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Variables that predict reintubation after open-heart surgery

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Abstract

Background: This study sought to determine patient characteristics, process of care, and outcome as predictors of reintubation after open-heart surgery.

Methods: We performed a retrospective case control study that included all patients undergoing cardiac surgery who required reintubation and an equal number of control patients not requiring reintubation. Putative risk factors were analyzed univariately by Moses, Kroskal Willis and χ^2 tests.

Results: Of the 300 consecutive patients reviewed, 39 required reintubation for cardio-respiratory reasons. Univariate predictors of reintubation (P= 0.05) were preoperative CO_2, ejection fraction, weight, diabetes, and intra-operative fluid balances. Multivariate predictors of reintubation for each group (with cardio-respiratory reasons) and for all patients were determined and included preoperative $PaCO_2$, type of operation, ejection fraction (EF), pre- operative PaO_2, number of grafts, age, intra-aortic balloon pump, pump time, clamp time, pH at extubation time, and PaO_2 at extubation time.

Conclusion: Patients who required reintubation had the worst respiratory function. Patients identified as having high risk factors for reintubation should be followed closely and treated for problems that will lead to reintubation.

Keywords: reintubation, open-heart surgery, risk factor.

Introduction

Cardiac surgical intervention has become a common method of treating coronary artery diseases and valvular dysfunction; weaning from mechanical ventilation and endotracheal extubation usually proceeds straightforwardly. Failure of the patients to tolerate extubation may reflect premature extubation or may be a marker of sicker patients.

Premature extubation may lead to hypercarbia, hypoxia, pulmonary hypertension, right heart failure, and myocardial ischemia [1]. Additionally, it subjects the patients to the physical risk of reintubation, including esophageal intubation, laryngeal trauma, and aspiration [2]. The aim of the present study was to determine the incidence of reintubation, the variables associated with reintubation and patient outcome.

Methods

300 consecutive patients undergoing open heart surgery during 2000-2002 were retrospectively studied. Data showed 39 patients who underwent reintubation. Control subjects, not requiring reintubation were selected from the same sample of 300 patients. Selection was conducted via random method.

Control patients and case patients had the same characteristics; age, sex, type of operation, and number of grafts in case of coronary artery bypass graft (CABG) (P<0.1). All patients had undergone general anesthesia with

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midazolam, pancuronium, fentanyl and thiopental. They were monitored with ECG, arterial catheter, pulse oximetry, and central venous line. During cardio-pulmonary bypass, the heart was cooled with ice slush and the patient was actively cooled to maintain rectal temperature at 28°C. After transfer to ICU, patients were weaned from respirator by conventional standard method. When the patients were awake and hemodynamically stable, they were considered for extubation. They then underwent extubation if they met standard criteria; respiratory rate of 10-30/min, tidal volume greater than 5 ml/kg, a negative inspiratory force greater than –20 cmH_2O, arterial carbon dioxide tension of 45 mm H_2O or lower and ability to maintain adequate oxygenation with supplemental oxygen.

Patients underwent extubation if they remained comfortable after a trial of continuous positive airway pressure without any pressure support.

The presence or absence of COPD and diabetes was defined from history as noted in the preoperative evaluation. Preoperative renal failure was defined as a serum creatinine greater than 1.5 mg/dl. Reasons for intubation were obtained from the clinical notes.

Statistical analysis

Case and control groups were univariately compared with χ^2 , Moses and Kroskal Willis tests. A discriminate multivariate analysis with a stepwise forward selection procedure was than used to develop a model predictive of reintubation. A variable that was univariately significant at 0.2 level was considered for inclusion in the model. A P value less than 0.05 was considered significant.

Linear regression with backward selection procedure was than used to develop a model predictive of reintubation to support cardio respiratory function.

Results

Of 300 consecutive patients undergoing cardiac operation a total of 45 patients required reintubation; 39 of whom required reintubation for the following cardiorespiratory reasons:

Respiratory fatigue or failure (N= 20)
Pulmonary edema (N=3)
Cardiorespiratory arrest (N= 4)
Arrhythmia (N=2)
Seizures (N= 1)
Agitation (N=2)
ARDS (N=3)
Blood gas disturbances (N=2)
Others (N=2)

An additional 6 patients required reintubation for unplanned operation (bleeding) that were removed from the study. Three of 39 patients died due to ARDS. For patients requiring reintubation for cardiorespiratory reasons, univariate predictors of reintubation ($P<0.05$) were operating time, preoperative $PaCO_2$, ejection fraction, weight, diabetes, COPD , and intraoperative fluid balances (Table 1).

In linear regression model, multivariate predictors of reintubation ($P= 0.05$) were $PaCO_2$ in

pH at extubation time	1	2	3	4	5	6	7
Preoperational $PaCO_2$	0.08	.-025	-257	0.142	0.002	.-007	.-114
EF	0.093	0.017	0.180	-222	0.188	0.025	.-144
Pump time	0.034	0.033	.-058	0.137	.-331	0.015	.-112
Operation time	0.069	0.082	0.051	0.153	.-313	.-002	.-248
Clamp time	0.015	0.066	.-017	0.123	-265	0.106	0.025
Preoperational $PaCO_2$	0.015	.-062	0.093	.-046	0.215	.-240	0.114
Gender	.-029	.-069	0.041	0.018	0.096	0.194	.-173
PaO_2 at extubation time	0.02	.-017	0.094	.-111	.-038	0.136	.-02
Age	.-025	0.037	.-005	0.216	.-181	.-182	0.399
$PaCO_2$ at extubation time	.-106	-041	.-082	.-225	.-082	0.191	0.245

Table 1. Variables predicting reintubation after open-heart surgery.

Model	Unstandardized Coefficient B		Standardized Coefficient BETA	t	Sig.
Pre-op CO_2	-124	0.046	-646	-2.706	0.027
Gender	1.584	0.723-	376	2.189	0.05
Type of operation	-612	230	-547	2.65	0.02
Number of graft	4.88	0.023	507	2.163	0.05
Body mass index	-271	0.061	-901	-4.451	0.001
pH at extubation time	-13.239	6.240	-659	-2.136	0.05
Age	3.713	0.017	0.371	2.164	0.047
EF	-7.32	0.032	-284	-2.140	0.04
Pre-op PaO_2	-117	0.025	-606	-4.670	0.05

Table 2. Linear regression analysis.

preoperative period, type of operation, number of grafts, pH at extubation time, body mass index, ejection fraction, age, and preoperative PaO_2 (Table 2).

In discriminate analysis, structure matrix showed seven discriminate columns; in which all except number seven showed 10 variables ordered by absolute size of correlation within function matrix that had the largest correlation with any discriminate function.

Variables that had positive correlation were operating time, intra-aortic balloon pump, preoperative PaO_2, pump time, clamp time, $PaCO_2$ at extubation time, gender, diabetes, age, and number of grafts. Variables that had negative correlation were pH at extubation time and preoperative PaO_2 (Table 3).

Discussion

Despite standard criteria for weaning from bypass and extubation [4], 39 patients from 300 patients required reintubation. Gross [5] found no reintubation procedures in 47 selected patients undergoing cardiac operation, but her population was limited to young patients. Prakesh [6] found 4.1% reintubation rates in 123 selected patients undergoing extubation within 3 hours of completion of cardiac operation. But again the patients were relatively young (mean age = 48years) in their study [7].

Cohen [7] found that 13.5 % of 37 patients with COPD undergoing bypass required reintubation. Patients with previous stroke that underwent heart surgery had a 9.9% reintubation rate [8]. London found a 7% reintubation rate in 290 consecutive patients undergoing cardiac surgery. The goal of the present study was to identify variables that could predict reintubation after extubation. We identified 8 variables by linear regression that predicted reintubation (Table 2). By discriminate analysis, 9 variables predicted reintubation (Table 3). By univariate

pH in extubation time	1	2	3	4	5	6	7
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EF	09.	.017	.180	-222	.188	.025	-144
Pump time	034.	.O33	-058	.137	-331	.015	-112
Operation time	.069	.082	.051	.153	-313	-002	-248
clamp time	015.	.066.	-017	.123	-265	.106	.025
Preoperation $PaCO_2$	.015	.-062	.093	-046	.215	-240	.114
Gender	-029	.-069	.041	.018	096	.194	-173
PO_2 in extubation time	.020	.-017	.094	-111	-038	.136	-02
age	.-025	.037	-. 005	.216	-181	-182	339
$PaCO_2$ inextubation time	-106	.041	-082	-225	-082	.191	.365
pH in extubation time	1	2	3	4	5	6	7

Table 3. Structure matrix function.

analysis, patients who had longer operating time were more likely to require reintubation. Operation time is physician related but probably reflects sicker patients.

Although fluid balance is a marker for prolonged intubation and is a variate predictor of reintubation, but it is not a multivariate predictor. Cardiopulmonary bypass has been shown to damage pulmonary vascular endothelium and to lead to increased lung water which may not correlate with total body water [9]. A history of COPD reflects patients' preoperative condition and is associated with a 13.5% rate of reintubation after cardiac surgery.

A limitation of our study is that the number of COPD patients is small, and diagnosis of COPD was taken from admission records rather than spirometry function test. Four patients who required reintubation died due to ARDS. In a general surgical intensive care unit, overall mortality was 14% in patients requiring reintubation which may be related more to the different patient population than to any other factor [10]. Our study found that multiple factors can easily be used to predict reintubation, although discriminate function revealed 100% original grouped cases correctly classified. But incidences of reintubation were low. We suggest extubation to be performed in those patients that have these predicted risk factors but they must be monitored closely.

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