Malignant Arrhythmia and Cardiac Arrest in the Operating Room
Mohd Husni Alqutamy1, Anwar Dhawi Almutairi2, Mahmoud Rashad Khairi3, Arwa Mohammad Alhoqail4, Asya Abdullah Alamri5, A Aham Essam M Saba6, Ahmad Adnan A Alsalam7, Mohammed Hamad S Al Habis8, Moafa, Ahmed Yahya M9, Mohammed Abdulaziz M Alomar10, Shahid Ibrahim Shahad Ibrahim Al Oraifi11, Haifa Nasser A Alkuwaytim12, Abdullah Hassan Ali Al Madan13

1 Anesthesia senior registrar at Health plus, Jeddah, KSA. Email: modalqutamy777@gmail.com
2 MBBS, Al-Qassim, Saudi Arabia. Email: Anwaard7@gmail.com
3 Medical Intern, Dar Al Uloom University in Riyadh, KSA. Email: Mahmoudkhairi96@gmail.com
4 Almaarefa university Riyadh, KSA. Email: Arwa1msh@gmail.com
5 Resident doctor, Ministry of health, KSA. Email: ambitious-18@hotmail.com
6 Resident Doctor, Al-Qurayyat General Hospital, Ministry of Health, KSA. Email: Lomey99@gmail.com
7 Resident doctor, King Faisal Hospital, Al-Hofaf, KSA. Email: Ahmad.1214@hotmail.com
8 Resident doctor, King Khaleed Hospital in Najran, KSA. Email: Alhabis300@gmail.com
9 Intern, Jazan University, Jazan, KSA. Email: Ahmedmoafa1997@gmail.com
10 Student, College of Medicine, Imam Muhammad bin Saud Islamic University in Riyadh, KSA. Email: Mohammad.1420.ksa@gmail.com
11 Health Informatics Specialist, King Fahad Specialist Hospital in Dammam, KSA. Email: Shahad.Lo@hotmail.com
12 King Faisal University, KSA. Email: Haioof-13@hotmail.com
13 Qatif Health Network, KSA. Email: abdullahahalmadan2020@gmail.com

Abstract
Malignant arrhythmias and cardiac arrest in the operating room are critical events that pose significant risks to patient safety and outcomes. This research paper aims to provide a comprehensive review of the current literature on the incidence, risk factors, and management of malignant arrhythmias and cardiac arrest in the operating room. The paper will also explore the potential role of advanced monitoring and early detection systems in improving the timely recognition and management of these life-threatening events. Additionally, the paper will discuss malignant arrhythmia and cardiac arrest in the operating room thoroughly as definitions. Ultimately, the findings of this research paper will contribute to a better understanding of the challenges and opportunities in addressing malignant arrhythmias and cardiac arrest in the operating room, with the goal of improving patient safety and outcomes.

Keywords: Malignant arrhythmia, cardiac arrest, ventricular arrhythmia, surgery, operating room.

Introduction
An arrhythmia refers to a disruption in the electrical system of the heart, which is responsible for maintaining a regular and constant rhythm of heartbeats. There are several classifications of arrhythmias. Cardiac arrhythmias may arise from either the atria or ventricles of the heart, resulting in tachycardia (excessive heart rate), bradycardia (insufficient heart rate), or arrhythmia (irregular or disordered heart rhythm). Certain forms of arrhythmias exhibit little perceptibility and provide a reduced likelihood of consequences. Other situations may pose a far higher level of severity, possibly leading to loss of life. These cardiac dysrhythmias are often referred to as malignant arrhythmias [1].

Malignant arrhythmia refers to abnormal heart rhythms that can be life-threatening, often leading to cardiac arrest in the operating room. These arrhythmias can occur due to various factors such as
medication side effects, electrolyte imbalances, or underlying heart conditions. Cardiac arrest, on the other hand, is a sudden cessation of the heart's function, leading to the stoppage of blood flow and vital organ failure. Both malignant arrhythmia and cardiac arrest require immediate intervention to prevent irreversible damage and save the patient's life [2]. Immediate intervention for malignant arrhythmia and cardiac arrest typically involves cardiopulmonary resuscitation (CPR) to restore blood circulation and the use of defibrillation to restore the heart's normal rhythm. In addition, identifying and addressing the underlying cause of the arrhythmia or cardiac arrest is crucial to prevent recurrence. This may include administering medications to correct electrolyte imbalances, adjusting medication dosages, or performing surgical procedures to treat any underlying heart conditions. Timely and effective intervention is essential for improving the chances of survival and minimizing long-term complications for patients experiencing malignant arrhythmia or cardiac arrest [3].

In addition to medical interventions, lifestyle changes such as maintaining a healthy weight, exercising regularly, and managing stress can also play a significant role in preventing future episodes. It is important for patients to closely follow their healthcare provider's recommendations and attend regular check-ups to monitor their heart health. Education and awareness programs can also help individuals recognize the symptoms of arrhythmia or cardiac arrest and seek immediate medical attention, further enhancing the chances of successful intervention. Overall, a comprehensive approach that includes medical, lifestyle, and educational interventions is necessary to ensure the best outcomes for patients at risk [4, 5].

The issue of arrhythmia and cardiac arrest is particularly important and impactful in surgical settings. During surgery, patients are often under anesthesia and their heart function is closely monitored. However, complications can still arise, and if arrhythmias or cardiac arrest occur, immediate intervention is critical to prevent serious consequences such as brain damage or death. Surgeons and anesthesiologists must be trained in recognizing and managing these emergencies, and have access to the necessary equipment and medications to respond effectively [6]. Additionally, preoperative screening and assessment of patients' cardiac health can help identify those at higher risk and allow for appropriate precautions to be taken. This may include adjusting medication regimens, optimizing fluid balance, and considering alternative anesthesia techniques. In some cases, patients with known cardiovascular issues may require a consultation with a cardiologist prior to surgery to ensure their heart is in the best possible condition. By taking these proactive measures, healthcare professionals can minimize the likelihood of complications and ensure the safety and well-being of their patients throughout the surgical process. However, even with these proactive measures, there can still be cases where complications arise during surgery. Healthcare professionals must be ready for a range of complications, from minor issues to more serious ones requiring additional medical intervention. This means having a well-equipped operating room, skilled surgical team, and access to emergency medical services. Additionally, a clear plan for post-operative care is essential to ensure patients receive appropriate follow-up care and monitoring. Being proactive and prepared can minimize the impact of complications [7, 8].

The objective of this research paper is to explore the various strategies and measures that healthcare professionals can take to minimize the impact of complications in surgical procedures. The paper will delve into the importance of having a well-equipped operating room and a skilled surgical team. By examining these factors, the research aims to provide valuable insights into how healthcare professionals can enhance patient outcomes and reduce the occurrence of complications.

Understanding Malignant Arrhythmia

Malignant arrhythmias refer to irregularities in the normal rhythm of the heart, which have the potential to result in a critical medical situation, such as sudden cardiac arrest. The primary etiology of these conditions is often attributed to the presence of an arrhythmia originating within the ventricular chambers of the heart. Illustrations of such conditions include ventricular fibrillation (V-Fib) and ventricular tachycardia (v-tach or VT). Ventricular fibrillation is a cardiac arrhythmia characterized by the uncontrolled trembling of the ventricles, which deviates from the normal rhythmic contraction pattern. In the case of this occurrence, the cardiac muscle may abruptly cease its pumping action, resulting in the cessation of blood circulation to the brain and other bodily organs. The medical condition referred to in this context is well recognized as cardiac arrest [1, 9]. Ventricular tachycardia term is used to describe arrhythmia characterized by the presence of abnormal electrical impulses in the ventricles of the heart, resulting in a heart rate above 100 beats
per minute. The duration of these episodes may be rather short, often spanning just a few seconds. However, in the event that this accelerated cardiac rhythm persists for a duration of beyond 30 seconds, it has the potential to pose a significant risk to an individual's life, perhaps resulting in a state of cardiac arrest. Atrial fibrillation (A-Fib), an arrhythmia originating in the atria of the heart, may pose significant risks if not well managed. A stroke is considered to be one of the most significant consequences that might arise from the lack of treatment for atrial fibrillation [10]. Atrial fibrillation, which impacts around 1-2% of the population in the United States, stands as the prevailing form of arrhythmia [11]. Ventricular arrhythmias have a relatively lower incidence, with prevalence estimates around 48 per 100,000 individuals according to some reputable sources [12].

The etiology of malignant arrhythmias remains uncertain, however there seems to be a higher prevalence in individuals with preexisting structural cardiac abnormalities. Additionally, the condition may be initiated in instances when an individual has a myocardial infarction, resulting in the heart's electrical instability. This phenomenon has the potential to elevate the likelihood of a potentially fatal cardiac arrhythmia [13]. Additional factors that may contribute to this phenomenon are congenital heart disease (CHD) which refers to a group of structural abnormalities in the heart that are present from birth. These abnormalities may affect the heart's chambers, an imbalance in electrolyte levels which can lead to symptoms such as weakness, confusion, and irregular heartbeat, hyperthyroidism which is a medical condition characterized by excessive activity of the thyroid gland, resulting in an overproduction of thyroid hormones, hereditary cardiomyopathy, and sarcoidosis which is a systemic inflammatory disease characterized by the formation of non-caseating granulomas in various organs, most commonly the lungs and lymph nodes [1].

Additionally, there are less prevalent medical disorders that may contribute to an increased susceptibility to malignant arrhythmias. As an example, a study conducted in 2017 on individuals diagnosed with takotsubo syndrome, often referred to as “broken heart syndrome,” indicated that around 11.4% of patients with this disease concurrently had a potentially fatal arrhythmia [14].

The management of a malignant arrhythmia consists of a two-stage treatment approach. The first phase of treatment entails the cessation of arrhythmia and the reestablishment of both pulse and blood pressure. This entails the use of cardiopulmonary resuscitation (CPR) or an automated external defibrillator (AED) which administers electrical stimuli to the cardiac muscle.

The subsequent phase includes therapeutic interventions aimed at mitigating the likelihood of a future occurrence of a malignant arrhythmia. This may include a variety of elements: 1) One aspect to consider in the field of healthcare is the use of medications. Pharmaceutical interventions, such as the administration of antiarrhythmic medicines, have the potential to facilitate the restoration of a regular cardiac rhythm. However, it is important to note that in some cases, the administration of these medications may exacerbate an existing arrhythmia or induce the occurrence of a new one. Therefore, it is imperative to exercise caution and thoroughly evaluate the appropriateness of their use. Beta-blockers, known for its ability to reduce cardiac workload, have shown potential benefits in some circumstances. 2) The implantable cardioverter defibrillator (ICD) is a medical device used for the prevention and treatment of life-threatening cardiac arrhythmias. The aforementioned little implantable device is designed to monitor an individual's cardiac rhythm and, when deemed essential, administer electrical shocks in order to restore and maintain a stable heart rhythm. 3) Catheter ablation is a minimally invasive technique that involves the insertion of a thin and flexible tube, known as a catheter, into the femoral vein located in the groin. The catheter is then carefully guided to the heart, where it targets and eliminates a group of cells that are impacted by the arrhythmia. 4) Left cardiac sympathetic denervation is a technique that is seldom performed and is aimed at reducing the activity of the sympathetic nervous system on the left side of the heart, hence resulting in a deceleration of its functioning. This treatment modality is used in individuals who exhibit uncontrolled ventricular fibrillation (V-Fib) as a result of a hereditary etiology [1, 15, 16].

Cardiac Arrest in the Operating Room: An Overview

The etiology of circulatory crisis and cardiac arrest inside the hospital setting may exhibit a distinct range of reasons compared to those seen outside the hospital. Perioperative bradycardia may be attributed to several factors, including vagal reactions triggered by surgical manipulation, the administration of vagotonic anesthetics, sympatholysis resulting from anesthetic drugs, the use of β-blockers, and the inhibition of cardiac-accelerator fibers originating from T1 to T4 in patients receiving neuraxial anesthesia [17]. The occurrence of hypoxia in relation to challenging airway...
management is well acknowledged as a significant factor leading to cardiac arrest inside the confines of the operating room [18, 19]. Pulseless electrical activity (PEA) resulting from hypovolemia is a prevalent etiology of cardiac arrest seen in hemorrhage patients within the surgical setting. The differential diagnosis for circulatory collapse during the periprocedural period encompasses a wide range of potential causes. These include anesthetic-related conditions such as overdose of inhalational or intravenous anesthetics, complications from neuraxial blockade, systemic toxicity from local anesthetics, and malignant hyperthermia. Respiratory factors, such as hypoxemia, auto-PEEP (positive end-expiratory pressure), and bronchospasm, can also contribute to circulatory collapse. Additionally, cardiovascular causes such as vasovagal and oculocardiac reflexes, hypovolemic shock, air embolism, increased intraabdominal pressure, transfusion and anaphylactic reactions, tension pneumothorax, pacemaker failure, prolonged QT syndrome, and electroconvulsive therapy may be implicated [18, 19].

In recent years, many studies have shown a rise in survival rates after periooperative arrest, in contrast to arrests occurring in the general community or inside inpatient hospital wards [20-22]. A separate investigation conducted on surgical patients yielded promising findings about survival rates. The research identified a subgroup of patients who exhibited the lowest survivorship, measuring below 20%. This subgroup was characterized by advanced age, greater American Society of Anesthesiologists status, emergency operations, contaminated wounds, and significant preoperative reliance [23]. The phenomenon of decreased survival rates after cardiac arrest during nighttime and weekend periods has been successfully reproduced in subsequent studies [22, 24, 25]. Surprisingly, the postanesthesia care unit exhibits superior survival and neurologic outcomes in cases of cardiac arrest, in contrast to the operating room or intensive care unit. The potential correlation might be attributed to the several underlying causes that result in arrest within that particular context [22].

Published research was conducted on cardiac arrest data obtained from the National Anesthesia Clinical Outcomes Registry. The findings of this analysis indicate that the occurrence rate of cardiac arrest in relation to anesthesia is roughly 5.6 per 10,000 instances. This figure is notably lower than earlier estimations [26, 27]. The present research further showed a positive correlation between advancing age and American Society of Anesthesiologists physical status with the incidence of cardiac arrest. Surprisingly, the research revealed a heightened incidence of cardiac arrest and mortality among the male population. According to recent research conducted on individuals who had surgery and then suffered cardiac arrest within a 24-hour timeframe, it was determined that asystole emerged as the prevailing rhythm associated with cardiac arrest occurrences [22]. The survival rate after asystole during the periooperative phase is notably greater (ranging from 30.5% to 80%) in comparison to the survival rate following asystolic arrest that occurs when the patient is admitted to the hospital (10%) [22, 28, 29].

Highlighting the Problem

Intraoperative occurrences, including both surgical and anesthetic interventions, elicit a range of significant homeostatic alterations that exhibit varied expressions in various bodily systems, including the cardiovascular system. The aforementioned modifications are also amplified by the previous medical problems and comorbidities of the individual. Cardiac dysrhythmias may be elicited by a range of stimuli. The vast majority of these arrhythmias do not have immediate hemodynamic implications. As a result, emergency treatment is not necessary, and they often respond well to pharmacological therapies, or a combination of both [30]. Nevertheless, particularly when inherited or acquired structural or conduction abnormalities are present, some dysrhythmias (such as prolonged ventricular tachycardia and ventricular fibrillation) might provide an imminent danger to an individual's life due to their capacity to induce severe hemodynamic instability. Consequently, these cardiac rhythm irregularities are classified as malignant arrhythmias. The manifestation of malignant arrhythmias may occur in two ways, either hemodynamic collapse or cardiac arrest. Atrial fibrillation (AF) accompanied with fast ventricular tachycardia (VT) may cause an abrupt cessation of efficient blood circulation, resulting in hemodynamic collapse. In the event of ventricular tachycardia (VT) or ventricular fibrillation (VF), cardiac arrest occurs, requiring cardiopulmonary resuscitation (CPR) or electrical defibrillation [30]. Approximately 5% of arrhythmias seen in the general population are classified as severe and potentially life-threatening malignant arrhythmias. The precise prevalence of malignant hyperthermia among the broader surgical community remains uncertain and lacks a clear definition.
The prevalent factors that possess the capacity to either initiate or facilitate the emergence of these dysrhythmias encompass advanced age, myocardial ailments, structural abnormalities in the heart, Wolff-Parkinson-White (WPW) syndrome, long QT syndrome, and J wave syndromes such as Brugada syndrome [31-33].

Management and Treatment Strategies for Malignant Arrhythmia

By considering pertinent surgical variables such as the type of cardiac procedure, the administration of local anesthetics, and the presence of hyperkalemia, along with the selection of anesthetic drugs, it becomes possible to adopt a proactive strategy towards malignant arrhythmias. This approach involves avoiding medications that may promote arrhythmias and promptly addressing and managing any abnormalities to prevent the onset of malignant arrhythmia and subsequent cardiovascular failure. Furthermore, in cases where a patient is deemed to have a predisposition to the occurrence of malignant arrhythmias during a surgical intervention, it is imperative to employ the appropriate equipment. This includes the utilization of extended monitoring of right precordial leads and the deployment of an external defibrillator equipped with transcutaneous electrodes. These measures are essential to promptly identify and address any malignant arrhythmias that may arise in their early stages [34]. However, despite the use of the aforementioned preventive steps and in the absence of any documented previous medical conditions, medical emergencies may still arise abruptly inside the operating room. Given the inherent nature of these occurrences, which inevitably result in cardiovascular collapse, it is imperative to adhere to the appropriate parameters for ventricular tachycardia or ventricular fibrillation as outlined by the Advanced Cardiovascular Life Support (ACLS) or Pediatric Advanced Life Support (PALS) protocols. The recommendations underwent a process of revision and reevaluation, which included conducting a systematic study of relevant issues and evaluating current clinical practices. Nevertheless, there was a lack of further information that would warrant a modification in the management strategy for malignant arrhythmia [35-39].

The recommendations for ACLS place significant emphasis on the need of promptly initiating appropriate cardiopulmonary resuscitation (CPR) and discontinuing the administration of any anesthetic medicines [38, 39]. The key points include the following aspects [39]:

1) After the attachment of the external defibrillator electrodes to the patient, it is necessary to examine the heart rhythm.

2) After confirming the presence of ventricular tachycardia (VT) or ventricular fibrillation (VF), it is necessary to administer an electric shock, followed by a period of cardiopulmonary resuscitation (CPR) lasting 2 minutes, prior to reassessing the underlying heart rhythm.

3) In the event of VT/VF persistence, it is necessary to provide an additional shock and inject epinephrine by the intravenous (IV) or intraosseous (IO) route or via the endotracheal tube.

4) If ventricular tachycardia or ventricular fibrillation continues to occur after the implementation of these interventions, intravenous administration of amiodarone should be considered.

5) It is important to identify and control any reversible factors contributing to cardiac arrest.

6) The repetition of the 2-minute CPR cycle, rhythm analysis, shock delivery, and administration of epinephrine is necessary until one of two outcomes is reached: either (a) the return of spontaneous circulation (ROSC) is successfully accomplished, or (b) it is decided that ROSC cannot be attained despite a protracted and correctly conducted resuscitation attempt.

7) In the event that asystole occurs, appropriate treatment should be implemented in line with the algorithm designed for asystole/pulseless electrical activity (PEA).

The following enumeration is designed to serve as a comprehensive sequential manual for crisis management in case of malignant arrhythmia [35, 36, 38, 39]:

1) Be vigilant in order to promote timely identification.

2) Once sufficient hemostatic control has been obtained, it is imperative to promptly discontinue all other patient care activities, including surgical intervention. The choice of whether to proceed with or terminate the surgery upon the restoration of circulation is contingent upon the specific clinical circumstances.

3) Cease the administration of all anesthetics and proceed with ventilation with a fraction of inspired oxygen (FiO2) of 100%.
4) The operating room team is required to undertake the responsibilities typically assigned to the ACLS team, with the anesthesiologist being the team leader.

5) The surgeon or any member of the team should promptly start chest compressions. In cases where the patient is in a prone position, it is necessary to reposition the patient in a supine position and transfer them onto a back board.

6) Simultaneously with the commencement of CPR, it is advised to promptly summon assistance and make a request for the provision of a defibrillator inside the operating room.

7) Designate an individual responsible for timekeeping and documentation to oversee the duration of CPR cycles and deal with serious incidents.

8) It is essential to maintain the airway and verify that breathing and oxygenation are sufficient.

9) Administer defibrillator pads and administer electric shocks according to the parameters of ACLS/PALS protocols.

10) It is recommended to continue CPR in accordance ACLS/PALS recommendations.

11) It is essential to establish effective IV or IO access and thereafter deliver epinephrine in accordance with ACLS/PALS recommendations.

12) Collect arterial blood gas (ABG) measurements, electrolyte levels, hemoglobin (Hb) concentration, hematocrit (Hct), and any other relevant laboratory tests based on the clinical context.

13) The intravenous administration of amiodarone is recommended for the treatment of VT that is unresponsive to direct-current (DC) cardioversion.

14) In case of hyperthermia, the appropriate action is to provide patient cooling measures.

15) It is important to make necessary preparations for the care of patients after successful ROSC.

16) It is important to establish effective communication and facilitate a comprehensive handover process when moving a patient to a different clinical unit, such as ICU.

**Improving Cardiac Safety in the Operating Room**

The most recent ACC/AHA Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery support the view that a finding of new-onset atrial fibrillation does not automatically mean that a patient has an active cardiac condition for which surgery needs to be cancelled [40]. This statement suggests that new-onset atrial fibrillation in patients undergoing surgery may not necessarily indicate a significant cardiac condition that would require surgery to be cancelled or postponed. Additionally, it has been observed that an initial malignant arrhythmia that is nonshockable is observed in over 60% of in-hospital cardiac arrests [41].

The prognosis for patients experiencing a cardiac arrest with an initial nonshockable malignant arrhythmia is extremely poor, with up to 80% of these patients demonstrating deteriorating physiology with hypoxia, hypotension, or reduced consciousness in the hours preceding cardiac arrest. In a large global retrospective analysis, it was found that 43% of patients who developed any arrhythmia were critically ill and required mechanical ventilation. Of these critically ill patients, 41% survived to hospital discharge, while only 51% of all patients who developed an arrhythmia while hospitalized survived to hospital discharge. Moreover, the analysis revealed that atrial fibrillation is the most common type of arrhythmia observed in patients who develop this condition, and it often occurs as a new onset in patients who are critically ill. The incidence of new-onset atrial fibrillation in patients with critical illness was found to be 14.9% [42].

**Conclusion**

In conclusion, this research paper has provided a comprehensive overview of the incidence, risk factors, management, and impact of malignant arrhythmias and cardiac arrest in the operating room. It is evident that these critical events pose significant risks to patient safety and outcomes, and addressing them requires a multifaceted approach. The review of the literature has highlighted the importance of advanced monitoring and early detection systems in improving the timely recognition and management of malignant arrhythmias and cardiac arrest. Additionally, the paper has emphasized the need for proactive measures, such as optimization of patient care, and improved communication and teamwork among healthcare providers, to prevent and intervene in these life-threatening events.
Moving forward, it is crucial for healthcare professionals to continue to work towards improving patient safety in the operating room. This includes further research to better understand the underlying mechanisms of malignant arrhythmias and cardiac arrest in the operating room, as well as the development and implementation of evidence-based protocols for early detection and management.

References


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