Original Article

Analyzing the Outcome of Early versus Prolonged Extubation Following Cardiac Surgery

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Objectives: This study considered the factors associated with prolonged ventilation and the effects of reduced extubation times on patient recovery, intensive care unit stay, and overall hospital stay.

Materials and Methods: A retrospective study was performed, including 86 consecutive patients who underwent cardiac surgery from August 2006 to January 2007. The patients were divided into two groups following intensive care unit admission: Group A, duration of intubation <4 h (n = 34); Group B, duration of intubation >4 h (n = 52).

Results: Two deaths occurred in 86 patients, and overall hospital mortality was 2.32%. Patients in Group A were younger (33.2 ± 12 versus 45.8 ± 13 years; p = 0.001) and had better preoperative left ventricular ejection fraction (LVEF) (62.4 ± 9.8 versus 44.6 ± 9.4; p = 0.003) than those in Group B. Moreover, Group A patients had a shorter intensive care unit length of stay (1.7 ± 0.5 versus 2.2 ± 0.8 days; p = 0.006) and were discharged earlier than Group B patients (2.7 ± 2.4 versus 4.01 ± 3.96; p = 0.014).

Conclusions: Early extubation offers a substantial advantage in terms of accelerated recovery, shorter intensive care unit, and hospital stay, suggesting that efforts to reduce extubation times are cost-effective. (Ann Thorac Cardiovasc Surg 2008; 14: 218–223)

Key words: intubation, cardiac surgery, intensive care unit stay, hospital stay

Introduction

Routine overnight postoperative ventilation following cardiovascular surgery was adopted in the 1960s, following a demonstration of frequent postoperative respiratory complications.[1,2] The development of high-dose opioid anesthetic techniques for use in patients undergoing cardiac surgery reinforced the need for postoperative mechanical ventilation.[3,4] In the past decade, this approach has been challenged, and early extubation following cardiac surgery has been considered for many patients as safer and more cost-effective.[5]

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Received August 20, 2007; accepted for publication September 3, 2007

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Mechanical ventilation and proper management remains an important clinical challenge in the intensive care unit (ICU). Patients are generally intubated and placed on a mechanical ventilator when their own ventilatory and/or gas exchange capabilities are outstripped by demands placed on them from a variety of diseases.[6–8] As in all situations in which clinicians try to hasten weaning, the risk is that they will precipitate premature termination of mechanical ventilation. The concern is greater in patients who have just undergone cardiac surgery, in which physiological stress may induce cardiac ischemia and heart failure.[9] This study was thus undertaken (i) to determine which demographic and intraoperative parameters were associated with early extubation, and (ii) to assess the impact of early extubation times on ICU and overall hospital stay, also the kind and occurrence of any postoperative complications.

Materials and Methods

Data were extracted from a group of 86 consecutive patients from August 2006 to January 2007 at Dow University of Health Sciences, Karachi. The patients were divided into two groups: Group A, those extubated in less than 4 h (n = 34) following ICU admission; Group B, those extubated in more than 4 h (n = 52). The procedures included were coronary artery bypass graft surgery (Group A: 32%; Group B: 65%), valvular replacement (Group A: 56%; Group B: 35%), atrial septal repair (Group A: 12%; Group B: 2%), comprising both urgent and emergent cases. Exclusion criteria included were off-pump surgeries and individuals less than 18 years of age. Both groups were analyzed on the following variables: type and severity of disease, comorbidity, type of operation, postoperative complications (infections and mortality), duration of mechanical ventilation, ICU stay, and overall length of stay (LOS) in hospital.

Surgical and anesthetic techniques

All patients underwent surgery by way of median sternotomy. Cardiopulmonary bypass (CPB) and anesthetic techniques were standardized.

All patients were given oral midazolam (10–30 mg) two hours before surgery and an oxygen 100% mask until the induction of anesthesia. The anesthetic technique was geared toward facilitating early extubation regardless of preoperative comorbid conditions. Anesthetic induction was achieved with sodium thiopental (5 mg/kg) and supplemented with midazolam (0.05 mg/kg) and nalbuphine (0.1 mg/kg) intravenously. During mechanical ventilation, all patients were given oxygen, nitrous oxide, and isoflurane (0.5%–1%). Nitrous oxide was stopped before heparin was administered. Heparin was given intravenously at a dose of 250–300 IU/kg, with additional intravenous doses of 3,000 IU to maintain the activated clotting time more than 480 s throughout CPB. During bypass, isoflurane (1%) was given via fresh gas flow to the oxygenator membrane. Pancuronium (8–11 mg) or midazolam (0.05 mg/kg) was used for muscle relaxation. The atropine was given at the termination of bypass along with protamine, midazolam, nalbuphine, and isoflurane. All patients were weaned off CPB with a small dose of adrenaline, used routinely as an anesthetic protocol in our hospital.

For conventional operations, the CPB circuit used a hollow fiber membrane oxygenerator, nonpulsatile flow generated by a roller pump, and a 40 μm arterial line filter. Flow rate was 2.4 L/min/m^2 at 37°C, falling to 1.8 L/min/m^2 at 32°C. Mean arterial pressure was maintained at 50 to 70 mm Hg and hematocrit from 0.20 to 0.25, and alpha stat blood gas management was used. Myocardial protection was achieved using intermittent antegrade and retrograde delivery of tepid blood cardioplegic solution. For coronary artery bypass grafting (CABG), all distal and proximal anastomoses were constructed during the same period of cross-clamp time. Intraoperative monitoring included radial artery pressure, electrocardiography, esophageal temperature, urine output, central venous pressure, arterial blood gases, and pulse oximetry.

At the end of the operation, patients were transferred to the ICU. The lungs were ventilated with 60% oxygen using volume-controlled ventilation. The patients were weaned off the ventilator using a standard protocol and extubated when standard criteria were met.[10)]

Ethical committee approval was obtained, and all patients gave written informed consent.

Statistical analysis

All data were retrospectively collected on standardized forms and entered into a computerized database. Data are reported as number and percentage (categoric data), and mean and standard deviation (normally distributed continuous variables). Statistical comparisons are done by the Wilcoxon signed-rank test with a probability of less than 0.05 considered significant.

Results

Significant demographic, clinical, and catheterization data for study groups are shown in Table 1. Patients in Group A were younger in contrast to patients in Group B. There was no significant difference between groups in the prevalence of hypertension, diabetes mellitus, smoking, and respiratory illness. With respect to preoperative cardiac parameters, Group B had lower left ventricular ejection fraction (LVEF) than Group A.

Intraoperative and procedural details for the early extubation group are listed in Table 2. Cross-clamp time and CPB times were not significantly dissimilar between groups. The total number of grafts performed was also similar in both groups. Two deaths occurred among patients of Group B, but there was none in Group A. The relationship of age to early extubation in Group A is shown in Fig. 1. With increasing age, the percentage of patients extubated in fewer than 4 h

Table 1. Patient demographics and clinical data

Variables	Group A (DOI <4 h)	Group B (DOI >4 h)	*p* value
Age (years)	33.2 ± 12	45.8 ± 13	0.001
Female (%)	35	19	NS
Respiratory illness (%)	0	8	NS
HTN (%)	12	27	NS
DM (%)	9	15	NS
Smoking (%)	32	40	NS
LVEF	62.4 ± 9.8	44.6 ± 9.4	0.003
Previous MI (%)	0	11.5	NS

HTN, hypertension; DM, diabetes mellitus; LVEF, left ventricular ejection fraction; MI, myocardial infarction; DOI, duration of intubation; NS, not significant.

Table 2. Intraoperative data

Variables	Group A (DOI <4 h)	Group B (DOI >4 h)	*p* value
X-clamp time (min)	55.8 ± 30.7	57.6 ± 19.6	NS
CPB time (min)	81.7 ± 37.2	88.2 ± 26.3	NS
No. of grafts (arterial and venous) (mean)	2.6 ± 0.5	2.6 ± 0.4	NS

X-clamp, cross-clamp; CPB, cardiopulmonary bypass; DOI, duration of intubation; NS, not significant.

showed a steady decline. For example, 47.05% of patients from ages 18 to 28 compared with 17.64% of patients older than 48 were extubated successfully in fewer than 4 h of ICU arrival.

Postoperative patient outcomes are listed in Table 3. There was no significant difference in the incidence of postoperative complications between groups. Figure 2 shows that 39.35% of patients were extubated successfully in 3.01 ± 0.9, and 60.46% of patients in 7.45 ± 4.40 h (p = 0.001). The ICU stay was shorter in Group A than in Group B, as shown in Fig. 3. Also, patients in Group A were discharged from the hospital earlier than those in Group B.

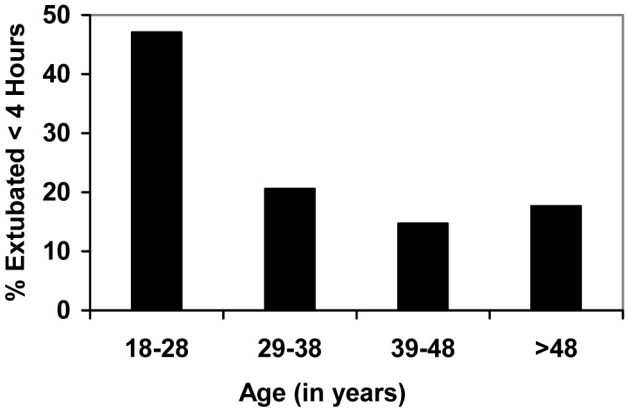

Fig. 1. Percentage of patients extubated in fewer than 4 h versus age.

Discussion

This study unequivocally demonstrates that extubation following cardiac surgery can be achieved successfully in less then four hours, as compared to previous conventional practices, and that it very likely leads to patients spending fewer hours in the ICU and less time in the hospital. Recent advances in surgical and anesthetic techniques have facilitated early hospital discharge following cardiac surgery.[11,12] Such fast-track protocols have placed a significant emphasis on prompt extubation on arrival at the ICU. As a fundamental component of fast-track protocols, early extubation has been shown to expedite the ICU discharge as well as the overall LOS, thus resulting in a net cost savings.[11,13] However, the timing of early extubation has varied among different reports, and a precise definition of it has not been established. This study has defined early extubation as endotracheal tube removal within 4 h of ICU admission.

Table 3. Postoperative data

Variables	Group A (DOI <4 h)	Group B (DOI >4 h)	*p* value
Intubation (h)	3.01 ± 0.9	7.5 ± 4.4	0.001
ICU LOS (days)	1.7 ± 0.5	2.2 ± 0.8	0.006
Ward stay (days)	2.7 ± 2.4	4 ± 3.9	0.014
Complications (%)			
a. Infections	3	8	NS
b. Mortality	0	2	NS

ICU, intensive care unit; LOS, length of stay; DOI, duration of intubation; NS, not significant.

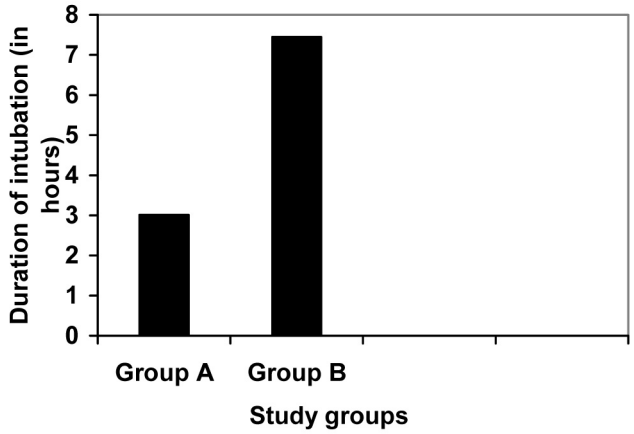

Fig. 2. Comparison of duration of intubation among the study groups.

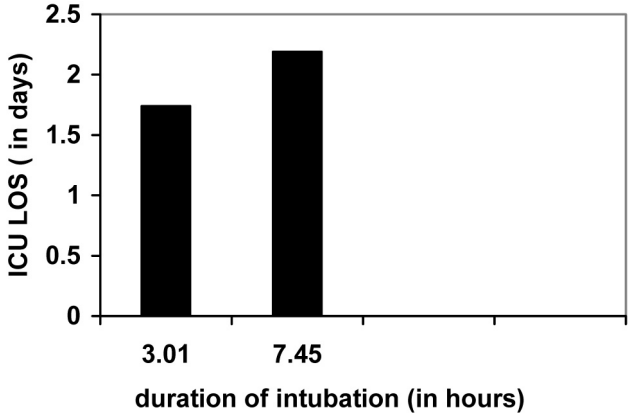

Fig. 3. Relationship of ICU stay to early extubation. ICU, intensive care unit; LOS, length of stay.

The analysis of preoperative and intraoperative demographics showed that the patients in Group A tended to be younger than in Group B. The presence of hypertension, diabetes mellitus, smoking, and respiratory illness preoperatively was not found to be associated with prolonged ventilation. Patients in Group B had an LVEF of less than 50%, suggesting that increased metabolic demands of breathing might be inadequately supported by the impaired pump function leading to prolonged ventilation, as suggested by others.[14,15] A statistically insignificant trend toward shortened CPB and aortic cross-clamp times was noted between the two groups, suggesting that these intraoperative factors do not play an important role in allowing patients to be extubated earlier in the ICU. Thus in patients undergoing early extubation, a decreased ICU stay is associated with a decreased total LOS. Therefore efforts should continue to be made to extubate postoperative cardiac surgery patients as soon as possible in ICU, particularly those who are younger.

Variables that have shown in some studies to affect intubation times include older age, female gender, presence of unstable angina, hemodynamic instability, abnormal temperature, renal insufficiency, use of preoperative diuretics, postoperative intra-aortic balloon counterpulsation, and banked blood transfusion; also, a longer duration of CPB.[16,17] Therefore it is not surprising that an analysis of preoperative and intraoperative variables in this study demonstrates differences among groups of patients extubated in fewer than 4 h after ICU admission versus those extubated in more than 4 h.

There are several potential benefits to early extubation. It has been shown that earlier endotracheal tube removal hastens the return of ciliary function and improves respiratory dynamics and coughing.[18] In fact, it has been proposed that early extubation should decrease the incidence of nosocomial pneumonia.[18] Cheng and colleagues[19] have shown in a prospective randomized study that intrapulmonary shunt fraction improved significantly among patients extubated early. Moreover,

mechanical ventilation itself can impair venous return and decrease cardiac output,[20] thus prolonging ICU stay for the adjustment of these parameters.

Although early extubation was successfully achieved in the majority of patients in this study, we believe that there should be no arbitrary time limit for postoperative extubation. In our institution, patients are extubated when they meet standard criteria: when they are awake, warm, not bleeding significantly and hemodynamically stable, and when they have adequate oxygenation and ventilation. We also learned in this study that several significant preoperative medical problems do not necessarily impede any component of the fast-track recovery process.[11]

Although this research has not plainly established the safety of early extubation, serious adverse effects were not observed in any patient, suggesting that early extubation has both clinical and economic benefits in cardiac surgery. Even though conclusive evidence demonstrating the safety and efficacy of early extubation among patients undergoing cardiac surgery awaits further future trials, we believe that early extubation is an integral part of the cardiac surgery fast-track recovery process. Adequate patient physiological reserve together with optimized postoperative ICU care should be the factors that determine the proper timing of early extubation after cardiac surgery.

Acknowledgment

We thank Dr. Abdullah Ahmad (MBBS) for his help in preparing this manuscript.

References

1. Dammann JF Jr, Thung N, Christlieb L 2nd, Littlefield JB, Muller WH Jr. The management of the severely ill patient after open-heart surgery. *J Thorac Cardiovasc Surg* 1963; **45**: 80–90.
2. Thung N, Herzog P, Christlieb II, Thompson WM Jr, Dammann JF Jr. The cost of respiratory effort in post operative cardiac patients. *Circulation* 1963; **28**: 552–9.
3. Lowenstein E, Hallowell P, Levine FH, Daggett WM, Austen WG, et al. Cardiovascular responses to large doses of intravenous morphine in man. *N Engl J Med* 1969; **281**: 1389–93.
4. Bovill JG, Sebel PS, Stanley TH. Opioid analgesics in anesthesia: with special reference to their use in cardiovascular anesthesia. *Anesthesiology* 1984; **61**: 731–55.
5. Higgins TL. Pro: early endotracheal extubation is preferable to late extubation in patients following coronary artery surgery. *J Cardiothorac Vasc Anesth* 1992; **6**: 488–93.
6. Raju P, Manthous CA. The pathogenesis of respiratory failure: an overview. *Respir Care Clin N Am* 2000; **6**: 195–212.
7. Tobin, MJ, Alex, CG. Discontinuation of mechanical ventilation. In: Tobin, MJ ed.; Principles and Practice of Mechanical Ventilation. New York: McGraw-Hill, 1994; pp 1177–206.
8. MacIntyre NR, Cook DJ, Ely EW Jr, Epstein SK, Fink JB, et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. *Chest* 2001; **120** (6 Suppl): 375S–95S.
9. Meade MO, Guyatt G, Butler R, Elms B, Hand L, et al. Trials comparing early vs late extubation following cardiovascular surgery. *Chest* 2001; **120**: 445S–53S.
10. Lee JH, Geha AS. Postoperative care of the cardiovascular surgical patients. In: Baue AE, Geha AS, Hammond G, Laks H, Naunheim K, eds.; Glenn's Thoracic and Cardiovascular Surgery, 6th ed. Stamford: Appleton and Lange, 1996; pp 1777–91.
11. Engelman RM, Rousou JA, Flack JE 3rd, Deaton DW, Humphrey CB, et al. Fast-track recovery of the coronary bypass patient. *Ann Thorac Surg* 1994; **58**: 1742–6.
12. Higgins TL. Pro: early endotracheal extubation is preferable to late extubation in patients following coronary artery surgery. *J Cardiothorac Vasc Anesth* 1992; **6**: 488–93.
13. Lee JH, Kim KH, vanHeeckeren DW, Murrell HK, Cmolik BL, et al. Cost analysis of early extubation after coronary bypass surgery. *Surgery* 1996; **120**: 611–9.
14. Harms CA. Effect of skeletal muscle demand on cardiovascular function. *Med Sci Sports Exerc* 2000; **32**: 94–9.
15. Pinsky MR. Clinical applications of cardiopulmonary interactions. *J Physiol Pharmacol* 1997; **48**: 587–603.
16. Habib RH, Zacharias A, Engoren M. Determinants of prolonged mechanical ventilation after coronary artery bypass grafting. *Ann Thorac Surg* 1996; **62**: 1164–71.
17. Bando K, Sun K, Binford RS, Sharp TG. Determinants of longer duration of endotracheal intubation after adult cardiac operations. *Ann Thorac Surg* 1997; **63**: 1026–33.
18. Quasha AL, Loeber N, Feeley TW, Ullyot DJ, Roizen MF. Postoperative respiratory care: a controlled trial of early and late extubation following coronary-artery bypass grafting. *Anesthesiology* 1980; **52**: 135–41.

19. Cheng DC, Karski J, Peniston C, Asokumar B, Raveendran G, et al. Morbidity outcome in early versus conventional tracheal extubation after coronary artery bypass grafting: a prospective randomized controlled trial. *J Thorac Cardiovasc Surg* 1996; **112**: 755–64.
20. Gall SA Jr, Olsen CO, Reves JG, McIntyre RW, Tyson GS Jr, et al. Beneficial effects of endotracheal extubation on ventricular performance. *J Thorac Cardiovasc Surg* 1988; **95**: 819–27.