Letter

Perioperative Cardiac Arrest in Mechanically Ventilated Older Patients Undergoing Thoracic Surgery

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Cardiac arrest (CA) is considered a state of clinical death in which the heart suddenly loses its ability to effectively expel blood, resulting in circulatory and respiratory arrest. CA is often catastrophic for patients, as it can cause serious long-term cardiovascular and cerebrovascular complications that affect their quality of life[1]. Survey data indicate that the overall incidence rate of intraoperative CA in patients undergoing thoracic surgery in China is currently 0.138%[2]. This rate is expected to increase because of the increasing proportion of older individuals (age > 60 years) in the population, as well as the increasing pulmonary surgery rates. However, the incidence rate during the perianesthetic period in older patients undergoing thoracic surgery has not yet been comprehensively reported.

In this study, we retrospectively analyzed patient data to determine the incidence rate, causes, and resuscitation outcomes of CA in older adults undergoing thoracic surgery during the perianesthetic period in Beijing Anzhen Hospital, Capital Medical University, between January 2016 and December 2021. The oldest patient was 82, the youngest was 60, and the average age was 73.4 ± 6.1 years.

Inclusion criteria: Cases of CA occurring in the operating room during the perianesthetic period that required extrathoracic and/or intrathoracic cardiac compressions and/or electrical defibrillation for resuscitation in patients aged > 60 years. Exclusion criteria: CA lasting less than 5 s or autonomous recovery of sinus rhythm without any intervention. CA diagnostic criteria: ventricular fibrillation, asystole, and pulseless ventricular tachycardia.

All data were analyzed using SPSS version 17.0 (SPSS, Chicago, IL, USA). Categorical variables were expressed as frequencies and percentages (%), while continuous variables were presented as median (interquartile range, IQR) or mean ± standard deviation (SD), based on compliance with normal distribution.

Case 1: A 60-year male underwent radical surgery for esophageal cancer under general anesthesia. Coronary computed tomography angiography revealed diffuse, calcification-dominated mixed plaques (< 50%) in the middle segment of the distal left main stem anterior descending branch and mild luminal stenosis (< 25%) in the proximal left ileal branch. After the surgeon resected the esophageal lesion along with the adjacent gastric wall on the lesser curvature side, the patient's blood pressure suddenly dropped to 55/35 mmHg, and his heart rate (*HR*) fell to 20 bpm. Two intravenous doses of epinephrine (1 mg each) were immediately administered, while the surgeon performed intrathoracic cardiac compressions. Next, external thoracic defibrillation was performed twice (200 Ws, biphasic, lateral position), followed by external thoracic defibrillation twice at 200 Ws, biphasic, in the flat position. After 17 min, the patient's heart resumed beating with a normal rhythm. The cause of CA was determined to be myocardial infarction.

Case 2: A 65-year-old man was preoperatively diagnosed with central squamous cell carcinoma of the left lung and underwent lung cancer resection with lymph node dissection under general anesthesia. While the surgeon was dissecting the tumor, the patient experienced sudden ventricular arrest. One minute after initiating extracorporeal cardiac compressions in the horizontal position, the patient's voluntary heart rhythm was restored.

Case 3: A 70-year female with second-degree atrioventricular block and occasional premature ventricular contractions underwent a middle esophagectomy under general anesthesia. However,

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during surgical ligation of the left gastric artery, the patient's blood pressure suddenly dropped sharply, and electrocardiogram (ECG) findings indicated a rapid transition from sinus to ventricular arrest. The anesthesiologist immediately administered epinephrine (1 mg) *via* the central vein, and the operation was aborted. Rapid intrathoracic cardiac compressions were performed, resulting in the restoration of normal voluntary heart rhythm.

Case 4: A 72-year male with a history of aortic and mitral valve replacement was admitted to the emergency department with active bleeding in the thoracic cavity and was prepared for exploratory open-heart surgery. A chest computed tomography (CT) scan revealed a large amount of blood in the left side of the chest cavity, which was associated with left lung compression and a rightward shift of the mediastinum. After anesthesia was administered in the right lateral position, the patient suddenly developed pulseless ventricular tachycardia. Cardiopulmonary resuscitation was immediately performed while the patient was in a flat position. However, after 30 min of unsuccessful resuscitation, the patient's family consented to abandon the resuscitation efforts, and the patient was declared clinically dead.

Case 5: A 67-year male with a history of left lower lung cancer underwent a left lower lung lobectomy with lymph node dissection under general anesthesia. He had previously received a coronary artery bypass graft and was admitted to the hospital for review of an occlusion in the anterior descending bridge vessel. During surgery, the patient experienced pulseless ventricular tachycardia and was immediately administered epinephrine (1 mg) and lidocaine (150 mg) *via* the central vein, which restored the sinus heart rhythm to normal. Demographic and clinical characteristics of the patients are presented in Table 1, 2.

Among the five CA cases that occurred during thoracic surgery, one (20.0%) was an emergency surgery, while four (80%) were elective surgeries.

Table 1. Characteristics of five patients with cardiac arrest

ID	Gender	Age (years)	Diagnosis	Surgical operation	Comorbidities	ASA	Operative category
Case 1	Male	60	Esophageal cancer	Esophageal cancer radical surgery	Hypertension, Coronary heart disease	III	Elective
Case 2	Male	65	Lung cancer	Lung cancer resection	No	II	Elective
Case 3	Female	70	Esophageal cancer	A middle aesophagectomy	A second-degree atrioventricular block with occasional premature ventricular contractions	III	Elective
Case 4	Male	72	Active thoracic haemorrhage	Exploratory open-heart surgery	Aortic valve replacement and mitral valve replacement	V	Emergency
Case 5	Male	67	Left lower lung cancer	Left lower lung lobectomy with lymph node dissection	Coronary artery bypass graft, Occlusion of the anterior descending bridge vessel	III	Elective

Note. ID, identity document; ASA, american society of anesthesiologists.

Table 2. Characteristics and treatment outcome of five patients with cardiac arrest

ID	Types of cardiac arrest	Anaesthesia	Cause	Cardiopulmonary resuscitation	Resuscitation outcome	Prognosis
Case 1	Ventricular fibrillation	General anaesthesia	Myocardial infarction	Epinephrine, intrathoracic cardiac compressions, external thoracic defibrillation	Voluntary heart rhythm recovered normally	Discharged without complications
Case 2	Ventricular arrest	General anaesthesia	Surgical traction stimulation	Extracorporeal cardiac compressions	Voluntary heart rhythm recovered normally	Discharged without complications
Case 3	Ventricular arrest	General anaesthesia	Surgical traction stimulation	Epinephrine, intrathoracic cardiac compressions	Voluntary heart rhythm recovered normally	Discharged without complications
Case 4	Ventricular fibrillation	General anaesthesia	Severe cardiorespiratory diseases	Epinephrine, extracorporeal cardiac compressions, external thoracic defibrillation	Unsuccessful resuscitation	Died
Case 5	Pulseless ventricular tachycardia	General anaesthesia	Anaphylactic shock	Epinephrine, lidocaine	Voluntary heart rhythm recovered normally	Discharged without complications

Note. ID, identity document.

The five patients with CA were classified according to american society of anesthesiologists (ASA) grade as grade II (1 case), grade III-IV (3 cases), and grade V (1 case). All patients were under general anesthesia.

CA occurred in 5 of 798 older patients undergoing thoracic surgery during the perianesthetic period, with an overall CA incidence rate of 0.627%, which is the ratio of the cases to the number of patients in 5 years.

Among these five CA cases, three were surgery-related (two due to intraoperative surgical traction stimulation and one due to intraoperative anaphylaxis), two were associated with patient comorbidities other than underlying cardiac disease (one case of intrathoracic hemorrhage after cardiac surgery and one case of intraoperative myocardial infarction), and four cases were related to underlying cardiac disease.

Thoracic surgery can greatly impact respiration and circulatory functions due to the intrathoracic effects of the procedures, as well as age-related factors such as heart disease and the effects of anesthetic drugs. Because of these factors, arrhythmias and CA incidents occasionally occur during the preanesthetic period and cannot be completely prevented. Of the five patients who experienced CA, four clearly suffered from heart disease. Among them, one patient had active thoracic haemorrhage caused by long-term anticoagulation following cardiac valve replacement that led to massive blood accumulation in the chest cavity and severe compression of the cardiopulmonary mediastinum. Another patient with a coronary artery bypass graft suffered complete occlusion of the coronary artery (the left anterior descending bridge vessel) that could not be recanalised due to surgically induced high blood loss and blood transfusion-induced anaphylactic shock, triggering pulseless ventricular tachycardia. The third patient had coronary artery disease of uncertain aetiology that led to intraoperative myocardial infarction with ventricular fibrillation. The fourth patient suffered from second-degree atrioventricular block.

Other studies have demonstrated that CA events during thoracic surgery are often related to surgically induced stimulation, whereas most CA events are caused by intraoperative hemorrhagic shock and inadequate perfusion of the heart and other vital organs and tissues. Thus, CA incidence rates are closely related to the level of thoracic surgical expertise at each hospital[3]. In this study, 40% (two cases) of CA incidents were caused by surgical stimulation, while 20% (one case) resulted from relative insufficiency of blood volume due to anaphylaxis.

Close monitoring of intraoperative vital signs, timely detection, and proper management of CA events in older adult undergoing thoracic surgery are critical for successful cardiopulmonary resuscitation. Therefore, the following measures were implemented for all thoracic surgical patients in this study: central venous puncture for central venous pressure monitoring and drug administration; radial artery puncture for invasive blood pressure monitoring; and ECG monitoring, pulse oximetry, and positive end-expiratory pressure monitoring. Importantly, invasive arterial pressure monitoring facilitates the timely detection of arrhythmias and changes in circulatory function, even when ECG monitoring cannot be conducted (due to interference from an electric knife during surgery)[4,5]. Additionally, central venous access ensures that drugs enter the heart directly and take effect quickly during emergency treatments.

In this study, we found that early initiation of defibrillation after CA played a pivotal role in achieving successful resuscitation by preventing or reducing biological damage to vital organs. Previous research has shown that defibrillation within 2 min of CA onset results in a cardioversion success rate of 70%–90%, which decreases by 7%–20% for every 2-min delay in defibrillation initiation[6].

In this study, we implemented cardiopulmonary resuscitation immediately after CA onset in patients receiving mechanical ventilation support (for the delivery of general anesthesia *via* tracheal intubation during surgery). Such patients tend to have high rates of successful cardiopulmonary resuscitation as a benefit of perioperative mechanical ventilation, which is associated with high oxygen reserves in vital organs[7].

Currently, epinephrine is the drug of choice for cardiac resuscitation, as it increases peripheral vascular pressure, coronary perfusion pressure, and myocardial blood flow, supporting the restoration of autonomic heart rhythms[8]. The American Heart Association resuscitation guidelines recommend administrating a standard dose of epinephrine (1 mg) every 3–5 min during CA[9].

In conclusion, the causes of intraoperative CA are complex. Surgical traction stimulation, massive blood loss, and perioperative infarction are primary causes of intraoperative CA. Effective and strict intraoperative monitoring of vital signs can help in the early detection of CAs for improved treatment. Timely and properly administered continuous

cardiopulmonary resuscitation is key to successful restoring heart rhythm following CA occurrence during the perianesthetic period in older adults undergoing thoracic surgery. Central venous access provides the most rapid and effective drug delivery route for CA treatment. However, owing to the small number of patients who experienced CA in this study, some results may have low statistical accuracy. Therefore, larger multicenter studies with a larger number of participants are needed to validate these findings. Several studies have shown that the clinical experience of the anesthesiologist influences cardiopulmonary resuscitation outcomes[10].

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Competing Interests All authors declare that they have no competing interests.

Ethics The study protocol was approved by the medical ethics committee of Beijing Anzhen Hospital, Capital Medical University (2022045X).

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