

## Aorto-Innominate Fistula by Gun-Shot Injury: A Case Report

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### ABSTRACT

We report an aorto-innominate fistula caused by gun-shot injury. The fistula was diagnosed by aortography and repaired under hypothermic circulatory arrest.

### INTRODUCTION

Gun-shot injury to the aorta usually requires prompt surgical intervention, otherwise the patient will die from acute blood loss. We encountered an unusual case of traumatic aortic tearing with adjacent innominate vein injury causing acute arteriovenous fistula. The patient was hemodynamically stable throughout the entire course and the fistula was repaired under circulatory arrest.

### CASE REPORT

A 24-year-old man was escorted to the emergency department by police officers after being involved in gun fire. He was awake and neurologically intact, but complaining of shortness of breath. There were several gun-shot wounds, including some to the bilateral anterior chest region. In the trauma bay, blood pressure was recorded as 122/60 mmHg, heart rate 140, respiratory rate 20, and oxygen saturation 98% on room air. He was intubated emergently and bilateral chest tubes were placed. Chest x-ray showed one bullet in the mediastinum and another in the upper abdomen (Figure 1). Secondary survey disclosed multiple gun-shot wounds including the chest, abdomen, and upper and lower extremities, as shown in Figure 2. The heart was tachycardic with no murmur. Pulses were equal and there was no blood pressure difference between the right and left arms. Electrocardiography showed sinus tachycardia. Hemoglobin was 12.4 g/dL. Other admission laboratory results were unremarkable.

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The patient was emergently taken to the operating room for exploratory laparotomy with an assumption of intra-abdominal organ injury; however, no intra-abdominal injury was found. Hemodynamics remained stable during the operation. No transfusion was given and his hemoglobin was 12 g/dL after abdominal surgery. Total drainage from the chest tubes was 300 cc from the right and 200 cc from the left since placement.

Due to the presence of a bullet in the chest, the patient was taken for a computed tomography (CT) scan with contrast 8 hours after presentation. CT showed substernal hematoma and a bullet in the aortopulmonary window (Figure 3). Because of the bullet and its artifact, aortic injury could not be ruled out. There was no further drainage from chest tubes and his hemoglobin was stable at 13.3 g/dL. He remained intubated but fully awake and neurologically intact.

Twelve hours after initial presentation, the patient was taken to angiography. The aortogram demonstrated dye extravagation from the aortic arch adjacent to the bovine arch.

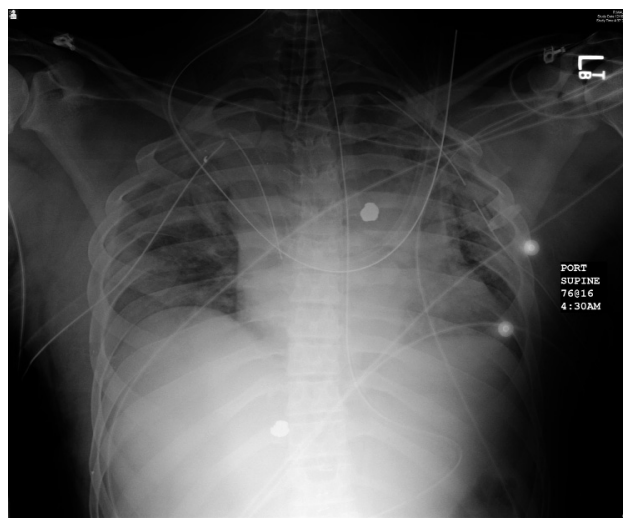


Figure 1. Chest x-ray shows a bullet in the chest and the upper abdomen.

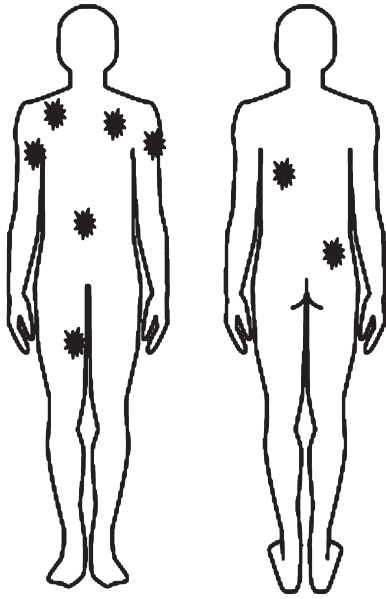


Figure 2. Schema of the multiple gun-shot wounds of the patients.

It drained into the innominate vein, and then into the right atrium (Figure 4). A diagnosis of aorto-innominate fistula was made, and no other vascular injury was observed. He remained hemodynamically stable.

The patient was taken to the operating room for aorto-innominate fistula repair. The left groin was prepared for cannulation prior to sternotomy. Median sternotomy demonstrated anterior mediastinal hematoma. The pericardium was opened and there was no pericardial effusion. At that time, cardiopulmonary bypass was established

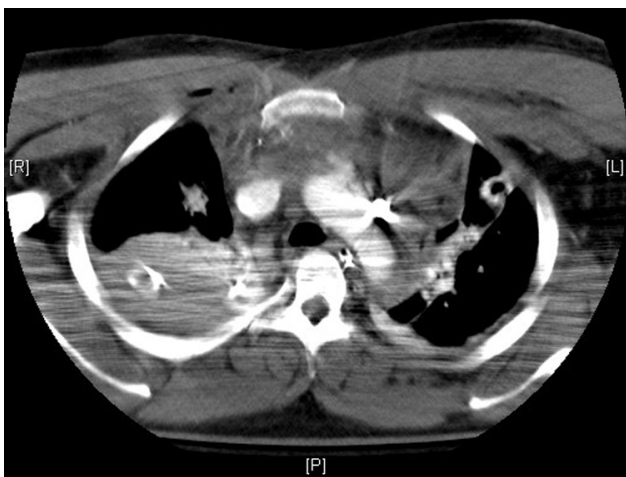


Figure 3. Computed tomography scan shows retrosternal hematoma.



Figure 4. Aortogram shows aorto-innominate fistula.

between the right atrium and the left femoral artery, and the patient was actively cooled down. Posterior to the hematoma, a tear in the innominate vein was identified, which was controlled with vascular clamps. Bleeding from the aorta just behind the innominate vein injury was found. The bleeding was temporally controlled with digital compression. Further exploration revealed that the bleeding was from the aorta between the bovine arch and the left subclavian artery. There was no space to place a vascular clamp between these major vessels. Circulatory arrest was achieved at temperature of 18°C. The aortic injury was repaired with multiple pledgeted sutures. A bullet was evacuated from the space just below the aortic arch. No further vascular injury was observed. The patient was rewarmed, weaned from cardiopulmonary bypass, and then the chest was closed. The patient was then transported to the intensive care unit.

The postoperative recovery was complicated with pneumonia and the patient required tracheostomy. Postoperative CT scan showed adequate repair, and the patient was discharged to home one month after surgery.

## DISCUSSION

Traumatic aorto-innominate fistula is rare. It was first reported in 1950 by Proctor, and since then only 29 cases including this patient have been reported in the English literature (Table 1) [Proctor 1950; McCook 1952; Sealy 1955; Meredith 1957; Conrad 1962; Beall 1962; Borst 1964; Giraud 1965; Pate 1965; Tarlov 1968; Fujise 1970; Symbas 1970; Treiman 1971; Astolfi 1976; Mavroudis 1980; Marinez 1981;

Reported Traumatic Aorto-Innominate Fistula\*

Case	Report	Age and Sex	CHF	Presentation	Interval to Presentation	Mechanism of Injury	Interval to Diagnosis	CHF	Murmur	Wide Mediastinum	Diagnosis	Approach	Shunt, CPB, DHCA	Aorta	Innominate Vein	Outcome
1	[Proctor 1950]	25M	CHF	Chronic	3 y	Laceration to zone 1	3 y	Yes	Yes	Yes	O2 step-up	Clavicle resection with upper sternotomy	No	Primary repair	Ligation	Survived
2	[McCook 1952]	25F	Murmur	Chronic	1 y	Stab to zone 1	1 y	Yes	Yes	Yes	Fluoroscopy	Partial clavicle resection with upper sternotomy	No	Primary repair	Ligation	Survived
3	[Sealy 1955]	25M	CHF	Chronic	6 y	Stab to the chest	6 y	Yes	Yes	NA	O2 step-up	Bilateral thoracotomy with transverse sternotomy	No	Primary repair	Primary repair	Survived
4	[Meredith 1957]	14M	GSW	Subacute	3 d	GSW to the upper right chest	3 d	No	Yes	NA	Exploration	Bilateral thoracotomy with transverse sternotomy	No	Primary repair	Primary repair	Survived
5	[Conrad 1962]	45M	CHF	Chronic	12 y	Stab to the left upper chest	12 y	Yes	Yes	Yes	Aortography	Median sternotomy with left anterior thoracotomy	No	Primary repair	Ligation	Survived
6	[Beall 1962]	23M	Stab wound	Acute	4 hr	Stab to zone 1	4 hr	Yes	Yes	Yes	Exploration	Median sternotomy with supraclavicular extension	No	Primary repair	Primary repair	Survived
7	[Borst 1964]	37M	CHF	Chronic	18 y	Blunt chest injury	18 y	Yes	Yes	No	Aortography	Left thoracotomy	DHCA, Fem-RA	Primary repair	Primary repair	Survived
8	[Giraud 1965]	19M	CHF	Chronic	2 y	Stab to zone 1	2 y	Yes	Yes	Yes	Aortography	Median sternotomy	No	Primary repair	Primary repair	Survived
9	[Pate 1965]	NA	NA	NA	NA	GSW to the chest	NA	Yes	NA	NA	NA	NA	NA	NA	NA	NA
10	[Tarlov 1968]	28M	Palpitation	Chronic	14 y	Stab to zone 1	14 y	No	Yes	No	Aortography	Bilateral thoracotomy with transverse sternotomy	No	Primary repair	Ligation	Survived
11	[Symbas 1970]	25M	Murmur	Subacute	22 d	GSW to the upper right chest	22 d	Yes	Yes	No	Aortography	Median sternotomy	Gott shunt	Primary repair	Primary repair	Survived
12	[Fujise 1970]	7M	CHF	Chronic	7 mo	Blunt chest injury	7 mo	Yes	Yes	Yes	O2 step-up	Median sternotomy	No	Primary repair	Primary repair	Survived

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13	[Treiman 1971]	30M	Stab wound	Acute	Stab to the zone 1	4 hr	NA	Yes	NA	Aortography	Median sternotomy	CPB	Primary repair	Primary repair	Survived
14	[Astolfi 1976]	48F	CHF	Subacute	Stab to the right upper chest	7 d	Yes	Yes	NA	Aortography	Median sternotomy	DHCA, Fem-fem	Primary repair	Primary repair	Survived
15	[Mavroudes 1980]	NA	NA	Acute	GSW to the chest	NA	NA	Yes	NA	Aortography	NA	NA	Attempted	Attempted	Dead
16	[Martinez 1981]	36M	CHF	Chronic	Stab to the upper chest	1 mo	Yes	Yes	Yes	Aortography	Median sternotomy	DHCA, Fem-fem	Primary repair	Primary repair	Survived
17	[Szymanski 1986]	20F	Stab wound	Acute	Stab to the left chest	Acute	No	No	Yes	Aortography	Median sternotomy	No	Primary repair	Primary repair	Survived
18	[Buchan 1995]	NA	Stab wound	NA	Stab to the chest	NA	NA	NA	NA	Aortography	Median sternotomy	Gott shunt	Primary repair	NA	Survived
19	[Buchan 1995]	NA	Stab wound	NA	Stab to the chest	NA	NA	NA	NA	NA	Median sternotomy	No	Primary repair	NA	Survived
20	[Buchan 1995]	NA	Stab wound	NA	Stab to the chest	NA	NA	NA	NA	NA	Median sternotomy	No	Attempted	NA	Dead
21	[Buchan 1995]	NA	Stab wound	NA	Stab to the chest	NA	NA	NA	NA	NA	Median sternotomy	No	Attempted	NA	Dead
22	[Roye 1995]	23M	Stab wound	Acute	Stab to zone 1	5 hr	Yes	Yes	Yes	Aortography	Median sternotomy	DHCA, Fem-RA	Patch repair	Ligation	Survived
23	[Roye 1995]	47M	GSW	Acute	GSW to the left chest	6 hr	Yes	Yes	Yes	Aortography	Median sternotomy	DHCA, Fem-RA	Primary repair	Primary repair	Survived
24	[Roye 1995]	39M	Stab wound	Acute	Stab to the left neck	7 hr	NA	Yes	Yes	Aortography	Median sternotomy	DHCA, Fem-RA	Primary repair	Primary repair	Survived
25	[Fulton 1997]	61M	Stab wound	Acute	Stab to the right upper chest	24 hr	No	Yes	Yes	Aortography	Median sternotomy	DHCA, Fem-fem	Primary repair	Primary repair	Survived
26	[Reddi 2003]	23M	CHF	Chronic	Stab to zone 1	4 y	Yes	Yes	Yes	Aortography, CT, MRI	Median sternotomy	DHCA, Fem-fem	Primary repair	Primary repair	Survived
27	[Seitelberger 2004]	56M	Stab wound	Acute	Stab to the upper chest	4 hr	NA	NA	Yes	Exploration	Median sternotomy	DHCA, Fem-fem	Primary repair	Primary repair	Survived
28	[Duara 2005]	19F	Iatrogenic	Acute	Open heart surgery	10 hr	NA	NA	NA	Aortography	Median sternotomy	NA	Primary repair	Primary repair	Survived
29	Current	24M	GSW	Subacute	GSW to bilateral chest	12 hr	No	No	Yes	Aortography	Median sternotomy	DHCA, Fem-RA	Patch repair	Ligation	Survived

\*CHF indicates congested heart failure; CPB, cardiopulmonary bypass; DHCA, deep hypothermic circulatory arrest; GSW, gunshot wound; Fem, femoral; RA, right atrium; NA, not available.

Szymanski 1986; Buchan 1995; Roye 1995; Fulton 1997; Reddi 2003; Seitelberger 2004; Duara 2005].

The mechanism of injury was stab wound in 19 cases, gunshot wound in 6, blunt trauma in 2, and others in 2. Correct diagnosis was made in the acute phase immediately after injury in 10 cases, in the subacute phase after initial trauma evaluation in 4, and in the chronic phase more than 1 month after injury in 10. Among 14 patients with subacute or chronic presentation of aorto-innominate fistula, 9 patients had typical symptoms of congestive heart failure and 13 had a murmur. Mediastinum widening was observed in 15 cases, but not in 3 cases. Venous blood sampling and O<sub>2</sub> step-up in the innominate vein was previously described for the diagnosis of aorto-innominate fistula; however, diagnoses are now made by aortography. To approach the aorto-innominate fistula, standard median sternotomy is adequate, although thoracotomy was used prior to the 1970s due to inadequate preoperative diagnosis. Cardiopulmonary bypass conjunction with or without deep hypothermic circulatory arrest was used in 11 cases and not in 13. Aortic injury was primarily repaired in all cases and the innominate vein was primarily repaired in 15 cases, ligated in 6, and interposed with a graft in 1.

The diagnosis of aorto-innominate fistula was made by aortography rather than CT scan. Contrast high-resolution CT scan is a good screening modality for diagnosis of aortic injury; however, evaluation of major vessel injury adjacent to the innominate vein is often difficult. [Bruckner 2006]. Contrast materials injected into the vein enhance the innominate vein so strongly that the overlapping major vessels are difficult to evaluate. Aorto-innominate fistula is impossible to diagnose by CT scan alone due to fistula flow from the aorta draining to the innominate vein. CT scan is not a good modality to observe the dynamics of the blood flow. In our case, CT scan showed equivocal findings of retrosternal hematoma, which were findings suggesting aortic injury requiring further investigation of the aorta with angiography.

Lack of extravasations maintained the patient's vital signs stable. Stable fistula between the aorta and innominate vein released the pressure of the hematoma on the aortic tear and prevented free rupture. If it had exsanguinated to the plural space or pericardial space, dismal outcome might have resulted. Certain arterial injuries may seal themselves with hematoma, resulting in a pseudoaneurysm. If a vein adjacent to the artery is similarly injured, and if the arterial pseudoaneurysm ruptures into the vein, an arteriovenous fistula can be created [Mavroudis 1980]. Once the arteriovenous fistula is made and no further rupture occurs, the patient may remain stable for years after injury. Dependent on the fistula flow, the patient with aorto-innominate fistula may stay asymptomatic or may develop heart failure. Heart failure and murmur in the upper chest with previous trauma to the area without valvular disease is a common presentation of chronic posttraumatic aorto-innominate fistula.

Surgical repair of aortic injury should be performed under cardiopulmonary bypass. Repair of arch injury usually requires deep hypothermic circulatory arrest to facilitate repair and to protect the brain. Retrograde brain perfusion should not be

performed due to innominate vein injury. An injured innominate vein can be either primarily repaired or ligated depending on the degree of injury. Tissue edema secondary to innominate vein ligation usually resolves spontaneously.

## REFERENCES

- Astolfi D, di Carlo D, di Eusano G, et al. 1976. Repair of traumatic aortic arch to innominate vein fistula under deep hypothermia and circulatory arrest. *Thorax* 31:753-6.
- Beall AC Jr, Roof WR, De Beakey. 1962. Successful surgical management of through-and-through stab wound of the aortic arch. *Ann Surg* 156:823-6.
- Borst HG, Schaudig A, Rudolph W. 1964. Arteriovenous fistula of the aortic arch: repair during deep hypothermia and circulatory arrest. *J Thorac Cardiovasc Surg* 48:443-7.
- Bruckner BA, DiBardino DJ, Cumbie TC, et al. 2006. Critical evaluation of chest computed tomography scans for blunt descending thoracic aortic injury. *Ann Thorac Surg* 81:1339-46.
- Buchan K, Robbs JV. 1995. Surgical management of penetrating mediastinal arterial trauma. *Eur J Cardiothorac Surg* 9:90-4.
- Conrad JK, Cartwright RS, Mostyn EM. 1962. Arteriovenous fistula of the aortic arch. Report of a case with hemodynamic data. *N Engl J Med* 267:15-9.
- Duara R, Suneel PR, Koshy T, et al. 2005. Brachiocephalic artery to left innominate vein fistula following median sternotomy. *Eur J Cardiothorac Surg* 28:328-9.
- Fujise Y, Nakayama K, Inatomi B, et al. 1970. Successfully treated case of arteriovenous fistula of the aortic arch and left brachio-cephalic vein due to trauma [in Japanese]. *Shujutsu* 24:793-9.
- Fulton JO, Brink JG. 1997. Complex thoracic vascular injury repair using deep hypothermia and circulatory arrest. *Ann Thorac Surg* 63:557-9.
- Giraud RM. 1965. Arteriovenous fistula of the aortic arch complicating stab wound of the neck. *S Afr Med J* 12;39:474-6.
- Martinez E, Meller J, Godoy M, et al. 1981. Arteriovenous fistula of the thoracic aorta: report of a case presenting with superior vena caval obstruction. *Thorax* 36:315-8.
- Mavroudis C, Roon AJ, Baker CC, et al. 1980. Management of acute cervicothoracic vascular injuries. *J Thorac Cardiovasc Surg* 80:342-9.
- McCook WW. 1952. Arteriovenous fistula of the aortic arch. *J Thorac Surg* 23:299-302.
- Meredith JH, Bradshaw HH. 1957. Fistula between aorta and superior vena cava; report of a traumatic case with surgical repair. *J Thorac Surg* 34:278-80.
- Pate JW, Sherman RT, Jackson T, et al. 1965. Cardiac failure following traumatic arteriovenous fistula: a report of fourteen cases. *J Trauma* 29:398-403.
- Proctor WH Jr. 1950. Arteriovenous fistula of the aortic arch; report of a case with successful treatment. *J Am Med Assoc* 144:818-9.
- Reddi A, Madansein R, Mathivha T. 2003. Traumatic arteriovenous fistula of ascending aorta and left innominate vein. *Ann Thorac Surg* 75:1637-40.
- Roye GD, Zorn GL, McGiffin DC, et al. 1995. Acute repair of aorto-innominate vein fistulas. *J Trauma* 39:753-6.

Sealy WC, Fawcett B. 1955. Arteriovenous fistula of ascending aorta and left innominate vein; report of a case with successful surgical repair. *Ann Surg* 142:302-3.

Seitelberger R, Bialy J, Rajek MA. 2004. Repair of stab-wound laceration of the aortic arch using deep hypothermia and circulatory arrest. *Ann Thorac Surg* 77:703-4.

Symbas PN, Sehdeva JS. Penetrating wounds of the thoracic aorta. 1970. *Ann Surg* 171:441-50.

Szymanski TJ, Llera JL. 1986. Traumatic thoracic aorta-innominate vein fistula: a case report. *Ann Emerg Med* 15:466-9.

Tarlov E, Greenfield LJ. 1968. Post-traumatic aortic arch aneurysm with arteriovenous fistula to the innominate vein. *J Thorac Cardiovasc Surg* 55:134-40.

Treiman RL, Cohen JL, Gaspard DJ, et al. 1971. Early surgical repair of acute post-traumatic arteriovenous fistulas. *Arch Surg* 102:559-61.