Pomeranian J Life Sci 2023;69(2):50-53 doi: 10.21164/pomjlifesci.921

The lethal assault, fall trauma or cardiac arrhythmia? – diagnostic difficulties associated with determining the cause of death in a patient with an ICD

Szymon Rzepczyk[A] ✉, Paweł Świderski[B], Bartosz Bijata[C], Damian Rusek[D], Beata Bożek, Czesław Żaba[E]

Poznań University of Medical Sciences, Department of Forensic Medicine, Rokietnicka 10, 60-806 Poznań, Poland

[A] ORCID: 0000-0001-6330-1511; [B] ORCID: 0000-0002-8518-8625; [C] ORCID: 0009-0005-5874-2183; [D] ORCID: 0009-0003-0183-1754; [E] ORCID: 0000-0001-7522-4568

✉ szymon.rzepczyk@interia.eu

ABSTRACT

The number of patients with implantable cardioverter-defibrillators (ICDs) is steadily increasing. Postmortem interpretation of the data recorded and stored by the device provides vital information about the time and cause of death. In this paper, we describe a case of a 67-year-old man found on the stairs. He had pulseless electrical activity and multiple fresh injuries, notably to the head. Despite an hour-long resuscitation attempt, it was unsuccessful. The subsequent postmortem examination revealed significant myocardial hypertrophy with post-infarction scarring in the left ventricle, and no significant central nervous system injuries were observed. The patient's ICD was dissected and submitted for analysis. Evaluation of the recorded data revealed the presence of ventricular fibrillation (VF) and tachycardia shortly before the patient was found. Analysis of all the evidence gathered during the investigation led to the conclusion that the cause of death was cardiopulmonary failure resulting from cardiac arrhythmia, and the head injury was a result of an unconscious fall down the stairs.

Keywords: sudden cardiac death; ICD; fall trauma; diagnostic difficulties; autopsy.

INTRODUCTION

The implantable cardioverter-defibrillator (ICD) is an increasingly utilized device designed to prevent sudden cardiac death in patients at risk [1]. The first successful implantation of ICD in a patient took place in 1980, and since then the number of implanted devices has been steadily increasing [2, 3]. Implantable cardioverter-defibrillator are surgically placed beneath the skin, typically in the left clavicular region, and lead electrodes are threaded into the heart to monitor the heart's rhythm and deliver an electrical impulse when necessary. The antiarrhythmic action of the ICD interrupts ventricular tachyarrhythmias and the device employs an overdrive mechanism to attempt to terminate the episode of arrhythmia.

When an accelerated ventricular action is detected above the predefined average heart rate limit but below the defibrillation threshold, the ICD responds by pacing the ventricle to terminate the ventricular tachycardia (VT) [4]. If antiarrhythmic therapy proves ineffective after a fixed number of attempts, the ICD will initiate defibrillation. The defibrillation function of the device recognizes high-frequency ventricular activity. If the ventricular rate exceeds the programmed threshold value, a high-energy discharge is delivered to the electrode in order to terminate a potentially life-threatening ventricular arrhythmia [4]. Additionally, the ICD includes a cardiac pacing function that activates when bradycardia (slow heart rate) is detected [5].

These devices are primarily intended for patients at increased risk of ventricular arrhythmia and sudden cardiac death. The implantation of an ICD is recommended for both primary and secondary prevention of sudden cardiac death. Eligibility criteria for ICD implantation include a history of ventricular fibrillation (VF) or VT that cause hemodynamic instability, irrespective of left ventricular ejection fraction, as well as left ventricular systolic dysfunction post-myocardial infarction or from causes other than ischemic heart disease with an ejection fraction below 35%, and long QT syndrome [6, 7]. Furthermore, these devices are capable of recording and storing cardiac information. Even after death, data readout using specialized software can be performed, and analysis of the recorded data provides essential information regarding the circumstances surrounding the patient's death.

CASE REPORT

A 67-year-old man was discovered in an unnatural position on the stairs showing no signs of breathing or pulse. The emergency medical team was called to the scene and conducted an electrocardiogram (ECG), which revealed pulseless electrical activity. Despite the resuscitation efforts performed by the team, circulation did not spontaneously return and asystole was observed on the ECG. After 1 h of unsuccessful attempts to revive the patient, the resuscitation efforts were ceased.

Upon examination of the patient, the emergency medical team noted fresh injuries to the skull, specifically in the left frontal-parietal and parietal-left frontal regions. Due to the presence of these injuries, the possibility of third-party involvement in the patient's death could not be ruled out. As a result, the police and prosecutor were notified to further investigate the circumstances surrounding the incident.

The corpse was transferred to the Department of Forensic Medicine in Poznań for a postmortem examination. During the external examination of the body, a contusion wound measuring 4.5 cm was observed in the left frontal and parietal areas. Abrasions of the epidermis were found in the left frontal and temporal area, extending to the frontal and parietal areas, as well as right and left frontal areas. Furthermore, numerous abrasions of the epidermis were visible in the thorax, abdomen, left hip, wrist area, as well as on the right side in the knee, shin, and shoulder area. Bruises were also observed on the right shoulder, left wrist, chest, and abdomen. Traces of intravenous insertions were evident on the dorsal surfaces of both hands, indicating previous medical procedures.

The postmortem examination revealed ecchymosis (bruising) on the inner surface of the scalp in the left and right frontoparietal and temporoparietal regions, as well as in the left temporal muscle projection (Fig. 1). Within the brain, only moderate edema (swelling) features and a small area of subarachnoid hemorrhage were identified.

FIGURE 1. Hemorrhage of the inner side of the scalp

Cardiac examination revealed massive hypertrophy – 885 g, 17 x 13 x 6 cm (Fig. 2), extensive post-infarction scarring in the left ventricular wall, thickening of the aortic and mitral valves, and advanced coronary atherosclerosis with a stent implanted in the left coronary artery.

There was fluid blood with clots in the heart cavities. Chest injuries manifested as fractures of ribs II–VIII on the right side and III–IV on the left side. Additionally, the postmortem examination revealed a condition following the implantation of a cardioverter-defibrillator (Punctua ICD, Boston Scientific), which was secured for recording assessment. Sample material was collected for toxicology and histopathology.

FIGURE 2. Massive myocardial hypertrophy and extensive postinfarction scarring in the left ventricular wall

Histopathological examination of myocardial sections showed post-infarction scar, extensive foci of intramuscular fibrosis, degenerative fatty myocardium, and cardiomyocyte hypertrophy. Histochemical staining using trichrome Masson was also performed (Fig. 3). Toxicological examination revealed no presence of ethanol or psychoactive substances.

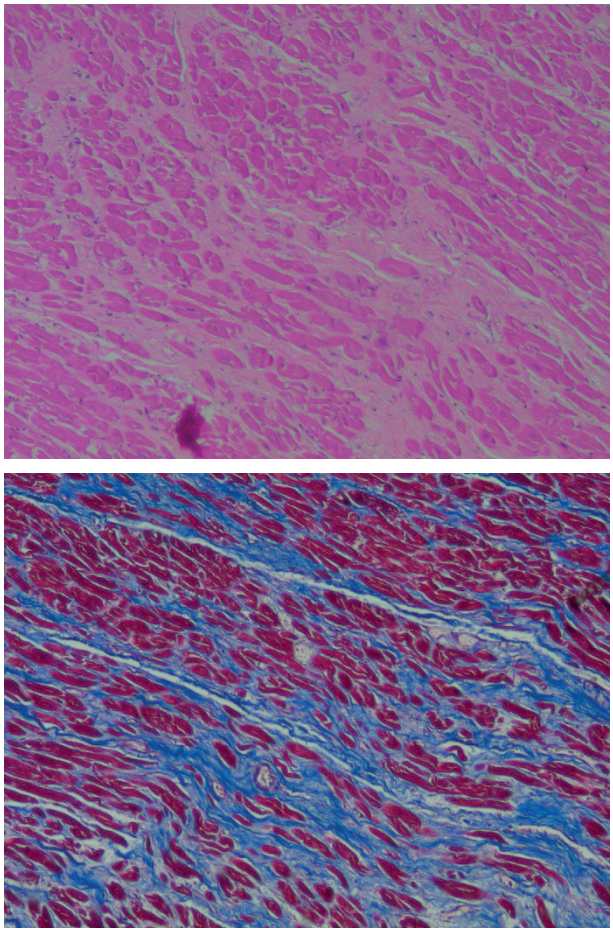

FIGURE 3. Myocardial sections in hematoxylin and eosin staining (up) and Masson's trichrome (down)

Analysis of the cardioverter-defibrillator readout taken from the deceased individual revealed recurrent episodes of VF and VT, with defibrillator discharges occurring approx. 2 h prior to the pronouncement of death.

Based on an analysis of all available material, it was determined that the patient experienced sudden death due to acute cardiopulmonary failure of cardiac origin in a patient with advanced myocardial lesions (advanced chronic ischemic disease and massive myocardial hypertrophy). The death occurred as a result of ventricular arrhythmia.

DISCUSSION

In cases where a corpse is found with no available information about the circumstances of the incident, in an unusual location and unnatural position, with multiple fresh injuries in the form of contusion wounds, bruises, and skin abrasions, the possibility of third-party involvement should be taken into consideration. The assessment of the mechanism of injury plays a crucial role in determining the circumstances surrounding the death. In cases where injuries, beatings or fights are suspected, it is important to look for injuries of a defensive nature, such as epidermal abrasions on the dorsal surface of the hand and fingers, as well as injuries to the peripheral parts of the forearm. It is also crucial to assess the presence of signs of incapacitation, both defensive and offensive. Indicative signs of incapacitation include subcutaneous bleeding on the arms or forearms resulting from a strong grip used to immobilize the victim [8]. Therefore, the presence of single epidermal abrasions in the finger area of both hands and unilateral epidermal abrasions and bruises on the arm and wrist makes the hypothesis of third-party violence against the victim unlikely in the analyzed case.

It is also vital to assess the mechanism of the head injury and its causal relationship to death. The classic method of differentiating between active and passive injury is to determine the location of the injury in relation to the so-called „hat line" – injuries located below usually have a passive character, while those above have an active character [9]. However, this method has several limitations and conditions, such as falling from one's height in a standing position, preserved defensive reflexes, and the absence of psychoactive substance intoxication or falling on a level ground [8, 10].

In the analyzed case, the victim was sober and fell from his height, but on an uneven staircase surface, which limits the feasibility of assessing the injury mechanism using the abovementioned method. However, a comprehensive analysis of the visual report from the scene of the accident, photographic documentation, and injury analysis indicated that the injuries were more likely to have resulted from a fall from the person's height. Furthermore, the head injuries observed in this case were primarily limited to epidermal abrasions and sub-concussive bleeding on the inner surface of the scalp, without any skull bone damage or notable brain contusion foci; therefore, these injuries could not have been the cause of death. On the other hand, moderate cerebral edema could have resulted from hypoperfusion and blood stasis during acute circulatory failure.

Chest injuries in the form of multiple rib fractures on the left and right sides should be associated with the resuscitation of the patient by the emergency medical team, which lasted for more than 1 h. Injuries such as rib or sternum fractures, especially in the elderly population with lower bone density, are among the typical complications of resuscitation [11, 12].

In the analyzed case, no medical records of the indications for ICD implantation in the deceased were submitted for analysis, which affects the ability to determine the mechanisms that may have led to death. Based on the ICD readout, it is possible to infer a potential sequence of events that resulted in unconsciousness and sudden cardiac death in the described case. The primary cause of death was an acute cardiopulmonary failure of cardiac origin with advanced myocardial lesions (advanced chronic ischaemic heart disease, massive myocardial hypertrophy). The death occurred through the mechanism of VF. However, when analyzing similar recordings recorded by an ICD, it is also important to consider the possibility of primary atrial fibrillation with rapid ventricular complex activity when determining the cause of death. Due to the extensive ischemic changes and associated reduced ejection fraction, supraventricular arrhythmias may have led to a decrease in minute volume and cardiogenic shock, resulting in loss of consciousness and the subsequent fall down the stairs. Atrial fibrillation with rapid ventricular activity can also contribute to acute coronary syndrome, which may have secondarily triggered VF. Furthermore, post-infarction scarring plays a significant role in contributing to arrhythmias [13].

In forensic medical practice, sudden cardiac death can pose significant diagnostic challenges [14, 15, 16]. Moreover, with the increasing population of patients with implanted ICDs due to their growing availability and popularity, it is essential to understand their operating principles, including in postmortem diagnosis [5]. Despite initial recommendations in the 1970s emphasizing the importance of postmortem evaluation of cardiac implantable electronic devices (CIEDs), their performance and recording analysis have not yet become routine [3, 17, 18, 19]. Nevertheless, studies demonstrate that postmortem analysis of CIEDs is critical in determining the time and mechanism of death [20]. Similar case reports can be found in the literature, where the analysis of an ICD extracted during autopsy aided in determining the cause of a car accident resulting from driver unconsciousness caused by supraventricular arrhythmia [21]. Importantly, device malfunction may also contribute to death [22]. Furthermore, accessing data from the device can help establish the identity of victims, particularly in mass disasters [23, 24].

CONCLUSIONS

The presented case highlights the importance of comprehensive assessment of scene documentation and medical data,

particularly those obtained from implantable electronic devices that record and store patient information, in determining the cause of death in diagnostically challenging cases. Reading and analyzing data recorded by an implantable cardioverter defibrillator can provide key information regarding the circumstances of death, especially in cases where the autopsy findings do not establish the cause of death. In situations where death is attributed to severe cardiac arrhythmias, the autopsy findings may not provide definitive conclusions. In such instances, the recorded data from the rhythm monitoring device can serve as the primary source of information, aiding in distinguishing between injuries resulting from a spontaneous collapse after loss of consciousness caused by arrhythmia. Therefore, postmortem data reading in individuals with an implanted ICD should be a routine diagnostic procedure.

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