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Case report

Right ventricular bullet embolism: Diagnostic and therapeutic decisions

Leonard A. Stallings^{a,b,*}, Mark A. Newell^c, Eric A. Toschlog^c, Christopher C. Thomas^d, Alan P. Kypson^e^a Department of Emergency Medicine, East Carolina University, Brody School of Medicine, Greenville, NC, USA^b Department of Internal Medicine, East Carolina University, Brody School of Medicine, Greenville, NC, USA^c Department of Surgery, Division of Trauma and Surgical Critical Care, East Carolina University, Brody School of Medicine, Greenville, NC, USA^d Department of Radiology, East Carolina University, Brody School of Medicine, Greenville, NC, USA^e Department of Cardiovascular Sciences, Division of Cardiothoracic Surgery, East Carolina Heart Institute at The Brody School of Medicine, Greenville, NC, USA

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ABSTRACT

Right ventricular bullet embolism is an extremely rare phenomenon documented sporadically in the medical literature. This occurs most commonly in the setting of small calibre, low velocity missiles. We report a case of a relatively large 0.40 calibre bullet that embolised to the right ventricle via the axillary vein after a patient sustained a gunshot wound to the right shoulder. After a failed attempt at endovascular removal, the intact bullet was removed through median sternotomy with cardiopulmonary bypass and cardioplegic arrest.

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A 23 year old male presented to an outside emergency department with a gunshot wound to the right upper extremity. Physical exam revealed an entrance wound in the back of the right shoulder with no exit. He denied any chest pain or shortness of breath. An X-ray of the chest demonstrated multiple fractures of the right shoulder complex in addition to a projectile lying in the middle of the thorax (Fig. 1a). This was further delineated with a computed tomogram of the chest which was notable for a foreign body in the region of the right ventricular apex (Fig. 1b).

On arrival to our facility, the patient was haemodynamically stable. There was a 1 cm gunshot wound to the posterior right shoulder with no identifiable exit wound. Neurovascular exam of the right upper extremity was normal. Cardiac auscultation revealed normal heart sounds with no rubs or murmurs. EKG demonstrated normal sinus rhythm with no abnormalities.

Vascular and interventional radiology (VIR) was consulted. The right atrium and ventricle were accessed via the femoral vein for attempted endovascular removal of the bullet. This failed despite using multiple guiding sheaths as well as Amplatz Goose neck snare (ev3 Endovascular, Inc., Plymouth, MN) and Triple loop En-Snare (Merit Medical, South Jordan, UT). Cardiothoracic surgery was consulted. A trans-thoracic echocardiogram (TTE) was

completed which demonstrated a normal ejection fraction of 60–65% with no valvular abnormalities and no pericardial effusion. The bullet was visualised within the right ventricle.

The patient underwent a median sternotomy with cardiopulmonary bypass and cardioplegic arrest. Immediately prior to the sternotomy, an intra-operative transoesophageal echocardiogram (TEE) was used to verify that the bullet had not moved since the TTE. A right atriotomy was performed and the tricuspid valve was retracted open. On inspection of the right ventricle, there was noted clot and fibrinous adhesions overlying and encasing the bullet (Fig. 2a). Removal was achieved without damage to the right ventricular wall (Fig. 2b). The bullet was an intact .40 S&W. The patient was discharged on post-operative day #4 in stable condition with no complications. He was seen 2 weeks after discharge and was doing well with only a complaint of some limited range of motion of his right shoulder.

Discussion

High velocity projectile or bullet embolus to the heart is an extremely rare event. Originally described in 1834, the first documented case details a 10 year old boy who was fatally wounded by a gunshot (wooden) to the chest. Findings at autopsy revealed an intact pericardium with a wooden bullet embedded in the right ventricle. The authors surmised that after causing a pulmonary injury, the bullet passed from the superior vena cava through the right “auricle” and into the right ventricle. Interestingly, this was met with scepticism since the concept of

* Corresponding author at: East Carolina University, Brody School of Medicine, 600 Moye Boulevard, Mailstop 625, Greenville, NC 27834, USA.
Tel.: +1 252 744 4184; fax: +1 252 744 4125.

E-mail address: stallingsl@ecu.edu (L.A. Stallings).

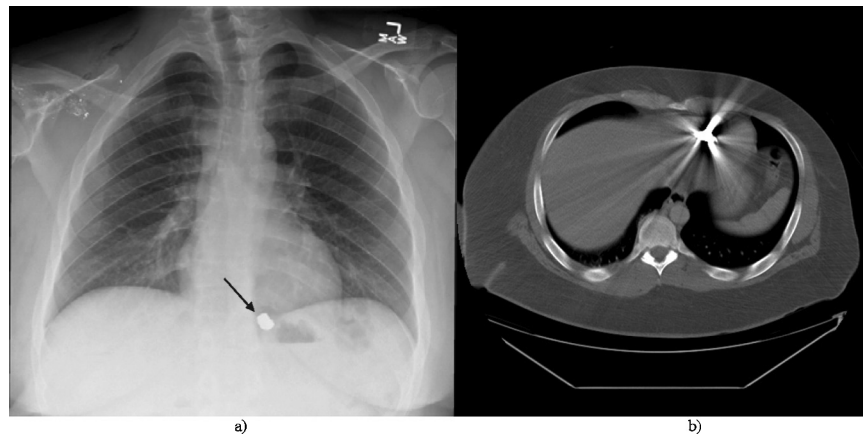


Fig. 1. (a) Initial X-ray. (b) CT chest cut demonstrating RV bullet embolism.

thromboembolic phenomenon had not been derived, much less accepted; Virchow did not posit these terms until 1863.^{2,1} The first documented case of cardiac lead bullet embolism appeared in 1917.¹¹ Specifically, a shell fragment was found in the left ventricle after a thigh wound in a victim with a patent foramen ovale.

To date, there have been approximately 300 published cases on intravascular bullet emboli.¹³ The literature supports that the majority are arterial (70–75%) in nature with the remainder being venous or paradoxical.^{9,3} However, these percentages are called into question by a recent literature analysis suggesting that 45.6% are arterial and 52% are venous.¹³ Regardless of the exact percentages, a bullet embolus of any type remains a rare phenomenon. Though most venous emboli travel with flow, retrograde emboli secondary to gravity has been described in up to 15% of injuries.⁹ Of note, a paradoxical bullet embolus originates as a venous embolism, travels to the right heart and, via either an intra-cardiac defect (i.e. patent foramen ovale or ventricular septal defect) or a traumatic communicating arterial-venous fistula, gains access to the arterial system.^{9,6} This is exceptionally uncommon with a recent article noting four cases in a 76 year period¹¹ and another estimating its incidence as 2.4%.¹³

Arterial bullet emboli, typically result in pain related to peripheral and end organ ischaemia, and should be extracted.⁹ There remains considerable controversy regarding the optimal management of venous bullet emboli to the heart particularly since most venous emboli are asymptomatic.¹² The two most common locations for venous emboli are the right heart and pulmonary arterial vasculature with some citing a figure as high as 82%.^{9,7} There is no clear consensus on management with some advocating observation while others also favouring removal given the risk of pulmonary embolism, bacterial endocarditis, valvular dysfunction, or cardiac tissue erosion.³ A phenomenon classified as

“cardiac neurosis” is also described whereby a patient becomes so obsessed by the knowledge of the venous bullet embolus that it causes psychological disturbance including fear of movement resulting in a shift in the location of the bullet.^{2,3,7} Indeed, one patient threatened suicide if the bullet was not removed forcing the surgeons to pursue removal.⁵

Though there is no way to be certain, it is highly likely that this right ventricular bullet embolus likely occurred as a result of a central venous injury at the right axillary vein before coming to rest in the right ventricle. No obvious source of vascular injury was noted during the VIR procedure or during surgery. However, this is not unexpected given that the entrance site of a bullet embolus often will not need surgical repair secondary to spontaneous tamponade or haemostasis.³

It has been previously noted that in order for a bullet to become an embolus it must only penetrate one side of a vessel or cardiac chamber and remain in the lumen of the structure.^{13,7} Bullet calibre and kinetic energy have also been identified as the primary variables for this to occur. Shotgun pellets and 22 calibre bullets accounted for the majority of intravascular emboli since the bullet diameter must be smaller than the vessel it enters with notation that shotguns and rifles have higher velocities than pistols.¹³ In this case, the exact distance of the patient from the assailant at the time of the shooting or the specific weapon (i.e. rifle vs. handgun, specific muzzle velocity) that fired the .40 S&W bullet is unknown though it was most likely a pistol. However, the fact that it was able to embolise given its size is impressive. In fact, review of the literature confirms that all reported cases have been 0.38 calibre or less,¹³ making this case the largest calibre bullet reported.

Given the potential risk that is associated with open heart surgery, the advent of endovascular techniques has ushered in a unique opportunity in these cases. Our attempt at endovascular

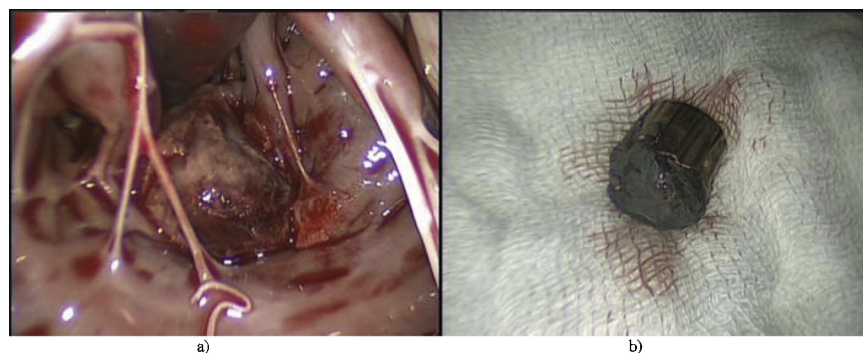


Fig. 2. (a) Intra-operative embedded RV bullet embolism. (b) Removed intact .40 S&W bullet.

snare removal of the venous bullet emboli is in agreement with several other recently presented cases in the literature.^{9,10} The first case of a successful endovascular snare of a bullet was in 1980 and involved removal of the bullet embolus from the right ventricle.⁸ As techniques continue to develop this will likely become the initial therapeutic approach. Of course, in the absence of experience with these techniques, surgery remains a viable option depending on institutional experience.⁴

It is of paramount importance to localise the bullet as accurately as possible when a decision has been made to intervene in the setting of an asymptomatic venous embolus. An initial chest X-ray should be completed for preliminary localisation and possible evidence of other sequelae from the missile. In the haemodynamically stable and asymptomatic patient, a CT scan of the chest should be the next imaging study.⁷ This is with the caveat that the projectile may generate too much artefact for exact localisation and further imaging may be necessary.⁷ Further localisation is advocated with focused assessment with sonography for trauma (FAST), TTE, TEE, fluoroscopy or even coronary angiography as findings with each test can aid in guiding decision making with regard to a conservative approach with serial imaging, percutaneous removal, or operative removal.⁷

Several recently published guidelines offer conflicting management strategies.^{9,7} One such study indicates that bullet emboli to the left heart should be removed (operative removal only) if the patient is symptomatic, the embolus is intracavitary, or it is partially embedded. Furthermore, if the patient is asymptomatic and the embolus is completely embedded in either side of the heart or the patient is asymptomatic with a right sided bullet embolus <5 mm then observation with serial imaging should be done.⁷ Another report suggests that asymptomatic venous emboli located anywhere other than the pulmonary artery should be retrieved. It further states that only emboli in the pulmonary artery that are accessible with endovascular techniques, should be removed.⁹ In contrast to the former, yet another publication recommends operative removal of a right ventricular bullet embolus from an asymptomatic patient due to a 42% mortality rate if the bullet embolises to the pulmonary artery.¹² Indeed, concern for sequelae from pulmonary artery embolism was the main reason behind our decision to remove the bullet given ~26% of venous emboli ultimately settle there,¹³ with the potential for erosion and fatal exsanguination.

In summary, given that there are no clear and universally accepted guidelines regarding management of venous bullet emboli, the debate is likely to be ongoing with each institution

in the interim favouring their own clinical and institutional experience. The continued expansion and development of endovascular techniques will continue to shift the pendulum towards intervention even in the setting of asymptomatic emboli. In our case, a combination of multiple imaging modalities and techniques were utilised to facilitate a positive outcome for the patient. Ultimately, management decisions for an asymptomatic patient with a right heart bullet embolus should involve considerations of patient interest, available institutional resources, circumstance of discovery, anatomic location of the embolus, and experience of the surgeon if an open approach is decided.

Conflict of interests

This is a statement certifying that there are no financial or personal relationships with any of the authors that could serve as a conflict of interest with the preparation or submission of this work.

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