Clinics in Surgery

Research Article
Published: 24 Apr, 2017

Early Extubation Protocol Following Valve and Coronary Artery Bypass Surgery

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Abstract

Background: Early extubation protocols can be safely implemented in most patients undergoing coronary artery bypass surgery. We have found that these results can be replicated in patients undergoing valve surgery and combined coronary bypass and valve surgery as well.

Methods: We implemented an early extubation protocol on Apr 4th, 2011. Our goal was to extubate all appropriately selected patients within 6 h after arrival to our ICU. We utilized the Society of Thoracic Surgeons Adult Cardiac Surgical Database at our institution and compared our extubation times from Jan 1st, 2008–Apr 3rd, 2011 to Apr 4th, 2011-Dec 31st, 2014. We used a chi square test to compare how many patients were extubated within 6h, before and after implementation of this quality improvement project. Fisher's exact tests were used as well when sample sizes were small.

Results: Nearly seventy percent, 1295 of 1855 patients having cardiac surgery at Lahey Hospital and Medical Center were extubated within 6h after implementing our rapid wean protocol. This was a significant improvement compared to 29%, 455 of 1570 patients prior to our quality improvement project ($p<0.0001$). These results were seen for coronary artery bypass as well as valve procedures including combined aortic valve replacement and coronary bypass procedures.

Conclusion: An early extubation protocol can be safely implemented in patients undergoing valve and combined valve and coronary artery bypass operations with similar success rates to those having coronary artery bypass surgery alone.

Keywords: Extubation protocol; Coronary artery bypass surgery; Postoperative care; Quality care management

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Received Date: *14 Feb 2017*
Accepted Date: *17 Apr 2017*
Published Date: *24 Apr 2017*

Citation:
Williamson C, Fitton TP, Smaroff GG, Teague PD, Shaff DA, Curran JN, et al. Early Extubation Protocol Following Valve and Coronary Artery Bypass Surgery. Clin Surg. 2017; 2: 1424.

Introduction

Early extubation of coronary artery bypass (CABG) patients has been shown to reduce costs as well as intensive care unit and hospital lengths of stay [1-4]. It has been a focus of several studies to improve outcomes in the care of CABG patients. According to an analysis from the Society of Thoracic Surgeons Adult Cardiac Surgery Database (STS ACSD) there is a significant variation in post-operative ventilation times in CABG patients providing an opportunity for quality improvement across many institutions [5]. Most studies have focused on CABG patients and few include the impact of early extubation protocols on patients undergoing valve or combined valve and CABG procedures. Prolonged ventilation, defined in the STS ACSD as intubation longer than 24 h, is now one of five morbidity measures utilized in composite scores for evaluating performance of isolated CABG, isolated aortic valve replacement (AVR), AVR plus CABG, and mitral or mitral plus CABG procedures [6-9]. In this report we outline our early extubation protocol and have found that it can be effectively adopted for patients having valve and combined CABG and valve procedures as well as isolated CABG procedures.

Methods

This is a retrospective review of prospectively collected data from the Lahey Hospital and Medical Center's STS ACSD. Our Institutional Review Board approved this study, with waiver of individual patient consent. We utilized the time intervals from Jan 1st, 2008–Apr 3rd, 2011 and Apr 4th, 2011–Dec 31st, 2014 for comparison. Jan 1st, 2008 was when STS ACSD started tracking

Table 1: Patient characteristics and risk factors.

	Jan 1st, 2008–Apr 3rd, 2011 (N (N= 1570)	Apr 4th, 2011–Dec 31st, 2014 (N=1855)	P-value
Age mean (SD)	67.2 (11.1)	67.6 (11.0)	0.29
Gender (N, % male)	1127 (71.8%)	1367 (73.7%)	0.21
BSA mean (SD)	1.97 (0.23)	1.98 (0.24)	0.30
EF ≤ 30%	149 (9.7%) (EF Not Done=33)	133 (7.3%) (EF Not Done=38)	0.01
COPD			
Mild	219 (13.9%)	223 (12.0%)	0.09
Moderate	52 (3.3%)	45 (2.4%)	0.12
Severe	53 (3.4%)	42 (2.3%)	0.05
No COPD	1246 (79.4%)	1540 (83.0%)	0.01
Severity Unknown	0 (0.0%)	5 (0.3%)	0.07
NYHC			
Class I	12 (0.8%)	23 (1.2%)	0.17
Class II	88 (5.6%)	63 (3.4%)	0.002
Class III	139 (8.8%)	166 (9.0%)	0.92
Class IV	61 (3.9%)	111 (6.0%)	0.005
No HF within 2 weeks	1270 (80.9%)	1492 (80.4%)	0.73

Table 2: Exclusion criteria for the early extubation protocol on arrival to the CTPACU.

Hemodynamic Instability [Cardiac Index< 2.0; Mean Arterial Pressure< 60 mmHg; SvO2<50; increasing vasopressor or inotropic requirements].
Persistent neuromuscular blockade.
Chest tube output >100cc/hour.
Oxygen saturation, SpO2< 93% on FiO2 >60%.
Metabolic derangements: PaO2< 70, PaCO2 >55, pH< 7.30.
Respiratory Rate >25 breaths per minute.
CNS dysfunction or mental status changes.
Attending preference order to exclude from rapid weaning protocol
High risk airway

time to extubation data and Apr 4th, 2011 was when we initiated our early extubation protocol. Patient characteristics and risk factors are outlined in Table1. There were no differences in the patient populations during these two time periods with respect to mean age, gender, and body surface area. There were more patients with ejection fractions below or equal to 30% in the 2008 to 2011 pre-protocol cohort but low ejection fraction was not a contraindication to initiating the rapid wean protocol. There was no difference in the two patient populations with respect to mild or moderate chronic obstructive pulmonary disease (COPD), but there were slightly more patients with severe COPD in the earlier time period. Unless the patient was on continuous pre-operative oxygen therapy at home we did not consider severe COPD to contraindicate rapid wean. In fact, we proactively tried to rapidly wean patients with COPD. Heart failure within two weeks of surgery based on the New York Heart Classification (NYHC) was not a contraindication to early extubation. There were more patients in class IV heart failure within two weeks of surgery in the early extubation group.

Exclusion criteria for early extubation included patients in cardiogenic shock and patients who were in pulmonary edema and required high flow supplemental oxygen or endotracheal intubation preoperatively. Aortic dissections were excluded as well.

All patients were considered to be candidates for the protocol on entry into the operating room with the exception of those meeting the exclusion criteria listed above. The anesthesiologists decreased the total dose of fentanyl, on induction, did not re-dose narcotics on re-warming, and reversed the neuromuscular blockade at the completion of the operation. The surgeon and anesthesiologist confirmed that the patient was a candidate for the early extubation protocol at the completion of surgery. At this phase of care patients were excluded if they met any of the exclusion criteria listed in Table 2. If any of these exclusion criteria were corrected in the Cardiothoracic Post Anesthesia Care Unit (CTPACU) within the first few h of arrival, the early extubation protocol was then activated. The early extubation protocol is outlined in detail in the Appendix.

Propofol was used sparingly on transfer to the CTPACU and discontinued immediately upon arrival. Postoperative pain management strategy was changed to a low dose IV fentanyl infusion on transfer that was discontinued prior to extubation. A hydromorphone (Dilaudid) patient controlled analgesia (PCA) was started once the patient was alert and capable of managing the digital delivery devise. In elderly patients hydromorphone PCA was used judiciously.

Chi square test was used to compare how many patients were extubated both within 4 h and within 6 h, before and after implementation of this quality improvement project. Fisher's exact tests were used as well when sample sizes were small.

Results

From Apr 2011 through Dec 2014, 1295 of 1855 (69.8%) patients who had a CABG, valve repair or replacement, or a combination of valve and CABG procedures were extubated within 6h of arriving to the CTPACU. This was a significant improvement compared to 29% ($p<0001$) that were extubated within 6h prior to instituting the rapid wean protocol (Table 3). Nearly three quarters (74.6%) of patients having CABG were extubated within 6h compared with 29.8% ($p<0.0001$). We were equally successful in achieving our goal in 215 of 291(75.3%) patients having single valve procedures compared

Table 3: Number of patients extubated in 6 h or less. Jan 1st, 2008- Apr 3rd, 2011 before the early extubation/rapid wean protocol. Apr 4th, 2011-Dec 31st, 2014 after the protocol.

	Jan 1st, 2008–Apr 3rd, 2011	Apr 4th, 2011–Dec 31st, 2014	P-value
All Procedures	455/1570 (29.0%)	1295/1855 (69.8%)	<0.0001
CABG	303/1016 (29.8%)	794/1064 (74.6%)	<0.0001
Valve	70/215 (32.6%)	215/291 (73.9%)	<0.0001
AVR	54/143(37.8%)	137/182 (75.3%)	<0.0001
MVR	3/19 (15.8%)	24/33 (72.7%)	0.0001
MV Repair	12/41 (29.3%)	38/45 (84.4%)	<0.0001
Valve (excl AVR, MVR, MV Repair)	1/12 (8.3%)	16/31 (51.6%)	0.01
CABG+Valve	40/166 (24.1%)	95/178 (53.4%)	<0.0001
CABG+AVR	32/126 (25.4%)	84/144 (58.3%)	<0.0001
CABG+MVR	3/14 (21.4%)	6/17 (35.3%)	0.46
CABG+Valve (excl CABG+AVR&CABG+MVR)	5/26 (19.2%)	5/17 (29.4%)	0.48
(CABG+Valve+Other), (CABG+Other), (Valve+Other), (Other)	42/173 (24.3%)	191/322 (59.3%)	<0.0001

Table 4: Number of patients' extubated in 4 hours or less. Jan 1st, 2008–Apr 3rd, 2011 before the early extubation/rapid wean protocol. Apr 4th, 2011–Dec 31st, 2014 after the protocol.

	Jan 1st, 2008–Apr 3rd, 2011	Apr 4th, 2011–Dec 31st, 2014	P-value
All Procedures	207/1570 (13.2%)	867/1855 (46.7%)	<0.0001
CABG	135/1016 (13.3%)	535/1064 (50.3%)	<0.0001
Valve	32/215 (14.9%)	142/291 (48.8%)	<0.0001
AVR	26/143 (18.2%)	88/182 (48.4%)	<0.0001
MVR	0/19 (0%)	12/33 (36.4%)	0.002
MV Repair	5/41 (12.2%)	28/45 (62.2%)	<0.0001
Valve (excl AVR, MVR, MV Repair)	1/12 (8.3%)	14/31 (45.2%)	0.03
CABG+Valve	16/166 (9.6%)	57/178 (32.0%)	<0.0001
CABG+AVR	14/126 (11.1%)	54/144 (37.5%)	<0.0001
CABG+MVR	1/14 (7.1%)	1/17 (5.9%)	1.00
CABG+Valve (excl CABG+AVR & CABG+MVR)	1/26 (3.8%)	2/17 (11.8%)	0.55
(CABG+Valve+Other), (CABG+Other), (Valve+Other), (Other)	24/173 (13.9%)	133/322 (41.3%)	<0.0001

with 70 of 215 (32.6%) in the control period. These results were achieved regardless of whether the patient had an AVR, mitral valve replacement (MVR), or mitral valve repair.

Eighty four of 144 patients (58.3%) who had combined AVR and CABG procedures were extubated within 6h compared with 32 of 126 (25.4%) before our quality improvement initiative (p<0.0001). We did not see a statistically significant improvement in our early extubation efforts in the combined MVR and CABG procedures.

Although the goal was to extubate patients within 6 h of arriving in the CTPACU, many were extubated even earlier than our target goal. Half of all patients undergoing CABG, 535 of 1064 (50.3%) were extubated within 4h compared to 13.3%, 135 of 1,016 before we initiated this quality improvement project (p<0.0001). We found similar results with AVR, MV Repair, and CABG/AVR (Table 4).

Reintubation rates were similar before and after instituting our rapid wean protocol, 4.3% and 3.8% respectively (p=0.46). Of the 1295 patients extubated after the protocol was started 36 of (2.8%) were reintubated and none suffered any adverse events from having to be re-intubated. The number of patients who remained intubated over twenty-fourth decreased from 8.8% to 6.8% (p=0.02) after initiation of our rapid wean protocol [10].

Discussion

Early extubation following cardiac surgery is not a novel concept. It was described as early as 1974 by Midell and colleagues in 100 consecutive patients undergoing AVR, MVR, and combined AVR and MVR. Ninety of their patients were able to be extubated in the operating room or within two hours of arrival in the ICU, challenging the standard practice of the time. Morphine was avoided during induction or during the procedure and was used sparingly in the postoperative period. Patients were awakened at the end of the procedure, given what today would be considered a "spontaneous breathing trial", and extubated with satisfactory clinical assessment and arterial blood gases. In the early days of cardiac surgery the routine use of mechanical ventilation was considered a mainstay in the treatment of respiratory failure following extracorporeal circulation. As many of the causes of post perfusion respiratory failure were eliminated, the need for prolonged ventilator support also decreased. Yet it was still standard practice to sedate and ventilate cardiac surgical patients overnight to minimize myocardial oxygen demand and resulting ischemia [11].

In 1977, Prakash and colleagues demonstrated that 123 of 142 adult cardiac surgical patients were able to be extubated in the operating room or within three h of admission to the recovery room

[12]. This included patients who had isolated valve replacements and coronary artery bypass procedures. Only five of the 123 patients were re-intubated. They also utilized a spontaneous breathing trial and established criteria for continued mechanical ventilation. If adequate ventilation was maintained with a stable end title CO_2 of less than 5.5% and other hemodynamic criteria were met their patients were extubated. The most common indication for continued mechanical ventilation was low mixed venous oxygen saturation and an elevated left atrial pressure of greater than 20 torr.

A controlled randomized trial comparing early extubation within 2 h–4 h to late extubation 18 h–21 h following coronary artery bypass surgery was published in the Anesthesia literature in 1980 [13]. This study demonstrated significantly less cardiopulmonary morbidity in patients who were extubated early. Supporting early extubation of patients following coronary artery bypass surgery was the well described evidence of the pulmonary and cardiac physiologic benefits on hemodynamics, and ventricular performance [14-16]. Another prospective, randomized, controlled trial by Cheng "et al." evaluated the outcomes and safety of early extubation after coronary artery bypass grafting [4]. Modifying fentanyl dosing during surgery enabled them to safely extubate 85% of their patients assigned to the early extubation group. They demonstrated an improvement in post-extubation intrapulmonary shunt fraction and a reduction in ICU and hospital length of stay in these patients.

Weaning the cardiac surgeon and the care team from the obligatory overnight use of mechanical ventilation has taken more time. The STS ACSD was utilized to study 274,231 patients who underwent elective isolated CABG from 1,008 centers to assess postoperative ventilation time in 2009 and 2010 [5]. In this multi-institutional study of uncomplicated patients who were ventilated for less than 24 h, there was substantial variation in ventilator time across centers. Ventilation times were 1.8 times higher in centers above the 90th percentile compared to those below the 10th percentile and that difference was not accounted for by patient characteristics after adjusting for case mix. This study was published in 2013 and was a clarion call for a quality improvement initiative to strive for the shortest possible ventilation times for all patients.

The institution of an effective rapid wean program for cardiac surgical patients is a multi-disciplinary team effort that includes cardiac surgeons, anesthesiologists, physician assistants, intensive care unit (ICU) nurses, and respiratory therapists. When we evaluated our traditional weaning process we recognized that one of the impediments to rapid weaning was the need for an individual order for each step of the process. We eliminated that by establishing a protocol with a single order set to initiate the Cardiothoracic Care Unit Rapid Wean Protocol on arrival from the operating room. We also recognized the importance of consistent application of objective criteria for determining the readiness to wean and extubate as outlined in Appendix 1. A Cochrane review and meta-analysis of weaning protocols in critically ill patients has concluded that weaning protocols decrease total duration of ventilation, weaning duration, and length of stay in the intensive care unit [17]. However these weaning protocols were not specific for cardiac surgery. A standardized protocol for decreasing postoperative mechanical ventilation for cardiac surgical patients is the framework that drives the process. These criteria provide a framework for our care team to proceed independently and proactively with weaning and extubation. The intensive care nurses as well as the respiratory therapists become the drivers of the process [18].

We recognize a major weakness of this manuscript lies in its retrospective and non-randomized design. In addition we did not attempt propensity matching of the patients. Our goal was to implement a rapid wean protocol for all of our cardiac surgical patients and measure how well we achieved that process as a quality improvement initiative.

We did not measure outcome variables in our assessment of this process improvement project but plan to do so. Other studies have demonstrated improved clinical outcomes as well as improved utilization of health care resources can result from early extubation of cardiac surgical patients [1-4]. We embarked on this quality improvement initiative and have demonstrated that a rapid wean protocol can be safely implemented for patients undergoing coronary artery bypass surgery, isolated valve surgery, and combined CABG and AVR procedures. It requires a multidisciplinary team effort with modification of the anesthetic management, adjustments in post-operative pain management, and protocol driven weaning parameters. Most importantly it requires a team effort to insure effective implementation.

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