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DETERMINANTS OF MORTALITY IN ADULT PATIENTS AFTER OPEN HEART SURGERY IN DUHOK CITY-KURDISTAN REGION

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ABSTRACT

Introduction: Despite improvements in the techniques and perioperative management in modern cardiac surgeries avoidable deaths still occur. In this regard, we aimed to determine the main causes of death following adult heart surgery and identify the most associated factors.

Patients and Methods: In this case-control study, the medical records of the patients who died (n=50) or survived open heart surgery (n=80) were used at Azadi Heart Center in Duhok city in the period between January 1, 2016, and December 31, 2020.

Results: The most common causes of mortality in cardiac patients were cardiogenic shock (26%) cardiac arrest (24%), renal failure (18%), septic shock (12%), CVA (6%), and cardiac events. The most associated factors were advanced age (P<0.000), occupation (P=0.007), hypertension (P=0.013), hyperlipidemia (P=0.013), heart failure (P=0.020), preoperative low ejection fraction (P=0.002), preoperative elevated renal function (P=0.015), type and timing of surgery (P=0.010, 0.023) for each, type of valve used (P=0.023), type of CABG (P=0.009), prolonged duration of bypass and aortic cross-clamp time (P<0.000, 0.000) for each, intraoperative event (P<0.000), duration of intubation and need for re-intubation (P<0.0001,0.0001) for each, need for inotropic agents (P<0.000), post-operative elevated renal function and WBC (P<0.000,0.000) respectively, need for re-admission (P<0.000), postoperative complications(cardiac P=0.031, chest P=0.039, wound P=0.031, neurological P=0.007, renal P<0.000, and arrhythmia P<0.000), and prolonged both ICU and overall hospital stay (P<0.000,0.000) for each.

Conclusion: This study showed that several general, pre-operative, intra-operative, and post-operative factors are associated with the mortality of cardiac patients.

KEYWORDS: Cardiac surgery, Intensive care unit, Risk factors, Mortality, Complications, Re-admission.

INTRODUCTION

Open-heart surgery is a surgical treatment of congenital and acquired diseases of the heart and great vessels, it is a procedure in which the chest is cut open and surgery performed on the heart's muscles, valves, or arteries. The term "open" refers to the chest rather than the heart. The first open-heart surgery was performed by Dr. Daniel Hale Williams on July 10, 1893. (Tesler, 2020).

Nowadays, over 2 million cardiac surgeries are estimated to be conducted yearly throughout the world, demonstrating both the advancement of the specialty as well as its effect on the present health state of the global population(Fuhrman Kellum, 2017). Depending on the particular indications of the surgery namely aneurysm repair, coronary artery bypass surgery, heart transplant, heart valve replacement or repair, left ventricular assist device, the heart may or may not be opened, coronary artery bypass grafting (CABG) is the commonest type of open-heart surgery performed on adults today (Vervoort et al., 2020).

Open heart surgery is a major operation that requires a hospital stay. Patients who undergo open heart surgery will need to stay in the hospital for several days, at least one day in the intensive care unit immediately after the operation. This surgery is performed for patients with valve pathology and those who did not get benefits from medical treatment and intervention, the goal of the surgery is to reduce symptoms, enhance the patient's quality of life, and extend the patient's lifespan (Elsaed et al., 2020).

Furthermore, minimally invasive heart surgery has been developed and deployed throughout the last two decades as a result of advancements in cardiac surgery. Due to significant advancements in procedures and tools, minimally invasive cardiac surgery

(MICS) has advanced and innovated significantly since 1990, progressing from mini-incision to thoracoscopy and robotics (Lee et al., 2008).

Although mortality and morbidity have fallen considerably as a result of advancements in procedures and perioperative treatment in modern cardiac operations, roughly 17% of patients in large trials have serious complications, and avoidable deaths still occur. The majority of in-hospital mortality occurs in the first week after heart surgery with few mortalities occurring after a protracted hospital course. The ability of postoperative complications to explain the variability in mortality timing is limited. Increased length of postoperative intensive care unit stay and hospital stay after cardiac surgery are associated with an increased likelihood of in-hospital mortality (Ball et al., 2016).

Because comorbidities and confounding variables make high-risk patients more likely to have a poor outcome, recognizing difficulties that occur in patients might help us better understand our practice. At a later stage, enhancements will be made for all heart surgery patients. (Davies Wilson, 2004).

Traditional cardiac surgery outcome analysis approaches focus on modifying mortality rates rather than objectively assessing the fundamental causal factor's; as a result, nonsurgical variables lose importance and are frequently unknown and underexplored (Mejia et al., 2021). Because of the lack of such studies in our country, the goal of this study is to determine main cause of death and identify the most associated surgical and non-surgical factors following the open-heart surgery.

PATIENTS AND METHODS

Study design

In this retrospective case-control study, the patients who underwent open heart surgery were included either as a case or control. The patients who passed away were considered cases and those who recovered from the surgery were determined as a control in this study. The medical records of the patients with any cardiovascular disease at a tertiary heart center were reviewed for the eligibility criteria. Those who received the open-heart surgery met the initial eligibility criteria. The cases were included from Azadi Heart Center in Duhok city in the period between September 1, 2021 and December 1, 2021. This study included 130 patients after excluding no eligible patients from the analysis.

Population and setting

The population of this study was the patients who underwent open heart surgery at Azadi Heart Center. The patients had different medical and socio-demographic characteristics within Duhok province. The Azadi Heart Center is the only tertiary specialized center for diagnostic and therapeutic services for cardiac patients in Duhok province. Therefore, we expect that we have included as many as possible patients who met the eligibility criteria in this region. Only a few numbers of patients attend the private sector for therapeutic services in this region. Hence, we do not expect that these few numbers affect the overall results of the study. The researchers had no access to the medical records of the private sector due to administrative difficulties.

Inclusion and exclusion criteria

The patients met the initial eligibility criteria if they received the open-heart surgery. Further, the patients' medical records were screened accordingly. All patients with age ≥18 years who underwent open heart surgery from 1, January 2016 to 31, December 2020 were included. The patients who had more than 20% missing information in their medical records were excluded from the analysis. In this case-control study, all dead patients were included as cases. The researcher obtained a random sample of the recovered patients as a control of the study. The randomization was performed using SPSS version 25. In this regard, a total of 569 numbers were entered into SPSS version 25. A random sample of 80 patients was obtained accordingly based on the codes entered into the statistical software. Finally, we included 50 patients as a case and 80 patients as a control group.

Data collection methods

The medical records of the patients who underwent open heart surgery were reviewed by a researcher. The records were checked by an assistant accordingly to avoid a possible mistake. The information was entered in a pre-designed questionnaire.

Statistical analyses

The general characteristics of dead and survived patients were presented in mean (SD) or number (%). The comparisons of demographic characteristics between cardiac dead and survived patients were examined in an independent t-test or Pearson chi-squared tests. In addition, the comparisons of preoperative, postoperative, and intra-operative characteristics and complications between cardiac dead and survived patients were examined in an independent t-test or Pearson chi-squared tests. The significant level of difference was determined by a p-value of less than 0.05. The statistical calculations were performed in JMP pro 14.3.0.

Ethical views

The ethical approval of this protocol was obtained from the Ethical committee statement from the Duhok Directorate General of Health on 24-October-2021 with a reference number: 2410202110-6. Email: scientific.research@duhokhealth.org

RESULTS

The study showed that the dead patients were older compared to survived patients, 66.45 vs. 60.26, P<0.00, respectively. The mortality rate significantly increased with the increasing age of the patients. The sex (P=0.71), BMI (P=0.52), and smoking (P=0.88) were non-significantly related to higher mortality rate among patients. **(Table 1)**

Table 1: Comparisons of demographic characteristics between cardiac dead and survived patients

Demographic	Study groups no (%)		p-value
	Dead (n=50)	**Survived (n=80)**	
Age (years) mean (SD)	66.45 (5.87)	60.26 (8.10)	**<0.0001**
Range: 22-80 years	25-80	22-80	
Age category			**0.0006**
22-30	1 (25.00)	3 (75.00)	
41-50	2 (15.38)	11 (84.62)	
51-60	5 (14.29)	30 (85.71)	
61-70	32 (53.33)	28 (46.67)	
71-80	10 (55.56)	8 (44.44)	
Sex			0.7129
Male	31 (39.74)	47 (60.26)	
Female	19 (36.54)	33 (63.46)	
BMI			0.5215
Underweight	0 (0.00)	1 (100.00)	
Normal weight	14 (46.67)	16 (53.33)	
Overweight	20 (33.33)	40 (66.67)	
Obese	16 (41.03)	23 (58.97)	
Smoking			0.8876
Ex-smoker	2 (50.00)	2 (50.00)	
No	36 (38.30)	58 (61.70)	
Yes	12 (37.50)	20 (62.50)	

Both groups (dead and survived) patients were compared the results showed that the mortality rate was significantly higher among the patients with hyperlipidemia 53.49% vs 31.03%, P=0.01, Heart failure 83.33% vs 36.29, P=0.02, preoperative Hb 12.48 vs 13.14, P=0.02, preoperative elevated renal function 61.90% vs 33.94%, P=0.01, preoperative low Ejection fraction 44,70 vs 50.97, P=0.00. On another hand, the mortality rate was significantly higher among the patients with preoperative non-hypertensive patients 55.56% vs 31.91%, P=0.01, compared to hypertensive patients, the higher mortality rate was not shown to associate with IHD (P=0.77), DM (P=0.73), chronic AF(P=0.43), previous MI (P=0.32), previous cardiac surgery (P=0.30), elevated preoperative WBC (P=0.29) and preoperative elevated Troponin (P=0.17). **(Table 2)**

Table (2): Comparisons of preoperative characteristics between cardiac dead and survived patients

preoperative characteristics	Study groups no (%)		p-value
	Dead (n=50)	**Survived (n=80)**	
IHD			0.7783
No	9 (36.00)	16 (64.00)	
Yes	41 (39.05)	64 (60.95)	
DM			0.7373
No	21 (36.84)	36 (63.16)	
Yes	29 (39.73)	44 (60.27)	
Hypertension			**0.0132**
No	20 (55.56)	16 (44.44)	
Yes	30 (31.91)	64 (68.09)	
Hyperlipidemia			**0.0133**
No	27 (31.03)	60 (68.97)	
Yes	23 (53.49)	20 (46.51)	
Heart failure			**0.0207**
No	45 (36.29)	79 (63.71)	
Yes	5 (83.33)	1 (16.67)	
Chronic AF			0.4350
No	45 (37.50)	75 (62.50)	
Yes	5 (50.00)	5 (50.00)	
Previous MI			0.3225
No	34 (36.17)	60 (63.83)	
Yes	16 (45.71)	19 (54.29)	
Previous cardiac surgery			0.3097
No	48 (37.80)	79 (62.20)	
Yes	2 (66.67)	1 (33.33)	
Hb preoperative (g/dl) mean (SD)	12.48 (1.83)	13.14 (1.44)	**0.0241**
Range (7.2-16.8 g/dL)	9.5-16.8	7.2-16.8	
WBC preoperative mean (SD)	8.66 (2.38)	8.24 (2.12)	0.2999
Range (3.8-16.6)	4.7-15.7	3.8-16.6	
Renal function preoperative			**0.0159**
Elevated	13 (61.90)	8 (38.10)	
Normal	37 (33.94)	72 (66.06)	
Troponin preoperative			0.1712
Elevated	9 (56.25)	7 (43.75)	
NA	16 (30.77)	36 (69.23)	
Normal	25 (40.32)	37 (59.68)	
Preoperative EF (%) mean (SD)	44.70 (13.36)	50.97 (8.72)	**0.0023**
Range (15-67 %)	15-63	20-67	

Abbreviations: IHD (ischemic heart disease); DM (diabetes mellitus); MI (myocardial infarction); Hb (hemoglobin); WBC (white blood cell); EF (ejection fraction).

Patients with combined surgery (CABG and valve) had a significantly higher mortality rate compared to the isolated valve and isolated CABG surgery 72.735% vs 52.38% vs 31.63%, P=0.01, respectively. Also, the patients with on-pump beating heart CABG had a significantly higher mortality rate compared to on-pump and off-pump CABG 100% vs 33.33% vs 25.00%, P=0.01, respectively. Patients with Emergency operations have a significantly higher mortality rate compared to Urgent and Elective operations 85.71% vs 42.86% vs 34.31%, P =0.00. patients with biological and biological + mechanical valve replacement had a significantly higher mortality rate compared to mechanical valve replacement 100% vs 100% vs 52.17%, P=0.02. The duration of bypass and cross-clamp time of dead patients were compared to survived patients 192.06 vs 121.40, P<0.00, 115.07 vs 74.14, P<0.00, the mortality rate was significantly increased with increasing duration of bypass and cross-clamp time. Patients with intra-operative events had a significantly higher mortality rate compared to those with no intraoperative event 83.33% vs 31.25%, P<0.00. **(Table3)**

Table (3_: Comparisons of intra-operative factors between cardiac dead and survived patients

intra-operative factors	Study groups no (%)		p-value (two-sided)
	Dead (n=50)	**Survived(n=80)**	
Surgery type			**0.0105**
CABG	31 (31.63)	67 (68.37)	
Combined	8 (72.73)	3 (27.27)	
Valve	11 (52.38)	10 (47.62)	
Type of CABG			**0.0098**
Off-pump	2 (25.00)	6 (75.00)	
On-pump	32 (33.33)	64 (66.67)	
On-pump beating heart	5 (100)	0 (0.00)	
Non-CABG	11 (52.38)	10 (47.62)	
Timing of surgery			**0.0233**
Elective	35 (34.31)	67 (65.69)	
Emergency	6 (85.71)	1 (14.29)	
Urgent	9 (42.86)	12 (57.14)	
CABG details (No of graft)			0.2046
1	0 (0.00)	6 (100.00)	
2	6 (66.67)	3 (33.33)	
3	14 (35.00)	26 (65.00)	
4	14 (34.15)	27 (65.85)	
5	4 (40.00)	6 (60.00)	
6	1 (33.33)	2 (66.67)	
Vein			0.0515
No	46 (36.80)	79 (63.20)	
Yes	4 (80.00)	1 (20.00)	
Artery			0.3110
No	45 (40.54)	66 (56.90)	
Yes	5 (26.32)	14 (100.00)	
Vein and Artery			0.9527
No	16 (38.10)	26 (61.90)	
Yes	34 (38.64)	54 (61.36)	
Type of valve used			**0.0231**
Biological	3 (100)	0 (0.00)	
Biological + Mechanical	1 (100)	0 (0.00)	
Mechanical	12 (52.17)	11 (47.83)	
Non-valve	34 (33.01)	69 (66.99)	
Duration of bypass (min) mean (SD)	192.06 (79.84)	121.40 (28.67)	**<0.0001**
Range (49-386 min)	87-386	49-223	
Cross-clamp time (min) mean (SD)	115.07 (53.35)	74.14 (17.52)	**<0.0001**
Range (31-270 min)	36-270	31-163	
Intra-operative events			**<0.0001**
No	35 (31.25)	77 (68.75)	
Yes	15 (83.33)	3 (16.67)	

Abbreviation: CABG (coronary artery bypass graft)

Duration of intubation of dead patients was compared to survived patients 96 vs 48, P<0.00. the mortality rate significantly increased with the increasing duration of intubation. The dead re-intubated patients had a significantly higher mortality rate compared to no re-intubated patients 83.33% vs 21.28%, P<0.00. The dead patients with the inotropic agents were compared to those without inotropic agents 55.56% vs 0.00%, P<0.00, the mortality rate was significantly higher among the patients with inotropic agents. Postoperative HB and WBC of dead patients were compared to survived patients 8.91 vs 9.3, P=0.03, 17.08 vs 11.32, P<0.00, respectively. The mortality rate was significantly higher in the patients with postoperative lower HB and postoperative higher WBC. The patients with post-operative elevated levels of renal function were more likely to die compared to those with normal renal function; 87.50% vs. 11.76%; P<0.00. The dead patients with re-admission and no re-admission to ICU were compared 80.77% vs 27.88%, P<0.00. the mortality rate was significantly higher in patients with re-admission to ICU. Length of both ICU and overall hospital stay of case group were compared to survived group 8.52 vs 3.00, P<0.00. 12.53 vs 9.9, P<0.03. The mortality rate significantly increased with the increasing length of ICU stay. The study showed that the mortality rate is highly associated with the length of stay at the hospital when compared between dead and survived group 12.53 vs 9.8, P=0.03. **(Table4)**

Table (4): Comparisons of postoperative characteristics between cardiac dead and survived patients

postoperative characteristics	Study groups no (%)		p-value (two-sided)
	Dead (n=50)	**Survived (n=80)**	
Duration of intubation (hrs.) Median (IQR)	96 (144)	48 (19)	**<0.0001**
Range (1-432 hrs.)	1-432	2-168	
Re-intubation			**<0.0001**
No	20 (21.28)	74 (78.72)	
Yes	30 (83.33)	6 (16.67)	
Re-operation			0.4350
No	45 (37.50)	75 (62.50)	
Yes	5 (50.00)	5 (50.00)	
Inotropic agents			**<0.0001**
No	0 (0.00)	40 (100)	
Yes	50 (55.56)	40 (44.44)	
Hb postoperative (g/dl) mean (SD)	8.91 (0.78)	9.30 (1.04)	**0.0345**
Range (6.7-14.7)	7.4-12.7	6.7-14.7	
WBC postoperative mean (SD)	17.08 (8.45)	11.32 (3.11)	**<0.0001**
Range (3.7-40.2)	3.7-40.2	4.9-27.7	
Renal function post-operative			**<0.0001**
NA	5 (100.00)	0 (0.00)	
Elevated	35 (87.50)	5 (12.50)	
Normal	10 (11.76)	75 (88.24)	
Troponin postoperative			0.5886
NA	6 (40.00)	9 (60.00)	
Elevated	31 (35.63)	56 (64.37)	
Normal	13 (46.43)	15 (53.57)	
Re-admission to ICU			**<0.0001**
No	29 (27.88)	75 (72.12)	
Yes	21 (80.77)	5 (19.23)	
Length of ICU stay mean (SD)	8.52 (6.45)	3.00 (0.00)	**<0.0001**
Range (0-25)	0-25	2-14	
Overall length of stay mean (SD)	12.53 (10.09)	9.9(3.43)	**<0.0341**
Range (1-75)	1-75	5-26	

The case group with post-operative cardiac complications 83.33% vs 36.29%, P=0.03, chest complications 48.28% vs 30.56%, P=0.03, wound complications 69.23% vs 35.04%, P=0.03, neurological complications 100% vs 36.00%, P=0.00, renal complications 100% vs 24.53%, P<0.0001, and post-operative arrhythmia 65.91% vs 24.42%, P<0.00 had significantly higher mortality rate compared to those with no postoperative complications. **(Table5)**

Table (5): Comparisons of complications between cardiac dead and survived patients

Complications	Study groups n (%)		p-value (two-sided)
	Dead (n=50)	**Survived (n=80)**	
Cardiac complication			**0.0311**
No	45 (36.29)	79 (63.71)	
Yes	5 (83.33)	1 (16.67)	
Type of Cardiac complication			0.1143
No complication	45 (36.29)	79 (63.71)	
Cardiogenic shock	1 (100)	0 (0.00)	
Endocarditis	1 (100)	0 (0.00)	
Graft failure	2 (100)	0 (0.00)	
Heart failure	1 (100)	0 (0.00)	
Pericardial effusion	0 (0.00)	1 (100)	
Chest complications			**0.0390**
No	22 (30.56)	50 (69.44)	
Yes	28 (48.28)	30 (51.72)	
Type of chest complication			0.8512
Chest infection	37 (38.95)	58 (61.05)	
No	13 (37.14)	22 (62.86)	
Yes			
Pleural effusion			0.7783
No	41 (39.05)	64 (60.95)	
Yes	9 (36.00)	16 (64.00)	

Pulmonary edema			0.4345
No	42 (37.17)	71 (62.83)	
Yes	8 (47.06)	9 (52.94)	
Pneumothorax			0.3846
No	49 (37.98)	80 (62.02)	
Yes	1 (100)	0 (0.00)	
Lung collapse			0.3846
No	49 (37.98)	80 (62.02)	
Yes	1 (100)	0 (0.00)	
Wound complications			**0.0316**
No	41 (35.04)	76 (64.96)	
Yes	9 (69.23)	4 (30.77)	
Type of wound complication			1.0000
Superficial wound infection	47 (38.84)	74 (61.16)	
No	3 (33.33)	6 (66.67)	
Yes			
Deep sternal wound infection			0.6383
No	48 (38.10)	78 (61.90)	
Yes	2 (50.00)	2 (50.00)	
Neurological complication			**0.0074**
No	45 (36.00)	80 (64.00)	
Yes (CVA)	5 (100.00)	0 (0.00)	
Renal complication			**<0.0001**
No	26 (24.53)	80 (75.47)	
Yes	24 (100)	0 (0.00)	
Arrhythmias			**<0.0001**
No	21 (24.42)	65 (75.58)	
Yes	29 (65.91)	15 (34.09)	
Type of arrhythmia			0.4288
AF	19 (43.18)	25 (56.82)	
No	31 (36.05)	55 (63.95)	

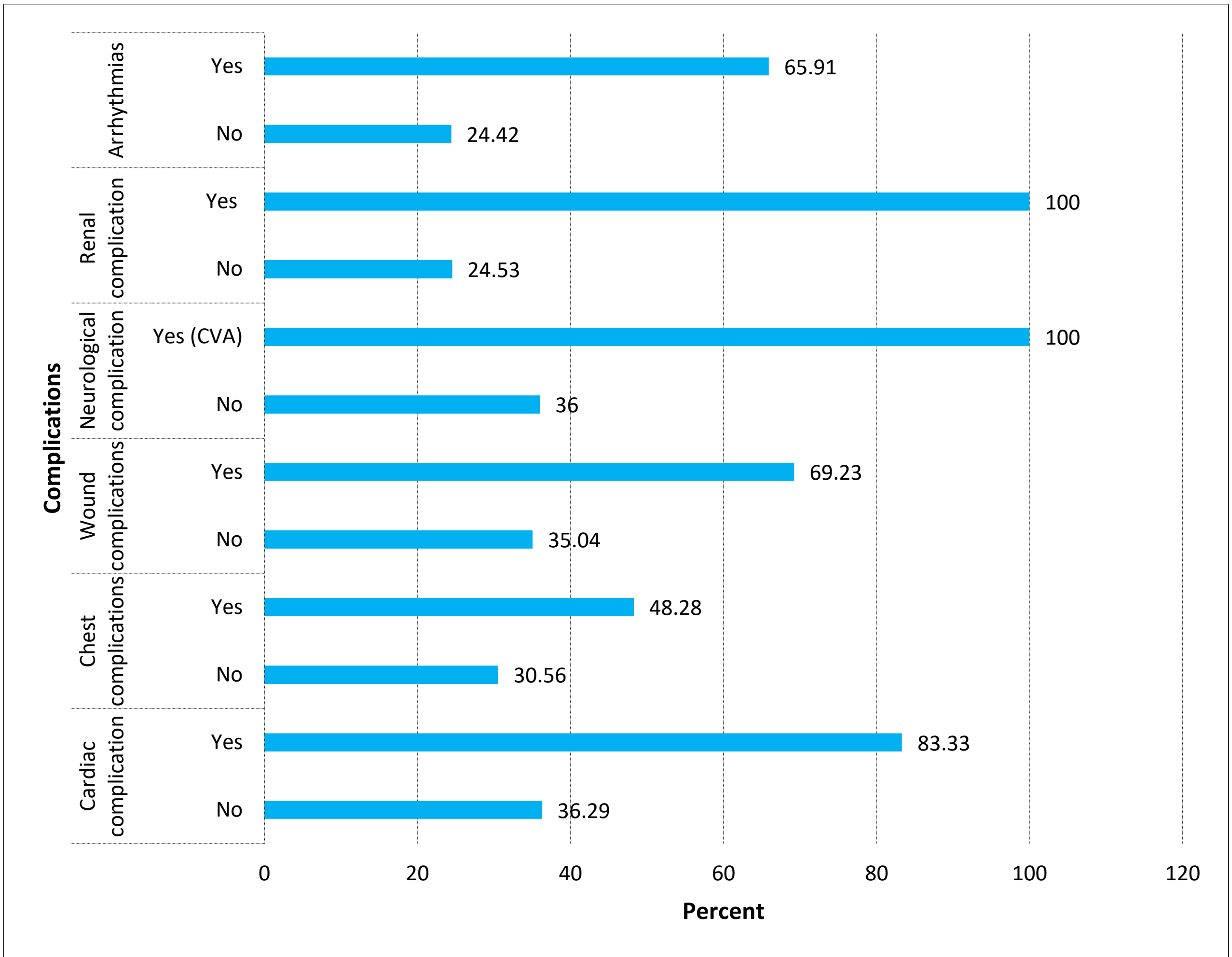

Fig. (1): Prevalence of mortality rate among dead patients with different complications.

*The most common cause of death following open-heart surgery was a cardiogenic shock (13 patients) followed by cardiac arrest (12 patients), renal failure (9 patients), septic shock (6 patients), CVA (3 patients), heart failure (2 patients), graft failure (2 patients), atrial fibrillation (1 patient), lung collapse (1 patient) and multiple organ failure (1 patient). **(Table6)***

Table (6): Causes of mortality among patients with open heart surgery

Causes	Number	Percentage
Septic shock	6	12.00
lung collapse	1	2.00
Atrial fibrillation	1	2.00
Graft failure	2	4.00
CVA	3	6.00
Cardiac arrest	12	24.00
Heart failure	2	4.00
Renal failure	9	18.00
Cardiogenic shock	13	26.00
Multiple organ failure	1	2.00

DISCUSSION

The main finding of this retrospective case-control study was that cardiogenic shock followed by cardiac arrest, renal failure, septic shock, and cerebral vascular accident were the prevailing causes of death following heart surgeries. Many preoperative factors were associated with mortality namely: advanced age, comorbidities, and preoperative low ejection fraction. Furthermore, the type and timing of surgery, the long duration of both bypass and cross-clamp time, intraoperative events, long duration of intubation, and need for re-intubation were associated with high mortality rates. Postoperatively, elevated renal function, need for re-admission to ICU, postoperative complications, and prolong both ICU and overall hospital stays were parameters directly linked to mortality.

Numerous studies concluded that age is an independent predictor of early mortality in cardiac surgery. Current study found the age of the patient in years to be strongly related to mortality. The average age of patients receiving surgery rises as the population ages. This is attributed to the impact of comorbidities that are common in elderly patients as well as age-related changes affecting multiple organ systems (Curiel-Balsera et al., 2013).

Recently published studies examining the association between BMI and post-heart surgery mortality, the studies have shown that underweight or extremely obese patients have increased risks for some early major complications such as prolonged ventilation, deep sternal wound infection, and renal failure. However, patients who are either mildly obese or overweight may have a lower in-hospital and operative mortality (Gao et al., 2016). The reason for the non-significant difference in BMI of current study groups is the fact that the vast majority of the patients in this study were overweight and obese.

In agreement with the current study, previous studies showed that presence one or more preoperative comorbidities and low EF with higher mortality rate. Comorbidities frequently indicate longer hospital stays, which also increase the death rate (Kurfirst et al., 2014). It is noteworthy that hypertension is managed by clinicians before surgery. This is why we found a converse association between hypertension and mortality. Moreover, Low EF is an independent risk factor for postoperative mortality. Carr et al(Carr et al., 2002) reported a mortality rate of 11% in patients with EF between 10–20%, and Di Carli et al revealed a 30-day postoperative mortality rate of 9.3% in patients with EF < 40%.(Di Carli et al., 1998).

Combined and complex valve surgery are associated with more physiologic stresses such as fluid and electrolyte shifts, prolonged duration of bypass, and a higher likelihood of exposure to low cardiac output, hypotension, end-organ injury, and death (Ribeiro et al., 2006). And non-elective surgeries represent an independent risk factor for perioperative mortality and additionally, it is frequently correlated with the worst clinical conditions and comorbidities that can negatively impact on outcomes. In non-elective surgery inadequate preoperative preparation and critical condition often lead to hemodynamic instability. Non-elective surgeries and older age predispose patients to higher overall morbidity and mortality. mentioned in other studies (Joshi et al., 2005). This finding was confirmed in this study.

Recent meta-analysis data have been published that do not support this results regarding the survival benefits of ON-BH CABG (Chaudhry et al., 2015). Current evidence indicates that the ON-BH CABG technique, has significantly lower morbidity and mortality particularly in high-risk patients and could be an attractive planned alternative for high-risk patient. ON-BH CABG is more technically demanding than conventional CABG. Therefore, while comparing the incidence of perioperative mortality, the difference in surgeon experience should be considered as well (Ueki et al., 2016). In agreement with current study, several large observational studies revealed that OPCAB patients had lower complication rates and risk-adjusted in-hospital mortality (Plomondon et al., 2001), whereas the other study found no differences in complication rates or risk-adjusted in-hospital mortality (Hernandez et al., 2001).

cardiopulmonary bypass time, and aortic cross-clamping period are correlated with each other and found to be a risk factors for major complications after surgery and higher rates of mortality. In line with present study, Garcia-Delgado et al.(García-Delgado et al., 2014) found that prolonged CPB causes extensive lung injury and respiratory distress by causing an intense systemic inflammatory syndrome and increasing lung capillary permeability. CPB duration has been revealed to be among the main predictors that has direct effect on the postoperative blood loss and bleeding time measured 2 hours after discontinuation of CPB, and lead mainly to platelet dysfunction. The similar findings were found elsewhere (Doenst et al., 2008, Al-Sarraf et al., 2011).

In agreement with this study, the literature has confirmed that prolonged duration of intubation and the need for re-intubation are other factors that increase morbidity and mortality following heart surgery. Patients who remain on mechanical ventilation for more than 48 hours have a 5.4-fold higher risk for developing a severe postoperative infection, a 4-fold higher risk for pneumonia, and a 4.1-fold increased risk for postoperative sepsis of unknown origin. Moreover, re-intubation is associated with many negative outcomes such as pneumonia, acute kidney injury, tracheotomy, infection of the incision, prolonged mechanical ventilation time, and prolonged both ICU and hospital stay. (Tarsia et al., 2005, Jian et al., 2013)

The current study showed that patients with cardiogenic shock or those with sepsis who required inotropic support had a higher association with mortality. Some patients with deep wound infections and sternal wound dehiscence required reoperation for wound closure. There was no significant correlation between the reoperation rate and mortality. Although inotropes have been demonstrated to ameliorate hemodynamics and measured physiological variables, they may be a source of increased morbidity and mortality as they can increase cardiac ischemia and arrhythmias. Few clinical trials have shown that (Gillies et al., 2004).

In line with the present study, several studies reported that readmission to the ICU following cardiac surgery is associated with an increase in hospital mortality rate compared to non-readmitted patients. The development of arrhythmias after surgery is also found to be a risk that increases the re-admission to the ICU. Furthermore, readmission to the ICU usually meant a significant change in condition, which is associated with a variety of factors, such as patient age, cardiac and renal function, and therapeutic drugs. (Litwinowicz et al., 2015)

Different studies have demonstrated the adverse effects of postoperative complications on the short-term outcomes after cardiac surgery. Generally, the postoperative complications rate of CABG is less than valve surgery and that of valve surgery is less than the complication rate of combined surgery. The development of postoperative complications is associated with an increased risk of death and prolonged hospital stay, and this is supported by present data (Seese et al., 2020). In their analysis of the results of cardiac surgery in octogenarians, Zingone et al. were able to demonstrate that postoperative complications are a greater risk factor for early mortality than preoperative comorbidities Specifically in the field of valve surgery, newly discovered techniques such as percutaneous aortic and mitral valve replacement, may significantly increase these high-risk patients' chances of survival (Zingone et al., 2009).

In the present study postoperative AF was associated with higher mortality rate. Post-operative AF is linked to a longer hospital stay, a greater risk of infections, renal failure, neurological problems, and mortality, according to a multicenter research on AF following heart surgery (Mathew et al., 2004). Recently, three systematic reviews and meta-analyses (Kerwin et al., 2020, Eikelboom et al., 2021, Woldendorp et al., 2021) that included up to 239,018 surgical patients(Woldendorp et al., 2021) attempted to summarize the clinical data that is available in the area. After CABG(Kerwin et al., 2020) or valve surgery(Eikelboom et al., 2021, Woldendorp et al., 2021), patients who develop postoperative AF have a much increased risk of death (19-29% on average)(Eikelboom et al., 2021, Woldendorp et al., 2021) and stroke (4%) (Kerwin et al., 2020, Eikelboom et al., 2021) than those who do not.

Other factors have been confirmed to associate with mortality; including AKI. Consistent with current findings, numerous studies have found that the occurrence of AKI following cardiac surgery is associated with an increase mortality, and postoperative AKI frequently occurs in patients undergoing the most complex cardiac surgery and in those who have the highest burden of preoperative comorbidities (Hobson et al., 2009). Recently, a number of studies have evaluated the long- and short-term complications of elevated serum creatinine following heart surgery and found that postoperative elevated serum creatinine is associated with increased duration of mechanical ventilation, prolong hospitalization, increase risk of end-stage renal failure and mortality (Falvo et al., 2008).

Some heart surgery patients experience serious postoperative complications and stay in the hospital and ICU for a prolonged period of time. Only a small number of studies have looked at the correlations between duration of ICU stay, length of hospital stays, and risk of in-hospital mortality. Also, it remains unclear how much the risk of mortality increases with each postoperative day spent in the ICU or hospital. In a large cohort of ICU patients, Williams and colleagues (Williams et al., 2010) previously reported that most ICU deaths occur shortly after admission with no clear association between length of ICU stay and the probability of in-hospital death. In the same study, an extended stay in the ICU was associated with lower long-term survival, but this effect plateaued after 10 days. Bashour and colleagues (Bashour et al., 2000) reported a 33% mortality rate for patients undergoing cardiac surgery who stayed for more than 10 consecutive days in the ICU.

Strengths and weaknesses of the study

This is the first study that has been conducted to uncover contributing factors to mortality in our region. But the study is not exempt from the limitations. The study was retrospective because we extracted the data from the medical records of the patients. The medical records have not been stored appropriately. In addition, several of these documents have missing information. Therefore, we have excluded some cases from the study due to having high missing information.

CONCLUSION AND RECOMMENDATIONS

Conclusion: The associated factors to mortality after cardiac surgery include advanced age, and comorbidities, preoperative low ejection fraction, type and timing of surgery, prolong cross clamp and cardiopulmonary bypass time, prolong duration of intubation, the need for re-intubation, readmission to ICU, poor renal function after surgery, prolonged ICU stay, and prolonged overall hospital stay. Optimization of the condition of the patient before surgery and early management of complications will reduce the hospital stay and the mortality.

Recommendations

It is suggested that the modifiable and most important factors contributing to the mortality of cardiac patients be managed appropriately upon admission to the hospital. These factors could be hypertension, renal function, hyperlipidemia, and HB. Controlling these factors could decrease the rate of mortality in the cardiac center significantly. In addition, it is suggested that the Ministry of Health focuses on preventive factors to decrease the incidence of mortality among cardiac patients, for example, smoking is considered a non-modifiable factor on admission because ex-smoking affects mortality.

Also, using the new technologies of surgery along with improving the clinical skills of medical staff may lower the incidence of mortality among cardiac patients despite this topic being outside the scope of this study.

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REFERENCES

Al-Sarraf, N, Thalib, L, Hughes, A, Houlihan, M, Tolan, M, Young, V, et al. (2011). Cross-clamp time is an independent predictor of mortality and morbidity in low-and high-risk cardiac patients. International Journal of Surgery, 9(1): 104-109.

Ball, L, Costantino, F & Pelosi, P (2016). Postoperative complications of patients undergoing cardiac surgery. Current opinion in critical care, 22(4): 386-392.

Bashour, CA, Yared, J-P, Ryan, TA, Rady, MY, Mascha, E, Leventhal, MJ, et al. (2000). Long-term survival and functional capacity in cardiac surgery patients after prolonged intensive care. 28(12): 3847-3853.

Carr, JA, Haithcock, BE, Paone, G, Bernabei, AF & Silverman, NAJTAots (2002). Long-term outcome after coronary artery bypass grafting in patients with severe left ventricular dysfunction. 74(5): 1531-1536.

Chaudhry, UA, Harling, L, Sepehripour, AH, Stavridis, G, Kokotsakis, J, Ashrafian, H, et al. (2015). Beating-heart versus conventional on-pump coronary artery bypass grafting: a meta-analysis of clinical outcomes. 100(6): 2251-2260.

Curiel-Balsera, E, Mora-Ordoñez, JM, Castillo-Lorente, E, Benitez-Parejo, J, Herruzo-Avilés, A, Ravina-Sanz, JJ, et al. (2013). Mortality and complications in elderly patients undergoing cardiac surgery. 28(4): 397-404.

Davies, S & Wilson, R (2004). Preoperative optimization of the high-risk surgical patient. British journal of anaesthesia, 93(1): 121-128.

Di Carli, MF, Maddahi, J, Rokhsar, S, Schelbert, HR, Bianco-Batlles, D, Brunken, RC, et al. (1998). Long-term survival of patients with coronary artery disease and left ventricular dysfunction: implications for the role of myocardial viability assessment in management decisions. 116(6): 997-1004.

Doenst, T, Borger, MA, Weisel, RD, Yau, TM, Maganti, M & Rao, V (2008). Relation between aortic cross-clamp time and mortality—not as straightforward as expected. European journal of cardio-thoracic surgery, 33(4): 660-665.

Eikelboom, R, Sanjanwala, R, Le, M-L, Yamashita, MH & Arora, RCJTAoTS (2021). Postoperative atrial fibrillation after cardiac surgery: a systematic review and meta-analysis. 111(2): 544-554.

Elsaed, MM, Mohamed, AH & Ebrahim, MN (2020). Factors Affecting Post Open-Heart Surgery Outcomes for Hospitalized patients. Egyptian Journal of Health Care, 11(1.

Falvo, A, Horst, HM, Rubinfeld, I, Blyden, D, Brandt, M-M, Jordan, J, et al. (2008). Acute renal failure in cardiothoracic surgery patients: what is the best definition of this common and potent predictor of increased morbidity and mortality. 196(3): 379-383.

Fuhrman, DY & Kellum, JA (2017). Epidemiology and pathophysiology of cardiac surgery-associated acute kidney injury. Current Opinion in Anesthesiology, 30(1): 60-65.

Gao, M, Sun, J, Young, N, Boyd, D, Atkins, Z, Li, Z, et al. (2016). Impact of body mass index on outcomes in cardiac surgery. 30(5): 1308-1316.

García-Delgado, M, Navarrete-Sánchez, I & Colmenero, MJCOiA (2014). Preventing and managing perioperative pulmonary complications following cardiac surgery. 27(2): 146-152.

Gillies, M, Bellomo, R, Doolan, L & Buxton, BJCC (2004). Bench-to-bedside review: Inotropic drug therapy after adult cardiac surgery–a systematic literature review. 9(3): 1-14.

Hernandez, F, Cohn, WE, Baribeau, YR, Tryzelaar, JF, Charlesworth, DC, Clough, RA, et al. (2001). In-hospital outcomes of off-pump versus on-pump coronary artery bypass procedures: a multicenter experience. 72(5): 1528-1534.

Hobson, CE, Yavas, S, Segal, MS, Schold, JD, Tribble, CG, Layon, AJ, et al. (2009). Acute kidney injury is associated with increased long-term mortality after cardiothoracic surgery. 119(18): 2444-2453.

Jian, L, Sheng, S, Min, Y & Zhongxiang, YJJocs (2013). Risk factors for endotracheal re-intubation following coronary artery bypass grafting. 8(1): 1-7.

Joshi, P, Fraser, JF, Mullany, DVJCA & Care, C (2005). The high risk cardiac surgical patient. 16(6): 369-383.

Kerwin, M, Saado, J, Pan, J, Ailawadi, G, Mazimba, S, Salerno, M, et al. (2020). New-onset atrial fibrillation and outcomes following isolated coronary artery bypass surgery: A systematic review and meta-analysis. 43(9): 928-934.

Kurfirst, V, Mokráček, A, Krupauerová, M, Čanádyová, J, Bulava, A, Pešl, L, et al. (2014). Health-related quality of life after cardiac surgery–the effects of age, preoperative conditions and postoperative complications. 9(1): 1-8.

Lee, LS, Daniel, JJTJoT & Surgery, C (2008). Highlights from the 11th annual scientific meeting of the international society for minimally invasive cardiothoracic surgery. 136(4): 1107-1109.

Litwinowicz, R, Bartus, K, Drwila, R, Kapelak, B, Konstanty-Kalandyk, J, Sobczynski, R, et al. (2015). In-hospital mortality in cardiac surgery patients after readmission to the intensive care unit: a single-center experience with 10,992 patients. Journal of cardiothoracic and vascular anesthesia, 29(3): 570-575.

Mathew, JP, Fontes, ML, Tudor, IC, Ramsay, J, Duke, P, Mazer, CD, et al. (2004). A multicenter risk index for atrial fibrillation after cardiac surgery. 291(14): 1720-1729.

Mejia, OAV, Borgomoni, GB, Lima, EG, Guerreiro, GP, Dallan, LR, de Barros e Silva, P, et al. (2021). Most deaths in low-risk cardiac surgery could be avoidable. Scientific reports, 11(1): 1-8.

Plomondon, ME, Cleveland Jr, JC, Ludwig, ST, Grunwald, GK, Kiefe, CI, Grover, FL, et al. (2001). Off-pump coronary artery bypass is associated with improved risk-adjusted outcomes. 72(1): 114-119.

Ribeiro, ALP, Gagliardi, SPL, Nogueira, JLS, Silveira, LM, Colosimo, EA & do Nascimento, CAL (2006). Mortality related to cardiac surgery in Brazil, 2000-2003. The Journal of Thoracic and Cardiovascular Surgery, 131(4): 907-909.

Seese, L, Sultan, I, Gleason, TG, Navid, F, Wang, Y, Thoma, F, et al. (2020). The impact of major postoperative complications on long-term survival after cardiac surgery. 110(1): 128-135.

Tarsia, P, Aliberti, S, Cosentini, R & Blasi, FJB (2005). Hospital-acquired pneumonia. 1(4): 296-301.

Tesler, UF 2020. *A history of cardiac surgery: an adventurous voyage from antiquity to the artificial heart,* Cambridge Scholars Publishing.

Ueki, C, Sakaguchi, G, Akimoto, T, Ohashi, Y & Sato, HJEJoC-TS (2016). On-pump beating-heart technique is associated with lower morbidity and mortality following coronary artery bypass grafting: a meta-analysis. 50(5): 813-821.

Vervoort, D, Meuris, B, Meyns, B & Verbrugghe, P (2020). Global cardiac surgery: access to cardiac surgical care around the world. The Journal of thoracic and cardiovascular surgery, 159(3): 987-996. e6.

Williams, T, Ho, K, Dobb, G, Finn, J, Knuiman, M & Webb, SJBjoa (2010). Effect of length of stay in intensive care unit on hospital and long-term mortality of critically ill adult patients. 104(4): 459-464.

Woldendorp, K, Farag, J, Khadra, S, Black, D, Robinson, B & Bannon, PJTAoTS (2021). Postoperative atrial fibrillation after cardiac surgery: a meta-analysis. 112(6): 2084-2093.

Zingone, B, Gatti, G, Rauber, E, Tiziani, P, Dreas, L, Pappalardo, A, et al. (2009). Early and late outcomes of cardiac surgery in octogenarians. 87(1): 71-78.