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Unexpected perioperative cardiac arrest

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ABSTRACT

Patient safety is the first priority of any medical activity. Anesthesiology is a medical discipline with imprinted critical events including perioperative cardiac arrest (POCA). Nevertheless, despite advances in modern perioperative medicine, there are still factors that may either provoke adverse reactions or negatively influence the treatment process. Negative sequelae may result if the problem is not avoided or managed sufficiently. Anesthesiology focuses on strategies aimed at prevention, the early recognition of problems, and actions to avoid or solve critical events. This review considers recently published evidence on the occurrence, recognition, and management of POCA and future research in this field of anesthetic practice.

Contents

1. Introduction

Anesthesiology is a medical discipline with imprinted critical events, occasionally associated with adverse outcomes, including perioperative cardiac arrest (POCA) and patient death [1,2]. Patient safety is the first priority of any medical activity. Nevertheless, despite advances in modern perioperative medicine, there are still factors that may either provoke adverse reactions or negatively influence the treatment process. Four sets of factors in perioperative management can affect the risk for complications: the patient and his/her comorbidities, genetic factors, and a modified response to anesthetics; the surgeon and surgical procedure; and the anesthetist, anesthetic management, and anesthesia equipment [3]. Each may involve hidden elements not known to the healthcare providers and triggering factors resulting in perioperative problems. Negative sequelae may result if the problem is not avoided or managed sufficiently. Anesthesiology focuses on strategies aimed at prevention, the early recognition of problems, and actions to avoid or solve critical events [4]. Adequate skills and knowledge

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combined with non-technical skills are essential to manage suddenly deteriorating patients during anesthesia [5].

This review considers recently published evidence on the occurrence, recognition, and management of POCA and future research in this field of anesthetic practice. A literature search was conducted using PubMed, Embase, and Google Scholar.

2. The problem

Intraoperative cardiac arrest is a catastrophic event. The reported incidence ranges from 1.1 to 34.6 per 10,000 anesthetics [6–10]. Fortunately, the rate has decreased significantly in recent decades compared to the early days of anesthesia. Anesthesia-related POCA has an even lower incidence of 0.04–7 per 10,000 administered anesthetics [2,10,11]. This represents a 10-fold decrease over the last three decades. However, up to 20% of operating room deaths are directly related to anesthesia [12]. The rate of cardiac arrest differs in regional versus general anesthesia and is much more common in general anesthesia [13]. Studies of obstetric populations have reported even 16-fold higher mortality in general versus regional anesthesia [14]. Considering regional anesthesia, spinal anesthesia is more frequently associated with cardiac arrest than other techniques (2.9 vs. 0.9 per 10,000 patients) [15].

In children, POCA is more common in neonates in special risk groups related to cardiac procedures with a POCA incidence of 127 per 10,000 anesthetics [16]. In cardiac surgery, the incidence of perioperative cardiac arrest is almost eight times higher than the overall risk for cardiac arrest, with 5.6 cases per 10,000 cases [17].

Other groups at higher risk include the elderly, with a reported POCA risk of 54.4 per 10,000 cases [18]. In patients undergoing emergency surgery, the incidence of POCA is 163 per 10,000 cases [19].

3. Risk factors and causes

Perioperative cardiac arrest may have its origin in initial problems with anesthetic management, such as volatile or intravenous anesthetic overdose, local anesthetic systemic intoxication [20], high neuraxial block, malignant hyperthermia [21], and errors in drug administration. Two other sets of causes have respiratory or circulatory origins. Respiratory problems are usually linked with hypoxemia, mainly associated with a difficult airway during either induction or recovery from anesthesia [22]. Another respiratory problem that may result in cardiac arrest during anesthesia is acute bronchospasm (isolated or secondary to an anaphylactic reaction) [23]. The circulatory causes include vasovagal reflexes, hypovolemia often resulting from hemorrhagic shock, gas embolism, acute electrolyte disturbances (K^+, Ca^{++}), transfusion-related or anaphylactic reactions, acute coronary syndrome, pulmonary thromboembolism, severe pulmonary hypertension, pacemaker failure, prolonged QT syndrome, oculocardiac reflexes, electroconvulsive therapy, and Takotsubo syndrome [7]. During anesthesia, a severe reduction in blood flow may result from increased intra-abdominal pressure, tension pneumothorax, high positive end-expiratory pressure (i.e., auto-PEEP), or surgical maneuvers [7].

Other reported risk factors for POCA include age <1 or >65 years and American Society of Anesthesiologists physical status ≥ III and pre-existing cardiomyopathy [10,17,24]. Males have a higher rate of cardiac arrest and death [17,24]. Other factors that increase the perioperative risk for cardiac arrest are the urgency and type of surgery [10,25].

4. Prevention and management of POCA

If it happens, POCA is usually witnessed and recognized swiftly. During anesthesia, the patient is adequately monitored, enabling a rapid diagnosis. Healthcare providers dealing with the patient are skilled in basic and advanced life support, although it is essential to maintain these skills. If the possibility of cardiac arrest is anticipated, the application of self-adhesive pads before anesthesia is justified. Nevertheless, there are sudden cases when the reason for patient deterioration is not evident and surprises the caregivers. Having adequate intravenous (IV) access and a plan for fluid management and blood transfusion seems reasonable. Controlling perioperative heat loss will support the treatment of POCA both in terms of relevant causes of cardiac arrest and perioperative heat loss [26]. Recognition of cardiac arrest may be facilitated by monitoring the end-tidal CO_2 ($ETCO_2$) or cardiac output (i.e., invasive blood pressure monitoring).

When cardiac arrest is confirmed, prompt cardiopulmonary resuscitation (CPR) should be initiated with high-quality chest compressions. The long-term outcome is strongly related to the quality of CPR. Adjusting the patient's position may improve the performance of CPR; the optimal delivery of chest compressions is with the patient in the supine position. The surgery and anesthesia should be put on hold or reduced, if feasible, minimizing risk of awareness when return of spontaneous circulation is achieved. However, the use of anesthesia in such circumstances is controversial [27]. Escalated patient monitoring, if not done already, and trend analysis of vital signs during patient deterioration may be useful for diagnosing the problem. A diastolic invasive blood pressure of 40 mm Hg and an $ETCO_2$ of 20 mm Hg are indicative of good blood flow during CPR [24]. Until the airway is secured, a 30:2 compressions-to-ventilations ratio is recommended. With a secured airway, the ventilation rate should be 10 per minute with 100% oxygen. If patient is mechanically ventilated during deterioration and cardiac arrest the influence of high positive end-expiratory pressure (auto-PEEP) should be considered. When a shockable rhythm is identified, defibrillation should be attempted every 2 min according to the universal algorithm for advanced life support [28]. Quick, effective recognition and treatment of reversible causes of cardiac arrest if present combined with high-quality CPR facilitate a good neurological outcome.

When cardiac arrest is recognized, adrenaline should be administered and amiodarone is recommended in the presence of a shockable rhythm [28]. Modifications of the standard cardiac arrest pharmacotherapy suggest reducing the initial dose of IV adrenaline ($1\ \mu g\ kg^{-1}$ instead of the standard dose of 1 mg) or IV atropine (0.5 mg) in the case of suspected excessive vagal activity [24,28]. It is recommended that the initial 300 mg dose of amiodarone should be given after the third shock and followed by 150 mg after the fifth shock [28]. For the three subsequent shocks when ventricular fibrillation/tachycardia (VF/VT) cardiac arrest is witnessed and monitored, modification of the pharmacotherapy may be considered [28].

For cardiothoracic surgery, guidelines have been established and address specific causes and management according to current knowledge and patient course and history [29,30].

Ultrasonography is a useful tool for supporting CPR management and facilitating differential diagnosis during cardiac arrest management [31]. In the operating room, either transthoracic or transesophageal ultrasound assessment may support diagnosis and treatment during POCA management.

Several recently published documents have addressed the specific management of POCA patients [24,32–37]. POCA involves several issues different from other in-hospital cardiac arrests that need to be addressed. First, there is often a need to continue the surgery and post-cardiac arrest management, including targeted temperature management (TTM). The guidelines for post-resuscitation care were recently updated according to current

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