respiratory function, Dinakara and colleagues [19] report that the diffusing capacity of the lung for carbon monoxide (DLco), which determines the ability of oxygen exchange between lung alveoli and blood, is severely compromised in anemic patients. For each 1 g/100 mL decrease in hemoglobin, an observed decrease in DLco of approximately 7% was observed [19]. Additionally, anemia has been reported to increase the strain and oxygen demand of the heart, eventually resulting in cardiac pathology and dysfunction [20].

Previously, perioperative RBC transfusion was the mainstay management for preoperative anemia; however, this practice is highly criticized due to its increased association with postoperative morbidity and mortality [21]. It is now generally accepted that unless hemoglobin levels fall below 7 g/dL, RBC transfusion should be avoided in preoperative anemic patients [21,22]. Before hastening to transfuse, preoperative anemia should be viewed as a surrogate for an underlying pathological condition or disease whose cause should be identified and treated [21]. Blood conservation strategies such as replacing volume with crystalloids, using intraoperative hyperoxic ventilation, optimizing hemoglobin with appropriate medications, minimizing blood loss perioperatively by using noninvasive monitoring [22] should rather be utilized to improve preoperative anemia.

5. Limitations

This study has its limitations. First, it is observational in nature, and this limits our ability to definitively determine the causal relationship between identified risk factors and UPR. Second, the retrospective nature of our study made it impossible to analyze all patient variables and outcomes. Hence, some predictors of UPR that could potentially influence clinical judgment may not have been identified. Third, this was a single-center study and so results may not be generalizable to all populations and geographical regions. Despite these limitations, results from this study should be considered when making clinical judgments to improve surgical outcomes as it adds to existing studies and provides a comprehensive assessment tool for UPR risk stratification.

6. Conclusion

Findings of this study suggest UPR is significantly associated increased morbidity and mortality after noncardiac surgery. Novel predictors contribute to UPR following noncardiac surgery. In addition to previously identified predictors of UPR, perioperative management

aimed at decreasing UPR should target preoperative anemia.

Disclosure information

Nothing to disclose.

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Ethical approval

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Author contribution

Study conception and design: Leitman, Mills, Inabnet.
 Acquisition of data: Leitman, Mills, Acheampong.
 Analysis and interpretation of data: Guerrier, Acheampong, Lavarias, Pechman, Leitman.
 Drafting of manuscript: Acheampong, Leitman, Guerrier.
 Critical revision: Leitman, Acheampong.

Conflicts of interest

None.

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Guarantor

Michael Leitman, MD.

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