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Outcome of Implantable Cardioverter Defibrillator in a Patient with Bradycardia due to Third-Degree AV Block after Electrical Shock: 8-year follow-up

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ABSTRACT
Cardiac arrhythmias due to electrical shock are rare in emergency admissions. We report a case of a 61-year-old male patient who was admitted to the emergency room for fainting after electric shock, presenting with bradycardia and third-degree AV block, and multiple episodes of Torsades de pointes ventricular tachycardia; This is a very dangerous cardiac complication that can easily lead to ventricular fibrillation and cardiac arrest. The patient was promptly detected and treated with electrical cardioversion to terminate Torsades de pointes ventricular tachycardia, resuscitation, temporary Pacemaker Implantation, and coronary artery examination. He then underwent Implantable Cardioverter Defibrillator (ICD) and has been followed up and managed for over 8 years. Currently, the ICD is functioning well, and his health is stable. Complications from electrical shock injuries need to be detected early for timely resuscitation and emergency treatment, especially for dangerous arrhythmias. Patients require long-term follow-up, treatment, and management of potential late complications.

Keywords: Bradycardia, Third-degree AV block, Implantable Cardioverter Defibrillator, Electrical shock

INTRODUCTION

Cardiac arrhythmias due to electrical shock are rare in emergency admissions. Injuries caused by electric shock are those caused by an electric current passing through the body [1], [2], [3]. The current passing through the body and the heart can cause myocardial damage, cardiac nerve damage, myocardial ischemia, reduced ejection fraction, and various cardiac arrhythmias, and may even lead to life-threatening arrhythmias such as Torsades de pointes ventricular tachycardia lead to ventricular fibrillation, causing cardiac arrest [4], [5]. Some studies have reported neurological, psychological, and physical sequelae of varying degrees of subtlety or obscurity that may appear 1 to 5 years after injury and lead to serious sequelae [1], [2], [3]. Therefore, we report the successful emergency treatment of a patient with cardiac nerve damage immediately after electric shock in June 2016, presenting with cardiac arrhythmia of third-degree atrioventricular (AV) block and ventricular fibrillation who was saved by timely resuscitation and implantation Cardioverter Defibrillator (ICD), end then report the follow-up results more than 8 years (2024) after ICD.

Clinical Case

A 61-year-old male patient with no prior medical history was admitted to the Emergency Department of the National Heart Institute, Bach Mai Hospital, Vietnam in June 2016 due to fainting. Three hours prior to admission, the patient was repairing electrical equipment when he was accidentally electrocuted and fell from a height of 3 meters. After the fall, he lost consciousness, did not vomit, did not have convulsions, and had no visible burns. He was brought to the hospital conscious, complaining of headache, dizziness, and left chest pain. His vital signs were: temperature 37.0°C, irregular heart rate averaging 35 beats/minute, blood pressure 140/80 mmHg, respiratory rate 20 breaths/minute, SpO2 94%, clear lung sounds bilaterally without rales, soft abdomen, and mild bruising around the right eye due to the fall.

Electrocardiogram (ECG): Third-degree AV block (Figure 1a-b). Followed on screen patient monitoring device showed the attacks of Torsades de pointes and ventricular tachycardia rhythm.

Echocardiogram (Figure 2): Thickened left ventricular wall, non-dilated left ventricle, normal left ventricular ejection fraction (EF: 79%), and mild mitral regurgitation.

Brain CT Scanner: Normal.

Laboratory tests: PT-INR: 1.0, RBC: 5.17, HGB: 155 g/L, PLT: 211 G/L, WBC: 10.15 G/L, Ure: 4.1 mmol/L, Creatine: 95 umol/L, CK/CK-MB: 156/13 U/L, CRP hs: 0.3 mg/dL, Troponin T: 0.043 ug/L, NT-proBNP: 71.34 pmol/L, Total protein/Albumin: 68.6/41.4 g/L, Cholesterol/Triglycerid/HDL-Cholesterol/LDL-Cholesterol: 6.02/2.29/1.12/3.86 mmol/L, Glucose: 4.9 mmol/L, HbA1C: 5.8%, Na/K+/Cl: 140/3.6/107 mmol/L, Ca/Ca++: 2.22/1.14 mmol/L.

Treatment: Upon admission, the patient was in critical condition with multiple episodes of Torsades de pointes ventricular tachycardia on continuous electrocardiogram monitoring. Immediate treatment included intravenous administration of atropine and magnesium sulfate, followed by four rounds of cardioversion to terminate the life-threatening arrhythmia, the patient was then continuously monitored.

During the monitoring period, the patient's blood pressure was elevated to 170/110 mmHg, which was managed with antihypertensive medication. A temporary pacemaker was implanted, and coronary angiography was performed approximately 40 minutes after admission. Less than an hour after admission, the patient underwent coronary angiography and temporary pacemaker implantation via the right subclavian vein with set a rate of 70 beats per minute. After temporary pacemaker implantation, the heart rate and hemodynamic parameters stabilized. Coronary angiography did not reveal any significant coronary artery disease.

On the second day, the patient underwent implantation of a dual-chamber ICD with rate-responsive function (DDDR) that was MRI-compatible, wireless, and capable of remote monitoring. The procedure was performed via the left subclavian vein. The right ventricular lead was placed in the right ventricular apex with a pacing threshold of 0.9V, impedance of 860 ohms, and sensing amplitude of 20.0 mV. The right atrial lead was placed in the right atrial appendage with a pacing threshold of 0.9V, impedance of 580 ohms, and P-wave amplitude of 5.8 mV. The DDDR was implanted subcutaneously without complications**.**

After one week of hospitalization, the patient was discharged without any complications **(Figure 3)**. After discharge, the patient continued to have regular monthly check-ups at the local hospital and remained stable. In August 2024, we re-evaluated the patient, and the ICD was still functioning well and pacing properly, Echocardiogram after evaluation showing ejection fraction (EF) 74%. The patient's overall health remained good 8 years after ICD (standby mode), with well-controlled hypertension on medication. The patient was advised to continue regular follow-up for ICD function and overall health **(Figure 4)**.

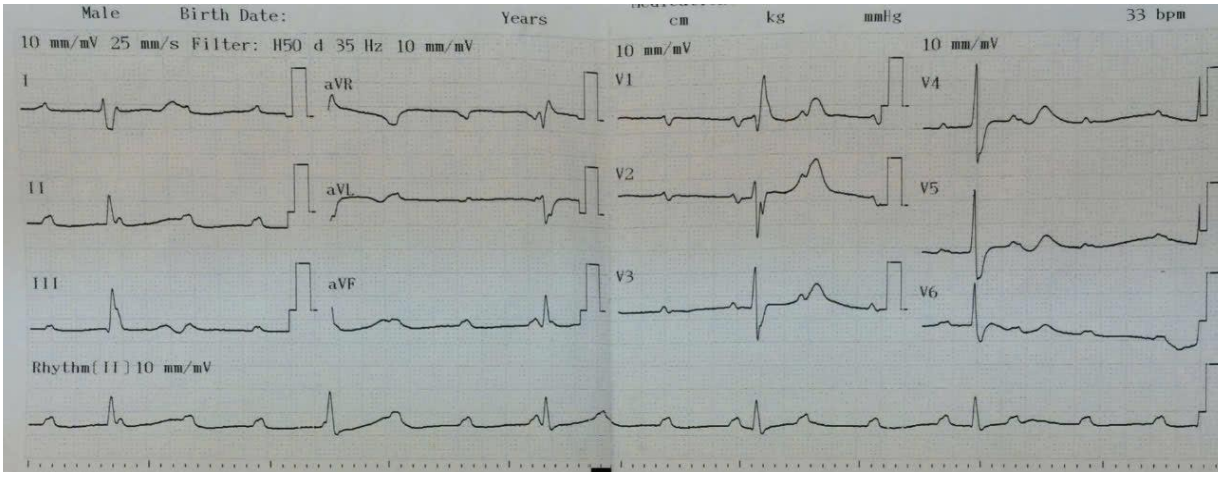

Figure 1a: Electrocardiogram (ECG) at hospitalized

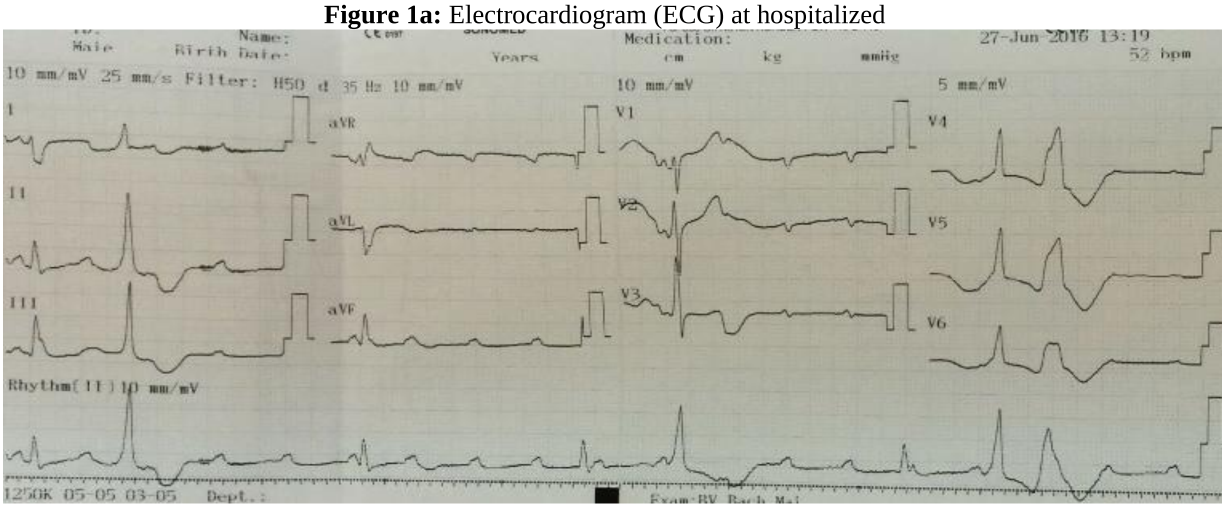

Figure 1b: Electrocardiogram (ECG) at hospitalized

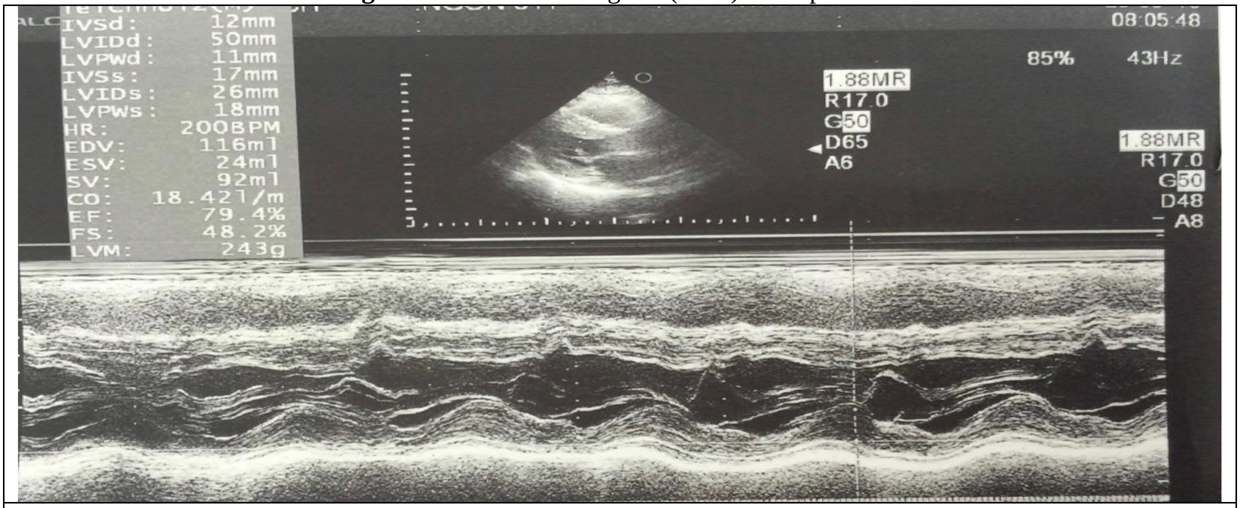

Figure 2: Echocardiogram at hospitalized

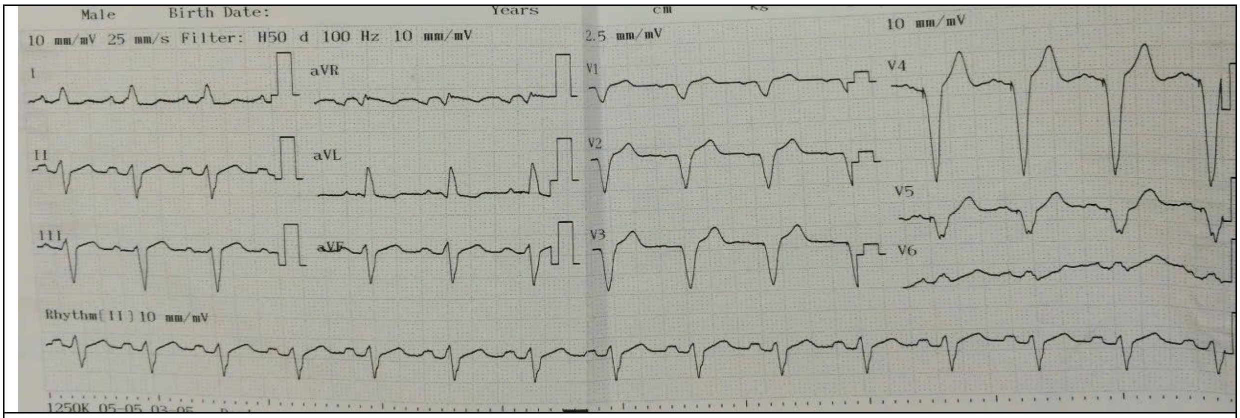

Figure 3: Electrocardiogram after ICD - before discharged from hospital

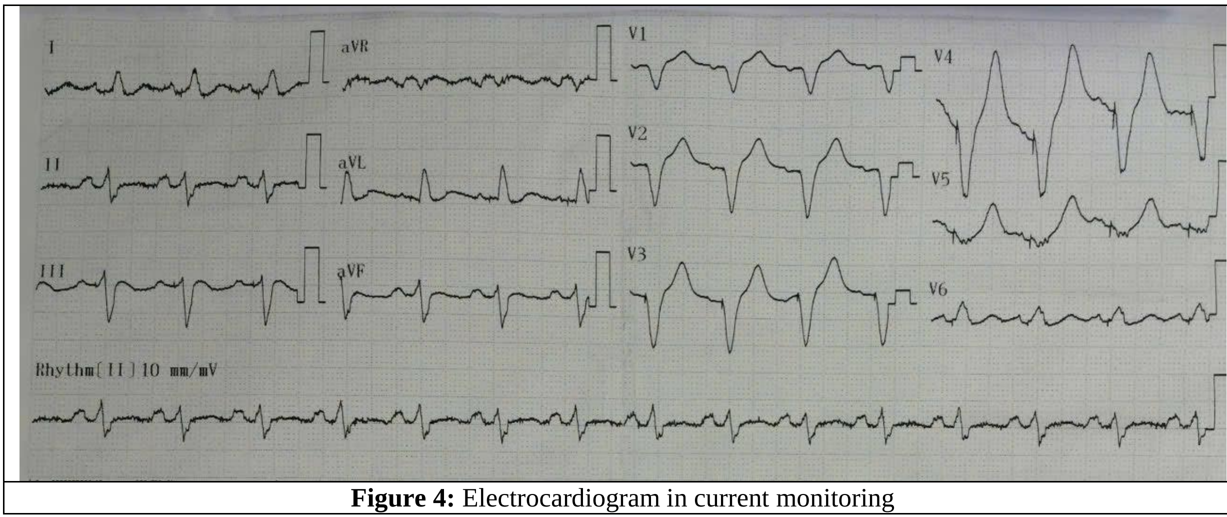

Figure 4: Electrocardiogram in current monitoring

DISCUSSION

The patient in this case suffered from a serious electrical shock injury that led to cardiac damage and nerve damage, resulting in life-threatening slow heart rate (third-degree AV block) and potentially fatal ventricular arrhythmias. Timely diagnosis and intervention, including cardioversion to terminate arrhythmias and emergency temporary pacemaker implantation and then ICD were crucial in saving the patient's life [6], [7], [8].

Electrical injuries can cause a range of damage, from skin burns to internal organ damage and arrhythmias that can lead to cardiac arrest. Even seemingly minor electrical shocks, such as those from household appliances, can have serious consequences, especially if they involve high-voltage electricity. In the United States, electrical injuries are responsible for approximately 300 deaths and over 30,000 non-fatal injuries each year. In addition to cardiac and nervous system damage, electrical injuries can also cause muscle spasms or falls, leading to fractures, spinal injuries, or internal organ damage [9], [10], [11].

The patient in this case suffered from cardiac damage and arrhythmias caused by electrical shock. However, the external manifestations of the injury, such as skin burns were relatively mild. This discrepancy between the severity of internal damage and external appearance can be explained by the physics of electrical injuries. The damage caused by electrical shock is primarily due to the conversion of electrical energy into heat, resulting in thermal injury. The amount of heat generated is determined by the square of the current (amperes), the resistance of the tissue (ohms), and the duration of exposure to the current. Therefore, for a given current and duration, tissues with higher resistance will experience more damage. The body's resistance is primarily determined by the skin as most internal tissues have negligible resistance. Skin thickness and dryness increase resistance; dry, well-keratinized, intact skin has an average resistance of 20,000 to 30,000 ohms/cm². For the palms or soles, resistance can be as high as 2 to 3 million ohms/cm². Conversely, wet or thin skin has a resistance of around 500 ohms/cm². Resistance can be as low as 200-300 ohms/cm² for punctured skin or moist mucous membranes. If the skin resistance is high, more electrical energy is dissipated in the skin, leading to skin burns but less internal damage. Conversely, if the skin resistance is low, there may be little or no skin burning, and more electrical energy is transmitted to internal structures. Therefore, the absence of external burns does not predict the absence of internal damage, nor does the severity of external burns predict the severity of internal damage. Internal tissue damage depends on both the tissue's resistance and the current density (current per unit area, the concentration of energy as the current passes through a smaller area) [1], [2], [3].

The extent of injury from electrical shock can vary widely. Even seemingly minor shocks can have serious consequences, especially if they involve high-voltage electricity. The extent of the impact of an electric shock on health depends on several factors, including the type and magnitude of the current, the frequency of the current, the voltage, the body's resistance, the duration of exposure to the current, and the path of the current through the body. The path of the current through the body can significantly affect which structures are damaged and the overall risk to life; Because alternating current continually reverses direction, the terms "source" and "ground" are used to describe the points where the current enters and exits the body. The most common entry points are the hands and head, while the feet are the most common exit points. A current flowing between the arms or between an arm and a leg is more likely to pass through the heart, potentially causing arrhythmias. This type of current is considered more dangerous than a current that flows from one leg to the other. It's important to note that during each heart cycle, which lasts about 1 second, there's a 0.1-second period of relaxation called diastole. This is a time when the heart is particularly vulnerable to electrical current. In addition to the heart, electric current passing through the brain can also cause damage to the central nervous system [1], [2], [3], [12], [13].

In electrical accidents involving low-voltage electricity, there may be initial discomfort and pain but rarely serious or long-lasting injuries. However, accidents involving high-voltage electricity can cause significant thermal and electrochemical damage to internal tissues. Potential injuries include: Hemolysis (destruction of red blood cells), Protein coagulation, Coagulative necrosis of muscle and other tissues, Blood clots, Dehydration, Muscle spasms [1], [2], [3], [14]. High-voltage electrical injuries can lead to severe swelling due to blood clots in veins and muscle swelling, potentially leading to compartment syndrome. Severe swelling can also cause hypovolemia (decreased blood volume) and hypotension (low blood pressure). Muscle damage can lead to rhabdomyolysis (breakdown of muscle tissue) and myoglobinuria (myoglobin in the urine), which can cause kidney damage. The severity of organ dysfunction is not always directly proportional to the amount of tissue damage; For example, ventricular fibrillation, a life-threatening arrhythmia, can occur even with minimal tissue damage [1], [2], [3], [14].

Therefore, diagnosis should be based on a comprehensive medical history, physical examination (including neurological and vascular examinations), assessment of any associated trauma or burns, and appropriate diagnosis tests. These tests may include an electrocardiogram (ECG), complete blood count, cardiac enzymes, muscle enzymes, and urine analysis (to check for myoglobin). Patients with altered mental status may require CT scanner or Magnetic Resonance Imaging (MRI) to assess brain and vascular damage. In addition to the immediate risks, electrical injuries can also have long-term consequences, such as: Peripheral neuropathy (nerve damage), Cataracts, Chronic pain, Psychological trauma [8].

It is important to seek immediate medical attention for any suspected electrical injury, even if there are no apparent external signs of injury. Life-threatening arrhythmias that occur after electrical shock should be promptly identified and treated as in the case we reported. In cases of cardiac arrest, Basic cardiac life support and advanced cardiac life support as well as trauma resuscitation should be initiated. Advanced cardiac life support should be performed concurrently with the investigation of other possible causes of shock, such as hemorrhagic shock and pneumothorax. In addition, critical care should be provided for any significant injuries. Due to the possibility of neurological, cardiovascular, psychological, and physical sequelae, which may manifest subtly or remain undetected for 1 to 5 years after the injury and lead to serious complications, so patients who have experienced electrical shock should undergo long-term follow-up to ensure optimal health management.

CONCLUSION

Electric shock injuries occur when an electric current passes through the body. When the current passes through the heart, it can damage the heart muscle and the heart's electrical conduction system, leading to potentially life-threatening arrhythmias such as slow heart rate (third-degree AV block) and torsades de pointes ventricular tachycardia; These arrhythmias can quickly lead to ventricular fibrillation and cardiac arrest. Therefore, need to prompt recognition and timely emergency of these arrhythmias, even temporary pacemaker implantation and then ICD are crucial.

However, even after successful treatment of the immediate arrhythmias, patients who have experienced electrical shock should undergo long-term follow-up, regular monitoring is necessary to identify and manage any potential complications; This is because electrical injuries can have long-term consequences, including neurological, cardiovascular, and psychological problems.

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