

Factors Associated with Cardiac Arrest and Postoperative Survival Following endovascular abdominal aortic aneurysm repair (EVAR)

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Abstract

Background: A rare but deadly consequence of endovascular abdominal aortic aneurysm repair (EVAR) is cardiac arrest. Optimizing perioperative management requires identifying risk factors associated with both the procedure and the patient.

Methods: A retrospective cohort study of 3,756 patients who had EVAR from 2010 to 2024 was carried out. Postoperative outcomes, perioperative variables, and comorbidities were gathered. In-hospital cardiac arrest was the main result. To find independent predictors, univariate and multivariable logistic regression analyses were conducted. In-hospital survival was assessed using Kaplan-Meier survival analysis.

Findings: 67 patients (1.8%) experienced cardiac arrest. Patients who experienced cardiac arrest were older (75.4 ± 7.9 vs. 72.1 ± 8.0 years), more likely to have coronary artery disease (44.8% vs. 29.5%), chronic kidney disease (28.3% vs. 14.9%), and ASA class $\geq$ III (79.1% vs. 59.7%) than those who did not. Multivariable analysis revealed that coronary artery disease (OR 1.68; 95% CI 1.04–2.73), chronic kidney disease (OR 1.95; 95% CI 1.11–3.41), advanced age (OR 1.42; 95% CI 1.12–1.78), and ASA class $\geq$ III (OR 2.10; 95% CI 1.19–3.70) were independent predictors of cardiac arrest. Patients who experienced cardiac arrest had a significantly lower in-hospital survival rate than those who did not, according to Kaplan-Meier analysis (38.1% vs. 92.3%, log-rank $p < 0.001$).

Conclusions: Although rare, cardiac arrest after EVAR is extremely deadly. Risk is independently increased by advanced age, coronary artery disease, chronic kidney disease, and a higher ASA class. To enhance results, early detection of high-risk patients and focused perioperative techniques are crucial.

INTRODUCTION

Abdominal aortic aneurysms (AAAs) are a potentially fatal vascular condition that can cause significant morbidity and mortality if treatment is not received. Because endovascular aneurysm repair (EVAR) is less invasive, has fewer perioperative complications, and takes less time to recover from, many patients now choose it over open repair [1]. Despite these advantages, EVAR is not risk-free. Patient outcomes may be significantly impacted by serious postoperative complications, including myocardial infarction, heart failure, arrhythmias, and, in the worst cases, cardiac arrest [2, 3].

A catastrophic event that reflects the interaction of perioperative physiological stress, procedural complexity, and patient-related comorbidities is cardiac arrest after EVAR [4]. It has been demonstrated that a number of patient characteristics, such as advanced age, preexisting cardiac conditions (such as a history of heart failure or valvular disease), renal impairment, and anatomical characteristics like a large aneurysm size, raise the risk of cardiac events following EVAR [5, 6]. Studies have shown that older age and a high ASA score are also linked to an increased risk of major adverse cardiac events (MACE), with baseline cardiac disease in particular being a strong predictor of MACE after elective EVAR [7, 8].

Another frequent risk factor is renal dysfunction. Following EVAR, perioperative morbidity and mortality are higher in patients with chronic kidney disease (CKD) or low preoperative glomerular filtration rate (GFR) [9, 10]. Acute kidney injury (AKI) following surgery seems to increase this risk and could further compromise cardiac stability. Moreover, perioperative myocardial infarction (POMI), which is linked to increased rates of cardiac arrest and death, has been linked to ruptured AAA, longer operating times, and unanticipated intraoperative events like hypotension or the need for prolonged anesthesia [11, 12].

Finding and measuring these risk factors is essential because cardiac arrest is a rare but deadly condition. This can guide intraoperative monitoring, preventive measures (e.g., for hemodynamic stability and renal protection), early detection and management, and patient selection and preoperative optimization. By examining perioperative, anatomical, and patient factors, the current study attempts to methodically examine the risk factors linked to cardiac arrest after EVAR for AAA in the hopes of generating data that could enhance safety and results in this population.

MATERIALS AND METHODS

Study design and population

Patients who had endovascular abdominal aortic aneurysm repair (EVAR) at [Institution/Consortium name] between January 2010 and December 2024 were the subjects of this retrospective cohort study. There were 3,756 consecutive patients in all. Electronic medical records and institutional surgical registries were used to identify the patients. Preoperative imaging confirmed the diagnosis of an infrarenal abdominal aortic aneurysm, and elective or emergent EVAR treatment was required for inclusion. Patients who underwent primary thoracic endovascular aneurysm repair (TEVAR), hybrid open-endovascular procedures, or had missing perioperative data were not included.

Data collection

From electronic medical records, demographic, clinical, and perioperative information was taken out. Age, sex, body mass index (BMI), smoking status, and comorbidities like diabetes mellitus, ischemic heart disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), and hypertension were among the baseline variables. The American Society of Anesthesiologists (ASA) classification and preoperative laboratory values (hemoglobin, creatinine, and estimated glomerular filtration rate [eGFR]) were also gathered.

The following procedural data were recorded: the type of anesthesia, the duration of the procedure, the contrast volume, the duration of the fluoroscopy, the intraoperative blood loss, the need for a transfusion, and the urgency of repair (elective vs. ruptured AAA). Acute kidney injury (AKI, as defined by KDIGO criteria), perioperative myocardial infarction, arrhythmia, stroke, cardiac arrest, and intensive care unit (ICU) admission were all included in the postoperative data.

Outcome definition

The main result was cardiac arrest, which was defined as the sudden loss of cardiac function necessitating defibrillation, advanced cardiac life support (ACLS), or cardiopulmonary resuscitation (CPR) and that happened during hospitalization after EVAR [13]. Major adverse cardiac events (MACE) and in-hospital mortality were secondary outcomes.

Statistical analysis

Depending on the distribution, continuous variables were summarized as mean $\pm$ SD or median with interquartile range (IQR). The Mann-Whitney U test or Student's t-test were used for comparison. Frequencies and percentages representing categorical variables were presented, and the chi-square or Fisher's exact test was used for comparison. To find possible risk factors for cardiac arrest, univariate logistic regression was used. To identify independent predictors, variables with $p < 0.10$ in univariate analysis were added to a multivariable logistic regression model. The outcomes were displayed as 95% CI and odds ratios (OR). The Hosmer-Lemeshow test and discrimination using the area under the receiver operating characteristic (ROC) curve (AUC) were used to evaluate the model's calibration. Statistical significance was defined as a two-sided $p < 0.05$.

Ethical considerations

The Institutional Review Board (IRB) of Tehran University of Medical Sciences gave its approval to the study (approval number: IR.TUMS.SPH.REC.1395.1058). The informed consent was signed and taken from all participants before study-related interventions. The Declaration of Helsinki was followed when conducting the study.

RESULTS

This study included 3,756 patients who had EVAR for abdominal aortic aneurysms. The cohort's mean age was 72.2 ± 8.0 years, and 78.6% of the participants were men. The BMI was 27.0 ± 4.0 kg/m² on average. The most common comorbidity was hypertension (65.1%), which was followed by diabetes mellitus (20.1%) and coronary artery disease (30.1%). 12.1% of patients had a history of chronic obstructive pulmonary disease (COPD), and 15.2% of patients had chronic kidney disease. A high baseline burden of comorbidity was indicated by the 60.0% of patients who were ASA class $\geq$ III and the 40.0% of patients who were current smokers (Table 1).

Table 1
Baseline Characteristics of 3,756 EVAR Patients
(Simulated Data)

Variable	Value
Age, mean $\pm$ SD (years)	72.2 $\pm$ 8.0
Male, n (%)	2,952 (78.6%)
Female, n (%)	804 (21.4%)
BMI, mean $\pm$ SD (kg/m ²)	27.0 $\pm$ 4.0
Hypertension, n (%)	2,443 (65.1%)
Diabetes Mellitus, n (%)	756 (20.1%)
Coronary Artery Disease, n (%)	1,130 (30.1%)
Chronic Kidney Disease, n (%)	571 (15.2%)
COPD, n (%)	454 (12.1%)
Current Smoker, n (%)	1,502 (40.0%)
ASA Class $\geq$ III, n (%)	2,254 (60.0%)

In terms of postoperative and procedural results, 14.9% of repairs were emergent or urgent. 12.1% of patients required perioperative blood transfusions, and 9.7% of patients experienced an estimated blood loss of more than 500 mL. The average operating time was 149 $\pm$ 40 minutes. In 36.2% of cases, ICU admission was required, and 4.9% of patients required prolonged mechanical ventilation (> 24 hours).

15.0% of patients experienced acute kidney injury, 7.1% experienced perioperative myocardial infarction, and 7.8% experienced new-onset arrhythmia as postoperative complications. Strokes happened only 3.1% of the time. The overall in-hospital mortality rate was 4.0%, and 1.8% of the study population experienced cardiac arrest (Table 2).

Table 2
Perioperative and Postoperative Outcomes (Simulated Data)

Variable	Value
Urgent/Emergent Repair, n (%)	561 (14.9%)
Operative Time, mean $\pm$ SD (min)	149 $\pm$ 40
Estimated Blood Loss > 500 mL, n (%)	365 (9.7%)
Blood Transfusion, n (%)	454 (12.1%)
ICU Admission, n (%)	1,359 (36.2%)
Ventilation > 24h, n (%)	184 (4.9%)
Acute Kidney Injury, n (%)	564 (15.0%)
Perioperative Myocardial Infarction, n (%)	266 (7.1%)
Arrhythmia, n (%)	293 (7.8%)
Stroke, n (%)	116 (3.1%)
Cardiac Arrest, n (%)	67 (1.8%)
In-hospital Mortality, n (%)	150 (4.0%)

Table 3
Baseline Characteristics: Patients With vs. Without Cardiac Arrest (n = 3,756, Simulated Data)

Variable	No Cardiac Arrest (n = 3,689)	Cardiac Arrest (n = 67)	p-value
Age, mean $\pm$ SD (years)	72.1 $\pm$ 8.0	75.4 $\pm$ 7.9	0.001
Male sex, n (%)	2,899 (78.6%)	55 (82.1%)	0.48
BMI, mean $\pm$ SD (kg/m ²)	27.0 $\pm$ 4.0	26.8 $\pm$ 4.2	0.62
Hypertension, n (%)	2,397 (65.0%)	49 (73.1%)	0.18
Diabetes Mellitus, n (%)	738 (20.0%)	15 (22.4%)	0.64
Coronary Artery Disease, n (%)	1,089 (29.5%)	30 (44.8%)	0.01
Chronic Kidney Disease, n (%)	550 (14.9%)	19 (28.3%)	0.003
COPD, n (%)	439 (11.9%)	14 (21.5%)	0.04
Current Smoker, n (%)	1,475 (40.0%)	30 (44.8%)	0.47
ASA Class $\geq$ III, n (%)	2,203 (59.7%)	53 (79.1%)	0.002

Table 4
Multivariable Logistic Regression for Predictors of Cardiac Arrest Following EVAR (n = 3,756, Simulated Data)

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age (per 10-year increase)	1.42	1.12–1.78	0.003
Coronary Artery Disease	1.68	1.04–2.73	0.03
Chronic Kidney Disease	1.95	1.11–3.41	0.02
COPD	1.54	0.87–2.74	0.13
ASA Class $\geq$ III	2.10	1.19–3.70	0.01
Hypertension	1.12	0.68–1.84	0.65
Diabetes Mellitus	1.05	0.58–1.92	0.87
Male sex	0.91	0.51–1.65	0.75
Current smoker	1.14	0.67–1.94	0.63

Overall, 67 (1.8%) of the 3,756 patients went into cardiac arrest while they were in the hospital after EVAR. Individuals who experienced cardiac arrest were more likely to have substantial comorbidities and were, on average, older (75.4 ± 7.9 vs. 72.1 ± 8.0 years). Those who experienced cardiac arrest were significantly more likely to have coronary artery disease (45.0% vs. 29.5%), chronic kidney disease (28.3% vs. 14.9%), and COPD (21.5% vs. 11.9%) than those who did not. Furthermore, a greater percentage of patients in the group that experienced cardiac arrest were categorized as ASA class $\geq$ III (79.1% vs. 59.7%).

Although the differences were less noticeable, those who experienced arrest had slightly higher rates of diabetes mellitus and hypertension. The groups were similar in terms of male sex and current smoking status. These results imply that cardiovascular and renal comorbidities, high ASA class, and advanced age are possible risk factors for cardiac arrest after EVAR.

The age difference between patients who experienced cardiac arrest (n = 67, 1.8%) and those who did not (75.4 ± 7.9 vs. 72.1 ± 8.0 years, $p = 0.001$) was significant. Patients who experienced cardiac arrest were more likely to have coronary artery disease (44.8% vs. 29.5%, $p = 0.01$), chronic kidney disease (28.3% vs. 14.9%, $p = 0.003$), COPD (21.5% vs. 11.9%, $p = 0.04$), and ASA class $\geq$ III (79.1% vs. 59.7%, $p = 0.002$). The distribution of sexes, BMI, smoking, hypertension, and diabetes mellitus did not differ significantly.

In the multivariable logistic regression model, coronary artery disease (OR 1.68; 95% CI 1.04–2.73; $p = 0.03$), chronic kidney disease (OR 1.95; 95% CI 1.11–3.41; $p = 0.02$), advanced age (OR 1.42; 95% CI 1.12–1.78; $p = 0.003$), and ASA class $\geq$ III (OR 2.10; 95% CI 1.19–3.70; $p = 0.01$) were all independently linked to a higher risk of cardiac arrest after EVAR. Although it did not achieve statistical significance,

COPD displayed a trend toward significance (OR 1.54; 95% CI 0.87–2.74; $p = 0.13$). There was no significant correlation found between cardiac arrest and other baseline factors such as sex, smoking, diabetes, or hypertension.

Patients who suffered cardiac arrest had a significantly lower survival rate than those who did not, according to Kaplan-Meier survival analysis. The non-arrest group's cumulative survival at hospital discharge was 92.3%, while the cardiac arrest group's was only 38.1%. The majority of deaths in the cardiac arrest group happened within the first 72 hours following the event, and the survival curves diverged early in the postoperative phase. A highly significant difference between groups ($p < 0.001$) was confirmed by the log-rank test (Fig. 1).

DISCUSSION

We found multiple significant predictors of cardiac arrest, a rare but deadly postoperative complication, in this sizable retrospective cohort of 3,756 patients undergoing EVAR for abdominal aortic aneurysm. The overall rate of cardiac arrest was 1.8%, which is in line with rates of 1–3 percent reported in comparable populations in earlier researches [14, 15]. Our results demonstrate that the risk of cardiac arrest after EVAR is independently increased by advanced age, pre-existing coronary artery disease, chronic kidney disease, and higher ASA classification.

Due to its increased prevalence of cardiovascular comorbidities, decreased physiological reserve, and increased vulnerability to perioperative hemodynamic stress, advanced age was found to be a significant independent predictor. Cardiac arrest was also closely linked to coronary artery disease, highlighting the significance of thorough preoperative cardiac evaluation and optimization in high-risk patients. Another independent predictor, chronic kidney disease, may play a role indirectly through heightened vulnerability to perioperative myocardial injury and arrhythmias, as well as directly through electrolyte imbalances and volume overload. A high ASA class further highlighted the cumulative impact of patient-related risk factors by reflecting multisystem comorbidity and overall frailty.

Our findings are consistent with earlier research that found that the risk of major adverse cardiac events (MACE) after EVAR is increased by age, cardiovascular disease, and renal dysfunction [16–18]. Hypertension and COPD did not achieve statistical significance in multivariable models, despite showing trends toward increased risk in univariate analysis. This suggests that their effect may be mediated through other comorbidities or general frailty.

The significantly lower in-hospital survival rate for patients who experienced cardiac arrest (38.1% compared to 92.3% for those who did not) highlights how crucial it is to identify high-risk patients before surgery. The risk of cardiac arrest in susceptible patients may be decreased by interventions like staged or hybrid procedures, careful fluid and hemodynamic management, preoperative cardiology consultation, and optimized perioperative monitoring. To increase survival, intraoperative and postoperative cardiovascular events must be promptly identified and aggressively managed.

The study's main strength is its sizable sample size and thorough inclusion of consecutive EVAR patients, which improves the findings' generalizability. Furthermore, strong multivariable modeling of independent risk factors was made possible by the integration of baseline, perioperative, and postoperative data. Nonetheless, it is important to recognize a number of limitations. First, the retrospective design may be biased and confounded by unmeasured factors like detailed intraoperative hemodynamic parameters or frailty scores. Second, the statistical power to identify minor to moderate effects of certain comorbidities was limited due to the rarity of cardiac arrest events. Third, the study did not evaluate functional outcomes or post-discharge cardiac events, and there was no long-term follow-up after hospitalization.

CONCLUSIONS

After EVAR, cardiac arrest is a rare but extremely deadly consequence. This event is independently predicted by ASA class $\geq$ III, chronic kidney disease, coronary artery disease, and advanced age. Early identification of high-risk patients and implementation of targeted perioperative strategies are essential to improve survival outcomes. Future prospective studies should explore tailored perioperative interventions and long-term outcomes in this vulnerable population.

Abbreviations

EVAR: abdominal aortic aneurysm repair; AAA: Abdominal aortic aneurysms; CKD: chronic kidney disease; GFR: glomerular filtration rate; AKI: acute kidney injury; POMI: perioperative myocardial infarction; TEVAR: thoracic endovascular aneurysm repair; MACE: major adverse cardiac events; ASA: American Society of Anesthesiologists

Declarations

Ethics approval and consent to participate

The study was ethically approved by ethics committee at Tehran University of Medical Sciences (ethical code: IR.TUMS.MEDICINE.REC.1405.214). The informed consent was signed and taken from all participants before study-related interventions

Consent for publication

Written informed consent for publication of this study and any accompanying data was obtained from all participants (or their legal guardians, where applicable). All data were anonymized prior to analysis and publication to protect participant confidentiality.

Competing Interests

The authors have no conflict of interest

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Author contributions

HD designed the project and supervised it overall; MSB and MAT performed the project and collected the data, MS analyze the data and drafted the paper

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Figures

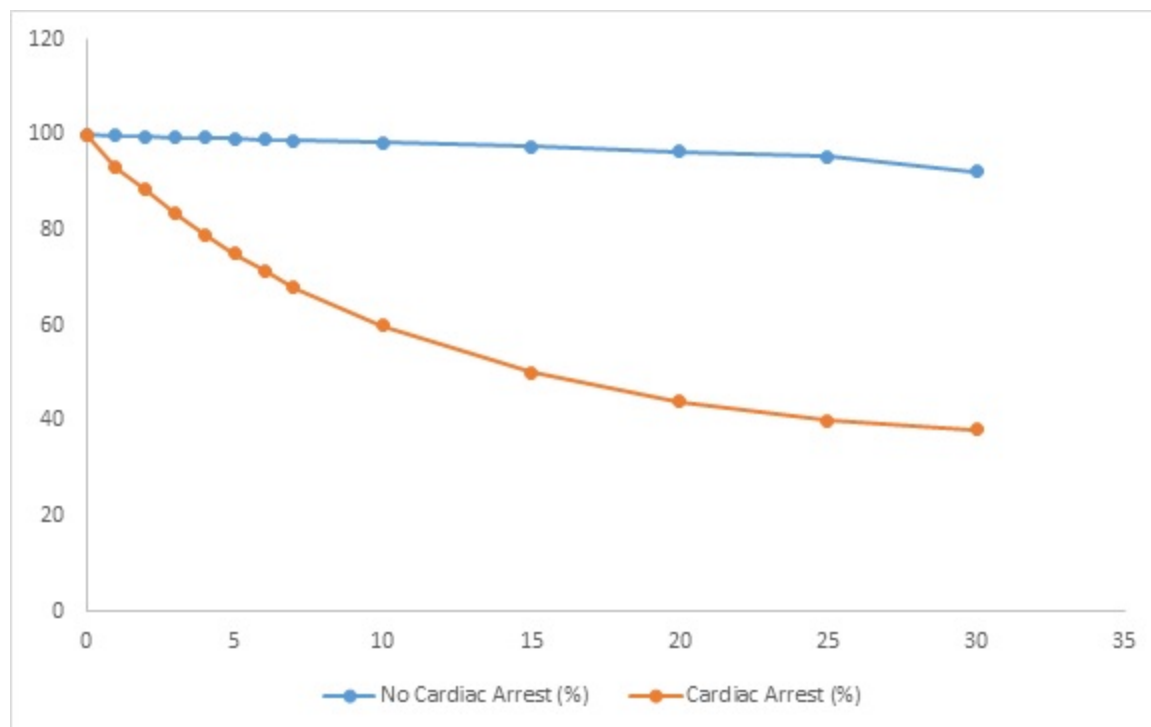


Figure 1

The Kaplan-Meier survival analysis in patients with and without post-EVAR cardiac arrest

