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Risk factors of intraoperative and 24-hour postoperative cardiac arrest in geriatric patients in non-cardiac surgery

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Background & aim. The study aimed to identify preventable risk factors for the occurrence of intraoperative and 24-hour postoperative cardiac arrest in geriatric patients.

Methods. This was a matched case-control study. Patients aged 65 and older who experienced intraoperative and 24-hour postoperative cardiac arrest between 2011 and 2018 were consecutively recruited into the case group. Cases were matched with controls by sex, age range, and in the same year of surgery in the ratio of 1:3. The outcome was the occurrence of intraoperative and 24-hour postoperative cardiac arrest. Univariate and multivariate logistic regression analyses were carried out to identify factor related outcomes.

Results. From a total of 20,024 geriatric patients, 98 cases and 294 controls were recruited. The risk factors of intraoperative and 24-hour postoperative cardiac arrest were ASA classifications 3 (odds ratio [OR] 3.95, 95% confidence interval [CI] 1.24-12.62) and 4 (OR 8.46, 95% CI 2.15-33.36) compared to ASA classification 2, aortic surgery (OR 16.86, 95% CI 2.9-97.99) compared to trunk and perineal surgery, potassium imbalance (OR 2.71, 95% CI 1.02-7.22), and receiving preoperative benzodiazepine (OR 3.92, 95% CI 1.36-11.28). Regional anesthesia (OR 0.18, 95% CI 0.04-0.83) and propofol (OR 0.09, 95% CI 0.03-0.24) were found to be protective factors.

Conclusions. The study found that potassium imbalance might be a preventable risk factor. If feasible, performing regional anesthesia while avoiding preoperative benzodiazepine is recommended.

Key words: cardiac arrest, geriatric patients, intraoperative, postoperative, risk factors

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INTRODUCTION

Geriatric patients have multiple comorbidities and increased rates of surgical morbidity and mortality [1,2]. Perioperative cardiac arrest is the most serious complication that can lead to a fatal outcome. The incidence of perioperative cardiac arrest in Thailand reported by the Thai Anesthesia Incidents Study was 30.8 per 10,000 while the incidence of perioperative cardiac arrest in Thai geriatric patients was higher at 40.4 per 10,000 with a mortality rate of 77.8% [1,3].

Although risk factors of perioperative cardiac arrest are studied widely, the studies in geriatric patients are limited. Turrentine et al. reviewed the data of 7,696 surgical procedures from the American College of Surgeons

National Surgical Quality Improvement Program database [2]. They found that the predictive factors of perioperative cardiac arrest and acute myocardial infarction in patients aged 80 years and older were peripheral vascular disease, preoperative transfusion, emergency operation, and physician work relative value units that serve as a marker of operative complexity. However, a systematic review reported that the rates of perioperative cardiac arrest in geriatric patients between the countries with a high human development index (HDI) and low HDI were different [4]. From 1990 to 2017, perioperative cardiac arrest rates in countries with a low HDI, which includes Thailand, were 4-fold higher than in high HDI countries. As a result, the reported risk factors in high HDI countries are not applicable in our setting.

Among the low HDI countries, Nunes et al. reported factors related to cardiac arrest in the operative room and postanesthesia care unit in older patients in Brazil [5]. The study found 3 significant predictive factors: American Society of Anesthesiologists (ASA) physical status classification 3-5, emergency surgery, and general anesthesia. Tamdee et al. studied factors related to 24-hour perioperative cardiac arrest in geriatric patients in a Thai university hospital [1]. The study found that the risk factors included older age, recent respiratory failure, ASA physical status 3-5, emergency surgery, intrathoracic surgery, upper abdominal surgery, and administration of ketamine. Nonetheless, most of the reported factors were patient and surgery related that could not be modified. Also, there was doubt that the administration of ketamine was a risk of cardiac arrest or it was given in cases of very poor cardiovascular status to preserve their heart rate and blood pressure. Accordingly, this study aimed to identify the preventable risk factors for the occurrence of intraoperative and 24-hour postoperative cardiac arrest in elderly patients.

MATERIALS AND METHODS

This matched case-control study was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University (Chairperson Assoc. Prof. Boonsin Tangtrakulwanich) on 29 September 2018 (EC6126681). The study setting was Songklanagarind Hospital which is a tertiary university hospital in southern Thailand.

Data collection was conducted from January 2011 to July 2018. The data were obtained from the hospital information system which was recorded by the doctors and nurses who took responsibility of the cases. If the data could not be extracted from the database, reviews of the anesthetic records case by case were also performed. The data consisted of the patient's age, sex, body weight and height, ASA classification, type of case, comorbidities, preoperative conditions, preoperative laboratory results, date of surgery, operating room or remote area, anatomical site of surgery, duration and technique of anesthesia, and anesthetic agents. Anemia was defined as hematocrit less than 30%. A platelet count less than 100,000 per microliter of blood and a white blood cell count greater than 12,000 per microliter of blood were defined as thrombocytopenia and leukocytosis, respectively. Hypoalbuminemia was defined as an albumin level less than 3 g/dL. Any electrolyte value below or above the following ranges was defined as imbalance: sodium 135-145 mmol/L, potassium 3.5-5 mmol/L, chloride 97-107 mmol/L, bicarbonate 22-29 mmol/L. The required information of each patient was recorded in a form before it was entered into Epidata software. The outcome of this study was the occurrence of cardiac arrest that was clarified by the anesthesiologists in charge. The time to arrest event was collected in case groups.

Case ascertainment

The data for patient selection were taken from extractable information of the hospital database. Eligibility for allocation in the case and control groups included geriatric patients (≥ 65 years old) who were in ASA classification 2-4 and received anesthesia for non-cardiac and non-extracorporeal membrane oxygenation (non-ECMO) operations. Patients who experienced intraoperative or 24-hour postoperative cardiac arrest were assigned into the case group. Patients with a history of cardiac arrest within 24 hours prior to surgery were excluded due to the difference in the risk of perioperative cardiac arrest. Patients with incomplete data were also excluded.

Control selection

The control group was matched by sex (male and female), age ranges of 65-74, 75-84, and ≥ 85 years old, and the same year of surgery as the case group using frequency matching in the ratio of 3:1. The matching randomization was obtained from a computer generation with R software. Two versions of the randomization were done to replace the excluded patients.

Sample size calculation

The sample size was calculated using a formula to test for binary outcomes in a case-control study. The lowest prevalence of exposure among the controls was estimated at 20%. An odds ratio (OR) of 2.2 was obtained from a previous study and the ratio of cases to controls of 1:3 were used at a level of significance of 0.05 and a power of 80% [1]. After allowing for a 10% dropout rate, the final calculated sample sizes of cases and controls were 93 and 278, respectively.

Statistical analysis

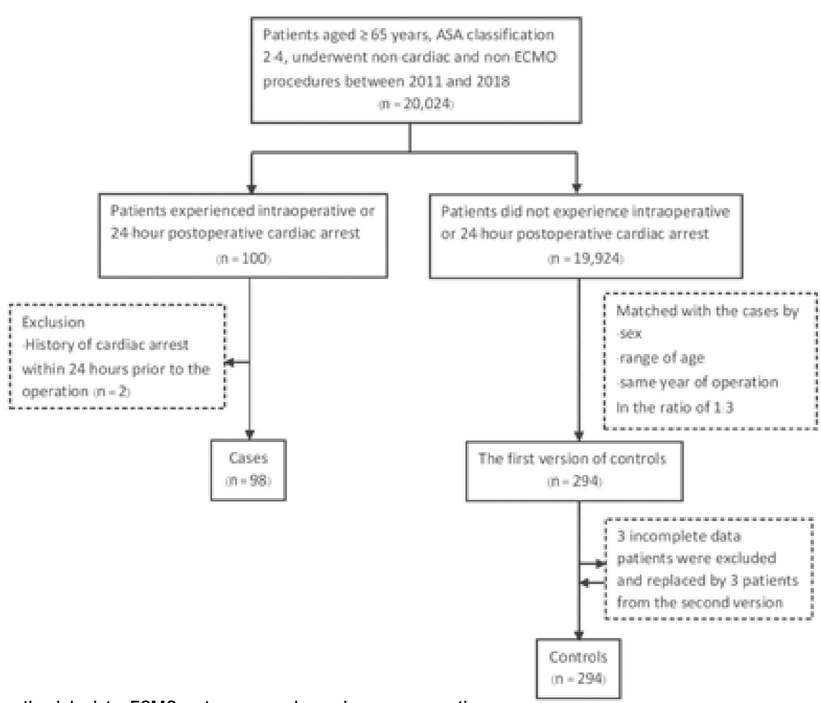
The statistical analysis was performed using R software, version 1.1.456. Categorical variables are presented as frequency and percentage while continuous variables are presented as median and interquartile range. Categorical variables were compared using the chi-square test or Fisher's extract test. Continuous variables were analyzed by Wilcoxon's rank-sum test. Multivariate logistic regression analysis was performed to identify the independent factors related to intraoperative and 24-hour postoperative cardiac arrest and the estimated adjusted OR and 95% confidence interval (CI). The factors with a p-value in the univariate analysis less than 0.2 were included in the backward stepwise logistic regression model. A p-value less than 0.05 was considered to be statistically significant.

RESULTS

The number of eligible subjects from the database was 20,024 geriatric patients (≥ 65 years old) who were in ASA classification 2-4 and underwent non-cardiac and non-ECMO procedures. Figure 1 shows the flow diagram of the study. The final 98 cases were matched with 294 controls. Thirty-one cases experienced intraoperative cardiac arrest with a mortality rate of 29%. Seventy-six cases experienced postoperative cardiac arrest with a mortality rate of 88.16%. Figure 2 shows the histogram of time from induction of anesthesia to cardiac arrest events in intraoperative and 24-hour postoperative periods. The first hour after induction of anesthesia had the greatest number of cardiac arrest cases (n = 18). The numbers of cardiac arrest cases between the second and the nineteenth hour were much lower and steady at a mean of 3.67 cases per hour.

Table I illustrates the baseline characteristics and preoperative conditions of the patients in both groups. The percentage of male cases was twice that of the female cases. The number of cases aged 65-74 was more than either of the age groups 75-84 and ≥ 85. Cases with ASA classification 4 experienced cardiac arrest more than cases with ASA classification 3 and 2. The comorbidities with a statistically significant difference between groups were history of ischemic heart disease (p = 0.049), congestive heart failure (p = 0.032), and significant arrhythmia (p < 0.001). The percentages of patients who received oxygenation and were dependent on mechanical ventilation in the case group were greater than the control group. Alteration of consciousness, abnormal body temperature, hypotension, packed red cell transfusion, and received analgesic drugs were also greater in the case group. All of the collected laboratory values were significantly different between the two groups.

Table II illustrates the intraoperative characteristics of the patients and anesthetic agents used. Most patients in



ASA: American Society of Anesthesiologists; ECMO: extracorporeal membrane oxygenation

Figure 1. Flow diagram of the study.

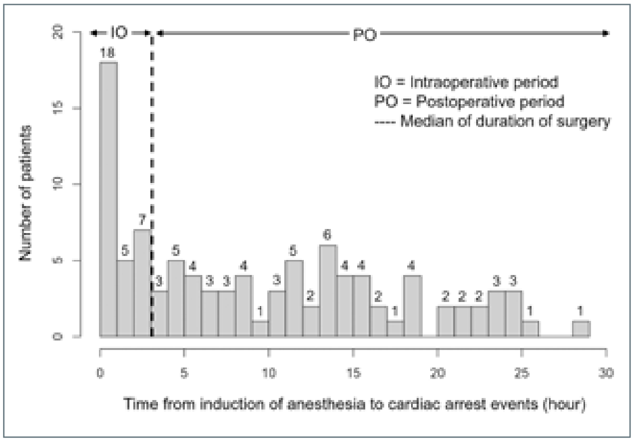


Figure 2. Histogram of time from induction of anesthesia to cardiac arrest events in intraoperative and 24-hour postoperative periods.

the case group underwent aortic surgery, limb surgery, and upper abdominal surgery while most patients in the control group underwent limb surgery, external organs of the trunk and perineal surgery, and eye and ear-nose-throat (ENT) surgery. Sole general anesthesia was used most often in both groups followed by sole neuraxial anesthesia and combined general anesthesia with neuraxial anesthesia. None of the patients who received peripheral nerve block experienced cardiac arrest. The most frequently used induction agents in the case group were midazolam, propofol, and etomidate, while propofol, midazolam, and etomidate were used most frequently in the control group. The majority of patients in both groups used sevoflurane as the inhaled agent, fentanyl as the opioid, and cis-atracurium as the muscle relaxant.

Logistic regression analysis revealed that ASA classification 3 and 4, aortic surgery, potassium imbalance, and the use of preoperative benzodiazepine increased the risk of intraoperative and 24-hour postoperative cardiac arrest. On the other hand, regional anesthesia and propofol were protective factors (Tab. III).

DISCUSSION

This study found a striking number of cardiac arrest cases in the first hour after induction of anesthesia compared with subsequent time points. The risk factors of intraoperative and 24-hour postoperative cardiac arrest in geriatric patients included ASA classification 3 and 4, aortic surgery, potassium imbalance, and preoperative use of benzodiazepine. The protective factors were regional anesthesia and propofol.

The 18 cases that experienced cardiac arrest in the first hour were reviewed. All cases were in ASA classification 3 and 4. The major causes of early cardiac arrest in most cases were related to poor preoperative patient conditions that included emergency aortic surgery, sepsis, impending upper airway obstruction, recent myocardial infarction, and trauma with massive bleeding. One case was related mainly to intraoperative surgical bleeding. None of the 18 cases were directly related to anesthesia. This finding corresponded with a previous study that reported the triggers contributing to deaths in the operating room and postanesthetic care unit [6]. They found that the patient's condition was the major cause of death and none of the deaths in the early operative period were related to anesthesia. Nevertheless, anesthesia might worsen a patient's condition since most anesthetic drugs and procedures affect the hemodynamics.

The ASA classification indicates the preoperative status of a patient and is used to predict operative risk. Patients with a higher level of ASA classification have a higher risk of perioperative cardiac arrest. This study strongly supported this probability with the adjusted OR of 8.46 compared with ASA classification 2. Many previous studies also supported this finding [1,5,7-9].

Aortic surgery is a high-risk procedure and was reported as a risk factor for perioperative cardiac arrest in this study which was the same as previous studies [6,10]. However, all cardiac arrest patients who underwent aortic surgery in this study were emergency cases. The true risk factor for perioperative cardiac arrest may be emergency aortic surgery. This was supported by Lieberg J. who reviewed mortality after surgical repair of elective abdominal aortic aneurysm and ruptured abdominal aortic aneurysm [11]. The study found that 30-day mortality of elective repair was only 0.9% while 30-day mortality of ruptured aneurysm repair was around 20 times higher (22.9%). Although emergency surgery was not found to be a risk factor in this study, this was probably because the number of cases of aortic surgery was only half the number of emergency cases and the other emergency cases possibly had low risk.

Potassium is a vital electrolyte. Previous studies in different settings found that potassium imbalance was associated with new-onset atrial fibrillation, ventricular arrhythmia, cardiac arrest, and death [12-17]. Arora et al. studied the association between preoperative serum potassium and clinical outcome after non-cardiac surgery in all age groups [18]. They found that the hazard ratios of the major adverse cardiac events were 2.17 (95% CI 1.75-2.70) in hypokalemic patients and 3.23 (95% CI 2.10-4.95) in hyperkalemic patients compared with normokalemic patients. This study found that potassium imbalance was a risk factor for cardiac arrest. Since potassium imbalance was analyzed as a dichotomous variable using normal potassium serum concentration as a reference, we could not report

Table I. Baseline characteristics and preoperative conditions of the patients.

	Arrest group	Non-arrest group	P-value
	N = 98	N = 294	
Sex			1
Male	68 (69.4)	204 (69.4)	
Female	30 (30.6)	90 (30.6)	
Age			1
65-74	50 (51)	150 (51)	
75-84	35 (35.7)	105 (35.7)	
≥ 85	13 (13.3)	39 (13.3)	
BMI, median (IQR)	22.6 (19.7,24.2)	22.7 (20,25.6)	0.41
ASA classification			< 0.001
2	5 (5.1)	120 (40.8)	
3	32 (32.7)	147 (50)	
4	61 (62.2)	27 (9.2)	
Case			< 0.001
Elective	22 (22.4)	221 (75.2)	
Emergency	76 (77.6)	73 (24.8)	
History of smoking (Y/N)	38 (38.8)/60 (61.2)	115 (39.1)/179 (60.9)	1
Comorbidities			
History of ischemic heart disease (Y/N)	21 (21.4)/77 (78.6)	37 (12.6)/257 (87.4)	0.049
History of valvular heart disease (Y/N)	5 (5.1)/93 (94.9)	10 (3.4)/284 (96.6)	0.542
History of congestive heart failure (Y/N)	6 (6.1)/92 (93.9)	5 (1.7)/289 (98.3)	0.032
History of peripheral arterial disease (Y/N)	8 (8.2)/90 (91.8)	15 (5.1)/279 (94.9)	0.385
History of significant arrhythmia (Y/N)	19 (19.4)/79 (80.6)	20 (6.8)/274 (93.2)	< 0.001
Hypertension (Y/N)	61 (62.2)/37 (37.8)	178 (60.5)/116 (39.5)	0.858
Asthma, COPD (Y/N)	13 (13.3)/85 (86.7)	41 (13.9)/253 (86.1)	1
DM (Y/N)	20 (20.4)/78 (79.6)	63 (21.4)/231 (78.6)	0.943
History of cerebrovascular accident			0.557
Yes, full recovery	4 (4.1)	15 (5.1)	
Yes, not full recovery	6 (6.1)	11 (3.7)	
No	88 (89.8)	268 (91.2)	
Cancer (Y/N)	20 (20.4)/78 (79.6)	89 (30.3)/205 (69.7)	0.079
On oxygen			< 0.001
$FiO_2 \leq 0.4$	41 (41.8)	39 (13.3)	
$FiO_2 > 0.4$	29 (29.6)	5 (1.7)	
No	28 (28.6)	250 (85)	
On ventilator (Y/N)	43 (43.9)/55 (56.1)	24 (8.2)/270 (91.8)	< 0.001
Alteration of consciousness (Y/N)	36 (36.7)/62 (63.3)	16 (5.4)/278 (94.6)	< 0.001
Preoperative body temperature			< 0.001
Hyperthermia	19 (20.4)	24 (8.2)	
Hypothermia	11 (11.8)	0 (0)	
Normothermia	63 (64.3)	270 (91.8)	
Preoperative hypertensive urgency (Y/N)	10 (10.2)/88 (89.8)	26 (8.8)/268 (91.2)	0.84
Hypotension or on inotropic drug (Y/N)	52 (53.1)/46 (46.9)	15 (5.1)/279 (94.9)	< 0.001
Preoperative PRC transfusion (Y/N)	32 (32.7)/66 (67.3)	19 (6.5)/275 (93.5)	< 0.001
Preoperative benzodiazepines (Y/N)	15 (15.3)/83 (84.7)	26 (8.8)/268 (91.2)	0.105
Preoperative analgesic drugs (Y/N)	48 (49)/50 (51)	68 (23.1)/226 (76.9)	< 0.001
Steroid use (Y/N)	13 (13.3)/85 (86.7)	20 (6.8)/274 (93.2)	0.074
Laboratory values			
Anemia (Y/N)	12 (12.2)/86 (87.8)	15 (5.1)/279 (94.9)	0.029

Continues

Follows

Table I. Baseline characteristics and preoperative conditions of the patients.

	Arrest group	Non-arrest group	P-value
Thrombocytopenia (Y/N)	12 (12.2)/86 (87.8)	8 (2.7)/286 (97.3)	< 0.001
Leukocytosis (Y/N)	45 (45.9)/53 (54.1)	54 (18.4)/240 (81.6)	< 0.001
Prolonged PT (Y/N)	14 (15.4)/77 (78.6)	4 (1.7)/235 (79.9)	< 0.001
Prolonged PTT (Y/N)	15 (16.7)/75 (76.5)	7 (2.9)/232 (78.9)	< 0.001
Creatinine ≥ 1.5 (Y/N)	46 (46.9)/52 (53.1)	52 (17.7)/242 (82.3)	< 0.001
Hypoalbuminemia (Y/N)	38 (38.8)/60 (61.2)	37 (12.6)/257 (87.4)	< 0.001
Electrolyte imbalance	77 (78.6)/21 (21.4)	135 (45.9)/159 (54.1)	< 0.001
Sodium (Y/N)	21 (21.4)/77 (78.6)	29 (9.9)/265 (90.1)	0.005
Potassium (Y/N)	27 (27.6)/71 (72.4)	15 (5.1)/279 (94.9)	< 0.001
Chloride (Y/N)	48 (49)/50 (51)	85 (28.9)/209 (71.1)	< 0.001
Bicarbonate (Y/N)	60 (61.2)/38 (38.8)	73 (24.8)/221 (75.2)	< 0.001
Preoperative blood sugar			< 0.001
Hyperglycemia	14 (18.4)	9 (6.6)	
Hypoglycemia	9 (11.8)	0 (0)	
Normoglycemia	53 (54.1)	127 (43.2)	

Data are presented as n (%) unless indicated otherwise; BMI: body mass index; IQR: interquartile range; ASA: American Society of Anesthesiologists; COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; FiO_2: fraction of inspired oxygen; PRC: packed red cells; PT: prothrombin time; PTT: partial thromboplastin time.

whether hypokalemia or hyperkalemia was the exact risk factor. We could not analyze serum potassium as a 3-level variable (hypo/normo/hyperkalemia) because there was no patient with hyperkalemia in the control group. However, the patients with potassium imbalance were revealed and found that the percentages of hyperkalemic patients in the case and control groups were considerably different (13.3 *vs* 0%) and roughly the same as the percentages of hypokalemic patients (14.3 *vs* 5.1%). Therefore, this study recommends a preoperative serum potassium level of 3.5-5 mmol/L.

We found that patients who received benzodiazepines within 24 hours prior to surgery had a higher risk of perioperative cardiac arrest. A study by Vashishta R. reported that preoperative antianxiety medications that included benzodiazepines were significantly associated with major adverse cardiac events that supported our results [19]. However, we reviewed 15 cardiac arrest patients who received preoperative benzodiazepines and found that 10 of those patients received intravenous benzodiazepines for sedation during intubation or to maintain mechanical ventilation which was possibly related to poor clinical status. More evidence is needed to support the use of benzodiazepines as a risk factor for perioperative cardiac arrest in geriatric patients. Nevertheless, we recommend avoiding preoperative benzodiazepines in geriatric patients if they are not necessary.

The study found that regional anesthesia was a protective factor for perioperative cardiac arrest in older patients. Regional anesthesia is used worldwide by anesthesiologists to avoid the risks of general anesthesia. Despite previous controversial reports, many studies support the advantages of regional anesthesia over general anesthesia [20-22]. A study in patients who underwent elective endovascular repair found that perioperative death in the regional anesthesia group was significantly lower than in the general anesthesia group (0.5 *vs* 4.3%, p = 0.007) [21]. A systematic review and meta-analysis that compared general anesthesia and neuraxial anesthesia in hip fracture patients showed that neuraxial anesthesia significantly reduced the in-hospital mortality rate (OR 0.85, 95% CI 0.76-0.95), p = 0.004) [20]. The study by Tamdee also found that general anesthesia was the risk factor for perioperative cardiac arrest in geriatric patients which supports our results [1].

Propofol is the most popular induction agent these days. It has a rapid onset and elimination time, short duration of action, and minimal adverse effects. Our study found that propofol reduced the risk of perioperative cardiac arrest in geriatric patients. Komatsu et al. reported that propofol decreased 30-day mortality and cardiovascular mortality compared with etomidate [23]. The study by Tamdee also found that ketamine was a risk factor for perioperative cardiac arrest in geriatric patients compared with other induction agents including propofol [1]. Although a multivariate regression analysis was done, the results may be confounded by some other factors. Propofol theoretically causes decreased systemic vascular resistance, myocardial depression, and baroreceptor blunting [24]. Therefore, propofol is potentially used in hemodynamically stable patients. Unstable patients were more likely to receive other induction agents such as etomidate and ketamine because those agents have fewer cardiovascular effects. In addition, sudden severe hemodynamic deterioration was reported due to acute heart failure following propofol and fentanyl administration in a patient without any previous significant medical history [25]. Using propofol for induction in unstable geriatric patients may need considerable caution and the benefit on perioperative cardiac arrest in geriatric patients may need more evidence.

From this study, potassium imbalance was a risk factor

Table II. Intraoperative characteristics of the patient and anesthetic agents used.

	Arrest group	Non-arrest group	P-value
	N = 98	N = 294	
Area			0.308
Operating room	97 (99)	283 (96.3)	
Remote area	1 (1)	11 (3.7)	
Duration (min), median (IQR)	186 (95,265)	140 (91.2,225)	0.037
Technique of anesthesia			< 0.001
GA	89 (90.8)	194 (66)	
Neuraxial block	6 (6.1)	65 (22.1)	
GA + Neuraxial block	3 (3.1)	20 (6.8)	
GA + Peripheral nerve block	0 (0)	7 (2.4)	
Peripheral nerve block	0 (0)	8 (2.7)	
Estimated blood loss, median (IQR)	500 (50,2425)	50 (10,250)	< 0.001
Site of surgery			< 0.001
Neuro and spine	6 (6.1)	18 (6.1)	
Eye and ENT	9 (9.2)	51 (17.3)	
Intrathoracic	3 (3.1)	5 (1.7)	
Upper abdomen	13 (13.3)	39 (13.3)	
Lower abdomen	6 (6.1)	28 (9.5)	
Aorta	36 (36.7)	11 (3.7)	
Trunk and perineum	3 (3.1)	52 (17.7)	
Extremities	17 (17.3)	68 (23.1)	
Urological scope	2 (2)	11 (3.7)	
Imaging and other interventions	3 (3.1)	11 (3.7)	
Induction agents			
Propofol (Y/N)	39 (39.8)/59 (60.2)	203 (69)/91 (31)	< 0.001
Etomidate (Y/N)	18 (18.4)/80 (81.6)	8 (2.7)/286 (97.3)	< 0.001
Midazolam (Y/N)	72 (73.5)/26 (26.5)	94 (32)/200 (68)	< 0.001
Ketamine (Y/N)	2 (2)/96 (98)	1 (0.3)/293 (99.7)	0.156
Inhalation agents			
Sevoflurane (Y/N)	57 (58.2)/41 (41.8)	160 (54.4)/134 (45.6)	0.598
Desflurane (Y/N)	7 (7.1)/91 (92.9)	37 (12.6)/257 (87.4)	0.196
Inhalation gases			< 0.001
Oxygen-in-air	90 (91.8)	195 (66.3)	
Oxygen-in-nitrous oxide	1 (1)	4 (1.4)	
Not use	7 (7.1)	95 (32.3)	
Neuromuscular blocking agents			
Succinylcholine (Y/N)	4 (4.1)/94 (95.9)	28 (9.5)/266 (90.5)	0.136
Non-depolarizing agent			< 0.001
Vecuronium	3 (3.1)	12 (4.1)	
Rocuronium	17 (17.3)	19 (6.5)	
Cis-atracurium	61 (62.2)	146 (49.7)	
Not used	17 (17.3)	117 (39.8)	
Opioids			
Morphine (Y/N)	3 (3.1)/95 (96.9)	24 (8.2)/270 (91.8)	0.134
Fentanyl (Y/N)	89 (90.8)/9 (9.2)	226 (76.9)/68 (23.1)	0.004

Data are presented as n (%) unless indicated otherwise; IQR: interquartile range; GA: general anesthesia; ENT: ear-nose-throat.

Table III. Factors related to intraoperative and 24-hour postoperative cardiac arrest in the patients (multivariate analysis).

	Crude OR (95% CI)	Adj. OR (95% CI)	P-value (Wald's test)	P-value (LR-test)
ASA (ref. = 2)				0.017
3	5.22 (1.98,13.82)	3.95 (1.14,11.32)	0.029	
4	54.22 (19.9,147.77)	8.46 (2.15,33.36)	0.002	
Site of surgery (ref. = trunk [external organs] and perineum)				< 0.001
Aorta	56.73 (14.77,217.83)	12.04 (2.16,67.2)	0.005	
Neuro and spine	5.78 (1.31,25.53)	1.81 (0.28,11.74)	0.533	
Eye and ENT	3.06 (0.78,11.95)	0.46 (0.08,2.7)	0.393	
Intrathoracic	10.4 (1.64,65.8)	2.33 (0.23,24.05)	0.478	
Upper abdomen	5.78 (1.54,21.68)	0.72 (0.12,4.3)	0.718	
Lower abdomen	3.71 (0.86,15.99)	3.69 (0.59,23.18)	0.163	
Extremities	4.33 (1.21,15.58)	1.21 (0.26,5.61)	0.804	
Imaging and other interventions	4.73 (0.84,26.6)	0.27 (0.02,3.96)	0.339	
Urological scope	3.15 (0.47,21.15)	3.29 (0.38,28.54)	0.281	
Potassium imbalance	7.07 (3.57,14)	2.92 (1.02,8.4)	0.047	0.045
Preoperative benzodiazepine	1.86 (0.94,3.68)	3.23 (1.16,8.96)	0.025	0.027
RA *vs* GA	0.2 (0.08,0.47)	0.14 (0.03,0.73)	0.02	0.017
Propofol	0.3 (0.18,0.48)	0.11 (0.04,0.32)	< 0.001	< 0.001
Emergency *vs* Elective	10.46 (6.07,18.01)	1.86 (0.8,4.32)	0.15	0.151

OR: odds ratio; Adj. OR: adjusted odds ratio; CI: confidence interval; ASA: American Society of Anesthesiologists; ENT: ear-nose-throat; RA: regional anesthesia; GA: general anesthesia.

that can be corrected or improved in order to reduce the incidence of perioperative cardiac arrest in geriatric patients. Performing regional anesthesia, if feasible, and avoiding benzodiazepines 24 hours prior to surgery in geriatric patients are also recommended. Controlling the patient's systemic diseases, if possible, to decrease the level of ASA classification before surgery may be beneficial. Although propofol was found to decrease risk, the benefit of propofol on perioperative cardiac arrest is still controversial and potentially harmful in unstable patients. For the risk factors that cannot be corrected, the best possible preparation should be carried out.

The study design was a case-control study since the main outcome was a rare event. Also, some additional predictive data needed to be collected. The estimated blood loss and duration of surgery were not in the multivariate analysis to ensure patient exposure to all of the analyzed factors before the outcomes occurred because some intraoperative cardiac arrests occurred before surgery was complete.

The strengths of this study were matching the variables between the case and control groups and the multivariate analysis that controlled important confounding factors. The limitation of the present study was the retrospective design and some of the data were possibly not completely accurate.

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