

Cardiopulmonary Bypass: Risk factors and complications of patients undergoing open heart surgery

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Abstract:

Background: Open heart surgery is a type of extracorporeal circulation used during surgery to keep the patient's blood and oxygen flowing. It temporarily substitutes the function of the heart and lungs. **Aim of the study:** To determine the risk factors and complications of patients undergoing open heart surgery. **Research design:** A descriptive research design was used in this study. **Setting:** Cardio-thoracic intensive care unit at Assiut University Heart Hospital. **Sample:** A convenience sample of 60 adult patients was involved in the study. **Tools:** Tool one: patient's assessment questionnaire; tool two: Patient evaluation tool of open heart surgery assessment questionnaire. **Results:** about 50% of risk factors of the studied patients were old age, as 45% had smoked, and hypertension had an increased complications of open heart surgery. The current study revealed a positive correlation between acute renal failure, hemorrhage, infection and age. **Conclusion:** Advanced age was considered the first risk factors for the occurrence of complications followed by hypertension and smoking. **Recommendations:** Develop intraoperative guidelines to reduce the systemic inflammatory response syndrome (SIRS) by decreasing the time of operation, maintain appropriate glucose levels and monitoring intraoperative fluid balance and hematocrit levels to help to reduce the incidence of postoperative complications.

Keywords: *Cardiopulmonary Bypass, Complications, open heart surgery & Risk Factors.*

Introduction

During open-heart surgery, a machine known as a cardiopulmonary bypass (CPB) machine assumes the role of the heart and lungs. Cardiopulmonary bypass grafting (CABG) or valve replacement surgery is an example of open cardiac procedures that carried out using a CPB machine (Ismail, et al, 2024). Open-heart surgery and other treatments that call for the temporary replacement or support of heart and lung function sometimes involve the use of CPB. The majority of heart surgeries use of CPB, and the remarkable results of these procedures demonstrate how safe and efficient contemporary perfusionists and "heart-lung machines" have evolved to be (Sofa & Rahman, 2024).

Postoperative major adverse events frequently occur after cardiac surgery with CBP, especially with an increasing number of older and more complex patients presenting for cardiac surgical care. Intraoperative hypotension is associated with postoperative acute kidney injury (AKI). Myocardial injury, stroke, delirium, and mortality (Hoz et al., 2022).

Advanced age, smoking, chronic obstructive pulmonary disease (COPD), diabetes, obesity, gastrointestinal hemorrhage, post-surgery lung injury, damage to the phrenic nerve during surgery, sternal wound infections and re-exploration after surgery

consider the risk factors of pulmonary complications for patients underdoing cardiac surgery with cardiopulmonary bypass (Naveed et al., 2017).

Risk factors for postoperative AKI are divided into preoperative risk factors (preexisting renal dysfunction, smoking, ASO, DM, heart failure) and one intraoperative risk factors (prolonged operation time). Apart from findings reported herein, longer duration of cardiopulmonary bypass (Yamauchi et al., 2017).

Significance of the study:

SriJayadeva Institute of Cardiovascular Sciences and Research, Bengaluru (Karnataka, India) study on morbidity after CPB reported that from 362 patients, 254 (70.2%) had at least one major complications, and the most frequently occurring complications has been low cardiac output state (29.8%). The ICU length of stay (LOS) was for > 2 days in 23.2% of patients, and the hospital LOS was for > 7 days in almost 60% of the patients (Patra et al., 2019). Documents from the Assiut cardiothoracic surgery department show that about 569 open heart surgery patients had CPB surgery (Cardiac Assiut university hospital records 2023).

Aim of the study:

The study aims to determine the risk factors and complications of patients undergoing open-heart surgery.

Research Questions:

Q1. What are the risk factors and complications of patients undergoing open-heart surgery?

Patients & Methods:**Research design:**

A descriptive research design was utilized to conduct this study.

Setting:

This study was conducted in the cardio-thoracic intensive care unit at Assiut University Heart Hospital, which has 12 beds, 9 head nurses, and 29 nurses.

Sampling:

A convenience sampling of both adult male and female patients undergoing cardiac surgery (CABG and valve replacement surgeries) with age groups ranging from (18-60) year within six months except those patients mentioned in the exclusion criteria.

Exclusion criteria:

1. Off pump operation
2. End stage renal disease.
3. Uncontrolled diabetes mellitus type 1.
4. Liver failure

Tools of data collection:

Data collection was obtained by two tools using the following tools:

Tool (I): Patient's assessment questionnaire:

This tool was developed by the researcher after a literature review (Andrea, 2020) to evaluate the patient conditions and consists of two parts:

Part I: Personal Data: This part was an assessment of socio-demographic: that included (sex, age, patient code, marital status, educational level, occupation).

Part II: Medical Data: This part included current medical data as past medical history (heart disease, hypertension, diabetes, smoking, obesity, thyroid dysfunction) and present medical history.

Part III: Patients risk factors assessment:

This part was developed by the researcher after a review of literature and identified risk factors and included: obesity, old age, smoking, hypertension, diabetes, hemorrhage, acute cerebrovascular stroke, recent MI, etc. (Wang X et al., 2023).

Tool II: Patient Evaluation tool of open heart surgery assessment questionnaire:

The researcher developed this tool after review of literatures (Huffmyer & Groves, 2020).

Part 1: Patients' outcomes and Post-operative complications of open heart surgery assessment questionnaire:

This part was to assess the patient conditions in the post-operative period as pneumonia, acute renal failure, hemorrhage, arrhythmias, acute liver injury, myocardial infraction, stroke, air embolism, respiratory failure, infection, and length of hospital stay; evaluate respiratory complications, cardiac,

gastrointestinal, renal, wound infection, and hospital stay. (Li X et al., 2018)

Method:**Preparatory phase:****Tools development:**

Data collection tools were developed based on reviewing the current, past, local and international related literature in the various aspects using books, articles, periodicals, magazines, and references were done.

Pilot study:

Pilot study was conducted on 10 % of the study subjects over one month in the selected setting to test the tools' applicability and clarity. The data from the pilot study were analyzed; no changes were made to the tools used, so the 10% of subjects chosen for the pilot study were not included in the study.

Ethical consideration

- Research proposal was approved from Ethical Committee in the Faculty of Nursing.
- There is no risk for study patients during application of the research.
- The study was followed common ethical principles in clinical research.
- Oral consent was obtained from patient or guidance that is willing to participate in the study, after explaining the nature and purpose of the study.
- Confidentiality and anonymity was assured.
- Study patients have the right to refuse to participate and or withdraw from the study without any rational any time.
- Study patient's privacy was considered during collection of data

Implementation phase:

This phase of data collection was started once official permission was granted to proceed with the proposed study; the researcher approached the head nurses of the Cardiothoracic department to obtain lists of patients, and reviewed those patients as considering the exclusion criteria to select eligible patients. Patients whom agreed to participate in the proposed study were interviewed individually to explain the purpose, benefits and the nature of the study and to establish rapport and cooperation. Then oral consent was obtained from each of the subjects.

Data collections:

- The researcher was assessed the studied patients 24 hours preoperatively and postoperatively in the first 48 hours of admission to the cardiothoracic ICU. Data collected over a period of six months.
- The researcher assessed the studied patients from the first day of admission and record patient demographic data before any collection by taking this information from his/her sheet use tool 1 (Part I).

- The researcher assessed medical data by use tool 1 (Part II).
- The researcher assessed the patient risk factors preoperatively by use tool 1 part (III)
- The researcher was assessed patient outcomes in first 48 hours postoperative by use tool two.
- Data collection of the study took about 6 months started at the beginning of December 2023, and completed by the end of May 2024. It involved the following:

Statistical analysis:

The collected data was organized, categorized, coded, tabulated and analyzed using the Statistical Package for Social Sciences (SPSS) **version 26**. Data was presented in tables and figures using numbers, percentages, means, standard deviation and chi-square was used in order to find an association between two qualitative variables. Statistical significant was considered at P-value < 0.05.

Results:

Table (1): Frequency distribution of personal data of studied patients (No=60)

Age	No	%
20-30	8	13.3
31-40	13	21.7
41-50	16	26.7
51-60	23	38.3
Sex		
Male	33	55.0
Female	27	45.0
Marital status		
Single	5	8.3
Married	46	76.7
Divorced	3	5.0
Widow	6	10.0
Occupation		
Employer	32	53.3
Dose not work	12	20.0
Retired	4	6.7
House wife	12	20.0

Table (2): Frequency distribution of studied patients' medical data (No =60)

Medical data	No	%
-Diagnosis		
MI	13	21.7
Valvular diseases	42	70.0
congenital heart diseases	5	8.3
-Blood Transfusion		
Yes	60	100.0
No	00.0	00.0
-Past medical history		
Heart disease		
Yes	18	30.0
No	42	70.0
Hypertension		
Yes	28	46.7
No	32	53.3
Diabetes		
Yes	25	41.7
No	35	58.3
Thyroid Dysfunction		
Yes	9	15.0
No	51	85.0
Renal Diseases		
Yes	2	3.3
No	58	96.7
Hepatic Diseases		
Yes	12	20.0
No	48	80.0

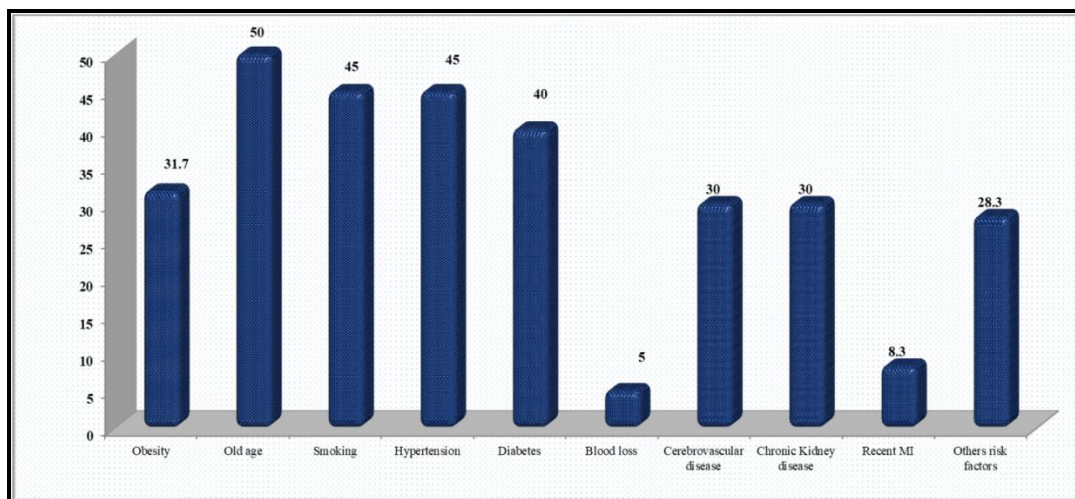


Figure (1): Frequency distribution of patients risk factors of studied (No =60)

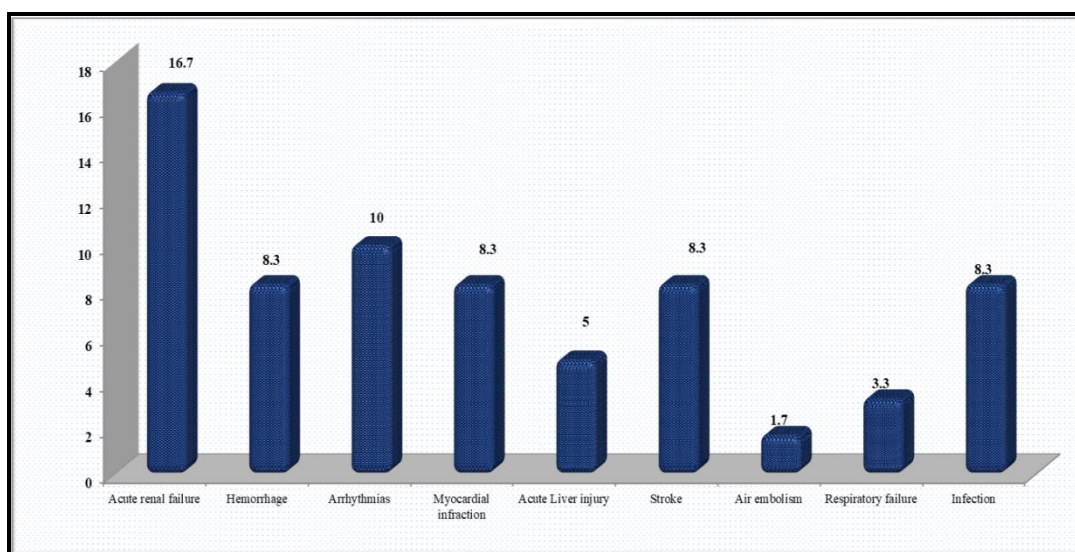


Figure (2): Frequency distribution of complications of open heart surgery of studied patients (No= 60)

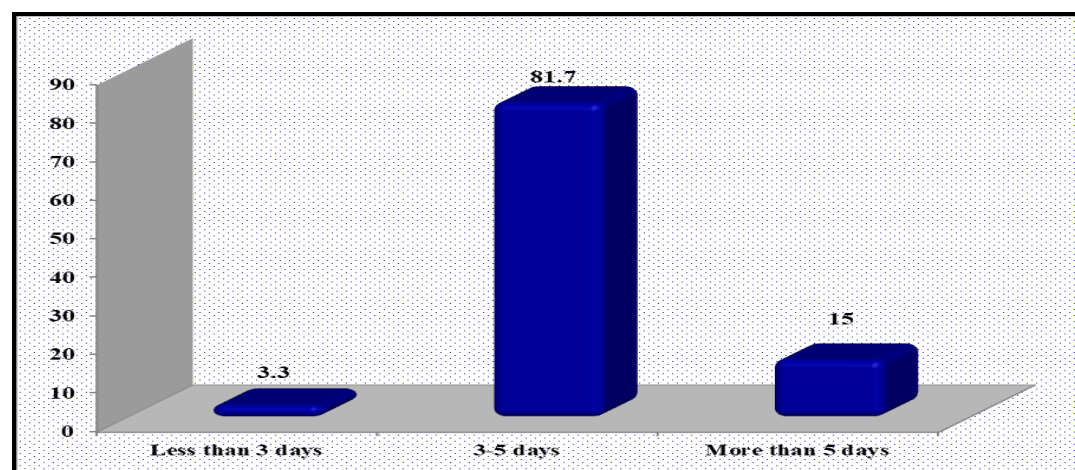


Figure (3): Frequency distribution of hospital stay of studied patients (No=60)

Table (3): Correlations between complications of studied patents and hospital stay (No= 60)

Complications	Hospital stay	
	R	P
Acute renal failure	0.023	0.861
Hemorrhage	0.360*	0.005
Arrhythmias	0.100	0.446
Acute Liver failure	0.069	0.601
Stroke	0.060	0.651
Air embolism	0.285	0.027
Respiratory failure	0.407	0.001
Infection	0.360*	0.005

Table (4): Correlations between complications of studied patients and personal data (N0= 60)

Complications	Age		Sex		Occupation		Education	
	R	P	R	P	R	P	R	P
Acute renal failure	0.500*	0.000	0.225	0.084	0.102	0.438	0.035	0.792
Hemorrhage	0.018*	0.890	0.152	0.248	0.183	0.161	0.031	0.816
Arrhythmias	0.176	0.178	0.078	0.553	0.084	0.521	0.106	0.419
Acute Liver failure	0.076	0.562	0.100	0.448	0.165	0.209	0.176	0.179
Stroke	0.089	0.497	0.030	0.818	0.122	0.353	0.031	0.816
Infection	0.073*	0.580	0.152	24.800	0.099	0.451	0.023	0.859

Table (1): Illustrates characteristics of the studied patients in relation to their age sex, marital status and occupation. **Regarding the age**, it was found that about 38.3 % from age group 51-60 years. **Concerning the sex**, 55% of the cases in studied patients was male and 45% was female, **As regard marital status**, it was observed that 76.7% from the study patients were married. **Regarding occupation**, it was found that 53.3% were employers.

Table (2): Shows medical data of the studied patients. Regarding diagnosis, it was observed that about 70% had valvular diseases and 21.7% had myocardial infarction. Concerning blood transfusion, it was found that 100% had taken blood transfusion. Regarding past medical history, it was observed that 30% from study patients had heart diseases and 46% had hypertension and 41.7% had diabetes.

Figure (1): Shows risk factors of studied patients. Regarding obesity, it was found that 31.7% had obesity. About 50% from patients had old age and 45% had smoking. 45 % from studied patients had hypertension. About 40% from studied patients had diabetes.

Figure (2): Shows complications of studied patients on open heart surgery. It was found that about 16.7% from patients had acute renal failure. 8.3% from studied patients had hemorrhage. 10% from studied patients had Arrhythmias.

Figure (3): Shows of patient's hospital stay, it was observed that 3.3% from studied patients were hospital stay Less than 3 day. 81.7% were 3-10 days and 15% more than 10 days.

Table (3): Shows correlations between complications and hospital stay. It was found that positive correlation between hemorrhage, infection and hospital stay with R= **0.360***.

Table (4): Shows correlations between complications and personal. It was found that positive correlation between acute renal failure, hemorrhage, infection and age with R= **0.500***, **0.018*** and **0.073***.

Discussion:

Cardiopulmonary bypass (CPB) is an important technique that allows safe and effective open-heart surgery. It comes with some potential complications that must be anticipated, minimized, and responded to optimize outcomes (Roberts et al., 2023). Cardiopulmonary bypass has allowed significant surgical advancements, but accompanying risks can be significant (Bartoszek & Karkouti, 2021). Thus, the present study aimed to assess the prevalence and risk factors of complications among patients undergoing open heart surgery.

Regarding the clinical data, the study revealed that the majority of valvular diseases and around half of the studied patients had hypertension and diabetes. These results agree with Patra et al. (2019), who reported that more than half of patients had valvular heart disease with a medical history of hypertension and diabetes in a study conducted in India to assess the morbidity after cardiac surgery and identify the preoperative and intraoperative factors associated with postoperative morbidity.

On the same line as Rateb et al. (2022), who reported that more than fifty percent of studied patients had ischemic heart disease and valvular heart disease with hypertension, diabetes, and rheumatic heart disease in a study conducted.

Regarding risk factors for complications of open heart surgery, this study revealed that the most frequently occurring risk factors were older age, smoking, hypertension, diabetes, and obesity. This result agrees with **Patra et al. (2019)**, who documented that the predictors of the presence of complications after cardiac surgery included male, old age, hypertension, type of surgical procedure, body weight of the patient, and blood lactate level at ICU admission. This result related to the importance of assessment of preoperative cardiac surgery risk factors and identifying the predictors of the presence of complications of cardiopulmonary bypass is the first step in preventing the complications of cardiac surgery with cardiopulmonary bypass.

This may be in contrast with **Fu et al. (2021)**, who studied only the risk factors for acute kidney injury in patients receiving valve surgery with CPB and reported that younger age, male gender, increase in height, weight, BSA, and BMI, increased serum creatinine, decreased e-GFR, longer open heart surgery duration, and lower open heart surgery target bladder temperature were related to the development of acute kidney injury postoperatively in valve surgery.

Regarding the patient's hospital stay, it ranged between 3-10 days in the majority of the studied patients, except for a few whose hospital stay was less than 3 days or more than 10 days. This result is on the same line with **Zhang et al. (2021)**, who observed that the hospital stay lasted more than three days in more than fifty percent of the patients. Also in agreement with **Patra et al. (2019)**, who found that LOS in the hospital was for more than seven days for almost sixty percent of the patients. The mean duration of stay in hospital was 7.9 days. In contrast with **Abou-Arab et al. (2021)**, who mentioned that the hospital stay was from 11–14 days in the majority in a study conducted in France to assess postoperative pulmonary and neurological outcomes following cardiopulmonary bypass.

Regarding complications of open heart surgery in the studied patients, this study demonstrated that the most frequently occurring complications were acute renal failure, arrhythmias, hemorrhage, myocardial infarction, stroke, and infection. This result is on the same line with **Rateb et al. (2022)**, who found that arrhythmias were the most common complication, followed by hyperglycemia. Followed by bleeding and anemia followed by acute renal failure. While, on the other hand, disagreed with **Patra et al. (2019)**,

who reported that the most frequently occurring complications was low cardiac output state, followed by renal dysfunction, mechanical ventilation Atrial fibrillation, hemorrhage, myocardial infarction.

Also in contravention with Naeem et al. (2022), who found that the most common postoperative cardiac complications was atrial fibrillation, Respiratory complications, including atelectasis, gastrointestinal complications, including nausea, vomiting, and constipation, and other complications included pain and prolonged length of stay in a study conducted in Assiut, Egypt, to examine postoperative complications in patients undergoing CABGs. These results related to the differences in patient characteristics such as educational level, age, sex and occupation.

From the researcher's opinion there is variations in the results of the available studies about the complications of patients undergoing cardiac surgery with cardiopulmonary bypass. There are not enough available current research papers about the topic so there is a need for further research in this topic.

In addition to, Naeem et al.,(2022) who reported that there was a positive correlation between patient Socio-demographic data (Age and ICU stay) and Postoperative atrial fibrillation. This can be explained as aging is associated with Frailty and physiological changes, including decreased cardiovascular reserve, reduced pulmonary function, and impaired renal function. These changes can predispose older patients to complications such as cardiovascular events, and acute kidney failure during and after cardiac surgery.

Conclusion:

Based on the results of the current study it was concluded that:

Advanced age was considered the first risk factors for the occurrence of complications, hypertension and smoking. Concerning complications of study patients in open heart surgery, it was found that acute renal failure as a complications took the higher percent (more than one sixth), followed by arrhythmias (one tenth). There was a positive correlation between obesity, old age, diabetes as a risk factors, and hospital stay. It was found a positive correlation between haemorrhage, infection as a complications, and hospital stay. There was a positive correlation between acute renal failure, haemorrhage, infection, and the patient's age.

Recommendations:

According to the study's conclusions, it was advised that:

- Develop intraoperative guidelines to reduce the systemic inflammatory response syndrome (SIRS) by decreasing the time of operation, maintain

appropriate glucose levels and monitoring intraoperative fluid balance and hematocrit levels to help to reduce the incidence of postoperative complications.

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