Section: Pathology

Original Research Article

CARDIAC LESIONS IN SUDDEN DEATH: INSIGHTS FROM AUTOPSY AND HISTOPATHOLOGICAL ANALYSIS

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Abstract

Background: Sudden death, defined by the WHO as unexpected fatality within 24 hours, poses challenges in medicine and forensic science. Coronary heart disease (CHD), prevalent worldwide, is a common cause of sudden death, particularly in middle-aged and older adults. Understanding the cardiovascular system's role in sudden death is vital. CHD, marked by coronary artery narrowing due to atherosclerosis, is a primary contributor to sudden and unexpected cardiac deaths. This study investigates the cardiac, coronary, and aortic pathology in autopsy cases linked to sudden death, shedding light on its complex nature. **Materials and Methods:** This retrospective observational study investigated sudden deaths using archived autopsy cases (June 2016 to May 2021) from a North Indian tertiary care hospital. Cases adhered to the WHO's sudden death definition, encompassing various ages and backgrounds, irrespective of pre-existing conditions. Detailed clinical histories, medical records, and witness statements informed case selection. Forensic pathologists followed rigorous protocols for external and internal examinations, focusing on the heart, lungs, and major blood vessels. Histopathological analysis involved standardized tissue processing and Hematoxylin and Eosin staining. Radiological imaging and data analysis were also incorporated for a comprehensive assessment. **Result:** In our study of 108 sudden death autopsy cases, cardiac lesions were present in 52.8% of cases. The majority of cases were in the 41-60 age group (42.1%), with males comprising 63.2%. Hypertension was common among those with coronary heart disease (73.5%). Atherosclerosis (70.2%) and myocardial infarction (45.6%) were the leading histopathological findings. Valvular abnormalities (24.6%) and myocarditis (10.5%) were also observed. Three-vessel involvement was frequent in atherosclerosis cases (45.0%), with the LCA being most affected (50.0%). Radiological findings included an enlarged heart in 40.0% of CT scans and coronary artery abnormalities in 26.7%. Angiography showed similar trends with an enlarged heart (50.0%) and coronary artery abnormalities (25.0%). **Conclusion:** In conclusion, our study provides critical insights into the pathology of the heart, coronaries, and aorta in autopsy cases with a history of sudden death. CHD emerged as a prevalent and significant comorbidity, emphasizing the need for early detection and intervention. Clinical risk factors, gross findings, and histopathological analyses highlighted the complex interplay of factors contributing to sudden death.

INTRODUCTION

Sudden death, as defined by the World Health Organization (WHO), is a catastrophic event characterized by an unexpected and rapid fatality within 24 hours of symptom onset, often occurring outside of a hospital or healthcare setting (10% of all deaths).[1] This phenomenon presents a profound challenge to the fields of medicine, forensic science, and society as a whole. The inexplicable nature of sudden death not only shatters families emotionally but also confounds healthcare providers and forensic experts.[2] Understanding the underlying pathologies, contributory factors, and potential preventive strategies surrounding these events is not only a matter of scientific interest but also carries significant implications for public health and clinical practice.[3] The prevalence of coronary heart disease is staggering, with millions of individuals affected worldwide (25% of deaths in India with less than 1% worldwide).[4] It is a condition that often manifests in middle-aged and older adults, although it can occur

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at younger ages. The age group most commonly associated with CHD comprises individuals aged 40 and above.[5] However, it is important to note that CHD can, on occasion, affect younger individuals due to genetic predispositions, lifestyle factors, or other underlying health conditions.[4,5]

Central to the investigation of sudden death is an in-depth examination of the cardiovascular system, with a specific focus on the heart, coronary arteries, and aorta. These components constitute a complex network responsible for maintaining essential blood circulation throughout the human body.[6] Dysfunctions or pathologies within this system can precipitate various cardiac events, including sudden death. Globally, coronary heart disease (CHD) stands as the leading cause of sudden death (80% of sudden and unexpected cardiac deaths). CHD is a condition characterized by the narrowing of coronary arteries, typically due to the buildup of atherosclerotic plaques, which impairs blood flow to the heart muscle.[7,8] Our study was conducted with an aim to explore the pathology found within the heart, coronary arteries, and aorta in autopsy cases associated with a history of sudden death.

MATERIALS AND METHODS

Study Design and Case Selection: This retrospective observational study among autopsy cases (experienced sudden death), who were painstakingly selected from the archives of the Forensic Pathology Department at tertiary care hospital of North India over a specific timeframe spanning from June 2016 to May 2021. Cases were included if they met the World Health Organization's (WHO) definition of sudden death, characterized by an unanticipated and rapid fatality occurring within 24 hours of symptom onset. Individuals of all ages and backgrounds were considered for inclusion to ensure a comprehensive representation of the population. Cases were included without discrimination based on pre-existing medical conditions or comorbidities. This inclusive approach aimed to capture the full spectrum of cardiovascular pathologies associated with sudden death, irrespective of pre-existing health status. Cases with comprehensive clinical histories, available medical records, witness statements, and relevant medical information were selected to facilitate a thorough analysis.

Data Collection

Clinical Data: Thorough clinical histories were gathered for each case, drawing from a variety of sources, including medical records, witness statements, and available medical information. These comprehensive histories encompassed patient demographics, past medical conditions, medication usage, lifestyle factors (such as smoking and alcohol consumption), and any pertinent clinical events leading up to the sudden death.

Autopsy Procedures: The autopsy procedures employed in this research study adhered to rigorous forensic and pathological protocols to ensure the highest standards of investigative practice. External Examination: The process commenced with a thorough external examination of the deceased individuals. Skilled forensic pathologists meticulously assessed the external features for any visible signs of trauma, injury, or external anomalies that could offer initial insights into the cause of sudden death. This included the examination of the skin, body habitus, and any external signs of cardiac events such as cyanosis or petechiae. Internal Examination: Following the external examination, an internal examination was conducted. This involved a careful and systematic dissection of the chest cavity to access and evaluate the internal organs, including the heart, lungs, and major blood vessels. The pericardium was opened to expose the heart, facilitating a detailed examination of its morphology and size. Cardiac Examination: The heart was meticulously examined to identify gross abnormalities, including hypertrophy, dilatation, congenital defects, or structural anomalies. The coronary arteries and their branches were carefully inspected for signs of stenosis, occlusion, or thrombosis. The presence of any pericardial effusion or cardiac tamponade was noted. Histological Sampling: During the autopsy, targeted tissue samples from the heart, coronary arteries, and aorta were procured for subsequent histopathological analysis. These samples were acquired following standardized protocols to ensure accurate representation of the regions of interest.

Histopathological Examination: Histopathological examination played a pivotal role in this study, offering detailed insights into the microscopic pathology of the cardiovascular structures in the examined cases. Tissue Processing: Tissue samples collected during the autopsy, specifically from the heart, coronary arteries, and aorta, underwent a series of processing steps. After collection, the samples were fixed in formalin, preserving their structural integrity. They were then processed, embedded in paraffin blocks, and sectioned to produce thin tissue slices for microscopy. Hematoxylin and Eosin (H&E) Staining: Histopathological analysis primarily employed hematoxylin and eosin (H&E) staining, a standard staining technique used to visualize cellular and tissue structures under the microscope. This staining method allowed for the identification of various pathological changes within the examined tissues. Identification of Pathological Findings: Skilled pathologists examined the stained tissue sections under a microscope. They meticulously assessed the cardiac muscle, coronary arteries, and aortic wall for a wide range of pathological findings, including but not limited to: Atherosclerosis: Evaluation of the extent and severity of atherosclerotic plaques within the coronary arteries; Myocardial Infarction: Identification of myocardial infarction or areas of cardiac muscle damage;

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Myocarditis: Detection of inflammatory changes or myocardial inflammation; Valvular Disorders: Assessment of heart valve abnormalities, including stenosis or regurgitation; and Other Cardiac Pathologies: Identification of additional cardiac pathologies, such as cardiomyopathies or congenital defects. Grading and Documentation: Pathologists graded the severity and extent of any identified pathological findings using established criteria. Detailed documentation of these findings, including their location and extent within the examined tissues, was systematically recorded.

Radiological Imaging: In select cases, advanced imaging modalities such as computed tomography (CT) scans and angiography were employed to enhance the understanding of cardiovascular anatomy and potential pathologies. These radiological findings were integrated with autopsy data to provide a comprehensive and multidimensional analysis.

Data Analysis: The data obtained from clinical histories, autopsy examinations, histopathological reports, and radiological imaging were subjected to rigorous and systematic analysis. Descriptive statistics were employed to summarize demographic characteristics, clinical histories, and pathological findings.

Ethical Considerations: This research study meticulously adhered to ethical principles articulated in the Declaration of Helsinki. Formal approval was sought and obtained from the Institutional Ethics and Review Board (IERB). In strict adherence to ethical standards, all data used in this study were de-identified and anonymized to ensure the utmost confidentiality and protection of patients' privacy.

RESULTS

In our study, a total of 108 Autopsy Cases with Sudden Death were examined and 57 cases showed cardiac lesions (52.8%). The age distribution of the cases revealed a varied representation, with the majority falling within the 41-60 years category (42.1%), followed by the 21-40 years group (20.4%). A smaller proportion of cases were observed in the 0-20 years (14.0%) and 61+ years (17.5%) age groups. The mean age of the study population was 55.3 years (± 12.6 standard deviation). In terms of gender distribution, the study cohort predominantly consisted of males, accounting for 63.2% of the cases, while females represented 36.8% [Table 1].

Among the 57 cases, 34 (59.6%) exhibited hypertension, with 17 (29.8%) having diabetes. Smoking was prevalent in 26 cases (45.6%), while 11 cases (19.3%) reported alcohol use. In the context of coronary heart disease (CHD) comprising 34 cases (59.6%), hypertension was prominent, affecting 25 cases (73.5%), alongside 13 (38.2%) cases with diabetes. Smoking was identified in 20 cases (58.8%), and 5 (14.7%) cases reported alcohol use. In the subset of individuals with a history of myocardial infarction (20 cases, 35.1%), 18 (90.0%) had hypertension, 5 (25.0%) had diabetes, and 6 (30.0%) were smokers, with 2 (10.0%) reporting alcohol use. Valvular disorders were observed in 15 cases (26.3%), with 9 (60.0%) having hypertension, 5 (33.3%) having diabetes, 7 (46.7%) being smokers, and 4 (26.7%) reporting alcohol use. In the subgroup of individuals with other cardiac pathologies (8 cases, 14.0%), 6 (75.0%) had hypertension, 3 (37.5%) had diabetes, 4 (50.0%) were smokers, and 2 (25.0%) reported alcohol use [Table 2].

Notably, 23 cases (40.4%) exhibited an enlarged heart. Among these cases, left ventricular hypertrophy (LVH) was observed in 15 cases (65.2%), while right ventricular hypertrophy (RVH) was identified in 5 cases (21.7%). Interestingly, a subset of individuals displayed both LVH and RVH, accounting for 3 cases (13.0%). Regarding pericardial effusion, 14 cases (24.6%) were found to have its presence, while 43 cases (75.4%) showed an absence of pericardial effusion [Table 3].

The histopathological examination, as outlined in [Table 4], unveiled critical findings within our study cohort. Atherosclerosis emerged as a prevalent condition, affecting 40 cases (70.2%). Myocardial infarction was also notably prevalent, identified in 26 cases (45.6%), underscoring its significance within the study population. Furthermore, myocarditis was observed in 6 cases (10.5%), while valvular abnormalities were present in 14 cases (24.6%).

One of the hallmark features in acute on chronic IHD is the presence of myocardial infarction. MI is characterized by the death of heart muscle tissue (myocardium) due to the insufficient blood supply, typically caused by the occlusion of coronary arteries. Under H&E staining, areas of infarcted myocardium appeared pale and eosinophilic (pink) due to cell death and the loss of cellular structure. Infiltration of inflammatory cells, such as neutrophils and macrophages, was also observed, indicating the acute phase of infarction [Figure 1 A]. Histopathologically, LVH was characterized by the thickening of the left ventricular wall due to the enlargement of cardiomyocytes. Under H&E staining, hypertrophied cardiomyocytes displayed increased cytoplasmic eosinophilia and larger, more prominent nuclei. The arrangement of myofibrils was altered, and interstitial fibrosis were present [Figure 1B].

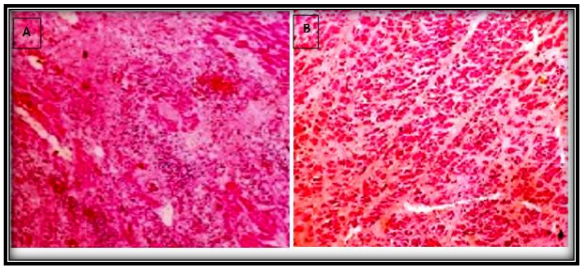

Figure 1. A: Acute on chronic ischaemic heart disease. B: Myocardial hypertrophy.

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Among the total of 40 cases, three-vessel involvement was observed in 18 cases (45.0%), with the left coronary artery (LCA) being affected in 10 cases (25.0%), the right coronary artery (RCA) in 5 cases (12.5%), and the left anterior descending artery (LADA) in 3 cases (7.5%). Two-vessel involvement was noted in 12 cases (30.0%), with 6 cases (15.0%) affecting the LCA, 4 cases (10.0%) involving the RCA, and 2 cases (5.0%) affecting the LADA. Single-vessel involvement was identified in 10 cases (25.0%), with 4 cases (10.0%) affecting the LCA, 3 cases (7.5%) involving the RCA, and 3 cases (7.5%) affecting the LADA [Table 5].

Atherosclerosis only was the most prevalent type, affecting 15 cases (37.5%). Atherosclerosis with calcification was identified in 10 cases (25.0%), while atherosclerosis with hemorrhage was present in 8 cases (20.0%). Atherosclerosis with thrombosis was observed in 7 cases (17.5%) [Figure 2].

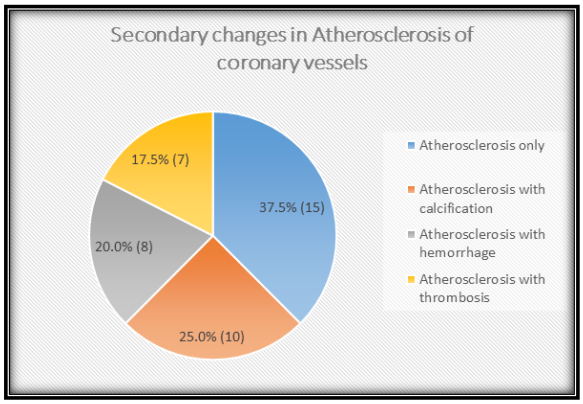

Figure 2: Secondary changes in Atherosclerosis of coronary vessels.

Within the affected coronary arteries, organized thrombi were identified. Organized thrombi represent the body's response to atherosclerotic plaque rupture or erosion. Over time, the initial thrombus undergoes a process of organization, where fibrin and platelets become infiltrated with inflammatory cells and fibrous tissue. In addition to organized thrombus, recanalization was evident. Recanalization is a dynamic process where new blood vessels form within or around the thrombus, potentially restoring blood flow to the affected area. It signifies the body's attempt to reestablish perfusion in response to the occlusion caused by the thrombus. This finding suggests a complex interplay between thrombotic events and the body's compensatory mechanisms. Pathologic calcification was also associated with the complicated atherosclerotic lesions. Calcification within the atherosclerotic plaques is a common feature and often represents advanced stages of atherosclerosis. Pathologic calcification can contribute to plaque stability but can also limit vessel flexibility and impede blood flow [Figure 3 A]. Additionally, within the left anterior descending coronary artery (LADA), atherosclerotic changes were observed, with luminal stenosis graded as Grade IV. Grade IV stenosis indicates a significant narrowing of the artery lumen due to the buildup of atherosclerotic plaque. This degree of luminal stenosis can substantially impede blood flow, potentially leading to ischemic cardiac events [Figure 3 B].

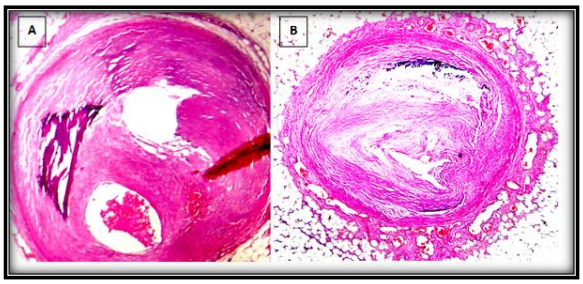

Figure 3: A: Complicated atherosclerosis. B: Atherosclerotic changes in Left anterior descending coronary artery.

Among the cases that underwent CT scans (n=15), 6 cases (40.0%) exhibited an enlarged heart, emphasizing the importance of this diagnostic marker in identifying cardiac pathology. Furthermore, 4 cases (26.7%) showed abnormalities in the coronary arteries, highlighting the value of CT scans in detecting structural cardiac issues. In the subset of cases that underwent angiography (n=12), 6 cases (50.0%) displayed an enlarged heart, corroborating the significance of this radiological marker. Additionally, 3 cases (25.0%) presented with coronary artery abnormalities, further underlining the utility of angiography in identifying cardiac-related abnormalities [Table 6].

Table 1: Demographic Characteristics of Autopsy Cases with Sudden Death (N=57).

Demographic Variable	Frequency (n)	%
Age Groups		
0-20 years	8	14.0
21-40 years	15	20.4
41-60 years	24	42.1
61 or more years	10	17.5
Mean age (in years)	55.3 ± 12.6	
Gender		
Male	36	63.2
Female	21	36.8

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Table 2: Clinical History and Risk Factors (N=57).

Clinical Variables	Frequency (n)	Hypertension	Diabetes	Smoking	Alcohol Use
Total	57 (100.0)	34 (59.6)	17 (29.8)	26 (45.6)	11 (19.3)
Coronary Heart Disease	34 (59.6)	25 (73.5)	13 (38.2)	20 (58.8)	5 (14.7)
Myocardial Infarction	20 (35.1)	18 (90.0)	5 (25.0)	6 (30.0)	2 (10.0)
Valvular Disorders	15 (26.3)	9 (60.0)	5 (33.3)	7 (46.7)	4 (26.7)
Other Cardiac Pathology	8 (14.0)	6 (75.0)	3 (37.5)	4 (50.0)	2 (25.0)

Table 3: Gross Findings in Autopsy Cases (N=57).

Anatomical Structures	Frequency	%
Enlarged Heart	23	40.4
Left Ventricular Hypertrophy (LVH)	15	65.2
Right Ventricular Hypertrophy (RVH)	5	21.7
Both LVH and RVH	3	13.0
Pericardial Effusion		
Present	14	24.6
Absent	43	75.4

Table 4: Histopathological Findings (N=57).

Histopathological Findings	Frequency	%
Atherosclerosis	40	70.2
Myocardial Infarction	26	45.6
Myocarditis	6	10.5
Valvular Abnormalities	14	24.6

Table 5: Atherosclerosis in Coronary Vessels.

Type of Coronary Vessels Involved	Total	LCA	RCA	LADA
Three Vessels	18 (45.0)	10 (25.0)	5 (12.5)	3 (7.5)
Two Vessels	12 (30.0)	6 (15.0)	4 (10.0)	2 (5.0)
Single Vessel	10 (25.0)	4 (10.0)	3 (7.5)	3 (7.5)
Total	40 (100.0)	20 (50.0)	12 (30.0)	8 (20.0)

LCA: Left Coronary Artery, RCA: Right Coronary Artery, LADA: Left Anterior Descending Artery

Table 6: Radiological Findings (for cases with imaging data).

Radiological Findings	Frequency	%
CT Scan (n=15)		
Enlarged heart	6	40.0
Coronary artery abnormalities	4	26.7
Angiography (n=12)		
Enlarged heart	6	50.0
Coronary artery abnormalities	3	25.0

DISCUSSION

The investigation into the pathology of the heart, coronaries, and aorta in autopsy cases with a history of sudden death provides valuable insights into the underlying factors contributing to this enigmatic phenomenon. Sudden death, as defined by the World Health Organization (WHO), is the unexpected demise of an individual within 24 hours of the onset of symptoms, where the cause of death is often cardiac in origin.[1] In the context of our study, we sought to unravel the intricate relationships between various cardiovascular pathologies and the occurrence of sudden death, shedding light on the prevalence, age distribution, and risk factors associated with these conditions.

Prevalence of Coronary Heart Disease (CHD): WHO identifies CHD as a condition characterized by the narrowing or blockage of the coronary arteries, which can result in myocardial infarction (MI).[2] Our findings indicate that a substantial proportion (approximately 60%) of the autopsy cases in our study exhibited CHD as a significant comorbidity. Notably, CHD was identified in a majority (52.8%) of cases with a history of myocardial infarction, highlighting the intimate relationship between these conditions. This observation aligns with the well-established association between CHD and sudden cardiac events.[3] Yazdi et al., reported a prevalence of 40%,[9] while Golshahi et al., found a prevalence of 28.9%.[10] Dhruva et al., observed a prevalence of 23.3%.[11] Additionally, Mukhopadhyay et al., reported a prevalence of 50.0%.[2] Sonawane et al., documented a high prevalence of 87.90%.[1] Coronary heart disease (CHD) remains a prominent cause of sudden death globally, with prevalence rates ranging from 50% to 100% in various studies such as Nichol et al., Chugh et al., Byrne et al., de Vreede-Swagemakers et al., and Hua et al., all contributed to our understanding of the prevalence of CHD as a significant contributor to sudden death.[6,12-15]

Gender and Age Distribution of CHD: Examining the age distribution of CHD within our cohort, we observed a notable prevalence in individuals aged 41-60 years. This demographic is in line with global trends, as CHD predominantly affects middle-aged and older individuals [4]. Importantly, our study underscores the importance of recognizing the

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potential risks of CHD in younger populations as well, as we identified cases of CHD in individuals as young as 21 years old. This finding emphasizes the critical need for early detection and intervention strategies aimed at preventing premature deaths due to CHD. Mukhopadhyay et al., reported that 72 (37.5%) cases of sudden death occurred in adults aged between 41-60 years.[2] Similar findings were reported by Garg et al., Agravat et al., Fishman et al., Singh et al., and Wig et al.[16-20] Kannel et al., noted that the proportion of coronary attacks presenting as sudden death increased from 13% at ages 35 to 64 years to 20% at ages 65 to 94 years.[4] In our study in terms of gender distribution, the study cohort predominantly consisted of males, accounting for 63.2% of the cases, while females represented 36.8%. Braggion-Santos et al., Padmavati et al., and Tandon et al., reported a male-to-female (M:F) ratio of 2:1.[21-23]

Clinical Risk Factors: Understanding the clinical risk factors associated with sudden death and cardiovascular pathologies is essential for risk stratification and prevention. Our analysis revealed that a significant portion of the study population had comorbidities such as hypertension, diabetes, smoking, and alcohol use. These risk factors have long been recognized as contributors to the development and progression of cardiovascular diseases.[5] Additionally, we noted the presence of other risk factors, including a family history of heart disease, stressful occupations, and substance abuse. These findings underscore the multifactorial nature of sudden death and emphasize the importance of comprehensive risk assessment and management.

Gross and Histopathological Findings: Gross and histopathological examination of the heart, coronaries, and aorta provided valuable insights into the structural abnormalities contributing to sudden death. Enlarged hearts were frequently observed in our cohort, and this finding may be indicative of compensatory responses to chronic cardiovascular stress. Likewise, aortic pathologies, including aortic dissection and aneurysm, were identified, highlighting the importance of assessing the entire cardiovascular system during autopsy investigations. In our study, myocardial infarction was also notably prevalent, identified in 26 cases (45.6%), underscoring its significance within the study population. The incidence of myocardial infarction (MI) on histopathological examination was consistent with the findings of Hathila et al., and Garg et al., who also reported similar results.[16,24] Vyas et al., observed acute MI in 10.8% of cases in their study.[25] Additionally, Dhruva et al., reported an observation of 9.72% acute MI cases, while Maru et al., documented 6.5% cases of acute MI, and a lower incidence of 3% was reported by Nisha et al., in their respective studies.[11,26,27]

In our study, we observed the prevalence of specific cardiac lesions in autopsy cases, and the findings were compared with relevant studies for contextual analysis. Atherosclerotic coronary artery disease was the predominant lesion, accounting for 70.2% of cases. This finding aligns with similar research conducted by Farioli et al., and Kasthuri et al., who reported prevalence rates of 78% and 76.92%, respectively.[28,29] Sonawane et al., also documented a high prevalence of atherosclerotic coronary artery disease (72.58%).[1] Additionally, Wang et al., and Ahmad et al., observed atherosclerotic coronary artery disease in their studies, with prevalence rates of 50.3% and 64.1%, respectively.[30,31]

Hypertrophic cardiomyopathy was identified in 40.4% of our cases. Hypertrophic cardiomyopathy was identified in 40.4% of our cases. This condition exhibited varying prevalence rates in other studies, with Farioli et al., Wang et al., Braggion-Santos et al., Ahmad et al., and Kasthuri et al., reporting prevalence rates of 4%, 4.5%, 32.1%, 8%, and 7.69%, respectively.[21,28-31] These discrepancies highlight the variability in the prevalence of hypertrophic cardiomyopathy across different research settings and populations.

Histopathological analysis of heart tissues, coronary arteries, and the aorta revealed the presence of atherosclerosis, myocardial infarction, myocarditis, and valvular abnormalities in a significant proportion of cases. These findings underscore the diverse range of cardiac pathologies that can underlie sudden death and emphasize the importance of comprehensive post-mortem examinations to elucidate the exact cause of death.

Limitations

It is essential to acknowledge the limitations of our study. The retrospective nature of autopsy data inherently poses limitations related to selection bias and incomplete clinical information. Additionally, the absence of imaging data in some cases may have limited our ability to comprehensively assess the cardiovascular system.

CONCLUSION

In conclusion, our study provides critical insights into the pathology of the heart, coronaries, and aorta in autopsy cases with a history of sudden death. CHD emerged as a prevalent and significant comorbidity, emphasizing the need for early detection and intervention. Clinical risk factors, gross findings, and histopathological analyses highlighted the complex interplay of factors contributing to sudden death. These findings underscore the importance of a multidisciplinary approach to sudden death investigation, integrating clinical, radiological, and pathological data to enhance our understanding and prevention of this devastating phenomenon.

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