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(Review Article)

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The factors that predict survival in out-of-hospital cardiac arrests and autopsy findings for individuals with unknown cause of death: A systematic review

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Abstract

Background: Histopathological examination in autopsies following cardiac arrest provides important guide into the underlying causes of sudden cardiac death. Common findings include coronary artery atherosclerosis, myocardial infarction, fibrosis, and myocarditis. These changes identify structural or pathological abnormalities missed clinically. Autopsy-based histology is essential for accurate diagnosis, in unexplained deaths, and supports preventive methods and better understanding of cardiovascular pathology. This systematic review aimed to evaluate the predictors of survival following OHCA and to summarize autopsy and postmortem findings where the cause of death was unknown.

Methods: A literature search was conducted in PubMed, PubMed Central, Scopus, and Google Scholar to find eligible studies published between 2010 and 2024. Studies were included if they focused on predictors of survival in adult OHCA cases or provided autopsy findings in unexplained deaths. Data were extracted regarding study design, population characteristics, survival rates, predictors, and outcomes.

Results: sixteen studies were included. Histopathological findings from included studies indicate coronary atherosclerosis, myocardial infarction, and structural heart changes as an important cause of sudden cardiac death, show autopsy's role in identifying cardiac pathology and guide prevention strategies. Predictors of survival included initial shockable rhythm, witnessed arrest, early defibrillation, bystander CPR, and rapid EMS response. Early coronary angiography and targeted temperature management correlated with better outcomes. Autopsy findings in unexplained deaths revealed cardiac causes. Molecular autopsy was needed to identify inherited arrhythmia syndromes in structurally normal hearts.

Conclusion: Survival after OHCA is influenced by early intervention and clinical factors. Autopsy, when combined with genetic testing, is essential to diagnose unexplained sudden deaths and guide family risk assessment.

Keywords: Out-Of-Hospital Cardiac Arrest; Survival Predictors; Autopsy Findings; Sudden Cardiac Death; Molecular Autopsy

1. Introduction

Histopathological examination during autopsy plays important role in detecting the underlying causes of sudden cardiac death (SCD). Coronary artery disease (CAD) is identified, with studies show that a proportion of SCD cases had severe atherosclerotic changes and myocardial infarction, indicating the impact of ischemic heart conditions (Marwah et al. 2021). Beyond CAD, myocardial hypertrophy and fibrosis are prevalent findings, associated with chronic hypertension

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or cardiomyopathies, which can predispose individuals to fatal arrhythmias (Duncanson et al. 2018). Myocarditis, characterized by inflammatory infiltrates and myocyte necrosis, is another notable cause, mainly in younger demographics, and do not present with overt clinical symptoms before death (Basso et al. 2001). Advancements in autopsy protocols show the importance of systematic tissue sampling and the integration of molecular techniques to detect genetic abnormalities, mainly in cases where structural heart anomalies are absent (Basso et al. 2017).

Out-of-hospital cardiac arrest (OHCA) is a public health concern worldwide, with an incidence of 55 to 113 cases per 100,000 people and poor survival outcomes (Yan et al. 2020). There is improvements in emergency medical services (EMS), defibrillator access, and public awareness, but survival to hospital discharge remains below 10% in many regions (Sasson et al. 2010). Factors associated with increased survival include a shockable initial rhythm, early defibrillation, immediate bystander cardiopulmonary resuscitation (CPR), and shorter EMS response times (Nguyen et al. 2018). These findings show the importance of strengthening the chain of survival through public training and rapid response infrastructure (Perkins et al. 2015).

In-hospital interventions such as targeted temperature management, coronary angiography, and neurological assessment play a role in determining long-term outcomes (Sawyer et al. 2020). A substantial proportion of OHCA patients, for those who die without resuscitation or in the absence of clear clinical history, the cause of death remains unknown.

Autopsy has long been the gold standard to identify the underlying pathology in sudden unexplained deaths, including OHCA cases with no known premorbid conditions. Conventional autopsy fails to reveal structural abnormalities in cases of primary electrical disorders (Bagnall et al. 2016). Molecular autopsy using postmortem genetic testing has emerged as a valuable tool to detect long QT syndrome and Brugada syndrome, giving diagnostic clarity and opportunities for screening (Hertz et al. 2015). This systematic review aims to evaluate the clinical and resuscitative factors associated with survival in OHCA, and to synthesize autopsy-based findings in cases where the cause of death is initially undetermined.

2. Method

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Fig 1). We aimed to synthesize existing evidence regarding predictors of survival and outcomes following out-of-hospital cardiac arrest.

2.1. Search Strategy

A literature search was performed using databases PubMed, PubMed Central, Scopus, and Google Scholar to find relevant studies published between 2010 and 2024. Search terms included combinations of: out-of-hospital cardiac arrest, OHCA, survival predictors, long-term outcomes, bystander CPR, coronary angiography, and shockable rhythm. Additional articles were retrieved from manual reference screening of included studies.

Inclusion Criteria: Studies were eligible if reported original data on adult patients with OHCA; investigated predictors of survival, neurological outcome, or long-term survival; used cohort, case-control, observational, registry-based, or machine learning methodologies and were published in English. We exclude studies with pediatric or in-hospital cardiac arrest populations; case reports; editorials; or narrative reviews and studies did not report relevant outcomes

2.2. Data Extraction and Synthesis

Two reviewers extracted data into a structured table, including: study design, population characteristics, survival rates, predictors of survival, and clinical outcomes. Methodological quality was assessed using the Newcastle–Ottawa Scale (NOS). Findings were synthesized narratively due to heterogeneity in study designs and outcome measures.

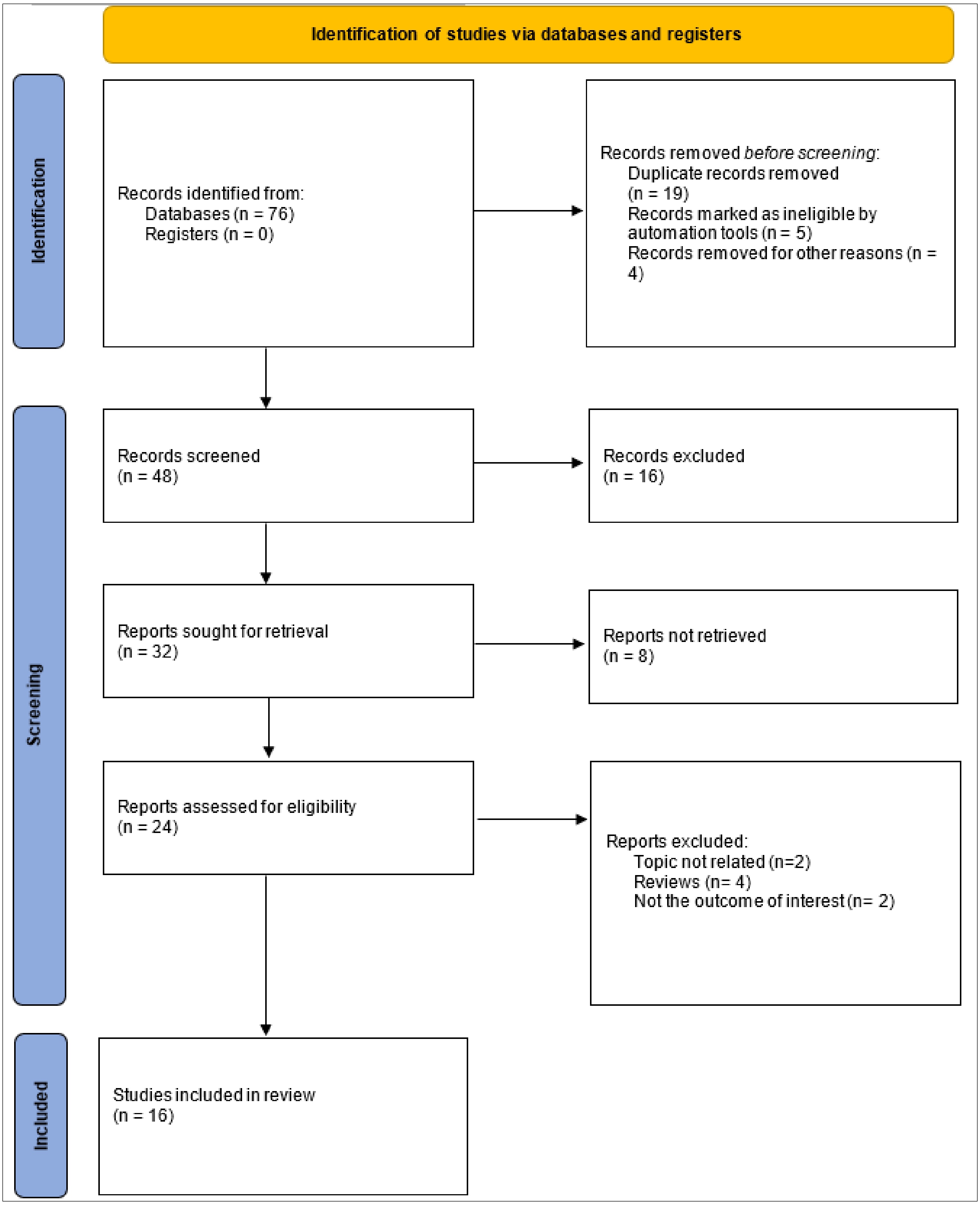

Figure 1 PRISMA consort chart of selected studies

3. Result and discussion

This systematic review analyzed 16 studies on OHCA (Fig 1), with various designs cohort studies, registry analyses, and machine learning approaches (Table 1). The studies provide insights into survival rates, predictors of survival, and patient outcomes following OHCA (Table 2).

3.1. Survival Rates

Survival rates following OHCA varied in studies. Elfwén et al. (2018) reported a 30-day survival rate of 67% in patients who received early coronary angiography, in comparison to 58% in those who did not. Geri et al. (2017) found a 5-year survival rate of 12.1% in patients who received bystander CPR. Ruch et al. (2019) noted a 1-year survival rate of 20.5% in their cohort. These findings were in line with broader meta-analyses for global survival rates to hospital discharge range from 7.6% to 13.3% in recent decades (Sasson et al. 2010; Yan et al. 2020).

3.2. Predictors of Survival

Several factors were associated with improved survival outcomes. Shockable initial rhythms, ventricular fibrillation or pulseless ventricular tachycardia, were predictors of survival (Al-Dury et al. 2020). Bystander CPR increased survival chances, as shown in studies by Geri et al. (2017) and Sasson et al. (2010). Early interventions, including defibrillation and coronary angiography, were linked to better outcomes (Elfwén et al. 2018). Machine learning approaches identified additional predictors, such as prior health conditions and EMS response times (Perry et al. 2024).

3.3. Outcomes

Long-term outcomes post-OHCA were favorable in survivors. Ruch et al. (2019) reported good quality of life in long-term survivors. Jentzer et al. (2018) found that left ventricular diastolic dysfunction was a predictor of in-hospital mortality, indicating the importance of cardiac function assessment post-resuscitation. Lauridsen et al. (2021) show that patients with OHCA had higher in-hospital mortality in comparison to those without, show the need for targeted post-arrest care.

Survival following OHCA is affected by a combination of factors, including initial cardiac rhythm, bystander intervention, and advanced medical care. Trials to improve public awareness and response, with optimized post-resuscitation care, were essential to improve outcomes for OHCA patients.

Table 1 Characteristics of the included studies

Citation	Study Design	Inclusion Criteria	Population Characteristics	Study Aim	Methodology
Mathipa et al., 2023	Cross-sectional autopsy study	100 sudden death cases autopsied at Madurai Medical College	Majority aged 40–60, mostly male	To identify histopathological cardiac changes in sudden deaths	Postmortem exam with heart tissue histopathology; common findings: atherosclerosis, infarction, myocarditis
Han et al., 2020	Retrospective case-control autopsy study	71 autopsy-confirmed sudden death cases with isolated MVP	Mean age 49, 51% women	To examine histopathology and arrest rhythm in iMVP sudden deaths	Compared cardiac mass and fibrosis with matched controls; 94% had VF as arrest rhythm
Edston, 2006	Cross-sectional forensic autopsy study	520 forensic autopsy cases	Mean age 56, 81% male	To assess link between earlobe crease and CAD/SCD	ELC, heart weight, coronary atherosclerosis evaluated; strong correlation found
Nugraha et al., 2021	Descriptive cross-sectional autopsy study	7 sudden cardiac death cases with histopathology over 5 years	Mostly elderly, 6/7 male	To describe histopathological causes of SCD in Indonesia	Coronary atherosclerosis, MI, and one aortic aneurysm rupture; no myocarditis or valve disease
Brooks et al., 2010	Prospective cohort study	Adults ≥20 years, non-traumatic OHCA of presumed cardiac cause, treated by EMS	9,667 patients, median age 68, 66.7% male	To evaluate temporal variability in OHCA frequency and outcomes	EMS data from 9 US/Canada sites, analyzed by time of day/week/month
Park et al., 2020	Observational cohort study	Survivors of OHCA treated with therapeutic hypothermia (TH)	100 patients, mean age 52, 80% male	To investigate the effect of Osborn waves during TH on recurrence of fatal arrhythmias	ECG analysis and 12-month follow-up for ICD shocks and survival
Perry et al., 2024	Population-based case–control study	OHCA cases and matched controls from UW medical records (2010–2021)	2,366 OHCA patients and 23,660 controls	To assess EHR data use for predicting OHCA	Machine learning applied to EHR data; predictors ranked by importance

				risk in general population	
Elfwén et al., 2018	Nationwide observational study	OHCA with shockable rhythm, unconscious, ST-elevation excluded	799 patients, 275 received early CAG	To evaluate if early coronary angiography improves survival in OHCA without STEMI	Compared early vs late/no CAG groups for 30-day and long-term survival
Søholm et al., 2021	Retrospective cohort study	OHCA due to AMI, treated at Danish heart centers (2007–2011)	292 patients, 27% received early ICD	To examine predictors and outcomes of early ICD implantation in OHCA survivors	Analyzed ICD therapy, survival outcomes, and predictors using multivariate analysis
Ruch et al., 2019	Mixed retrospective/prospective study	OHCA patients resuscitated by EMS Winterthur in 2013	88 patients, 14 survived to follow-up	To analyze survival, quality of life, and direct costs after OHCA	EMS protocol review and follow-up interviews using QoL questionnaires
Al-Dury et al., 2020	Machine learning analysis	OHCA cases in Sweden (2008–2016) with attempted CPR	45,067 patients, all EMS-attended OHCA	To assess importance of 16 predictors of OHCA survival	Applied machine learning to rank prehospital factors affecting survival
Holmgren et al., 2020	Autopsy and registry analysis	OHCA patients with no meds or hospital care in prior 2 years	781 patients, 16% women, 72% autopsied	To explore OHCA causes in patients presumed healthy before arrest	Autopsy reports and ECGs reviewed to determine causes
Geri et al., 2017	Retrospective cohort study	OHCA before EMS arrival, age ≥12, not in nursing facilities	4,448 patients, 539 survived 5 years	To assess survival and cost-effectiveness of bystander CPR	Linked EMS data and hospital cost registry to compute QALYs
Jentzer et al., 2018	Retrospective cohort study	OHCA patients who underwent TTE and TTM	173 patients, mean age 61.6, 72.7% male	To determine if LV diastolic dysfunction predicts	Echocardiographic measurements correlated with hospital outcomes

				mortality after OHCA	
Lauridsen et al., 2021	Nationwide retrospective cohort	First-time hospitalized MI-CS patients, with and without OHCA	3,107 patients, 979 with OHCA, median age 65 (OHCA)	To assess impact of OHCA on mortality and heart failure in MI-CS patients	Registry data analyzed using Cox models for hospital and 5-year outcomes
Tateishi et al., 2023	Retrospective observational study	Witnessed OHCA with initial shockable rhythm	86,495 patients; 22.2% had favorable neurological survival	To develop a decision tree model predicting neurological survival	Recursive partitioning analysis on national registry to identify key prehospital predictors

Table 2 OHCA Survival Predictors and Outcomes

Citation	Demographic Characteristics	Survival Rates	Predictors of Survival	Outcomes
Mathipa et al., 2023	Majority aged 40–60, mostly male	Not reported (autopsy-based)	Histopathological findings (atherosclerosis, infarction, myocarditis)	Atherosclerosis most common; useful for prevention and risk assessment
Han et al., 2020	Mean age 49; 51% women	All deceased; 94% had VF at arrest	Isolated MVP, cardiac mass, mitral annulus size, LV fibrosis	iMVP associated with increased risk of malignant arrhythmias and VF
Edston, 2006	Mean age 56; 81% male	All deceased (autopsy study)	Earlobe crease, age, BMI	ELC significantly correlated with CAD and sudden cardiac death, especially in men
Nugraha et al., 2021	Mostly elderly, 6/7 male	All deceased (autopsy-based)	Atherosclerosis, myocardial infarction, aneurysm rupture	Coronary atherosclerosis primary cause of SCD in Indonesian sample
Brooks et al., 2010	Median age 68; 66.7% male	Survival not reported; patterns varied by time	Time of day, day of week, location of arrest	Survival and bystander CPR rates varied seasonally and diurnally
Park et al., 2020	Mean age 52; 80% male	Not specified; ICD shock rate analyzed	Osborn waves on ECG during TH	Osborn waves linked to higher risk of fatal arrhythmia
Perry et al., 2024	No specific demographics (EHR data)	Not reported; model performance focused	Prior diagnoses, medications, healthcare utilization	ML model successfully stratified high-risk individuals

Elfwén et al., 2018	OHCA w/ shockable rhythm, no STEMI	30-day survival: 67% (early CAG) vs 58% (no CAG)	Early coronary angiography	Early CAG improved both short- and long-term survival
Søholm et al., 2021	Median age 63; 78% male	Survival to discharge ≈64%	Early ICD, shockable rhythm	Early ICD associated with improved long-term survival
Ruch et al., 2019	88 patients; 14 long-term survivors	1-year survival: 20.5%	Witnessed arrest, EMS delay, shockable rhythm	Long-term survivors reported good quality of life
Al-Dury et al., 2020	Median age 70; 70% male	Overall survival: 10.3%	Shockable rhythm, EMS delay, bystander CPR	ML model identified top survival predictors; rhythm was most important
Holmgren et al., 2020	Mean age 68; 16% women	All deceased (autopsy study)	Not applicable	Cardiac disease most common undiagnosed cause of OHCA
Geri et al., 2017	Median age 65; 68% male	5-year survival: 12.1%	Bystander CPR, EMS delay, initial rhythm	Bystander CPR improved survival and was cost-effective
Jentzer et al., 2018	Mean age 61.6; 72.7% male	In-hospital mortality: 45%	Diastolic dysfunction, age, comorbidities	LV diastolic dysfunction independently predicted mortality
Lauridsen et al., 2021	Median age 65 (OHCA group)	In-hospital mortality: 45% (OHCA) vs 27% (non-OHCA)	Presence of OHCA, age, comorbidities	OHCA associated with worse in-hospital and long-term outcomes
Tateishi et al., 2023	86,495 patients; national database	Neurological survival: 22.2%	Witnessed arrest, shockable rhythm, AED use	Decision tree stratified survival probability with high accuracy

List of abbreviations

- OHCA= Out-of-hospital cardiac arrest,
- CPR= Cardiopulmonary resuscitation,
- EMS= Emergency medical services,
- TH= Therapeutic hypothermia,
- ECG= Electrocardiogram,
- ICD= Implantable cardioverter-defibrillator,
- CAG= Coronary angiography, STEMI=
- ST-segment elevation myocardial infarction,
- AMI= Acute myocardial infarction,
- EHR= Electronic health record,
- TTE= Transthoracic echocardiography,
- TTM= Targeted temperature management,
- LV= Left ventricle,
- QoL= Quality of life,
- ML= Machine learning,
- PRISMA= Preferred Reporting Items for Systematic Reviews and Meta-Analyses,
- NOS= Newcastle–Ottawa Scale.

4. Conclusion

Histopathological findings from included studies indicate coronary atherosclerosis, myocardial infarction, and structural heart changes as an important cause of sudden cardiac death, show autopsy's role in identifying cardiac pathology and guide prevention strategies. We also find that that survival after OHCA is affected by several key factors, which include, initial cardiac rhythm, bystander CPR, early defibrillation, and timely coronary interventions. Studies showed improved outcomes in patients with shockable rhythms and those who received immediate bystander response. Machine learning and registry-based analyses indicate the significance of prehospital care, EMS response time, and individual clinical profiles as predictors of survival.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict-of-interest to be disclosed.

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