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Change in anaesthesia practice and postoperative sedation shortens ICU and hospital length of stay following coronary artery bypass surgery

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We randomized prospectively 144 patients, undergoing elective coronary artery bypass surgery, to either early or to routine extubation [mechanical ventilatory support for 4–7 h (Group A), or 8–14 h (Group B)]. Anaesthesia was modified for both groups. The groups were well matched in terms of sex, age, NYHA class, preoperative left ventricular ejection fraction, bypass time and aortic cross-clamp time, number of grafts used, and blood units transfused. All patients had normal preoperative respiratory, renal, hepatic and cerebral functions. Mechanical ventilatory support (mean ± SD) was 6·3 ± 0·7 h for Group A and 11·6 ± 1·3 h for Group B. Mean ICU stay was 17 ± 1·3 h for Group A and 22 ± 1·2 h for Group B, while the mean hospital stay was 7·3 ± 0·8 days and 8·4 ± 0·9, respectively. There were no statistically significant differences in the frequency of all postoperative complications among the two groups. There were no reintubation, readmission to the ICU or death in either group. We concluded that change in anaesthesia practice and early postoperative sedation in patients undergoing elective coronary artery bypass graft (CABG) surgery resulted in earlier tracheal extubation, shorter ICU and hospital length of stay without organ dysfunction or postoperative complications. Early extubation was only possible due to the modification of anaesthesia and ICU sedation regime.

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Introduction

In recent years, cost containment and reduction have become major issues in cardiac surgery. Rising medical costs mandate the evaluation of new practices in order to lower hospital costs, without compromising quality of care. All these savings tend to revolve around getting patients off ventilators as quickly as possible. In order to reduce the cost of cardiac surgery, some cardiac surgery centres propose rapid tracheal extubation and discharge from the ICU subsequently reducing the hospital stay (1,2).

Anaesthetic agents directly affect the duration of mechanical ventilatory support in the ICU for cardiac surgery patients. Improvements in anaesthetic and perfusion techniques and equipment refinements for extracorporeal circulation, may allow rapid extubation of selected patients. However, it is still debated if early extubation is preferable, or, whether it is better to delay it for some hours (3,4). There are also other related questions. Is early extubation appropriate and safe in coronary artery bypass grafting surgery? What groups of cardiac surgery patients are ideal candidates for early extubation?

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The aim of this study was to evaluate the effect of modified anaesthesia and ICU sedation on tracheal extubation and the subsequent ICU and hospital length of stay in patients undergoing elective coronary artery bypass graft (CABG) surgery. We also evaluated whether this regime has any implication on postoperative morbidity and mortality rates.

Patients and Methods

Following Institutional Ethical Committee approval and informed consent, we prospectively randomized 144 consecutive patients, who underwent elective CABG surgery, to either early extubation (mechanical ventilatory support for 4–7 h) in Group A or to routine extubation (mechanical ventilatory support for 8–14 h) in Group B. Each group consisted of 72 patients.

INCLUSION CRITERIA

Patients undergoing elective coronary bypass graft surgery, under 70 years old, with preoperative left ventricular ejection fraction ≥35%, New York Heart Classification Class I to III, and with normal preoperative respiratory function (FVC ≥75% of predicted and FEV_1/FVC ratio ≥70%) were included.

TABLE 1. Patient characteristics in both groups

	Group A (mechanical ventilation 4–7 h)		Group B (mechanical ventilation 8–14 h)		P
	n	(%)	n	n	(%)
Patients	72		72		
Males/females	67/5	(93·1/6·9)	66/6	(91·7/8·3)	n.s.
Smokers	52	(72·2)	50	(69·4)	n.s.
Age (mean ± SD)	58·9 ± 7·6		60·2 ± 8·3		n.s.
Preop. left ventricular ejection fraction (%)	0·45 ± 0·1		0·44 ± 0·1		n.s.

TABLE 2. Type of anaesthesia and ICU sedation and analgesia regime in both groups

	Group A (mechanical ventilation 4–7 h)	Group B (mechanical ventilation 8–14 h)
Induction	etomidate (0·1–0·2 mg kg^{-1})	etomidate (0·1–0·2 mg kg^{-1})
	or thiopentone (1–2 mg kg^{-1})	or thiopentone (1–2 mg kg^{-1})
	fentanyl (total dose 15–20 $\mu g\ kg^{-1}$)	fentanyl (50 $\mu g\ kg^{-1}$)
	pancuronium bromide (0·1 mg kg^{-1})	pancuronium bromide (0·1 mg kg^{-1})
	midazolam (2 mg)	midazolam (0·1–0·2 mg kg^{-1})
Maintenance	isoflurane or halothane 0·5%	isoflurane or halothane 0·5%
	or propofol (2–4 mg $kg^{-1}\ h^{-1}$)	midazolam (total dose 0·1 mg kg^{-1})
	fentanyl (5 $\mu g\ kg^{-1}$, total dose)	fentanyl (10–15 $\mu g\ kg^{-1}\ h^{-1}$)
	pancuronium bromide (as needed)	pancuronium bromide (as needed)
ICU	(for a maximum 2 h)	(during the first 6 postop hours)
Analgesia	morphine (0·01–0·03 mg $kg^{-1}\ h^{-1}$)	morphine (0·03–0·05 mg $kg^{-1}\ h^{-1}$)
Sedation	{propofol (1–2 mg $kg^{-1}\ h^{-1}$)}	midazolam (30–50 $\mu g\ kg^{-1}\ h^{-1}$)

EXCLUSION CRITERIA

All patients who did not fulfil the above criteria, i.e. those with chronic renal failure, hepatic failure, cerebral dysfunction, or those who underwent redo CABG surgery, were excluded from this protocol.

Demographic data, New York Heart Association Class and preoperative left ventricular ejection fraction assessed by angiography (grade 1, >50%; grade 2, 35–50%) were recorded in a database program for each patient. Variables recorded were number of grafts, bypass times, aortic cross-clamp times, blood units transfused, and number of inotropes administered. The inotropes were recorded when they were used in the operating room and in the ICU for at least 6 h (see Table 3). Mean arterial pressure was maintained between 65 and 90 mmHg, and central venous pressure between 7 and 12 cm H_2O. This was achieved by administration of blood and/or colloids and crystalloids. Blood transfusion was given when haematocrit was less than 27%.

The groups were similar in terms of sex, age, NYHA class and preoperative left ejection fraction (Table 1). In all patients, moderate (28°C) to mild (34°C) core hypothermia was achieved, while antegrade cold crystalloid cardioplegia was used. The same surgical technique was performed in all patients. Modified general anaesthesia and ICU sedation for both groups are presented in Table 2.

Duration of mechanical ventilation, perioperative complications, length of ICU and hospital stay and patient's outcome in ICU and hospital discharge were also recorded. Operative and postoperative complications were assessed blinded to the randomization of the group. Atelectasis was assessed by an intensivist and a radiologist blinded to the study.

DEFINITIONS

All definitions were used as stated in the study protocol. For cardiogenic shock, adult respiratory distress syndrome (ARDS) and coma were used definitions as in previous scientific papers (5–7).

The presence of dyspnoea associated with deterioration of hypoxaemia, bilateral pulmonary infiltrates in chest X-ray and pulmonary artery occlusion pressure (PCWP) more than 15 mmHg were used as diagnostic criteria for cardiogenic pulmonary oedema. For this study, perioperative arrhythmias included atrial fibrillation or flutter and ventricular tachycardia or fibrillation. A postoperative myocardial infarction was determined by the development

TABLE 3. Operative and immediate postoperative variables in both groups

	Group A (mechanical ventilation 4–7 h)		Group B (mechanical ventilation 8–14 h)		P
	n	(%)	n	(%)	
Grafts*	2·3 ± 0·6		2·5 ± 0·7		n.s.
Aortic cross-clamp time (min)*	48 ± 11		51 ± 14		n.s.
Bypass time (min)*	82 ± 39		87 ± 30		n.s.
Blood (units)*	2·2 ± 0·9		2·9 ± 1·3		n.s.
Inotropes (>6 h)	4	(5·5)	3	(4·2)	n.s.
Intra-aortic balloon pump	0	(0)	0	(0)	n.s.

*Data are in (mean ± SD).

of new and persistent Q waves at electrocardiograph associated with an abrupt rise in CPK, CPK-MB and troponine values for more than 24 h.

The diagnosis of atelectasis (segmental or lobar) was based on chest radiograph findings such as volume loss of the hemithorax, a parenchymal density, elevation of the hemidiaphragm and shift of the mediastinum, associated with deterioration of hypoxaemia and bronchial breath sounds.

Acute renal failure was defined as an acute postoperative rise of serum creatinine above 2 mg % in patients with normal preoperative renal function. Hyperbiliribinaemia was defined as an absolute postoperative increase in the total serum bilirubin level to greater than 3 mg dl^{-1} for more than 2 days.

Bleeding was considered as blood loss of more than 500 ml during the first 6 postoperative hours or blood loss necessitating more than 3 red cell units transfused during the first 12 postoperative hours. The criteria of the World Health Organization were used for stroke definition. Brain death was defined as the irreversible cessation of all functions of the entire brain. Mortality rate refers to death occurring in the hospital after coronary artery bypass grafting regardless of total length of stay.

EXTUBATION CRITERIA

They were exactly the same in both groups. Decision for extubation was made when all these criteria were met: (1) patient alert, awake and haemodynamically stable, (2) temperature >36°C, (3) bleeding <100 ml h^{-1} for >2 h, (4) tidal volume >8 ml kg^{-1}, respiratory rate greater than 10 but less than 30 breaths min^{-1} and negative inspiratory force >2 cm H_2O, with a pressure support ventilation of 5 cm H_2O, and (5) PaO_2 >80 mmHg with $FIO_2 \leq 0{\cdot}5$, pH>7·35 and $PaCO_2$ less than 50 mmHg for 1 h in the pressure support mode.

STATISTICAL ANALYSIS

Data was analysed using the BMDP Statistical Software (Los Angeles, CA, U.S.A.) (8). Continuous variables were analysed using the two sample *t*-test. Chi-square test was used for discrete variables. Differences between variables of Table 4 at each study time were analysed by analysis of variance (ANOVA). Data was reported as the mean ± SD and was considered to be significant when *P* values were less than 0·05 (9).

Results

No patient developed postoperative cerebral complications, infection, hyperbilirubinaemia–jaundice, acute renal failure, ARDS or sepsis. Atelectasis developed in six patients (8·3%) in Group A and in seven patients (9·7%) in Group B (*P*=n.s.). Postoperative complications for both groups are shown in Table 4. Mean (± SD) FIO_2/PaO_2 ratio, $PaCO_2$ and pH values at 30 min after admission in the ICU (AA), immediately after extubation (AE), and just before discharge from the ICU (BD) for both groups are presented in Table 5. Mean (± SD) mechanical ventilatory support, ICU and hospital length of stay for both groups are shown in Table 6. No reintubation, readmission to the ICU or death were recorded in either group.

Discussion

Critical care consumes a significant portion of health care expenditures following open heart surgery. Efforts to curtail hospitalization costs have focused, in part, on the issue of early tracheal extubation following coronary artery bypass graft surgery, in order to lower ICU and hospital lengths of stay.

In this study, operative use of low-dose fentanyl with a small amount of volatile agent (isoflurane or halothane 0·5%) or propofol that was continued for a maximum 2 h in ICU, allowed the rapid discontinuation from mechanical ventilation successfully. Early tracheal extubation resulted in rapid ICU independence and hospital discharge safely.

Our findings are in agreement with previous studies which also showed that early extubation was a safe procedure in selected CABG surgery patients resulting in a

TABLE 4. Immediate postoperative complications in both groups

	Group A		Group B		*P*
	n	(%)	*n*	(%)	
Central nervous system					
stroke	0	(0)	0	(0)	n.s.
ICU psychosis	0	(0)	0	(0)	n.s.
Respiratory system					
atelectasis	6	(8·3)	7	(9·7)	n.s.
ARDS	0	(0)	0	(0)	n.s.
Cardiovascular system					
arrest	0	(0)	0	(0)	n.s.
arrhythmia	8	(11·1)	9	(12·5)	
pacing	1	(1·4)	1	(1·4)	n.s.
shock	1	(1·4)	2	(2·8)	n.s.
ischaemia	3	(4·2)	4	(5·5)	n.s.
acute myocardial infarction	0	(0)	0	(0)	n.s.
arterial hypertension	53	(73·6)	49	(68·0)	n.s.
Bleeding	3	(4·2)	5	(6·9)	n.s.
Infection	0	(0)	0	(0)	n.s.
Acute renal failure	0	(0)	0	(0)	n.s.
Jaundice–hyperbilirubinaemia	0	(0)	0	(0)	n.s.

TABLE 5. PaO_2/FiO_2 ratio (mmHg), $PaCO_2$ (mmHg), and arterial pH at 30 min after admission in the ICU (AA), immediately after extubation (AE), and just before discharge from the ICU (BD) in both groups

	(AA)		(AE)		(BD)		*P*
	Group A	Group B	Group A	Group B	Group A	Group B	
PaO_2/FiO_2	324 (± 76)	319 (± 79)	287 (± 54)	281 (± 61)	227 (± 52)	232 (± 55)	n.s.
$PaCO_2$	34 (± 4)	36 (± 4)	35 (± 4)	35 (± 4)	37 (± 4)	38 (± 4)	n.s.
pH	7·37 (± 0·06)	7·36 (± 0·08)	7·40 (± 0·04)	7·41 (± 0·03)	7·39 (0·06)	7·38 (± 0·07)	n.s.

*Data are in (mean ± SD).

TABLE 6. Duration of mechanical ventilation, length of ICU stay, and hospital stay in both groups

	Group A	Group B	*P*
Mechanical ventilatory support (h)	7·3 ± 0·7	11·6 ± 1·3	0·0001
ICU stay (h)	16·0 ± 1·3	23·0 ± 1·2	0·0001
Hospital stay (days)	7·3 ± 0·8	8·4 ± 0·9	0·0001

*Data are in (mean ± SD).

shorter hospital stay (10,11). In our study, mean hospital stay in the early extubation group was found to be 1 day less compared to the conventional group. That means not only saving money for the patient, but most importantly, a significant decrease in the waiting list for cardiac surgery is achieved. Since in our centre the average hospital stay is 10 days and 1800 cardiac operations are performed annually, the policy of early extubation will result in about 180 more operations per year. This is of vital importance because beds in cardiac surgery centres are limited and of high cost all over the world.

Saving money is achieved not only from a shorter hospital stay, but also because the patient remains under mechanical ventilation for a shorter amount of time resulting in reduced medication and shorter ICU stay. This is supported from previous studies suggesting that early extubation is associated with economic benefits (12,13). Early discharge from the ICU not only means saving money but

it is also associated with a better patient comfort since the ICU environment is generally characterized by increased noise and less patient contact with relatives and friends.

It has also been supported that early extubation improves ventricular performance (14), renal function (15), and respiratory function. However, some previous studies found increased myocardial ischaemia rates in the 'fast track' CABG surgery patients (16,17). This was mainly attributed to increased activity of the sympathetic nervous system, increased myocardial oxygen demand, and haemodynamic instability during this period (18). Studies showed that a relationship may exist between perioperative ischaemia and persistent tachycardia and that the severity of ischaemic episodes can be diminished with intensive analgesia (19,20).

Although it is possible that some patients will require tracheal reintubation, especially if strict extubation criteria are not followed, no patient in our series needed reintubation. No patient needed readmission to the ICU.

In conclusion, early discontinuation of mechanical ventilation had no significant complications in the immediate postoperative period, after elective cardiac surgery, in a selected group of patients. Early tracheal extubation (within 4–7 h of arrival in the ICU) should be the goal, especially in patients under 70 years of age, undergoing elective CABG surgery, with preoperative left ventricular ejection fraction $\geq 35\%$ and normal preoperative respiratory system. Benefits include improved patient comfort, earlier mobilization, cost savings, and more efficient resource utilization.

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