Case Report

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Penetrating cardiac injury resulting in a bullet embolus: a case report

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Bullet embolism is a potential complication of a gunshot wound, especially with a low-velocity missile. This is because the trajectory of the low-velocity bullet can be significantly slowed as it passes through tissue. An unusual form of travel can occur in which the bullet enters the vasculature but does not have enough kinetic energy to create a through-and-through wound, leading it to remain inside the vasculature. Once inside the vasculature, the bullet could migrate to different parts of the body, potentially causing complications such as ischemia, becoming a source of thromboembolism, or functioning as a nidus for infection. The management of a bullet embolism varies from case to case, as each patient with this issue has a unique body habitus that can result in infinite possibilities of the trajectory and destination of the bullet embolus. Additional damage to surrounding vasculature or tissue can occur, as well as embolization of the bullet to critical areas of the body. Here we present the case of a 72-year-old man who had a self-inflicted gunshot wound to the chest with a low-velocity bullet, which penetrated the right atrium of the heart. It traveled into the venous vasculature through the right atrium, into the inferior vena cava, and eventually settled in the right internal iliac vein. He refused further intervention and management after initial workup and resuscitation.

Keywords: Heart injuries; Wound ballistics; Gunshot wounds; Case reports

INTRODUCTION

Bullet embolism, also known as missile embolism, is a rare and potentially lethal consequence of vascular trauma secondary to a gunshot wound (GSW). The potential complications from bullet embolism include end-organ ischemia, sepsis, and cardiac valvular abnormalities depending on the affected vessels, associated inflammatory processes, and the final destination to which the bullet embolizes [1]. The frequency of bullet embolism is difficult to ascertain, but it has been reported in the literature that 0.3% of approximately 7,500 casualties of the Vietnam War, and 1.1% of 346 casualties from the Afghanistan and Iraq Wars, demonstrated evidence of bullet embolism [2–4]. The low incidence rate of this condition in combat scenarios is attributed to the immediate fatal complications associated with high-velocity GSWs, as high-velocity bullets are more likely to create exit wounds and collateral tissue damage due to high kinetic energy, increasing the risk of mortality [5]. Kuo et al. [6] determined that the number of

reported cases of bullet emboli in the United States exceeded 260 from 1988 to 2018, with an estimated frequency of 10 cases of bullet emboli in the United States per year; domestic incidents are much more common and typically involve weaker projectiles, increasing the probability of bullet embolism through incomplete penetration of blood vessels. Additionally, the literature demonstrates that almost all instances of bullet emboli result from bullet calibers of 0.38 or smaller, which are insufficient to completely pierce the body but enough to cause soft tissue damage that may allow the bullet to enter the vasculature if the trajectory is aligned [7]. The rare incidence and highly variable clinical presentation have led to an absence of centralized treatment strategies or management [8]. The present literature suggests that bullet emboli that are present within the arterial circulation are best managed with timely surgical or endovascular removal due to the high probability of future ischemia. The suggested management for venous embolism varies and depends on clinical symptoms [9]. Imaging modalities, most commonly computed tomography (CT), are the best diagnostic tool. Ultimately, a combination of multiple factors will determine patient prognosis and care.

CASE REPORT

The patient was a 72-year-old man with depression who presented to the emergency room after a self-inflicted GSW to the chest. The patient reported using a .380 Ruger (Strum, Ruger & Co Inc) held 1 inch (2.54 cm) away from the chest toward the midsternal area. The patient had laid on the ground for 1 to 2 hours before getting up to use the restroom and call emergency services. The patient was depressed due to his recent stage IV bone cancer diagnosis 3 months prior and his wife's death 2 years ago. The patient was given 2 units of packed red blood cells and 500 mL of crystalloids. The patient was normotensive, tachycardic with a heart rate of 110 beats/min, and tachypneic. The patient denied significant chest pain but experienced intermittent and random episodes of shortness of breath and constant anterior right thigh pain. On physical examination, the patient was noted to present a normal sinus rhythm with clear breathing sounds bilaterally. There was no evidence of an acute abdomen or peritonitis. Subsequent, serial physical examinations conveyed unchanged findings. Focused assessment with sonography for trauma revealed unremarkable findings. Initially, x-rays of the chest and abdomen were obtained, but neither revealed the location of the bullet. As the next step in diagnosis, a full-body CT scan was performed, with attention to the chest, abdomen, and pelvis. The CT scan of the thorax demonstrated a ballistic tract traversing the sternum and right heart; a sternal fracture with small pockets of loculated air within the right atrium near the atrial appendage was visualized (Fig. 1A); a small, stable hematoma was also visualized in the right atrium where the bullet likely entered (both shown in Fig. 1B).

Additional small air loculi traveling to the inferior vena cava (IVC) and common iliac vein were observed. No trauma or air in the right ventricle was seen. Neither mediastinal air nor pericardial effusion was observed. A ballistic fragment within the right internal iliac vein was visualized (Fig. 2). Transthoracic echocardiography did not reveal any structural or valvular abnormalities.

There was no evidence of missile trajectory in the mesentery

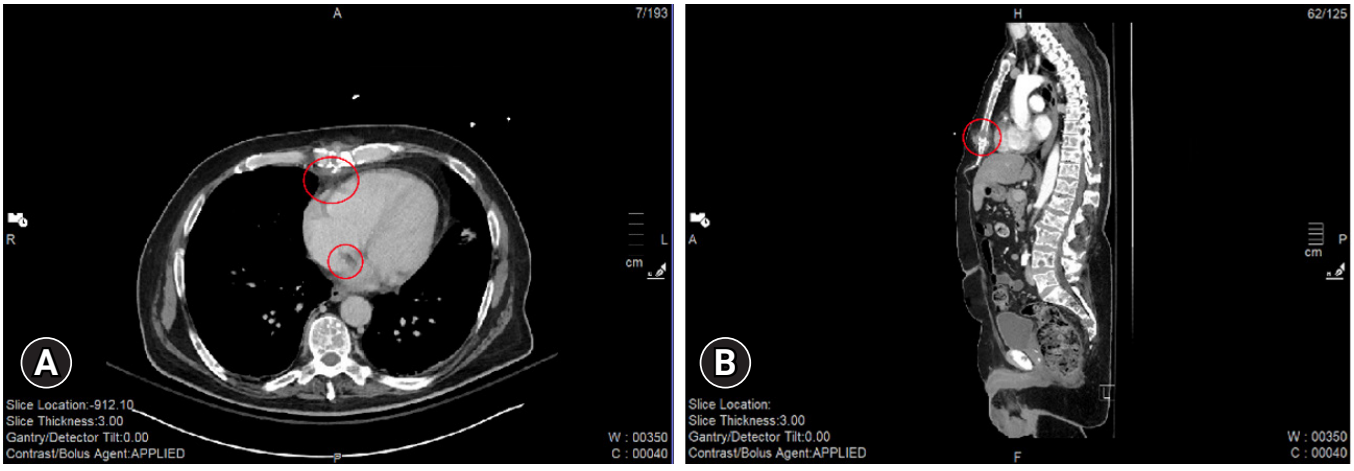

Fig. 1. Computed tomography scans of the patient. (A) Sternal hematoma and loculated air (circles) present in the right atrium. (B) Another view demonstrating a sternal fracture (circle).

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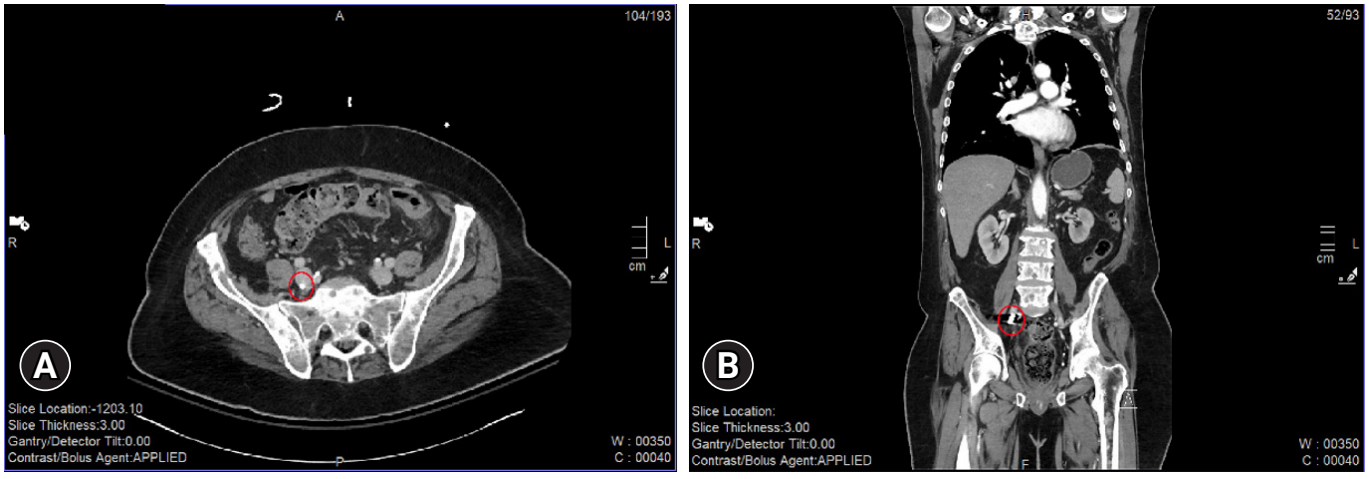

Fig. 2. Computed tomography scans of the patient. (A) Bullet fragment (circle) shown within the right internal iliac artery. (B) Bullet fragment (circle) within the right internal iliac artery seen on a coronal view.

or paravertebral areas. This was supported by the patient's lack of peritoneal symptoms. The initial laboratory values demonstrated leukocytosis and low hemoglobin and hematocrit, likely from blood loss at the scene. Troponin was observed to be elevated at 138 ng/L, which may have been associated with demand ischemia and/or cardiac myocyte damage. Subsequently, the patient was determined not to be critically ill. As of postinjury day 7, the patient remained hemodynamically stable. He was assessed by the psychiatry department. He declined further imaging and interventional procedures and at that point was discharged to hospice care to address his terminal malignant neoplastic process.

Ethics statement

The patient provided written informed consent for publication of the research details and clinical images.

DISCUSSION

Bullet emboli can have an infinite number of presentations due to the trajectory of the bullet, dynamics of blood flow that may cause the bullet to migrate, and locations where the bullet enters and eventually lodges. Nguyen et al. [10] described a 23-year-old patient who was shot in the right posterior shoulder, with a CT scan showing the bullet traversing from the right axilla to the right ventricular apex, without evidence of cardiac tamponade or effusion. This led the authors to believe that the myocardium and pericardium had not been penetrated. Due to the motion of the bullet independent of the right ventricle, it seemed to be most probably located within the pericardial fat, but the location still remained unclear with intraoperative transesophageal echocardiography. The differential diagnosis included direct injury to the pericardium or bullet embolism through the venous system, and the latter was confirmed via exploratory surgery that showed entry into the superior vena cava. Intraoperatively, cardiac massage was performed to milk the bullet to the IVC where it was then retrieved via venotomy. The authors recommended CT scans and echocardiography as the gold standard for imaging diagnosis. Potential complications of bullet emboli if untreated include pulmonary embolism, dysrhythmias, and endocarditis. The authors also reviewed the literature, describing various treatments for bullet emboli in addition to venotomy, such as atriotomy, ventriculotomy, and percutaneous retrieval.

Another case report described a 26-year-old man who was shot in the upper back overlying the scapula, with a hematoma present in the right upper chest [11]. No pneumothorax, effusion, or cardiac tamponade was observed. A CT scan showed extravasation of contrast from the right axillary artery, a thrombus in the right subclavian vein, and a bullet present in the right ventricle, which was confirmed by transthoracic echocardiography. Prior to operative intervention, transesophageal echocardiography confirmed that the bullet was in the right ventricle without movement. The patient was then placed on cardiopulmonary bypass. A right atriotomy was performed and a long tonsil clamp was advanced from the right atrium past the tricuspid valve to the right ventricle, in which a 0.38 caliber bullet was found to be seated between the trabeculae and subsequently removed. The authors noted that bullet emboli are probably more frequent with low-velocity handguns because high-powered weapons cause through-and-through damage, being much less likely to lodge in a vessel and embolize. The authors also recommended using CT

and transesophageal echocardiography, but preferred echocardiography due to its higher accuracy and resolution. Management recommendations included observation, intravascular retrieval, and removal with surgery.

Bakir et al. [12] discussed the case of a patient who had a bullet embolus that moved to the right internal iliac vein from the right atrium, before traveling back through the vasculature to the pulmonary artery. Initial CT angiography following a GSW to the right side of the back showed the bullet in the right atrium with hemothorax. The bullet eventually traveled to the right internal iliac vein 3 weeks later. The patient was discharged home after refusing surgery due to being asymptomatic. However, 3 months later he was readmitted for chest pain, dyspnea, and hidrosis. A chest CT scan revealed the bullet to be lodged within the left lower lobe pulmonary artery. It was removed by thoracotomy, revealing a 0.36 caliber bullet. The authors also discussed possible complications of venous bullet emboli, including pulmonary embolism, endocarditis, cardiac valve dysfunction, thrombosis, and local tissue erosion, which may vary with time to presentation.

Yoon et al. [13] conducted a systematic analysis of venous bullet emboli in the right-sided heart and vasculature, extracting data on patient demographics, foreign body entry site and destination, presenting symptoms, and management. Compiling more than 60 cases, they determined that most patients were male, with an average age of 25 years, most were diagnosed in the acute setting, almost 90% of patients were asymptomatic, and there was a roughly equal distribution of bullet entry sites throughout the body with fewer entries in the neck. Seven of these patients had cardiac symptoms, in which four were treated with open surgery; three patients had delayed symptoms years after injury; and endovascular retrieval was successful 53% of the time, while the rest were converted to open surgery.

Miller et al. [14] proposed circumstances that prompt suspicion for bullet emboli, such as identifying an incongruous number of entry and exit wounds for bullets, an inconsistency between the imaging-confirmed bullet location and its trajectory, and changing locations of the bullet following serial imaging. The authors noted that most bullet emboli were located arterially (80%), and 15% of venous emboli traveled retrograde due to the effects of gravity. It was observed that most sites of venous emboli were in the right ventricle and pulmonary tree; Sabour et al. [15] opined that CT scans of the chest insufficiently convey the location of the layer the bullet is in (e.g., intraparenchymal, intravascular, or intrabronchial).

These cases are just a sample demonstrating the wide variety of ways in which a bullet embolus may travel following a GSW to the torso with a low-powered, low-velocity weapon. The discussion of these similar cases illustrates how unique this patient and every other patient's case is, as the bullet in our patient could have entered a different part of the heart or migrated elsewhere. Furthermore, the other cases demonstrate variability in presentation due to the weapon used, entry/ exit wounds, hemodynamic signs, symptom course, surgical/nonsurgical treatment, and outcomes. Our case was unusual as a venous embolism, contrasting against the majority of the cases being arterial, and rarer yet in that retrograde flow was observed. As the patient's troponin level was slightly elevated, it was considered that the bullet had likely entered the right atrium causing cardiomyocyte damage, which is unusual as most cases in the literature have identified the bullet in the right ventricle. The injury to the atrium was likely quickly stabilized with a hematoma as no effusion or tamponade was observed; this is supported by the fact that the bullet was small. The bullet then migrated towards the right iliac vein due to gravity via the IVC. Given the patient's psychological status and wishes, no further treatment was sought thereafter, although subsequent treatment would have mostly likely been a vascular exploration and venotomy, taking into account the bullet's location. As a consequence, he is at risk for complications such as a latent risk of potential proximal embolization, venous thrombosis, and inability to receive magnetic resonance imaging and some invasive intravascular procedures due to high risk of dislodging the bullet fragment.

In conclusion, bullet emboli are a rare complication of GSWs, especially those inflicted with low-velocity weapons. The paths of bullet emboli vary widely among cases, manifesting with a myriad of presentations and symptoms. The management is time-sensitive and heavily dependent on the trajectory/migration of the missile and the patient's associated complications. In the event of a low-caliber GSW, a bullet embolus should be ranked highly in the differential diagnosis and emergently imaged with echocardiography; furthermore, surgical removal should be considered.

ARTICLE INFORMATION

Author contributions

Conceptualization: KW, AAR, AC; Formal analysis: SS, KW, AAR, AC; Investigation: SS, AK, AC; Methodology: SS, KW, AAR, AC; Writing–original draft: SS, AK; Writing–review & editing: all authors. All authors read and approved the final manuscript.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Data availability

Data sharing is not applicable as no new data were created or analyzed in this study.

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