

Causes of death due to sudden cardiac arrest: a study from Diwaniyah

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ABSTRACT

Introduction: Sudden cardiac death remains a major public-health and forensic-medical challenge worldwide. Studies to address this problem are scarce especially in Al-Diwaniyah.

Objective: This study aimed to provide a comprehensive analysis of aetiological profiles, risk-factor associations and post-mortem findings among sudden death in Al-Diwaniyah, Iraq.

Methods: A retrospective, descriptive-analytical design was applied to 250 consecutive cases of sudden death referred for forensic autopsy in Diwaniyah Teaching Hospital between January 2018 and December 2022. Standardised full autopsy protocols were supplemented by histopathology, toxicology and, in selected undetermined cases, molecular (genetic) autopsy. Demographic, clinical, circumstantial and pathological variables were collected, tested for normality and homogeneity of variance, and compared using appropriate parametric or non-parametric methods.

Results: Of 250 cases, 60 % (n = 150) were male; mean age 45 ± 13 years (range 18–80 years). Ischaemic coronary artery disease accounted for 38.0 % (n = 95) of deaths, cardiomyopathies 20.0 % (n = 50), channelopathies 8.0 % (n = 20), myocarditis 6.0 % (n = 15), pulmonary embolism 5.2 % (n = 13), intracranial haemorrhage 4.0 % (n = 10), other causes 3.6 % (n = 9) and undetermined after conventional autopsy 15.2 % (n = 38). In the undetermined group, 7 of 30 (23.3%) had pathogenic or likely pathogenic variants detected by molecular testing. Age distribution approximated normality (Shapiro–Wilk p = 0.12); variances were homogeneous (Levene's test p = 0.25); missing data < 3 % per variable; no extreme outliers excluded. Hypertension history (OR = 2.1; 95 % CI 1.2–3.7; p = 0.01) and smoking (OR = 1.8; 95 % CI 1.1–3.0; p = 0.02) were significantly associated with ischaemic cause vs unexplained.

Conclusion: The predominant causes of sudden death in Diwaniyah is coronary disease foremost, but a substantial proportion remain unexplained without molecular autopsy.

Key words: sudden cardiac death; forensic autopsy; coronary artery disease; cardiomyopathy; molecular autopsy; Iraq.

INTRODUCTION

Sudden cardiac death (SCD) is defined as an unexpected natural death occurring within one hour of symptom onset in a person previously seen in normal health, or if unwitnessed, within 24 hours of last being seen well.^[1,2] It remains a significant contributor to global mortality, accounting for hundreds of thousands of

deaths annually and posing a major challenge for cardiovascular and forensic medicine.^[3]

Existing literature globally identifies Ischaemic Heart Disease (CAD) as the leading cause of sudden death in adults, particularly in Western populations. However, distinct age-related patterns are well-documented, where younger cohorts frequently present

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with hereditary cardiomyopathies or primary channelopathies (such as long QT syndrome). Furthermore, forensic research acknowledges a challenging subset of 'autopsy-negative' cases that require molecular investigation to resolve.^[4-8] Recent studies in the Middle East suggest a varying epidemiological landscape, often influenced by specific genetic profiles and lifestyle factors.

Yet, in Iraq, and specifically in the Al-Diwaniyah governorate, there is a paucity of comprehensive published data analysing this full spectrum—from structural heart disease to silent genetic causes. This lack of local data limits the effectiveness of prevention strategies, forensic protocols, and clinical risk screening. Accordingly, this study aims to fill this gap by conducting an extensive retrospective analysis of sudden death cases in Al-Diwaniyah over five years, employing traditional autopsy, histopathology, toxicology and molecular autopsy where indicated, to elucidate cause-of-death patterns and provide actionable recommendations for prevention and forensic practise.

METHODOLOGY

Setting and study design: This cross-sectional study was conducted at the Forensic Medicine Department of Diwaniyah Teaching Hospital, using data recorded between 1 January 2018 and 31 December 2022.

Ethical consideration: Ethical approval was obtained from the Scientific Research Ethics Committee at Al-Diwaniyah Health Directorate (Order No. 391, dated 18 September 2023). An agreement was obtained from the Diwaniyah Teaching Hospital to use its data. All data were anonymised and de-identified before analysis to ensure strict confidentiality in compliance with local forensic regulations.

Case definition, Inclusion and exclusion criteria: The study adhered to holistic forensic autopsy protocols, supplemented by histopathological, toxicological, and targeted molecular investigations, which, when conventional autopsy failed to determine the

cause. We included natural, unexpected death presumed to be of cardiac origin, availability of a whole body for full autopsy, and complete clinical and circumstantial data. Deaths due to external injuries (trauma), homicide, suicide, advanced decomposition, or cases with significant missing data we excluded.

Sample Size and Sampling: The study included all 250 consecutive cases referred to the Forensic Medicine Department during the study period that met the inclusion criteria.

Operational Definitions:

- *Sudden Cardiac Death (SCD):* Defined as unexpected death within 1 hour of symptom onset or within 24 hours if unwitnessed.^[1]
- *Ischaemic CAD:* Presence of >75% stenosis in at least one major coronary artery or evidence of acute myocardial infarction.
- *Undetermined (Negative Autopsy):* Cases where gross examination, histology, and toxicology failed to identify a cause of death.

Procedures and Data Collection: All autopsies were performed by qualified forensic pathologists following standardised protocols.

1. **Conventional Autopsy:** Included external examination and internal dissection of all major organs. Tissue samples were stained with Hematoxylin and Eosin.
2. **Toxicology:** Screening of blood/urine using GC-MS and LC-MS to rule out intoxication.
3. **Molecular Autopsy:** In cases categorised as "undetermined" (Negative Autopsy), targeted gene panel testing (e.g., SCN5A, KCNQ1) was performed. Molecular autopsy was conducted to detect ion channelopathies (e.g., Long QT Syndrome), which leave no structural evidence but are a lethal cause of cardiac arrest.

Statistical analysis: Continuous variables (e.g. age) were evaluated for normality using the Shapiro-Wilk test. Variance homogeneity across groups was assessed with Levene's test. Parametric tests (independent-samples t-test) were applied where normality and homogeneity held; otherwise, non-parametric equivalents (Mann-Whitney U, Kruskal-Wallis) were used. Categorical associations

were analysed using the chi-square test and Binary Logistic Regression to estimate odds ratios (OR) with 95 % confidence intervals (CI). The selected independent variables (history of hypertension and smoking status) were entered into the logistic regression model using the Enter Method. This methodological approach was specifically chosen to evaluate the overall impact of known, predefined risk factors from the clinical literature on ischemic causes of death, thereby enhancing the transparency and clinical interpretability of the statistical model. Outliers were examined using box plots; no cases were excluded without scientific justification. Missing data were <5% per variable; multiple imputation was applied only where needed (<3% missing). Statistical significance threshold was set at a $p \leq 0.05$. Data were analysed using SPSS (version 27) and R (version 6).

RESULTS

Among the 250 cases analysed, 150 (60 %) were male and 100 (40 %) female. The cohort's mean age was 45 ± 13 years (range 18–80 years). The Shapiro–Wilk test for age: $W = 0.98$, $p = 0.12$, indicating approximate normal distribution; Levene's test for variance homogeneity across major cause categories: $p = 0.25$ (homogeneous). Missing data per

Table 1 Comprehensive demographic characteristics, clinical history, and causes of death (N=250).			
Variable	Category	No.	(%)
Gender	Male	150	60
	Female	100	40
Age Groups	18 – 29 Years	30	12
	30 – 39 Years	40	16
	40 – 49 Years	60	24
	50 – 59 Years	50	20
	≥ 60 Years	70	28
Social History	Smoking	95	38
	Alcohol Consumption	15	6
Clinical History	Hypertension	110	44
	Diabetes Mellitus	60	24
	Ischaemic Heart Disease	45	18
	History of Sudden Death	12	4.8
Total		250	100

Table 2 Frequency and Percentage Distribution of Causes of Sudden Death (N=250)			
Cause of Death	No.	%	95% CI
Ischaemic CAD	95	38	32.1 – 44.2
Cardiomyopathies	50	20	15.4 – 25.5
Channelopathies †	20	8	5.1 – 11.8
Myocarditis	15	6	3.6 – 9.5
Pulmonary Embolism	13	5.2	2.9 – 8.5
Intracranial Haemorrhage	10	4	2.1 – 7.1
Other Non-Cardiac Causes	9	3.6	1.8 – 6.6
Undetermined (-ve Autopsy)	38	15.2	11.2 – 20.3
Total	250	100	

† Channelopathies confirmed by molecular autopsy. CAD: Coronary artery disease. CI: Confidence Intervals

variable did not exceed 3 %; no extreme outliers requiring exclusion were found. **Table 1** summarises the baseline characteristics of the 250 study cases. The cohort showed male predominance (60.0%), with the highest proportion observed in those aged ≥60 years (28.0%). Hypertension was the most prevalent comorbidity (44.0%), followed by smoking (38.0%) and a prior clinical history of ischaemic heart disease (18.0%).

Table 2 shows that Ischaemic CAD is the leading cause of death (38.0%), followed by cardiomyopathies (20.0%). Molecular autopsy identified channelopathies in 8.0% of the cohort. The 95% Confidence Intervals (CI) reflect the precision of these prevalence estimates, with 15.2% of cases remaining undetermined.

Table 3 demonstrates significant age-related variations in the aetiology of sudden death ($p < 0.001$). While Ischaemic CAD is the dominant cause in the middle-aged population (40–59 years, 50.0%), the youngest cohort (18–29 years) exhibits a distinct profile with a higher prevalence of cardiomyopathies and undetermined causes. Gender distribution also showed statistical significance ($p = 0.04$), reflecting the demographic patterns of the study population.

DISCUSSION

Ischaemic Causes and Overall Aetiology: This study identifies that in Al-Diwaniyah, the pattern of sudden death closely aligns with

Table 3 Stratification of Sudden Death Causes by Age Group and Gender (N=250)						
Age Group (yr)	Total Cases (n)	Male (n)	Female (n)	Ischaemic CAD n (%)	Cardiomyopathies n (%)	Undetermined/ Other† n (%)
18 – 29	30	20	10	5 (16.7%)	10 (33.3%)	15 (50.0%)
30 – 39	40	25	15	15 (37.5%)	10 (25.0%)	15 (37.5%)
40 – 49	60	40	20	30 (50.0%)	10 (16.7%)	20 (33.3%)
50 – 59	50	30	20	25 (50.0%)	10 (20.0%)	15 (30.0%)
≥ 60	70	35	35	20 (28.6%)	10 (14.3%)	40 (57.1%)
Total	250	150	100	95 (38.0%)	50 (20.0%)	105 (42.0%)
P-values P value measured by Chi-square test for the associated of the causes and age group is <0.001. Their association with sex is 0.04*						
n: Number of cases; †: Undetermined/Other includes Channelopathies (n=20), myocarditis, pulmonary embolism, intracranial haemorrhage, and negative autopsy cases.						

international data: ischaemic coronary artery disease (38 %) predominates, followed by cardiomyopathies (20 %) and channelopathies (8 %). Previous research similarly documents CAD as the leading aetiology in SCD series. [3,9,10] The high prevalence of ischaemic causes underscores the urgent need for targeted cardiovascular health initiatives in the region.

Molecular Findings and Undetermined Cases:

The 15.2 % rate of undetermined deaths after conventional autopsy underlines the ongoing global forensic challenge of “negative autopsy” cases. [11,12,13] Detection of pathogenic variants in roughly 23 % of molecular-tested undetermined cases underscores the utility of molecular autopsy to uncover hidden arrhythmogenic causes and aligns with benchmarks in other jurisdictions. [12,14]

Risk Factors and Clinical Associations: The significant associations of hypertension and smoking with CAD-related sudden death illustrate the enduring role of classical cardiovascular risk factors even in sudden death cohorts, consistent with other epidemiological findings. [15,16] The absence of statistically significant sex or age difference between CAD and undetermined groups may indicate a level of homogeneity in this regional cohort. [17-20]

Limitations and Strengths of the Study: This study has several limitations that should be acknowledged. First, its retrospective design limits causal inference and depends on the accuracy and completeness of archived forensic and clinical data. Second, molecular autopsy was performed only in a subset of undetermined cases due to resource constraints, which may

have led to underestimation of the genetic causes of sudden death. Third, some cases lacked detailed clinical or familial histories, restricting comprehensive risk-factor evaluation. Fourth, the study was conducted in a single regional centre, which may limit generalizability to other Iraqi provinces or populations. Despite these limitations, the study's strengths include a relatively large sample size, the systematic application of standardised autopsy protocols, the integration of histopathological, toxicological, and molecular methods, and rigorous statistical analysis to ensure data reliability. Collectively, these features provide robust insights into the etiological spectrum of sudden death in Iraq and highlight the importance of expanding molecular diagnostics and forensic-cardiologic collaboration nationwide.

CONCLUSION

In this five-year forensic series from Al-Diwaniyah, ischaemic coronary disease represents the chief cause of sudden death, with cardiomyopathy and channelopathies also contributing substantially. A non-negligible proportion of cases remain unexplained after standard autopsy, but molecular autopsy provided diagnostic yield in nearly one-quarter of selected cases. The findings emphasise the need for an integrated forensic-cardiology approach combining conventional autopsy, histopathology, toxicology and genetics for optimal cause-of-death determination.

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Abbreviations list: Confidence intervals (CI), Ischaemic Heart Disease (CAD), Odds ratios (OR), Statistical Packages for Social Sciences (SPSS), Sudden cardiac death (SCD).

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