Journal of Clinical Anesthesia 50 (2018) 78–90

Contents lists available at ScienceDirect

Journal of Clinical Anesthesia

journal homepage: www.elsevier.com/locate/jclinane

Original contribution

Perioperative cardiac arrests – A subanalysis of the anesthesia -related cardiac arrests and associated mortality

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ARTICLE INFO

Keywords:
Retrospective observational study
Cardiopulmonary arrest
Perioperative period
Anesthesia
Patient safety
Incident reporting
Hospital

ABSTRACT

Study objective: To determine the incidence, risk factors, and predictors of survival of perioperative cardiac arrests (PCAs) occurring in patients who underwent non-cardiac and non-obstetric surgery from January 2008 to May 2015 at a tertiary hospital; determine the incidence and risk factors of anesthesia-related PCA.
Design: Retrospective observational study.
Setting: Operating room and postoperative recovery area.
Patients: Sixty-two PCA cases from an anesthesia database of 122,289 anesthetics.
Interventions: Each PCA was classified as anesthesia-related, partially anesthesia-related, or anesthesia unrelated. The main outcome variables were occurrence of PCA, survival at least 1 h after initial resuscitation and survival to hospital discharge. To determine the risk factors for PCA, for each patient who suffered a PCA, two other patients that underwent anesthesia on the same day and in the same operating suite were selected.
Measurements: Three sets of variables were collected; patient-related, surgical procedure-related, and PCA-related.
Main results: The incidence of PCAs of all causes was 5.07 per 10,000 anesthetics, and the associated mortality was 2.9 per 10,000 anesthetics. The independent risk factors for occurrence were: ASA PS score higher than 3, diagnosed cardiac disease, and the use of vasopressors. Decreased survival was associated with: higher ASA PS score, urgent surgical procedures of a higher complexity, use of vasopressors, documented hypotension prior to PCA, and arrests due to bleeding. The incidence of anesthesia-related PCAs was 0.74 per 10,000 anesthetics, and the associated mortality was 0.08 per 10,000 anesthetics. The main causes of anesthesia-related PCAs were associated with medication and airway/ventilation, and the independent risk factors for occurrence were: ASA PS score higher than 3 and diagnosed cardiac disease.
Conclusions: Most PCAs were not due to anesthesia-related causes, and anesthesia-related PCAs were associated with improved survival. Improvements in the management of high-risk patients, medication administration, and airway/ventilation management may result in better outcomes.

1. Introduction

Perioperative cardiac arrest (PCA) is a rare but catastrophic event associated with high morbidity and mortality. Anesthesia-related mortality has been investigated in the United States for over 60 years, with the first publication in 1954 by Beecher and Todd [1–14]. Numerous subsequent publications on PCAs have shown that the incidence varies considerably among countries [3–9]. This heterogeneity is related to the definitions used for the perioperative period and anesthesia-related mortality (direct complication vs. contributing factor), in addition to the studied populations (age and surgical procedures) and time periods [3, 5]. Although trends in the frequency of PCA remain controversial, the majority of cases are not anesthesia-related [2, 3, 10].

Previous studies have focused on the incidence and causes of PCA, but little is known regarding the independent factors associated with the occurrence of PCA or survival following such an event [11]. The most important challenge in determining such factors is related to the limited number of PCAs. In Portugal, there have been limited studies on PCA, with none being anesthesia-related [12]. The main goals of the present study, therefore, were to determine the incidence of PCA and

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https://doi.org/10.1016/j.jclinane.2018.06.005
Received 25 February 2018; Received in revised form 23 May 2018; Accepted 1 June 2018

the associated risk factors, in addition to the predictors of immediate and late survival following such an event, at our institution in patients undergoing non-cardiac and non-obstetric surgery between January 2008 and May 2015. As a secondary goal, we aimed to determine the incidence and risk factors of anesthesia-related PCAs.

2. Materials and methods

2.1. Study population

The present study was approved by the Ethics Committee and Research Board of the Department of Education, Training, and Investigation of Centro Hospitalar do Porto, Portugal. Centro Hospitalar do Porto is a tertiary university hospital that provides over 700 active care beds and includes all surgical specialties distributed among 26 operating rooms, with the exception of cardiothoracic surgery. The Department of Anesthesiology, Intensive Care and Emergency Medicine, is certified by the Hospital Visiting and Training Accreditation Programme of the European Society of Anesthesiology since 2013 (www.anestesiologiachp.com). It is composed of 83 Certified Anesthesiologists and 40 Residents. The anesthetic care is provided by Certified Anaesthesiologists, and Residents in their final year of training (5th year) only if there is a Certified Anesthesiologist present in the same operating theater.

All PCAs that occurred in patients undergoing noncardiac and nonobstetric surgery at Centro Hospitalar do Porto, Portugal, between January 1, 2008, and May 1, 2015, were included in the present retrospective observational study, addressing both out- and inpatients.

For the purpose of the present study, cardiac arrest was defined as an event that required resuscitation with closed-chest compressions, and the perioperative period as the amount of time from the patient entering the operating theater until discharge from the recovery room to the ward or intensive care unit.

PCAs were identified from an anesthesia database; a quality assessment tool where all perioperative critical events occurring in our hospital are registered. A critical incident is one that could have led to harm and could have been prevented by a change in processes [15]. The number of anesthetics was extracted from the anesthesia database, and these numbers were used as denominators for the calculation of PCA incidence, for both the entire study period and for each separate year.

To determine the risk factors for PCA, a comparison group of cases that underwent anesthesia but that did not suffer a cardiac arrest, called “non-PCA cases”, was required. For each patient who suffered a PCA, the case immediately preceding and immediately following were selected. Therefore, for each patient who suffered a PCA, two other “non-PCA patients” who underwent anesthesia on the same day and in the same operating theater were selected. In cases where it was not possible to identify a “non-PCA case” that was submitted to a surgical procedure on the same day, a “non-PCA case” that was submitted to the same surgical procedure by the same operating and anesthetic team, but on a different day, was selected.

The main outcome variables were the occurrence of PCA, survival for at least 1 h following initial resuscitation (immediate survival [IS]), and survival until discharge from hospital (hospital discharge [HD]).

2.2. Analyzed factors

Based on the available literature, three sets of variables were collected for each patient who suffered a PCA: patient-related, surgical procedure-related, and PCA-related [3, 10]. Patient characteristics included age, gender, American Society of Anesthesiology physical status (ASA PS) score (patients were grouped by ASA PS scores I–III or IV–V), and diagnosed comorbidities.

To grade the surgical procedures according to the magnitude of physiological stress, the estimated blood loss and the duration and invasiveness of the procedure were considered, so as to assign surgeries into the following categories: minor/intermediate, major, and major complex (Appendix A). Surgeries were considered urgent if surgical treatment was required within 24 h following the diagnosis of an urgent medical condition by surgeons. The type of anesthesia was recorded as the primary type of anesthetic being used at the time of PCA; general, regional (all types of peripheral regional blocks or neuraxial anesthesia), combined/general anesthesia, or monitored anesthesia care (MAC). In addition, the duration of the procedure at the time of the PCA was categorized: < 60, 60–119, 120–179, and equal to or > 180 min. Moreover, the patient's hemodynamic stability prior to PCA was also documented as hypotension (medium arterial pressure (MAP); $< 30\%$ of basal MAP for > 3 min) or the need for the infusion of vasopressors. Further, the type of invasive monitoring present at the time of the PCA was registered as arterial line, central venous pressure monitor, or both. Finally, the status of the patient regarding endotracheal intubation prior to PCA was also recorded.

To characterize the timing and etiology of PCAs, the following variables were recorded; the primary electrocardiographic rhythm (asystole, ventricular fibrillation, or pulseless electrical activity), the duration of the PCA (in minutes), the moment when the PCA occurred (induction, maintenance and emergence of anesthesia, and recovery room), the number of cardiac arrests during the same event (1 or > 1), the time of the PCA with respect to standard working hours (08:00–20:00, Monday through Friday) or nonstandard working hours (20:01–07:59, Monday through Friday; Friday 20:01 through Monday 07:59), and the primary provider at the time of the PCA (Resident or Certified Anesthesiologist). For the purpose of this analysis, all probable causes were assigned to three categories: primary bleeding, cardiac causes, and “other causes”, including pulmonary embolic events, hypoxia (medication-related and post-extubation).

2.3. Data collection

All variables were collected from the anesthetic records by three Anesthesiology Residents at our institution at the time of the present study. A group of experts identified the cause of each PCA following review of the collected data, and classified each PCA as anesthesia-related, partially anesthesia-related, or unrelated to anesthesia. Any PCA that occurred after an anesthetic drug was given to a stable patient who had either immediate arrest or depression of ventilation leading to hypoxemic cardiac arrest, and all obvious mishaps in airway management, were considered anesthesia-related. PCAs that occurred in unstable patients (e.g., hemorrhagic shock due to a ruptured aortic aneurysm) after an anesthetic induction agent was given were considered partially anesthesia-related. For the cases in which the cause and the contribution of anesthesia to the PCA were unclear, the attending Anesthesiologist at the time of the PCA was contacted to gather more related information. The group of experts was specifically established for the purpose of the present study and included three senior Certified Anesthesiologists and co-authors, who needed to be in agreement regarding the cause and the contribution of anesthesia to the PCA prior to final categorization.

2.4. Statistical analysis

An exploratory analysis of the data was performed; using measures of central tendency and dispersion for quantitative variables and absolute and relative frequencies in the case of qualitative variables. For all “non-PCA cases”, all data were obtained with the exception of variables characterizing PCAs. Simple comparisons between PCA cases and “non-PCA cases” were performed using a Chi-square test (for qualitative variables) and non-parametric Wilcoxon test (for quantitative variables). To identify the potential predictors of survival following PCA, the two groups defined by IS and HD were compared according to the three sets of variables defined in the Methods section. An independent *t*-test or Mann-Whitney test was used to compare