Predictors of Postoperative Mechanical Ventilation Time, Length of ICU Stay and Hospitalization Period after Cardiac Surgery in Adults

Hayel Al-Adwan MD, Ashraf Fadel Moh'd MD*, Rami Qsous MD*, Mohammad A. Khasawneh MD*, Haitham Altaani MD**, Rani Abu-Jubbah RN ^*

ABSTRACT

Objectives: To study the effect of perioperative factors on patients' recovery after cardiac surgery in adults.

Methods: This is a prospective observational analysis of 101 adult patients (age range 19-78 years) who had undergone coronary artery grafting, heart valve(s) replacement / repair or combined (coronary and valve) surgeries, was conducted at Queen Alia Heart Institute. The influence of 22 perioperative parameters (age, gender, co-morbidities, body mass index, type of surgical procedure, left ventricular function, cardiopulmonary bypass time (CPB), inotropic support, analgesia, postoperative blood losses,...) on recovery variables (time of extubation, ICU and hospital discharge) was studied. European system for cardiac operative risk evaluation (EUROSORE) has been calculated. Univariate and multivariate analysis of results was performed.

Results: Mean time of mechanical ventilation was 11±8.5 hours. Delay in extubation was noticed in patients with left ventricular impairment, chronic respiratory disease, morbid obesity, urgent surgery, age above 61 years, patients who had reopening for control of bleeding and lower temperatures during deliberate hypothermic cardiopulmonary bypass. The mean length of ICU stay was 1.8 ± 1.2 days. The average length of hospitalization was 5.1±1.2 days. There was a correlation between Length of intensive care unit stay and CPB (p-value=0.02), and between Length of intensive care unit stay and aortic cross clamp time (p-value=0.006). Prolonged operative time (OT) was associated with increased length of hospitalization (p-value=0.008). Average EUROSCORE value was 1.4 (ranged between 0.5 - 5.3).

Conclusion: Left ventricular dysfunction, urgent surgery, inotropic support, considerable postoperative bleeding, morbid obesity, longer cardiopulmonary bypass and aortic clamp times, are main risk factors of delayed (or prolonged) extubation, and ICU/ hospital discharge.

Key words: Cardiac surgery, Length of hospitalization (LOH), Length of intensive care unit stay (LOICUS), Time of mechanical ventilation (TOMV).

JRMS December 2015; 22(4): 31-39 / DOI: 10.12816/0018548

From the Departments of:
*Anaesthesia, Queen Alia Heart Institute (QAHI), King Hussein Medical Center, (KHMC), Amman-Jordan
**Cardiac Surgery, (QAHI), (KHMC)
^Nursing, (QAHI), (KHMC)
Correspondence should be addressed to Dr. A. Fadel (QAHI), (KHMC)
Manuscript received November 9, 2014. Accepted July 2, 2015

Introduction

The concept of fast-track surgery was introduced in the early 1990s.[1] Recent advances in anaesthesia, surgical techniques, myocardial protection, extracorporeal perfusion techniques, critical care protocols and improved perioperative management all had contributed to the success of early extubation and shorter hospitalization in the cardiac surgical population.[2]In the last years cardiac anaesthesia has fundamentally changed from high-dose opiate based technique to a more balanced approach using moderate-dose narcotics, inhalational agents, and shorter acting narcotics.[3] This allows for shorter Time of Mechanical Ventilation (TOMV), early mobilization, decreased Length of Intensive Care Unit Stay (LOICUS) and avoidance (or reduction) of the multiple complications of prolonged mechanical ventilation. Other benefits of early extubation are patient comfort, better utilitization of resources and reduction of cost.[4] The benefits of early extubation in the field of cardiac surgery had been shown by many authors.[5,6] However there are some factors that render the cardiac surgical patient in need for longer periods of ventilator time such as post operative mediastinal bleeding, neurological dysfunction and hypoxia. Several studies attributed delayed extubation and longer LOICUS to co-morbidities, old age, urgency of surgery, left ventricular dysfunction, postoperative bleeding, longer cardiopulmonary bypass and aortic clamp (ischemia) time.[7] Along with the mentioned factors we studied the effect of pleurotomy (usual occurrence during harvest of internal mammary artery), use of inotropes, morphine infusions, Body Mass Index (BMI), operative time, surgical procedure, diabetes, hypertension, previous myocardial infarction, and left ventricular dysfunction.

There is lack of consensus regarding the definition for fast tract extubation (FTE), delayed extubation and prolonged TOMV. Some authors considered FTE within 1-6 hours since arrival to ICU, for others it was 2-8 hours or up to 10 hours. Prolonged TOMV was defined as more than 24 hours, or more than 48 hours according to different authors. Risk stratification models can be used by anaesthetists, surgeons and patients not only to estimate risk of mortality and morbidities, but also for estimation of length of postoperative TOMV and LOICUS. Among several risk stratification models and scoring systems used (Parsonnet score, EUROSCORE, Cardiac anaesthesia risk evaluation (CARE) score, Society of Thoracic Surgeons (STS) score and many others), the STS scoring system is more frequently used for prediction of postoperative TOMV and LOICUS, and the EUROSCORE as a widespread tool for estimation of mortality risk preoperatively.[9,10] According to the STS risk model outcome definitions postoperative TOMV is defined as prolonged if patient remained intubated for $\geq$ 24 hours. Recurrent variables (risk factors) that appeared in most scoring systems are studied in our study.

Rarely, delay in extubation can be due to clinical decision to keep on ventilator overnight if probability of need of surgical reintervention is high (persistent arrhythmias, postoperatively low cardiac output, for control of profuse bleeding and risk of pericardial tamponade), and even more rare, delay of sternal closure is decided (chest kept open), to allow for rapid interventions in patients with severely compromised cardiac function.[11]

Methods

This prospective observational study was performed at Queen Alia Heart Institute from November 2013 till June 2014. Ethical committee approval obtained. 101 adult patients undergoing coronary artery grafting, valve(s) surgery or combined (CABG and valve) surgeries with cardiopulmonary bypass and aortic cross clamping were enrolled in this study. Data collected in a special form designed for the purpose of this study. Inclusion criteria included: Adult age, on-pump CABG, valve(s) or combined (CABG and valve). Exclusion criteria included: OPCAB (off-pump coronary artery bypass), ASD (atrial septal defect), AAR (aortic arch replacement), pre-operative cardiac arrest, mechanically ventilated prior to surgery, redo-surgeries and paediatric surgeries.

European system for cardiac operative risk evaluation (EUROSORE) has been calculated using the new model (EUROSCORE II), values ranged between 0.5 to 5.3, with an average of 1.4.

For comparison of different age groups; patients were divided into three groups: Group 1: less

than 40 year old, Group 2: between 40 and 60 year old and Group 3: more than 61 year old. Most of the patients were in group 2 (56 patients).

Anaesthetic Protocol:

All patients had a standard balanced anaesthetic technique: fentanyl (10-15 µg/kg) + midazolam (0.05 mg/kg) + pancuronium (0.1 mg/kg) for induction, remifentanyl infusion (0.05-2 µg/kg/min) + propofol infusion (50-100 µg/kg/min) + isoflurane (1-2%) or sevoflurane (2-2.5%) for maintenance of anaesthesia. Pharmacological reversal of neuromuscular blockade was not used. Mechanical ventilation was given through a closed circuit with tidal volume of 7 ml/kg. Along with the standard ASA monitors (pulse oximetry, ECG, capnography and nasopharyngeal temperature probe), all patients had an arterial line, central venous line, urinary bladder catheter. Frequent laboratory values for arterial blood gases, blood sugar, hematocrit and electrolytes were obtained. CXR and echocardiography were upon physician request.

Surgical Protocol:

Surgeries were performed through median sternotomy. After heparinization with a dose of 3mg/kg and achieving ACT (activated clotting time) of above 500 seconds hypothermic cardiopulmonary bypass was initiated through aortic and right atrial or bicaval cannullae. Aortic cross clamping with antegrade cold crystalloid cardioplegia to achieve isoelectric cardiac arrest was done in all patients. Patients with left ventricular dysfunction were given an additional hyperkalemic cold blood cardioplegia via a retrogradely inserted cannula in the coronary sinus to ensure proper myocardial preservation. At the end of surgery normothermia was achieved, patients weaned from CPB machine and heparin reversed with protamine sulphate. After obtaining hemostasis and chest closure, patients were transferred to ICU.

Weaning from Mechanical Ventilator:

Readiness for weaning from mechanical ventilator was assessed clinically and by 1) Good ABGs or acceptable results according to patient's specific condition, 2) Hemodynamic stability, 3) No bleeding or bleeding within the acceptable range, 4) Return of muscle strength (head lift /strong hand grip>5 seconds). Weaning started with ongoing assessment of the above mentioned parameters at each step of the weaning process. Weaning includes decreasing the rate of ventilator synchronized with decreasing the FiO_2. The last step before extubation must be: CPAP mode for at least 15 minutes with FiO2<50%, PEEP< 4cm H_2O and pressure support<10 cm H_2O. Arterial blood gases (ABGs) criteria for extubation are: PaO2 range of 80 - 100 mmHg, oxygen saturation (SpO_2) above 94%, $PaCO_2$ between 35 to 45 mm Hg and pH between 7.35 and 7.45. Tidal volume should be greater than 5 ml/ kg (ideal body weight), respiratory rate less than 35 breaths per minute and negative inspiratory force (NIF) > 20cm H_2O.

Transfer to the Surgical Floor:

Patients were considered suitable to be transferred to the surgical floor if they fulfilled these criteria: 1. Hemodynamic stability with no inotropic support. 2. Adequate level of consciousness. 3. Minimal chest tube drainage. 4. Adequate respiratory parameters. These criteria were assessed by two surgeons; at least one of them is a consultant.

Dismissal from the Hospital:

Home dismissal was assessed by the consultant after checking patient's wounds and assuring adequate haemodynamics.

Definitions:

Left Ventricular impairment: LV impairment was defined by either an echocardiographic assessment or visual estimation of the left ventricular segmental motion by the left heart catheterization or both.

Previous Myocardial infarction: Previous myocardial infarction was defined if the patient had any Q wave appearance or enzyme leak in the past 6 months from surgery.

Respiratory disease: This was considered for any patient who is being followed or treated by the pulmonology team.

Smoking Status:

Any patient who did not quit smoking for the last 6 months from surgery.

Table I: Patients Characteristics

Variable	n (%) or mean ± SD
Age(years) mean ± SD	57.5±11.5
BMI (kg/m ²) mean ± SD	28.9 ± 4.6
Morbid obesity BMI≥40 kg/m ² n (%)	2 (2%)
Female n (%)	17 (16.8 %)
Male n (%)	84 (83.2 %)
Respiratory disease n (%)	30 (29.7%)
Hypertension n (%)	73 (72.3%)
Diabetes n (%)	54 (53.5%)
Smoking n (%)	57 (56.4%)
Previous MI n (%)	24 (23.8%)
LV impairment n (%)	38 (37.6%)
CABG surgery n (%)	85 (81%)
Harvest of internal mammary artery n (%)	60 (59%)
One valve surgery n (%)	8 (7.9%)
>1 valve n (%)	4 (4%)
CABG + Valve (combined) surgery n (%)	4 (4%)
Urgent surgery n (%)	5 (5%)
Operation time(minutes) mean ± SD	247.6 ±46.8
CPB time (minutes) mean ± SD	86.2±26.5
Hypothermia (⁰ Celsius) mean ± SD	33 ±1.4
AXC time (minutes) mean ± SD	48.2±21.3
Inotropic support n (%)	33 (32.7%)
Post operative blood loss (ml) mean ± SD	412.7±328.7
Reopening (resternotomy) n (%)	4 (3.96%)
Post-operative morphine infusion n (%)	78 (77.2%)

Statistics:

Independent t-test was used to determine the effect of gender, hypertension, diabetes, smoking, morbid obesity, left ventricular impairment, urgency of surgery, history of previous myocardial infarction, incidence of reopening for bleeding, use of inotropic support and use of morphine.

One way ANOVA was used to determine the effect of age on TOMV, LOICUS and LOH.

Correlation test was used for determine the effect of the BMI, operative time, CPB time, AXC time, hypothermia. Multivariate analysis was performed to examine the relation between gender, age and type of surgery with TOMV, LOICUS and LOH (dependent variables).

Results

Male patients were 84 (83.2%) and female patients were 17 (16.8%). The patients ranged in age from 19-78 years (average 57.5 years). Patients' demographics, co-morbidities and risk factors are illustrated in Table I. The number of patients who underwent CABG is 85 (81%), the internal mammary artery was harvested and used in 60 patients (70.5% of those undergoing CABG, and 59% of the total number of patients enrolled in the study). One valve surgery was performed in 8 patients. Four patients had more than one valve repaired and/or replaced, and another 4 patients had combined valve and CABG surgery. Most of the cases were elective (96 patients) and five cases were urgent.

About 29.7% of patients were known to have respiratory illness, 73% were hypertensive, 54% diabetics, 56.4% were smokers and 23.8% had previous myocardial infarction. Pre-operative left ventricular function was evaluated by two-dimensional echocardiography in all patients, and left ventricular impairment was documented in 37.6%.

Preoperative factors:

Mean duration of TOMV was almost the same in age group 1 (less than 40 years) and group 2 (40-60 years) as it lasted for 9.5±2 hours and 9.3±4 hours respectively, but longer mean TOMV was seen in group 3 (above 61 years) was

Table II: Effect of preoperative factors on durations of TOMV, LOICUS, and LOH

Variable		Number of patients (%)	Extubation time Mean± SD	ICU time Mean± SD	Hospital time Mean± SD
Gender	Male	84 (83.2%)	11 ± 9	1.7 ±1.1	4.9 ±0.9
	Female	17 (16.8 %)	10.5 ±4.8	1.9 ±1.4	5.8 ± 2
	p-value		0.798	0.580	0.007
	Yes	38 (37.6%)	14 ± 12.7	2.2 ± 1.4	5.4 ± 1.2
LV Impairment	No	63(63.4%)	9.2 ± 3.6	1.5 ± 0.9	4.8 ± 1.2
	p-value		0.006	0.002	0.024
HTN	Yes	73(72.3%)	11.4 ± 9.3	1.8 ± 1.2	5.1 ± 1.3
	No	28 (27.7%)	10.1 ± 6.2	1.6 ± 1	5 ± 0.8
	p-value		0.505	0.446	0.790
DM	Yes	54 (53.5%)	11.4 ± 10.4	1.8 ±1.2	5 ±1
	No	57 (56.5%)	10.6 ± 5.6	1.7 ± 1.2	5.1 ±1.4
	p-value		0.630	0.597	0.654
Previous MI	Yes	24 (23.8%)	8.5 ± 3.3	1.7 ±1.2	4.8 ± 1
	No	77 (77.2%)	11.8 ± 9.5	1.8 ± 1.1	5.1 ±1.3
	p-value		0.102	0.847	0.336
Morbid obesity	<=40	2 (2%)	11.1 ± 8.6	1.7 ± 1	5 ± 1
	>40	99 (99%)	9 ± 2.8	3.5 ± 3.5	8.5 ± 5
	p-value		0.731	0.043	0.001
Smoking	Yes	57 (56.4%)	12 ± 10.3	1.7 ± 1.2	4.9 ± 1
	No	44 (44.6%)	9.8 ± 5.2	1.8 ± 1.2	5.3 ± 1.4
	p-value		0.208	0.850	0.104
Respiratory illness	Yes	30 (29.7%)	15.4 ± 14	2 ± 1.3	5.1±1.3
	No	71 (70.3%)	9.2 ± 3.5	1.7 ± 1.1	5.1 ± 1.2
	p-value		0.001	0.195	0.817
	Elective	96 (96%)	10.58± 6	1.7±1.2	5± 1.25
Urgency	Urgency	5 (5%)	20.6± 28.9	2.8±1.5	5.8± 0.8
	p-value		0.01	0.056	0.19

noticed (13.8±12.4 hours). Group 3 patients also had longer ICU stay and longer hospitalization period. After applying one way ANOVA we found that the delay in mean TOMV due to old age was statistically significant (p-value=0.03).

Gender had no effect on mean TOMV (around 11 hours in both sexes), LOICUS was slightly longer in females (1.7 days in males vs. 1.9 days in females), but the LOH was longer in females (4.9 days in males vs.5.8 days in females).

Body mass index (BMI) ranged from 20-48 kg/m² (mean 29±4.6 kg/m²). The average BMI in this study is in the overweight category, 37 patients were obese and 2 patients were morbidly obese. There was statistically significant correlation between BMI and LOH was (p-value=0.001).

Left ventricular impairment significantly prolonged TOMV (p=0.006), LOICUS (p=0.002) and LOH (p=0.02). Diabetic and hypertensive patients had mild delay in recovery variables which was not significant. The prevalence of smoking was 5.5 times higher among males (54/84 or (64.2%)), in comparison to (2/17 (11.7%)) among females. Smoking prolonged mean TOMV (p-value=0.2), LOICUS (p-value=0.8) and LOH (p-value=0.1), but the results were statistically not significant. Patients with chronic pre-operative respiratory disease (COPD or asthma) had a prolonged mean TOMV with 5 hours more on ventilator than in patients with normal lungs (p-value=0.001), but the delay in LOICUS (p-value=0.19) and LOH (p value=0.8) was mild. Patients who underwent urgent surgery were mechanically ventilated for around 10 hours more than those who underwent elective surgery which caused significant delay in mean TOMV (p-value=0.01), also had longer mean LOICUS (p-value=0.05). (Table II)

Intraoperative factors:

Mean operative time (OT) for all cases was 247.5 minutes (±46.7 minutes). The correlation between OT and LOH was significant

Table III: Postoperative factors

Postoperative variables		Number of patients (%)	TOMV Mean± SD	LOICUS Mean± SD	LOH Mean± SD
Inotropic support	Yes	33 (33)	14.9± 13.5	2.4± 1.4	5.4±1
	No	74 (74)	9.2± 3.4	1.5± 1	4.9± 1.2
	p-value		0.001	0.001	0.058
Resternotomy	Yes	5 (5)	35± 26	3± 1.6	6± 0.8
	No	96 (96)	10± 5.4	1.7±1.2	5± 1.2
p-value			0.001	0.04	0.1
Postop. Morphine Infusion	Yes	78 (77.2)	11.5± 9.5	1.8± 1.2	5± 1
	No	23 (23.8)	9.5±3	1.7± 1.3	5.4± 1.8
	p-value		0.3	0.8	0.18

Table IV: Multivariate analysis of the effects of gender, age and type of surgery on recovery characteristics

		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.884	223.695[b]	3	88	0
Gender	Pillai's Trace	0.02	.590[b]	3	88	0.623
Type of surgery	Pillai's Trace	0.229	2.483	9	270	0.01
Age	Pillai's Trace	0.113	3.745[b]	3	88	0.014
Gender * Type of surgery	Pillai's Trace	0.003	.074[b]	3	88	0.974
Gender * age	Pillai's Trace	0.015	.459[b]	3	88	0.712
Age * type of surgery	Pillai's Trace	0.179	2.922	6	178	0.01

(p-value=0.008). Average cardiopulmonary bypass (CPB) time was 86±26 minutes. There was significant correlation between CPB time and LOICUS (p-value=0.02). Mean AXC time (ischemia time) was 48±21 minutes. Ischemia time had statistically significant correlation with LOICUS (p-value=0.006). Mean temperature during hypothermic CPB was 33±1.3 ºC. Hypothermia had statistically significant correlation with TOMV (p-value=0.016) and with LOICUS (p-value=0.001).

Postoperative factors:

The average amount of postoperative blood losses via chest tubes was 412±328 millilitres. Correlation between amounts of blood loss and mean TOMV was significant (p-value=0.001).

Chest reopening increased mean TOMV threefold in the subpopulation of patients who were returned back to theatre for resternotomy (p-value=0.001), also significantly increased mean LOICUS (p-value=0.04). The use of inotropic support was associated with significant delay in TOMV (p-value=0.001), increased LOICUS (p-value=0.001) and increased LOH (p-value=0.05). Most of the patients received morphine infusion (2-5 mg/hour) postoperatively (78 patients or 77% of patients). Patients who received morphine infusion had shorter overall hospitalization period, but was not associated with statistically significant influence (Table III).

Multivariate analysis that included age, gender and type of surgery showed that gender alone had no effect on hospitalization period, while type of surgery and age had an effect. The interaction of age and type of surgery affected the length of hospital stay (Table IV).

Discussion

Three important moments after cardiac surgery are extubation, ICU and hospital discharge. We decided to analyze factors that may affect or delay each of these recovery indicators (variables) in one study to allow us for better understanding of the early recovery period. Although the EUROSCORE (European system for cardiac operative risk evaluation) was originally designed to calculate the risk of mortility after cardiac surgery, Hirosea *et al.* in the journal of Interactive and Cardio Vascular and Thoracic Surgery describe its validity in

prediction duration of recovery after cardiac surgery.[9]

Due to the lack of unified definitions, we will consider TOMV, LOICUS and LOH delayed (or prolonged) if the value was more than the average of our study population. The target time of extubation after CABG or valve surgery in our institute is individualized for each patient. Most of patients who had undergone surgical repair of isolated atrial septal defect are extubated immediately after surgery "on table", but things are not the same after coronary artery grafting, valve(s) surgery or when coronary and valve procedures are combined. The reasons why patients are kept anesthetized and mechanically ventilated in the first few postoperative hours are: 1) to allow for more rapid reintervention if needed, 2) to observe for bleeding, hypothermia, ischemia, infarction and arrhythmia in the ICU. It was noticed that the events resulting from inadequate myocardial protection during cardiopulmonary bypass (CPB), usually manifest within the first postoperative hour.[12] Weaning is usually started after this initial period of observation.

Even for patients with normal lungs, the effects of general anesthesia and sternotomy have deleterious effects on pulmonary function, as general anesthesia causes diminished functional residual capacity (FRC), and median sternotomy can cause 50-75% reduction in vital capacity (VC).[3] Risk factors like old age, smoking, COPD, hypothermia, pleurotomy, obesity, bleeding, and other risk factors can further exaggerate the decrease in postoperative lung volumes, delay extubation, increase TOMV, LOICUS and LOH.[13]

Due to the fact that the world population is ageing, the number of elderly patients undergoing CABG or heart valve(s) surgery is increasing.[14,15] Age is used in most of the risk scoring models for cardiac surgery. When we compared patients according to their age, we found that patients between the age of 18 and 60 years had nearly the same recovery variables (TOMV, LOICUS and LOH), but these durations were increased in patients above 61 years. This statistically significant delay in the postoperative recovery is attributed to various anatomical, physiological, immunological and pharmacological considerations, along with the increased incidence of co-morbidities in older age (senior) subpopulation. Blankstein et al. in the Circulation journal consider female gender as an independent predictor for mortality, morbidity and delayed hospital discharge, explained by their increased incidence of co-morbidities, smaller size of their coronaries and less frequent use of arterial grafts.[16] In our results, female patients had significantly increased LOH (p-value=0.007), but their TOMV was little shorter than males probably because smoking prevalence is low in females.

Chronic obstructive pulmonary disease might be expected to be a major risk for postoperative morbidity and mortality and appears as a factor in many risk scoring models. The huge lung volumes and the concerns about adding tension on the left internal mammary graft in addition to the poor status of the coronary targets made some surgeons reluctant to use such a conduit in their revascularization.

Diabetes and hypertension were recurrent variables in this study population, but neither diabetes, nor hypertension as variables caused delays in ventilator weaning or ICU and hospital discharge. Blood sugar was monitored regularly and GIK (glucose, insulin, potassium) infusion regimen was used aiming for blood sugar levels less than 200 mg/dl. Blood pressure was monitored and controlled continuously.

Preoperative left ventricular function is an important determinant of postoperative recovery and its role is well studied in literature.[17] We found that preoperative left ventricular impairment was associated with considerable delay in recovery.

Patients who underwent urgent surgery had statistically significant delay in mean TOMV and mean LOICUS. Urgency of the procedure is included in risk scoring models such as EUROSCORE, STS score and other.[10] Patients admitted for urgent surgery were usually given antiplatelet therapy (clopidogrel) recently, (before coronary angiography), and had more tendencies for bleeding, which may attribute for the delay in recovery as they were closely observed for bleeding in the intensive care unit.

Prolonged CPB and aortic clamp times are risk factor for neurological complications and inverse outcome.[3,18] Brown et al published a study in the Stroke journal showing that longer duration

of CPB was associated with increased embolic load and for each one hour increase in the duration of CPB, the embolic load increased by 90.5%.[19] Prolonged operative time (OT), CPB and ischemia time with some patients could be attributed to smaller size of coronaries, calcific (atheromatous) aorta, bleeding tendency or difficult weaning after CPB due to low cardiac output syndrome (LCOS).[6,20]

Hypothermia reduces cerebral metabolic rate; subsequently it might protect the brain by preferentially decreasing energy utilization and maintaining the integrity of brain cells.[3] Patients are weaned from CPB when normothermic, but usually become hypothermic again due to heat loss. In fact, this is one of the reasons why we wait untill active rewarming is completed in the ICU. A study by Mills et al. published in the BJA (British Journal of Anaesthesia) describes the effect of whole body hypothermia and the use of iced saline around the heart and the phrenic nerve on diaphragmatic function using magnetic nerve stimulator, and after analyzing 26 consecutive diaphragmatic electromyograms intraoperatively, the authors concluded that diaphragmatic function may be affected by mild hypothermia after cardiac surgery.[21] Incomplete rewarming can be added to other factors increasing tendency for bleeding such as platelet dysfunction, rebound heparin effect, loss of coagulation factors due to hemodilution and blood transfusions. Reopening delayed extubation and recovery because patients when readmitted to surgical theatre for control of bleeding are given anaesthetic medications de novo and are not expected to be extubated soon thereafter, so that TOMV is increased.

The use of inotropic support necessitated by low cardiac output is a predictor of delayed convalescence that was noticed by many researchers to be associated with delayed recovery. Micholopoulos et al. in BJA considered inotropic support as a predictor of prolonged stay in the ICU.[12,22] All of the three phases (extubation, ICU discharge and hospital discharge) were significantly delayed in patients who needed inotropic support among this study population.

It is not surprising that pain relief after cardiac surgery can accelerate recovery and will lead to a more rapid hospital discharge, as it improves respiratory mechanics, decrease physiological stress response to surgery and adds to patient comfort.[1]

Among the population in the study only three patients (or 3%) had prolonged TOMV (extubated at 72, 36 and 24 hours from arrival to ICU), all of them had inotropic support, and two of them underwent reopening for control of bleeding.

Limitations of this study

The observational nature of the study, the relatively small patients' sample which may affect the power of the study by increasing the chance of type II error (false negatives) and that it is a single centre study.

There were seven cases of mortality (6.4%). Mortalities occurred between first and 13-Th day after surgery in the postsurgical intensive care unit, and were attributed to heart failure (in 3 cases), multi-organ failure (in 3 cases) and cerebrovascular event (in 1 case). They had a higher average EUROSCORE when compared to total group of patients (4.5 versus 1.4) which reflects the higher incidence of more serious co-morbidities. They also had longer mean CPB (99 minutes versus 86 minutes) and aortic cross clamp (56 minutes versus 48 minutes) times than the average study population, which reflects more complex pathology.

Conclusion

Left ventricular impairment, chronic respiratory disease, old age, obesity, long CPB and aortic clamp times and inotropic support are the main risk factors of delayed extubation and discharge from ICU in this study. Identification of risk factors (predictors) can help development of strategies to improve outcome.

References

1. **White PF, Kehlet N, Neal JM.** The role of the anesthesiologist in fast track surgery: from multimodal analgesia to perioperative medical care. *Anesthesia and Analgesia* 2007 Jun; 104(6):1380-96.
2. **Herlihy JP, Koch SM, Jackson R.** Course of weaning from prolonged mechanical ventilation after cardiac surgery. *Texas Heart Institute Journal* 2006; 33(2): 122-129.

3. **Kaplan JA, Cheng CH, Brainbridge D, *et al.*** Kaplan's cardiac anesthesia. 5th ed. Saunders, Elsevier 2006; Ch: 32: 1043-1059.
4. **Habib RH, Zacharias A, Engoren M.** Determinants of prolonged mechanical ventilation after coronary artery bypass grafting. *Ann Thorac Surg* 1996 Oct; 62(4):1164-71.
5. **Ender J, Borger MA, Scholz M, *et al.*** Cardiac surgery fast-track treatment in a postanesthetic care unit, six-month results of the Leipzig fast-track concept. *Anesthesiology* 2008; 109:61–6.
6. **Bansal S, Thai HM, HSU CH, *et al.*** Fast Track extubation post coronary artery bypass graft: a retrospective review of predictors of clinical outcomes. *World Journal of Cardiovascular Surgery* 2013; 3: 81-86.
7. **Yende S, Wunderink R.** Causes of prolonged mechanical ventilation after coronary artery bypass surgery. *Chest* 2002; 122:245–252.
8. **Eltheni R, Giakoumidakis K, Brokalaki H.** Predictors of prolonged stay in the intensive care unit following cardiac surgery. *ISRN Nurs* 2012; 2012: 691561.
9. **Hirosea H, Inabaa H, Noguchi C, *et al.*** EuroSCORE predicts postoperative mortality, certain morbidities, and recovery time. *Interact Cardio Vasc Thorac Surg* 2009; 9(4): 613-617.
10. **Geissler HJ, Holzl P, Marohl S, *et al.*** Risk stratification in heart surgery: comparison of six score systems. *European Journal of Cardio-thoracic Surgery* 2000; 17:400-406.
11. **Christenson JT, Maurice J, Simonet F, *et al.*** Open chest and delayed sternal closure after cardiac surgery. *Eur J Cardio-thorac Surg* 1996; 10: 305- 311.
12. **Akhtar MI, Hamid M.** Success and failure of fast track extubation in cardiac surgery patients of tertiary care hospital: One year audit. *J Pak Med Assoc* 2009; 59(3):154-156.
13. **Urell C, Westerdahl E, Hedenstrom H, *et al.*** Lung function before and two days after open-heart surgery. *Crit Care Research and Practice* 2012; 2012: 291628.
14. **Frelich M, Tutka F, Pokorn P, *et al.*** Cardiac surgery in elderly patients. *Scripta Medica (BRNO)* 2003 December; 76 (6): 341–346.
15. **Sundermann S, Dademasch A, Rastan A, *et al.*** One-year follow-up of patients undergoing elective cardiac surgery assessed with the Comprehensive Assessment of Frailty test and its simplified form. *Interactive CardioVascular and Thoracic Surgery* 2011; 13; 119-123.
16. **Blankstein R, Ward RP, Arnsdorf M.** Female gender is an independent predictor of operative mortality after coronary artery bypass graft surgery: Contemporary analysis of 31 midwestern hospitals. *Circulation* 2005; 112: I-323-I-327.
17. **Haanschoten MC, Straten AHM, Woorst JF, *et al.*** Fast track practice in cardiac surgery: results and predictors of outcome. *Interactive Cardio Vascular and Thoracic Surgery* 2012; 1-6.
18. **Piotto RF, Ferreira FB, Colósimo FC, *et al.*** Independent predictors of prolonged mechanical ventilation after coronary artery bypass surgery. *Rev Bras Cir Cardiovasc* 2012; 27(4):520-8.
19. **Brown WR, Dixon MM, Challa VR, *et al.*** Longer duration of cardiopulmonary bypass is associated with greater numbers of cerebral microemboli. *Stroke* 2000; 31:707-713.
20. **Kiessling AH, Huneke P, Reyer C, *et al.*** Risk factor analysis for fast track protocol failure. *J Cardiothorac Surg* 2013, 8:47.
21. **Mills GH, Khan ZP, Moxham J, *et al.*** Effects of temperature on phrenic nerve and diaphragmatic function during cardiac surgery. *British Journal of Anesthesia* 1997; 79: 726-732.
22. **Micholopoulos A, Tzelepis G, Pavlides G, *et al.*** Determinants of duration of ICU stay after coronary artery bypass grafting. *British Journal of Anesthesia* 1996; 77: 208-212.