

CASE REPORT

PATHOLOGY/BIOLOGY

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Intravascular Bullet Embolism to the Right Atrium

ABSTRACT: Bullet embolism is a relatively unusual complication of gunshot wounds. Embolism to the right atrium comprises <5% of all reported intravascular bullet emboli. We report an additional case of bullet embolus to the right atrium of a 0.38-caliber bullet following a gunshot wound to the chest. The intracardiac bullet was recognized radiologically on presentation, but the patient was hemodynamically stable and managed conservatively, with the bullet left in place. The missile remained within the heart without clinical significance for several years and was recovered from the right atrium only at the time of autopsy. To the best of our knowledge, this is the first documented case of a 0.38-caliber bullet which embolized to the right atrium and remained inconsequential for an extended period of time.

KEYWORDS: forensic science, forensic pathology, autopsy, gunshot wound, bullet, embolism, heart, right atrium

Intravascular bullet embolism was once considered a rare complication of gunshot wounds. There are now nearly 300 published cases since the first report in 1834 by Davis, who described embolization of a wooden bullet fragment to the right ventricle (1). An almost equal number of bullet emboli in both the venous and arterial circulations have now been reported, with *c.* one-fourth embolic to the cardiac chambers, primarily the right ventricle. To our knowledge, there are only six well-described cases of bullet embolus to the right atrium, all but one of which were surgically removed immediately following trauma (1–6). The current case details a bullet embolus to the right atrium that was recovered at the time of autopsy more than 5 years posttrauma.

Case Report

A 35-year-old Asian man with a history of ethanol use presented to the emergency room at the Medical Center of New Orleans in June 2002 after being shot in the left chest with an unknown caliber weapon. He complained of localized chest pain and mild shortness of breath. Physical examination revealed a bullet entrance wound in the left mid-axillary line at approximately the fifth intercostal space. He was hemodynamically stable on presentation, and chest radiograph showed a bullet within the anterior mediastinum (Fig. 1). It was radiographically unclear whether the bullet lay within the mediastinal soft tissue or the heart itself. However, as he did not exhibit cardiac instability, sepsis, or shock, no surgical intervention was deemed necessary and he was managed conservatively with a thoracotomy tube. He was discharged home 10 days later in stable condition.

He presented to the same hospital in July 2007 with shortness of breath, fever, abdominal pain, and hemoptysis that had persisted for several days. While in the emergency room, he became



FIG. 1—Anterior–posterior chest radiograph from June 2002 following gunshot wound to the left chest. There is a radiodense projectile within the anterior mediastinum at the level of the heart.

hypotensive and had labored breathing, requiring intubation. Chest radiograph revealed right pulmonary upper lobe consolidation and the bullet in the anterior mediastinum (Fig. 2). Computed tomography of the chest revealed right upper lobar consolidation with right pleural effusion and a mild left mediastinal shift. Laboratory results showed leukopenia, thrombocytopenia, acute renal failure, elevated transaminases and bilirubin, coagulopathy, and an increased anion gap metabolic acidosis. Urine alcohol screen was negative. He was admitted to the intensive care unit (ICU) and treated for probable community-acquired right lobar pneumonia with broad-spectrum intravenous antibiotics. Blood, urine, and sputum cultures grew *Klebsiella pneumoniae*. During his ICU admission, he remained hypotensive despite vasopressor and fluid support. He rapidly deteriorated into septic shock, disseminated

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Received 8 Oct. 2009; and in revised form 5 Jan. 2010; accepted 10 Jan. 2010.

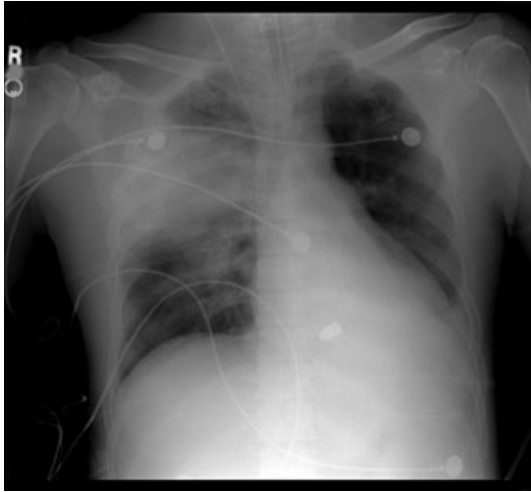


FIG. 2—Anterior–posterior chest radiograph from July 2007 admission shows marked right upper lobe consolidation and persistence of the radio-dense projectile in the anterior mediastinum.

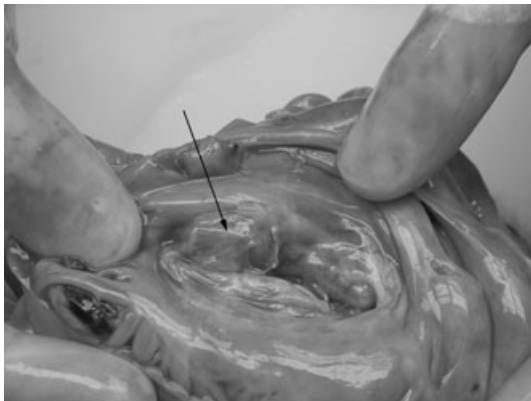


FIG. 3—A bullet (arrow) is seen within the wall of the right atrium at the level of the posterior tricuspid annulus, surrounded by fibrous tissue. The leaflets of the tricuspid valve were pliable.

intravascular coagulation, and multisystem organ failure. He became asystolic and expired 18 h after presentation. An autopsy was performed at the request of the coroner secondary to the decedent's chronic ethanol abuse and brief hospital course.

Major findings at autopsy included acute right lobar pneumonia, growth of *K. pneumoniae* in postmortem lung culture, alcoholic cirrhosis, and acute pancreatitis. Additional findings included a 3.5-cm hypopigmented, linear scar in the left mid-axillary line over the fourth to fifth intercostal spaces, as well as significant anterior, posterior, and lateral left pleural adhesions. Gross examination of the heart revealed no evidence of trauma, with an unremarkable pericardium and epicardium, and intact ventricular and atrial walls. There was a bullet surrounded by fibrous tissue within the wall of the right atrium at the level of the posterior tricuspid annulus (Fig. 3). Following dissection and removal from the right atrium, this bullet was visually determined to be of 0.38 caliber. The cause of death was *K. pneumoniae* sepsis secondary to right lobar pneumonia, and the manner of death was classified as natural.

Discussion

Bullet embolism is an unusual but now well-recognized complication of gunshot wounds. Large multicase reports, such as

TABLE 1—Origins of bullet emboli within venous system (n = 109).

	Number	Percent
Inferior vena cava	38	34.9
Common or external iliac vein	19	17.4
Femoral vein	14	12.8
Right ventricle	7	6.4
Right atrium	6	5.5
Internal jugular vein	5	4.6
Subclavian vein	4	3.4
Axillary vein	3	2.8
Pulmonary artery	2	1.8
Sigmoid sinus	2	1.8
Transverse sinus	1	0.9
Superior sagittal sinus	1	0.9
Superior vena cava	1	0.9
Portal vein	1	0.9
Hepatic vein	1	0.9
Truncus arteriosus	1	0.9
Renal vein	1	0.9
Brachiocephalic vein	1	0.9
Mediastinal vein	1	0.9

Harkan's analysis performed in Europe during World War II, described 134 instances in which bullets or shrapnel was found within the heart or vessels, and three (2.2%) of these presented as emboli (7). An analysis of vascular trauma during the Vietnam War by Rich et al. (8) reported 22 bullet emboli out of 7500 total cases, equivalent to 0.3%. Since the publication of these large landmark case series, most bullet emboli have been reported as single nonwartime cases and varied in regard to bullet origin, final destination, embolic pathways, and caliber of bullet.

To become an embolus, a bullet must penetrate one but not both sides of the vessel or cardiac chamber, thus allowing for the potential of intravascular travel. Undoubtedly, fatal exsanguination occurs in many such instances before embolization can occur. However, significant hemorrhage may not occur depending on the vessel's elastic properties and the surrounding hematoma (2). Caliber size and kinetic energy are the primary variables in the occurrence of bullet emboli. The bullet diameter must be smaller than that of the vessel it enters to travel within the vascular system. As such, shotgun pellets and 0.22-inch caliber bullets account for the majority of projectile emboli (2,4,9). Several factors influence a bullet's kinetic energy. Firearms vary in their muzzle velocities, with air guns and pistols generally having lower velocities than shotguns and rifles (<http://library.med.utah.edu/WebPath/TUTORIAL/GUNS/GUNBLST.html> [accessed on October 2, 2009]). A pathway that includes viscera and denser soft tissue, as well as any tumbling the bullet does during its travel will also decrease its kinetic energy. The conformation of a projectile will also influence its kinetics, as blunt-nose bullets are retarded more by the soft tissue they enter than pointed-nose bullets and therefore lose greater amounts of kinetic energy (9).

Our review of the English literature through December 2007 revealed 296 reported bullet emboli. Fifty-two percent of these embolic bullets traveled within the venous system, 45.6% within the arterial system, and 2.4% were paradoxical emboli (venous origin with arterial destination). There were 206 cases in which the bullet's vascular origin was identified (Tables 1 and 2). Within the venous system, the inferior vena cava and iliac veins represent the most common vascular origins, comprising 34.9% and 17.4% of the total, respectively. Within the arterial system, the descending aorta represents over half (57.7%) of the origination sites, followed distantly by the left ventricle (17.5%). There were 232 cases in which the bullet's final destination site was reported (Tables 3 and

4). The right ventricle and pulmonary artery predominate in the venous system, comprising 53.1% and 25.9%, respectively. Within the arterial system, the femoral and popliteal arteries are slightly more common than the other peripheral arteries, at 25.8% and 19.1%, respectively. Although many of these reports do not

indicate the caliber of the embolic missile, those that do describe small caliber bullets (0.38 or less) or shotgun pellets, and the majority are <0.38.

We identified the right atrium as an embolic destination in 10 of the 232 cases in which the final destination was listed, amounting to 7.0% of the reported venous destinations and an overall frequency of 4.3% (1–6,10). Of these cases, details were available in the literature for only six (Table 5). Consistent with the other reported venous emboli cases, the most frequent site of origin was the inferior vena cava (66%). Caliber size varied in the six described cases, with three cases involving 0.38-caliber bullets (2,3,5). These entered either the inferior vena cava or left common iliac vein. In all but one case, the bullet was retrieved immediately either surgically or through interventional radiology. In one case, the injury involved 4-mm shotgun pellets to the groin, one of which entered the left femoral vein and embolized to the right atrium. This pellet was not removed. The patient remained stable over an 8-month period until which time he committed suicide by drug overdose. Examination of the heart at autopsy revealed the pellet encapsulated by fibrous tissue within the pectinate muscles of the right atrium (4). The current case describes an additional case of right atrial bullet embolus involving a 0.38-caliber projectile. It is unique because it is the only reported case of a 0.38-caliber bullet that embolized to the right atrium and remained asymptomatic until death from unrelated causes. It is also the longest reported postinjury survival after any right atrial bullet embolus at 5 years postinjury.

Missiles that enter the arterial or venous system and travel to a noncardiac destination may result in organ or limb infarct, erosion of the vascular wall, sepsis, lead intoxication, or reembolization. One report calculated the combined risk of delayed migration, partial organ infarct, sepsis, and thromboembolism of at least 10% (10). A ventricular or atrial embolic bullet that does not cause immediate symptoms becomes entrapped between the trabeculations or pectinate muscles and eventually becomes encapsulated with fibrous tissue. It may then remain inconsequential, produce myocardial instability or valvular dysfunction, become a nidus for endocarditis, or embolize further downstream (1,11).

An embolic bullet should be suspected at autopsy in any gunshot wound victim without an exit wound and either lack of a missile in the bullet pathway, no radiologic evidence of a missile in the injured area, unexpected radiologic demonstration of a missile in a remote body area, or premortem signs and symptoms unexpected for the presumed pathway of the bullet, such as distant ischemia or infection (4,7,12–14). A blurred bullet within the cardiac silhouette on chest radiograph is suggestive of an intracardiac bullet without direct penetration of the heart (25). One must also be aware that despite certain veins and arteries being more common destinations than others, it is clear that essentially any major vein or artery can be the final resting place of an embolic bullet.

As was often the circumstance throughout our literature review, the embolic vascular origin in our case was not known, as the decedent was hemodynamically stable on initial presentation and

TABLE 2—Origins of bullet emboli within arterial system (n = 97).

	Number	Percent
Descending aorta	56	57.7
Left ventricle	17	17.5
Pulmonary vein	7	7.2
Femoral artery	4	4.1
Left atrium	4	4.1
Common or external iliac artery	2	2.1
Subclavian artery	2	2.1
Common carotid artery	2	2.1
Internal carotid artery	1	1.0
Vertebral artery	1	1.0
Brachial artery	1	1.0

TABLE 3—Destinations of bullet emboli within venous system (n = 143).

	Number	Percent
Right ventricle	76	53.1
Pulmonary artery	37	25.9
Right atrium	10	7.0
Common or external iliac vein	6	4.2
Hepatic vein	4	2.8
Popliteal vein	3	2.1
Inferior vena cava	2	1.4
Superior mesenteric vein	2	1.4
Femoral vein	1	0.7
Saphenous vein	1	0.7
Renal vein	1	0.7

TABLE 4—Destinations of bullet emboli within arterial system (n = 89).

	Number	Percent
Femoral artery	23	25.8
Popliteal artery	17	19.1
Common or external iliac artery	8	9.0
Middle cerebral artery	5	5.6
Internal carotid artery	5	5.6
Peroneal artery	4	4.5
Axillary artery	4	4.5
Renal artery	4	4.5
Anterior tibial artery	3	3.4
Common carotid artery	3	3.4
Aorta	2	2.2
Left ventricle	2	2.2
Brachial artery	2	2.2
Subclavian artery	2	2.2
Coronary artery	2	2.2
Posterior tibial artery	1	1.1
Superior cerebellar artery	1	1.1
Ulnar artery	1	1.1

TABLE 5—Bullet emboli to the right atrium (n = 6).

	Origin	Bullet Caliber	Clinical Outcome
Michelassi et al. (1)	Inferior vena cava	n/a	Immediate surgical intervention with removal of bullet
Patel et al. (2)	Inferior vena cava	0.38	Immediate surgical intervention with removal of bullet
O'Neill and Feldman (3)	Inferior vena cava	0.38	Immediate surgical and radiologic intervention with removal of bullet
Pollak et al. (4)	Left femoral vein	0.16 (shotgun pellet)	Pellet not removed, uneventful recovery
Kaushik and Mandal (5)	Left common iliac vein	0.38	Immediate surgical and radiologic intervention with removal of bullet
Best (6)	Inferior vena cava	n/a	Immediate surgical and radiologic intervention with removal of bullet

treated nonsurgically, and a postmortem search for a previously injured vessel was not performed once the bullet was discovered within the right atrium. In retrospect, however, a more thorough search for the evidence of remote vascular penetration, such as hemosiderin deposition or fibrous scarring, would have been helpful in uncovering the pathway of the bullet. Grewal et al. (15) reported a case of bullet embolism to the right ventricle following a gunshot wound to the left arm with passage into the left chest. The patient was taken to surgery for the removal of the bullet, where it was noted on direct visual inspection that the pericardium was not violated in any way and the heart itself showed no external evidence of trauma. They hypothesized that the site of entrance was probably a venous structure in the mediastinum. Similarly, we believe that the bullet in our case entered the left chest, passed through the subcutaneous tissue, penetrated a large posterior venous structure, such as the inferior vena cava, hemiazygos vein, or azygos vein, and quickly traveled antegrade into the right atrium, where it remained inconsequentially for the next 5 years. The lack of any pericardial or epicardial scar tissue at autopsy suggests against direct penetration of the heart.

Conflict of interest: The authors have no relevant conflicts of interest to declare.

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