

Factors Influencing Prolonged ICU Stay After Open Heart Surgery

Rasoul Azarfarin¹; Nasibeh Ashouri^{1,*}; Ziae Totonchi¹; Hooman Bakhshandeh¹; Alireza Yaghoubi¹

¹Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, IR Iran

*Corresponding author: Nasibeh Ashouri, Rajaie Cardiovascular Medical and Research Center, Vali-Asr St., Niyesh Blvd, Tehran, IR Iran. Tel: +98-2166353011, Fax: +98-2122663293, E-mail: nasibeh362@yahoo.com

Received: May 11, 2014; Revised: July 1, 2014; Accepted: September 11, 2014

Background: There are different risk factors that affect the intensive care unit (ICU) stay after cardiac surgery.

Objectives: The aim of this study was to evaluate possible risk factors influencing prolonged ICU stay in a large referral hospital.

Patients and Methods: We conducted a case-control study to determine causes of prolonged ICU stay in 280 adult patients undergoing cardiac surgery in a tertiary care center for cardiovascular patients, Tehran, Iran. These patients were divided into two groups according to ICU stay ≤ 96 and > 96 hours. We evaluated perioperative risk factors of ICU stay > 96 hours.

Results: Among the 280 patients studied, 184 (65.7%) had stayed ≤ 96 hours and 96 (34.3%) had stayed > 96 hours in ICU. Frequency of prolonged ICU stay was 34.2% in patients undergoing coronary artery bypass graft (CABG), 30.8% in patients with valve surgery, and 44.8% in patients with CABG plus valve surgery. Patients with > 96 hours of ICU stay received more blood transfusion and intravenous inotropes. They also had longer anesthesia, cardiopulmonary bypass, and postoperative intubation time. There were higher incidence of postoperative tamponade, re-exploration, re-intubation, hemodialysis, and hypotension in this group ($P < 0.05$ for all comparisons).

Conclusions: In this study, about one-third of patients had prolonged ICU stay. Factors influencing prolonged ICU stay were medical and some non-medical factors. In the present study, up to 30% of the patients had a prolonged ICU stay of > 96 hours. Additional data from well-designed investigations are needed for further assessment of the factors influencing prolonged ICU stay after cardiac surgery.

Keywords: Cardiac Surgery; Hospitalization; Intensive Care Units; Length of Stay

1. Background

Cardiac surgery techniques have improved considerably during the last few years. The patients undergoing heart surgery are exposed to the risk of postoperative complications. Most of these patients have advanced heart disease [New York Heart Association functional class (NYHA FC) III and IV], along with some coexisting disease. Therefore, postoperative complications will increase and more patients will need a longer stay in intensive care unit (ICU). Through employing available high technologies, we afford these patients a longer life (1). Intensive care after a heart operation is a standard component of the treatment for most of the patients. However, long stay in ICU usually results in increased hospital mortality, poor long-term prognosis, increased morbidity (2), increased hospital stay, and consequently, increased cost and expenses (3). Knowing these correlations can be effective in reducing the length of ICU stay (4). Some measures such as early tracheal extubation can reduce the length of stay in ICU (5); however, there will be some concern that earlier discharge might increase the probability of readmission in ICU (6). Readmission in ICU is usually accompanied with increased hospital mortality and might have poor outcomes (4). More than 36%

of patients undergoing cardiac surgery have a long (> 36 hours) postoperative stay in ICU. This results in failure of some organs and increase in the mortality rate, ranging from 11% to 94%, as well as longer and higher utilization of healthcare resources. The determinants of long stay in ICU are not very clear but some risk factors such as older age, lower ejection fraction, pulmonary diseases, failure of organs, and re-operation to check the mediastinal area might affect it (7). In fact, the only factor that differentiates open-heart operation from other surgeries is cardiopulmonary bypass (CPB), and due to complications of CPB and prolonged anesthesia, these groups of patients occupy the ICU bed for about 36 hours. Improvement of extracorporeal technology has reduced the total probability of postoperative complications including neurotic, cardiopulmonary, renal, and hemorrhagic complications (8). Predicting the risk of long postoperative stay in ICU is a critical issue in heart operation, especially considering the population of elderly people and increased number of high-risk patients. Longer ICU stays will block ICU beds for a longer time, which in turn results in delay or cancellation of other operations. Ability to predict the length of stay in ICU can help the surgeon in deciding on

the time of treatment and length of stay in ICU (9). In this way, a better relation will be developed with the patients and their families. Generally, scheduling an operation list based on patients' risk factors and prediction of length of ICU stay can help the surgeon in deciding on the operation time of elective patients. Therefore, the number of operations will increase without an obligation to increase the number of occupied ICU beds. This means a higher job quality and efficiency with some advantages for the patients, hospital, and its staff (10).

2. Objectives

Considering the fact that the length of ICU stay can be predictable, we decided to conduct a study to determine the perioperative risk factors that might affect the length of ICU stay in a cardiovascular tertiary care center, Tehran, Iran.

3. Patients and Methods

In this cross-sectional study, the sampling was done by non-random method and 280 consecutive patients who aged over 18 years and were referred to Rajaie Cardiovascular Centre for cardiac surgery were recruited. The exclusion criteria were as following: 1) death during operation; 2) death in ICU within four days of operation; and 3) transferring the patient to another ward or hospital within the first four days of postoperative stay in ICU. All preoperative, intraoperative, and postoperative data were collected and based on the length of postoperative stay in ICU, the patients were divided into two groups of ≤ 96 hours and > 96 hours ICU stay. In our center, the criteria for discharge the patients from ICU to general ward were full consciousness and hemodynamic balance, no incisional drainage, water and electrolyte balance, and discharge orders by all three disciplines, namely, cardiac surgeon, cardiologist, and the anesthesiologist. In order to evaluate the factors affecting the length of ICU stay,

statistical tests including Fisher's exact test, Pearson chi square, and Mann Whitney U test were used. We used Binary Logistic Regression to perform multivariate analysis. $P \leq 0.05$ was considered as statistically significant. SPSS 15 for Windows (SPSS Inc., Chicago, Illinois) was used for the statistical analysis.

4. Results

In this study, the mean duration of ICU stay was 70.9 hours with a median (interquartile range [IQR]) of 72 (48-72) hours in group A (≤ 96 hours) and mean stay of 374 hours with a median (IQR) of 192 (156-420) hours in group B (> 96 hours). The mean age of patients in groups A and B were 52.70 ± 15.92 and 60.72 ± 16.05 years, respectively, which showed a significant difference between the two groups ($P = 0.01$). The demographic data of participants is shown in Table 1.

According to the results of this study, NYHA FC IV was a risk factor for longer stay in ICU, which was seen in two patients (1.1%) in group A and 7 (7.3%) in group B ($P = 0.01$). The intraoperative factors affecting the length of ICU stay are shown in Table 2. Table 3 demonstrates the postoperative factors and Table 4 shows the influence of number of transfused blood and blood products units during and after cardiac surgery on the length of ICU stay. Out of 146 patients who had undergone isolated CABG, only 50 patients (34.2%) stayed >96 hours in ICU and 96 patients had a stay of ≤ 96 hours. In comparison to group B, the following parameters were significantly higher in groups A: age, left ventricular ejection fraction (LVEF), PAP, weight, number of administered inotropes in ICU, duration of inotropes administration in ICU, transient ischemic attack, need for dialysis, cardiopulmonary resuscitation (CPR), re-intubation, need for IABP, tamponade, re-operation, infection rate, diastolic pressure after operation, readmission to ICU, units of blood transfused in operation room and ICU, used units of platelets and fresh frozen plasma (FFP) in ICU. Out of 91 patients with a valve replacement

Table 1. Demographic Data of Patient According to the Length of Stay in Intensive Care Unit ^{a,b}

| Variables | ICU Stay (n = 280) | | P value |
|-------------------------------|---------------------------|-----------------------|---------|
| | ≤ 96 Hours (n = 184) | > 96 Hours (n = 96) | |
| Age, y | 52.70 (45-65.75) | 60.72 (53-72) | 0.01 |
| LVEF, % | 43.69 (40-50) | 40.70 (30-50) | 0.01 |
| DM | 58 (31.5) | 41 (42.7) | 0.06 |
| Cigarette Smoking | 50 (27.2) | 27 (28.1) | 0.87 |
| Opium Addiction | 27 (14.7) | 15 (15.6) | 0.83 |
| NYHA FC Classification | | | 0.01 |
| 1 | 22 (12) | 8 (8.3) | |
| 2 | 119 (65) | 50 (52.1) | |
| 3 | 40 (21.9) | 31 (32.3) | |
| 4 | 2 (1.1) | 7 (7.3) | |

^a Abbreviations: LVEF, left ventricular ejection fraction; DM, diabetes mellitus; and NYHA FC, New York Heart Association functional class.

^b Data are presented as median (interquartile range) or No.(%).

surgery, 28 patients (30.8%) stayed >96 hours and 63 (69.2%) stayed ≤96 hours in ICU.

Age, diabetes, hypertension, hyperglycemia, PAP, emergency surgery, using defibrillator during operation, administration of inotropes during operation, duration of anesthesia, duration of aortic cross-clamp, number of administered inotropes in ICU, duration of inotropes administration in ICU, CPR, re-intubation, tamponade, re-operation, infection rate, systolic and diastolic blood pressure after surgery, readmission to ICU, number of

blood, platelets, and FFP transfused units in ICU had significant difference between groups A and B.

Out of 29 patients who had undergone combined CABG and valve surgery, 13 patients (44.8%) stayed > 96 hours and 16 (55.2%) stayed ≤ 96 hours in ICU. Age, PAP, FC, duration of anesthesia, length of CPB, duration of inotropes administration in ICU, CPR, and infection rate has significant difference between groups A and B. The data obtained after multivariate analysis of factors affecting length of stay in ICU are shown in Table 5.

Table 2. Intraoperative Factors Affecting the Length of Stay in Intensive Care Unit ^{a,b}

| Variable | ICU Stay (n = 280) | | P value |
|--------------------------------|----------------------|---------------------|---------|
| | ≤ 96 Hours (n = 184) | > 96 Hours (n = 96) | |
| Elective/Emergency | | | 0.06 |
| Elective | 166 (90.2) | 79 (82.3) | |
| Emergency | 18 (9.8) | 17 (17.7) | |
| Surgery | | | 0.58 |
| Valve | 63 (34.2) | 28 (29.2) | |
| CABG | 96 (52.2) | 50 (52.1) | |
| CABG + Valve | 16 (8.7) | 13 (13.5) | |
| Others | 9 (4.9) | 5 (5.2) | |
| Inotropes Use in OR | 147 (79.9) | 60 (62.5) | 0.01 |
| Defibrillator Use in OR | 8 (4.3) | 14 (14.6) | 0.01 |
| Anesthesia Time, min | 310 (255-360) | 354.68 (300-360) | 0.01 |
| Aorta Clamp Time, min | 56.23 (32-73.75) | 65.55 (35-100) | 0.16 |
| CPB Time, min | 97.88 (65-125.75) | 128.45 (77-156) | 0.03 |

^a. The data are shown as median (interquartile range) or No. (%).

^b. Abbreviations: CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass; and OR, operation room.

Table 3. Postoperative Factors Affecting the Length of Stay in Intensive Care Unit ^{a,b}

| Variables | ICU Stay (n = 280) | | P value |
|------------------------------------|--------------------------|---------------------|---------|
| | ≤ 96 Hours (n = 184) | > 96 Hours (n = 96) | |
| Intubation Time | | | 0.01 |
| ≤ 24 Hours | 166 (90.2) | 46 (47.9) | |
| > 24 Hours | 18 (9.8) | 42 (43.8) | |
| Tracheotomy | 0 | 8 (8.3) | |
| Intubation Time, h | 10.56 (6-12) | 210.21 (21-144) | 0.01 |
| Inotrope Use in ICU | | | 0.01 |
| 0 | 137 (74.45) ^a | 38 (39.58) | |
| 1 | 35 (19.02) | 26 (27.08) | |
| ≥ 2 | 12 (6.52) | 32 (33.33) | |
| Duration of Inotrope in ICU | | | 0.01 |
| - | 137 (74.5) | 40 (41.7) | |
| ≤ 24 Hours | 34 (18.5) | 8 (8.3) | |
| > 24 Hours | 13 (7.1) | 48 (50) | |
| TIA | 0 | 9 (9.4) | 0.01 |
| Infection | 0 | 18 (18.8) | 0.01 |
| Hemodialysis | 1 (0.5) | 4 (4.2) | 0.03 |
| CPR | 4 (2.2) | 19 (19.8) | 0.01 |
| Re-intubation | 1 (0.5) | 20 (20.8) | 0.01 |

^a Abbreviations: CPR, cardiopulmonary resuscitation; ICU, intensive care unit; and TIA, transient ischemic attack.

^b The data are shown as median (interquartile range) or No. (%).

Table 4. Number of Blood and Blood Products Units Transfused During and After Surgery ^{a,b}

| | ICU Stay (n = 280) | | P value |
|----------------|----------------------|---------------------|---------|
| | ≤ 96 Hours (n = 184) | > 96 Hours (n = 96) | |
| OR | | | |
| Packed cell, U | 0.64 [0-1] | 1 [0-2] | 0.01 |
| FFP, U | 0.79 [0-2] | 1.15[0-2] | 0.30 |
| Platelet, U | 0.65 [0-1] | 0.81[0-2] | 0.60 |
| ICU | | | |
| Packed Cell, U | 0.81 [0-1] | 3.60 [1-5] | 0.01 |
| FFP, U | 0.39 [0-0] | 2.23 [0-3] | 0.01 |
| Platelet, U | 0.35 [0-0] | 1.15 [0-2] | 0.01 |
| Total | | | |
| Packed Cell, U | 1.48 [0-2] | 3.75[0-5] | 0.01 |
| FFP, U | 1.25 [0-3] | 2.63[0-4] | 0.01 |
| Platelet, U | 1.02 [0-2] | 1.57[0-3] | 0.01 |

^a All data are shown with median (interquartile range).

^b Abbreviations: FFP, fresh frozen plasma; ICU, intensive care unit; and OR, operation room.

Table 5. Logistic Regression Analysis of Factors Affecting Length of Intensive Care Unit Stay ^{a,b}

| Variables | β | P value | OR (CI 95%) |
|--------------------------------------|------|---------|---------------------|
| Packed Cell in ICU | 0.55 | 0.05 | 1.74 [0.99-3.03] |
| Intubation Time | 0.12 | 0.01 | 1.13 [1.04-1.23] |
| Inotrope Infusion Time in ICU | 2.80 | 0.01 | 16.54 [1.96-139.21] |

^a All data are shown with median (interquartile range).

^b Abbreviations: OR, odds ratio; CI, confidence interval.

5. Discussion

Several studies have been done to determine the risk factors influencing the length of patients' stay in ICU after cardiac surgeries. Numerous factors and wide range of patients' conditions make the interpretation of each factor's effect difficult. Meanwhile, any of these factors can affect other factors and strengthen or weaken their effect. The more complicated the surgery is, the higher the rate of mortality and postoperative complications will be. Generally, the rate of postoperative complications of CABG is less than valve surgery and that of valve surgery is less than the complication rate of combined CABG and valve surgery (5). In this study, the average age of patients with a prolonged ICU stay (group B) was significantly higher than the group A. The effect of older age can be due to increase in accompanying diseases as well as other physiologic alterations, which result in lower ability of these patients to stand the surgical stress and other perioperative factors. Although we expected the cigarette smoking and opium addiction to influence the length of stay in ICU, the high consumption of these products did not show any significant difference between the two groups. Our study also showed a significant association between the length of ICU stay and low LVEF. Patients with left ventricular failure and an ejection fraction <

40% need more time to achieve a hemodynamic stability. Therefore, they are weaned off the mechanical ventilator later and hence, stay longer in ICU (11-15). Among the postoperative and intraoperative factors, units of transfused blood and other blood products in operation room, administer of inotropes, duration of CPB, and using defibrillator during operation affected the duration of ICU stay. On the other hand, the units of transfused blood and other blood products in ICU, duration of inotropes administration in ICU, duration of mechanical ventilation in ICU, pericardial hematoma, need for re-operation, need for CPR, and need for re-intubation had effect on ICU stay time. Blood transfusions can cause lung problems due to activation of the complement system and cytokines. As a result, blood transfusion can increase the risk of infection and mortality after cardiac surgery. The most common cardiac and pulmonary hemodynamic change after pump is reducing peripheral vascular resistance. Prescribed vasopressor before stopping the pump can lead to normal systemic vascular resistance. Causes of prolonged intubation might be decreased cardiac output, neuromuscular weakness, and electrolyte disturbances. Most studies reported prolonged (> 72 hours) ICU stay rate of about 33% while we faced with the same

rate by defining prolonged ICU stay as stay > 96 hours. For example, in study of Hein et al. ICU stay was longer (> 72 hours) in 26% of cardiac surgery patients (16). In another study by Mahesh et al. prolonged ICU stay (> 72 hours) rate was 18.7% (12). Type of operations and their proportions might play roll in ICU stay time. Only 50% of cases in our study underwent CABG, whereas in most centers (even in our center) about 70% of the adult cardiac surgeries are CABG, which might affect the study result and prolonged ICU stay. Duration of intubation, units of transfused blood and inotrope administration in ICU can be considered as independent predictors of prolonged ICU stay in our study.

5.1. Limitations

The main limitation to our study was obtaining patients' data from ICU nursing and medical records; thus, our collected data might be inaccurate. The collection of exact numbers of non-medical causes of prolonged ICU stay was not feasible. The researchers could not be able to collect the preoperative patients' data regarding the respiratory function such as pulmonary tests or the incidence of COPD. Thus, additional data from well-designed prospective controlled study are needed to assess the medical and non-medical factors of prolong ICU stay after cardiac surgery. In this study, about one-third of patients had prolonged ICU stay (> 96 hours). Factors that influenced the prolonged ICU stay were all preoperative, intraoperative, and postoperative medical factors, as well as non-medical factors such as not transferring the patients from ICU to the surgical wards in weekends or holidays or staying in ICU just due to postoperative atrial fibrillation rhythm and absence of the beds with monitoring systems.

Authors' Contributions

Rasoul Azarfarin, Nasibeh Ashouri, and Ziae Totonchi participated in producing study idea, conducting research protocol, and collecting data; Hooman Bakhshandeh contributed in data analysis and writing thesis and manuscript; Rasoul Azarfarin and Nasibeh Ashouri wrote the manuscript and submitted it; Alireza Yaghoubi participated in cardiac surgeries.

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