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Original Research Article

Histopathological Changes in Sudden Cardiac Death: A Prospective Autopsy-Based Study at Bhopal Region.

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Abstract: Background: Cases of sudden cardiac death (SCD) and autopsy-revealed coronary artery lesions in central India have been reported in the literature. **Aim:** The purpose of this study was to assess cardiac histopathological lesions in sudden cardiac death and their correlation with age and sex. **Methods:** In this prospective autopsy study (01 March 2025–28 February 2026), a total of hundred sudden, non-traumatic deaths suspected to be cardiac were studied at Gandhi Medical College Bhopal. The heart and coronaries were examined grossly and histopathologically using standard parameters. **Results:** 73% of cases were males and half of cases aged 40-59 years. Among the participants, a significant 62% showed signs of coronary atherosclerosis, with a notable increase observed as age progressed. 46% had a myocardial infarction acute and/or healed and 35% had left ventricular hypertrophy. Myocarditis and cardiomyopathies together accounted for around 16% of cases, especially in youth. **Conclusion:** The major cause of SCD in this setting is coronary atherosclerosis which can or cannot have a myocardial infarction. Importantly, this is the case in middle-aged men. Myocarditis and cardiomyopathies are important minorities in younger victims. Carrying out systematic autopsy and histopathology is very important for establishing the cause of SCD. Thereby allowing an opportunity for implementing preventive measures.

Keywords: sudden cardiac death, autopsy, histopathology, coronary atherosclerosis, myocarditis

INTRODUCTION

Sudden cardiac death (SCD) is an important health issue worldwide. The majority of natural deaths happen due to sudden cardiac death. Usually, the death occurs in a healthy individual within a few hours of onset of first symptom and even without a prodromal symptom.[1] In low- and middle-income countries (LMIC) especially India, SCD in community is underreported and under-investigated. Systematic autopsy remains the gold standard to confirm the cause of SCD.[2] Various autopsy-based studies from India and other countries have shown cardiac causes to be the most common causes of sudden natural deaths. There was evidence of cardiovascular lesion in 60-70% cases of

SCD.[3,4]Coronary artery disease (CAD) and ischemic heart disease (IHD) are well-recognised as the most common substrates for SCD in adults, more particularly in middle-aged and older men.[2] Indian autopsy studies from different geographical regions have illustrated that coronary atherosclerosis and acute or healed myocardial infarction are the frequently found histopathological alterations in SCD. These studies have shown that the left anterior descending artery is the most commonly affected artery in SCD and that there is a strong link association between its involvement and increasing age.[3,5,6] Concurrently, non-ischemic lesions such as myocarditis and cardiomyopathies (dilated and hypertrophic) are important causes of SCD in younger individuals. SCD in younger individuals can be diagnosed only through careful gross and histopathological examination of the heart.[7,8] Internationally, the same pattern has been documented where coronary atherosclerosis and MI dominate the older age groups while myocarditis or cardiomyopathy contribute substantially in young SCD victims.[4].Owing to increasing burden of CVD in India, prospective autopsy based studies focusing on histopathological spectrum of cardiac lesions in SCD from central India are scarce. Gandhi Medical College, Bhopal, caters to a mixed urban–rural population of great size and receives a considerable number of sudden and unexpected deaths for medicolegal autopsy. This provides an opportunity for systematic studies of heart in GMCH. According to the Association for European Cardiovascular Pathology (AECVP), the recommended protocols for collaborative autopsy require comprehensive macroscopic and microscopic examination of the heart and coronary arteries, with specific sampling for ischemic and non-ischemic substrates. [1,5,6]In this regard, the present study was done to document the histopathological changes in the heart in cases of sudden cardiac death subjected to medicolegal autopsy over a period of one year at a tertiary care teaching hospital.

MATERIALS AND METHODS

Study design and setting

This was a prospective, autopsy-based observational study conducted in the Department of Forensic Medicine and Toxicology in collaboration with the Department of Pathology at Gandhi Medical College, Bhopal, Madhya Pradesh, India. All medicolegal autopsies were performed as per prevailing legal requirements, institutional protocols and standard forensic procedures.

Study period and sample size

The study included cases from 01 March 2025 to 28 February 2026 (one year). A total of 100 cases meeting the inclusion criteria and in which the heart was available and suitable for detailed gross and histopathological examination were included.

Inclusion criteria

- Sudden, unexpected, non-traumatic deaths brought for medicolegal autopsy, in which death was suspected to be of cardiac origin based on history, circumstances and/or preliminary autopsy findings
- Adolescents and adults (≥15 years), of both sexes
- Cases with intact hearts permitting complete gross and microscopic evaluation

Exclusion criteria

- Deaths due to obvious external causes such as major trauma, hanging, drowning, burns, poisoning or firearm injuries
- Advanced decomposition precluding meaningful cardiac examination
- Incomplete records or inadequate cardiac tissue samples

Data collection

For each case, the following data were recorded from inquest papers, hospital records (where available) and relatives' statements:

- Age and sex
- Circumstances and place of death (home, workplace, transit, hospital)
- History of known cardiovascular risk factors or comorbidities (hypertension, diabetes, known IHD, cardiomyopathy) where documented
- Time interval between onset of symptoms (if any) and death

Autopsy procedure and gross examination

Autopsies were performed using a standard protocol similar to that recommended in contemporary guidelines on autopsy practice in SCD. The thoracic cavity was opened, and the heart was removed en bloc with a portion of the great vessels. After measurement of heart weight and external inspection, the heart was dissected using an inflow–outflow and short-axis ventricular slicing technique. The following gross features were systematically assessed:

Chamber sizes and wall thickness, including left ventricular, right ventricular and interventricular septal thickness Coronary artery anatomy, presence and location of atherosclerotic plaques, stenosis, calcification, and thrombosis

Evidence of acute or healed myocardial infarction, areas of pallor, haemorrhage, thinning or scarring Valvular morphology and any observable myocardial or pericardial abnormality

Histopathological examination

Representative tissue blocks were taken from:

- Proximal segments of left anterior descending, left circumflex and right coronary arteries
- Anterior, lateral and posterior walls of the left ventricle, interventricular septum and right ventricle
- Any grossly abnormal areas (suspected infarct,

scars, focal lesions)

Conduction system regions (e.g., atrioventricular node region) in selected cases when feasible Tissues were fixed in 10% neutral buffered formalin, processed routinely, embedded in paraffin, sectioned at 3–5 µm and stained with hematoxylin and eosin. Special stains (such as Masson's trichrome, elastic stains and others) were used where indicated to better characterise fibrosis, vascular changes or other specific lesions.[10]

Operational definitions

Significant coronary atherosclerosis: luminal narrowing ≥75% in at least one major epicardial coronary arteryAcute myocardial infarction: coagulative necrosis of myocytes with loss of nuclei and striations, associated with acute inflammatory infiltrate and early granulation tissue, consistent with accepted temporal criteria Healed myocardial infarction: replacement of normal myocardium by fibrous scar tissue with or without thinning of the ventricular wall Myocarditis: inflammatory infiltrates with associated myocyte necrosis consistent with established histological criteria

Cardiomyopathy: structural myocardial abnormality (e.g., hypertrophic or dilated pattern) not entirely attributable to ischemic or valvular disease

Statistical analysis

Data were entered into a spreadsheet and analysed using appropriate statistical software. Categorical variables were expressed as frequencies and percentages. Continuous variables were summarised as mean and standard deviation or median and interquartile range as appropriate. Associations between histopathological lesions and age or sex were examined using chi-square or Fisher's exact test, with $p<0.05$ considered statistically significant.

RESULTS

Table 1: Age and sex distribution of cases (n=100)

Age group (years)	Male n (%)	Female n (%)	Total n (%)
15–29	10 (10)	4 (4)	14 (14)
30–39	14 (14)	5 (5)	19 (19)
40–49	20 (20)	6 (6)	26 (26)
50–59	18 (18)	6 (6)	24 (24)
≥60	11 (11)	6 (6)	17 (17)
Total	73 (73)	27 (27)	100 (100)

Most victims of sudden cardiac death were male (73%), and the majority belonged to the 40–59 years age group, with a mean age in the mid-40s to early 50s.

Table 2: Major histopathological lesions in the heart (n=100) – cases may have multiple lesions

Histopathological finding	n (%)
Significant coronary atherosclerosis	62 (62)
Acute myocardial infarction	28 (28)
Healed myocardial infarction / scar	18 (18)
Left ventricular hypertrophy (LVH)	35 (35)
Myocarditis	8 (8)
Dilated cardiomyopathy	5 (5)
Hypertrophic cardiomyopathy	3 (3)
Valvular heart disease	4 (4)
Others (pericarditis, conduction lesion, etc.)	5 (5)

Table 3: Distribution of significant coronary atherosclerosis by age group (n=100)

Age group (years)	Cases with significant coronary atherosclerosis n/N (%)
15–29	1/14 (7.1)
30–39	8/19 (42.1)
40–49	18/26 (69.2)
50–59	20/24 (83.3)
≥60	15/17 (88.2)

Significant coronary atherosclerosis was present in 62% of cases, and its prevalence increased with age, being highest in those aged ≥50 years. Acute and/or healed myocardial infarction was documented in 46% of cases. **Left ventricular** hypertrophy was observed in 35%, and non-ischemic myocardial lesions (myocarditis and cardiomyopathies) were

identified in approximately 16% of cases, particularly among younger individuals.

DISCUSSION

According to this prospective autopsy-based study from a tertiary centre in Central India, SCD was more common in males in the age group of 40–59 years.[6] This trend has been reported by various autopsy series in India. As per one article the majority of sudden death patients with cardiac lesions were males in the 40–60-year bracket.[2] On the other hand, another article also reported male predominance and clustering in the middle age in SCD hearts. The South Gujarat cohort of sudden natural death also showed that cardiovascular causes predominated in middle-aged men.[3] Thus, all these articles taken together show that premature SCD is a bigger burden in Indian men and is probably due to a combination of lifestyle factors and the high prevalence of risk factors like hypertension and diabetes, not-to-mention late access to cardiac care.[5]The major fitting we observe in this study is that most SCD (sudden cardiac death) hearts present with significant coronary atherosclerosis. In fact, two-thirds of these SCD hearts have significant coronary atherosclerosis. In addition, a major proportion has acute or healed myocardial infarction as well. This strengthens the key position of CAD and IHD as the main substrates of SCD among this population, in concurrence with earlier autopsy studies from India and abroad. According to Mathipa et al.[1], atherosclerosis was the most common lesion in their cohort from Madurai, with critical narrowing of one or more major coronary arteries, most often the LAD. SCD was also frequently associated with myocardial infarction. Moreover, it was reported that acute, old and mixed infarcts together constituted the majority of cases of SCD in their series of autopsies of three years, reflecting the pre-dominance of ischemic heart disease. The main cardiovascular cause of sudden death, identified by the South Gujarat study, was coronary atherosclerosis and MI. Outside India, the autopsy experience in Bandung similarly found CAD to be the most common cause of SCD. In the 7-age group, the most common cause of SCD is CAD, 8 Age-wise there are differences in SCD due to CAD.[3]According to our data, there is an unmistakable and clear age-related gradient such that the prevalence of significant coronary atherosclerosis increases from approximately 7% in less than 30-year-olds to more than 80% in those aged 50 years and older. This also corroborates with other autopsy studies being a positive correlation between coronary block and age. Paswan MK et al. noted in their [6] study on sudden cardiac death that the presence of coronary artery disease is well recognized, especially among individuals aged 40 years and older. Likewise, Godbole S et al.[7] noted that the most common age for cardiac lesions is 41-50 years, with a predominance of atherosclerosis and multivessel disease. According to Agale SV, et al [9], severe multivessel coronary disease was the most common finding in victims of sudden cardiac death at a tertiary health care centre. The similar findings support the idea that progressive coronary atherosclerosis, usually in the context of uncontrolled risk factors, is the main cause of SCD in middle-aged and older people.Around one-third of cases in our series had left ventricular hypertrophy, often in the presence of significant coronary atherosclerosis and infarction, pointing to a potential history of long-standing hypertension and/or combined pressure–ischemic load. Various studies on autopsy in India have reported somewhat similar finding, that is hypertrophy of the myocardium is commonly found in the SCD heart. According to Mathipa et al.[1], myocardial hypertrophy occurs in some cases of SCD with CAD. Godbole S et al,[7] author of a research paper, found myocardial hypertrophy in one-fifth cases of sudden death. Also, Agale SV, et al[9] author a study where they emphasis that hypertrophy in combination with IHD increases risk of malignant arrhythmias and sudden death. So, that's why that's one of the important finding of the present study. Collectively, these data highlight the importance of effective detection and control of hypertension as an SCD prevention strategy.In our study, an important minority of SCD cases arise from non-ischemic myocardial diseases, notably myocarditis and cardiomyopathies, especially in younger adults. Around 8% of the hearts had myocarditis, which is consistent with previous Indian and global autopsy studies. According to Mahapatra et al.[2], myocarditis was reported in a smaller proportion of their SCD hearts. On the other hand, Agale SV, et al [9] reported myocarditis and combined myocarditis–pericarditis in relatively 15% of cases. Paswan MK, et al. also recognized myocarditis and cardiomyopathies as important causes of SCD, particularly in the Indian scenario. According to Mahapatra et al.[2], cardiomyopathy is the second most common underlying cardiac lesion after IHD, and hypertrophic and dilated cardiomyopathies are well described causes of SCD.Our findings and the reports quoted above suggest that a careful gross and microscopic examination is necessary to detect non-ischemic causes of SCD, especially when coronary arteries are normal or show only mild disease.

In some cases of ours, no structural cardiac lesion could be established despite in-depth investigations, and the heart appeared normal or showed just non-specific changes. Our sample has a rate of unexplained or SCDs with structurally normal hearts in line with those found in the study by Mahapatra et al.[2] Agale SV et al [9] and others, so 14 – 22%. According to the position paper of AECVP, these cases should always be considered sudden arrhythmic death syndrome and inherited arrhythmogenic conditions, and a complete autopsy (preferably toxicology and histology) must be combined post-mortem genetic testing and family screening (if possible). The need for developing cardiogenetic autopsy pathways in India along with histopathology has been highlighted by this approach, especially in younger victims.

CONCLUSION

Coronary atherosclerosis, often with acute or healed myocardial infarction, emerged as the leading cause of sudden cardiac death in this central Indian cohort, especially among middle aged men. Left ventricular hypertrophy was frequent and commonly coexisted with CAD, indicating a major role of long standing hypertension. Myocarditis and cardiomyopathies contributed a smaller but important share of SCD, particularly in younger individuals, highlighting the need to consider non ischemic causes when coronaries are normal.

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