

# Successful Repair of Traumatic Aortic Tears Using Left Heart Bypass

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## ABSTRACT

**Aortic tears commonly occur in multiply injured patients. Recognizing this injury is important. A chest X-ray is helpful and a CT-angiogram or aortogram confirmatory. After attending to life-threatening injuries, the aortic tear should be repaired immediately. Using the left heart bypass technique has the lowest risk of operative neurologic injury. We review our experience over the last 2 years, discuss our preferred technique and report on the outcome.**

**Keywords:** Traumatic aortic tears, multiple injuries, left heart bypass, centrifugal pump, spinal cord ischemia

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## INTRODUCTION

Traumatic aortic tears occur commonly in patients with multiple injuries<sup>(1)</sup>. It remains a challenging surgical problem for three reasons. Firstly, it is often missed because of the presence and magnitude of other injuries<sup>(2)</sup>. Secondly, once diagnosed, correct prioritizing of all major injuries is essential for proper care. Finally, the risk of neurologic injury with surgical repair varies with the technique used<sup>(3)</sup>. We report here three cases managed in our department over the last two years. In all three cases, left heart bypass was used to repair the tears with a good surgical outcome.

## PATIENTS AND METHODS

### Case 1

A 41-year-old male construction worker fell from a height of about 30 feet and landed on his left side. He was brought in hypotensive. With resuscitation, he was stable enough to undergo a skeletal survey and CT scans of the head, thorax and abdomen. He suffered the following injuries: facial lacerations, left periorbital hematoma, supracondylar closed contaminated fracture of the left humerus and hemoperitoneum with blood around the liver and spleen with a small laceration in the right lobe of the liver. The diagnosis of an aortic

tear was however missed despite the CT scan showing a mediastinal hematoma, periaortic hemorrhage and a localized irregularity of the aortic wall. As he was hemodynamically stable, he underwent open reduction and internal fixation of the left humeral fracture under general anesthesia on the day of admission. The next day a more senior radiologist reviewed the CT Scan and alerted the team to the possibility of an aortic tear. A CT angiogram was ordered which confirmed a localized dissection of the descending thoracic aorta and a left hemothorax. An urgent operative repair was carried out. The surgical technique was essentially left heart bypass using the Sarns Delfin centrifugal pump (Sarns Inc/3M, Ann Arbor, Mich.) with partial heparinization. At the operation the aorta was found transected along half of its circumference just distal to the ligamentum arteriosum. An interposition 18mm Vascutek Gelseal (Sulzer Medical) graft was used. Total clamp time was 35 minutes. The postoperative recovery was complicated by a short period of mental confusion and obstructive jaundice. There were no neurological sequelae and the other injured sites (esp, intraabdominal) did not demonstrate excessive bleeding from the heparinization. He was discharged well 21 days after admission. At three weeks after discharge he remains well.

### Case 2

A 25-year-old male was involved in a road traffic accident. He was the driver trapped in his car and had to be extricated. He was admitted to another hospital in a hypotensive state. Following resuscitation, a chest X-ray, a skeletal survey and a CT scan of the head, thorax and abdomen were done. He sustained the following injuries: mediastinal hematoma, a short segment dissection of the proximal descending aorta, bilateral mild hemothoraces, a liver laceration and a closed fracture of right femur and humerus. He became hemodynamically unstable with a slowly enlarging abdomen. An emergency laparotomy was undertaken to stop the bleeding; the right lobe of the liver had a grade IV injury with avulsion of the right hepatic vein. This required a right hepatectomy and a

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cholecystectomy. He remained ill after the operation. When his general condition improved, an aortogram was done. This revealed a pseudoaneurysm of the aorta (Fig. 1). He was immediately transferred to our unit where an emergency operation was done to repair the tear. The same technique of left heart bypass with partial heparinization was used. An 18-mm interposition Gelseal graft was used. The total clamp time was 51 minutes. The postoperative recovery was complicated by prolonged ventilation, methicillin resistant *Staphylococcus aureus* infection of the left pleural space and left vocal cord palsy. There were no other neurologic sequelae. He was discharged relatively well about 3 months after he sustained his injuries. He was last seen about a month after discharge and was noted to be well.



Fig. I Pseudoaneurysm at proximal descending thoracic aorta.



Fig. II Pseudoaneurysm immediately opposite left subclavian artery.

### Case 3

A 32-year-old male fell 40 feet whilst trying to enter his flat through a window. He sustained multiple fractures involving transverse processes of the fifth thoracic, second, third and fourth lumbar vertebrae, right olecranon process, bilateral malleoli of the left ankle and the right eleventh rib. A CT scan of the abdomen revealed a subcapsular hematoma of the spleen and liver. The chest X-ray showed a widened mediastinum. A CT scan of the thorax showed periaortic hemorrhage. An aortogram confirmed the presence of an aortic tear just before the left subclavian artery (Fig. 2). An urgent repair was carried out the same day. The technique used was a left heart bypass utilizing the roller pump with an oxygenator with full heparinization. At operation the aorta was found to be partially transected between the left common carotid artery and the left subclavian artery, involving three-fourths of its circumference. A 20mm Gelseal interposition graft was used. Total bypass time was 2 hours 40 minutes with a clamp time of 2 hours and 12 minutes. The long clamp time was due to a difficult anastomosis. The proximal clamp was applied just distal to the left common carotid artery leaving little space for the proximal anastomosis. Despite full heparinization, bleeding from the associated injuries was not problematic. His postoperative recovery was uneventful and on the 10th postoperative day he underwent fixation of his fractures (olecranon process and malleoli).

### Surgical technique of left heart bypass

A left thoracotomy is performed via the 4th intercostal space. The left atrium is exposed by incising the pericardium posterior to the phrenic nerve. The left common femoral artery or distal descending aorta is simultaneously prepared. Heparin is given. The left atrium is cannulated for venous return and the common femoral artery/descending aorta is cannulated for arterial return. The right radial artery is monitored for pressure (cerebral perfusion) and the right femoral is monitored for distal aortic perfusion pressure. Ventilation is maintained throughout. The flow is adjusted to obtain a proximal systolic pressure of 80-100 mmHg and the distal mean pressure of 70 mmHg. After obtaining proximal and distal control with the shortest inter-clamp distance, the torn aortic edges are trimmed and the interposition graft anastomosed. On completion the patient is slowly weaned off bypass.

### DISCUSSION

Aortic tears seldom occur in isolation<sup>(1)</sup>. They occur in the setting of multiple injuries due to industrial or vehicular accidents. The majority (80%) die at the

scene due to exsanguinating hemorrhage<sup>(4)</sup>. Those who make it to hospital alive are a self-selected group<sup>(14,18)</sup> where the tear is usually limited and contained by the overlying adventitia. In all 3 cases the tear was incomplete and held together by the overlying adventitia. The hemorrhage usually tracks beneath this “protective” wall along the aorta. Left undetected they may rupture with catastrophic consequences or present later as a pseudoaneurysm. It is therefore important that this injury is not missed. The mechanism of trauma (acceleration or deceleration) and an initial CXR showing a widened mediastinum are sufficient to raise an index of suspicion. The CT scan that is done should then be examined carefully for the features consistent with a tear especially peri-aortic hemorrhage. We believe that a standard aortogram should follow the CT scan unless a CT-angiogram was done. The features consistent with a tear include a pseudoaneurysm, change in caliber of the vessel or an obvious intraluminal flap signifying a localized dissection<sup>(6)</sup>. In case 1 the injury was missed on the CT scan thus delaying the diagnosis of an aortic tear. It was fortunate that the patient underwent fixation of this fracture without incident.

With the diagnosis made, instituting a hypotensive regimen and prioritizing the injuries are important<sup>(7)</sup>. Those that are life-threatening should be managed first as seen in case 2 viz. intraabdominal hemorrhage from a torn liver. Other examples would include craniotomy for cerebral decompression and bleeding from other intra-abdominal injuries. Once these are managed we believe that the aortic tear should then be repaired. There are literature reports of delayed repair<sup>(5,13)</sup> of the tears weeks to months later as part of a planned procedure to reduce operative mortality. The tears are followed closely with repeated CT or MRI scans and any enlarging pseudoaneurysm or labile hypertension would prompt the repair. We believe that an aggressive rather than such a conservative initial management is better in terms of cost-effectiveness and safety provided the injuries are carefully assessed, correctly prioritized and managed expediently.

Another challenging aspect of this injury is the conduct of the repair. The available options<sup>(8)</sup> included a “clamp & sew” technique, full cardiopulmonary bypass<sup>(10)</sup>, Gott shunts and left heart bypass with a centrifugal or roller pump<sup>(11,12)</sup>. The two issues of concern here are avoiding further bleeding from other sites of injury due to heparin and the safety of the procedure in reducing distal spinal and visceral ischemia. Left heart bypass has the lowest incidence of operative neurologic sequelae (defined as lower extremity sensorimotor deficit, partial or total, not present preoperatively) due to spinal cord ischemia in

most reports. (2.3% Pate<sup>(10)</sup>, 2.5% Von Opperl<sup>(17)</sup>). This is not surprising as distal perfusion is important especially with clamp times of more than 30 minutes under normothermic conditions in an acutely traumatized aorta<sup>(16)</sup> (with no collaterals). Case 3 had a clamp time of more than 2 hours. Intermediate risk exists when passive shunts are used (Gott shunt), risk 10-15%<sup>(17)</sup>. The risk is highest with the clamp and sew technique risk 15-20%<sup>(17)</sup>. A second advantage of left heart bypass over simple clamping is the effect of unloading the left ventricle. Although most of the patients are young with presumably good left ventricular function, clamping the aorta may still be deleterious where there is cardiac contusion or pulmonary contusion as in a multiply injured patient and in the older patient who may have underlying coronary artery disease. The acute increase in afterload with the application of the clamp may precipitate acute left ventricular failure. If severe, eventual right-sided failure will raise central venous pressure. This in turn will decrease spinal blood flow due to a rise in CSF pressure further aggravating cord ischemia. The third advantage of left heart bypass is in reducing the time-constraint on the surgeon to complete the repair. A final advantage of using left heart bypass is avoidance of declamping shock.

The major disadvantage however is that heparin is required. With multiple injuries this is a real concern not only for associated injuries but also for instances of pulmonary laceration/contusion. However bleeding is seldom a problem for 2 reasons. The aortic tear is usually contained by the adventitia and the more life threatening injuries such as splenic or liver tears are managed first. A two to three day delay in the repair of the aorta past this critical period is seldom met with increased bleeding from these sites. Secondly, the centrifugal pump requires minimal (1 mg/kg body weight) or no heparin. There is however a place for the clamp and sew technique when there is exsanguinating hemorrhage or when clamp times of less than 30 minutes are anticipated.

## CONCLUSION

In conclusion, aortic tears today should not be missed in acceleration/deceleration injuries. A chest X-ray with mediastinal widening should raise an index of suspicion, prompting an aortogram/CT-angiogram to confirm the tear. All injuries should be prioritized, treating life-threatening injuries first. After a short delay, the aortic tear should be repaired. With few exceptions, left heart bypass can and should be used to conduct the repair. This distal perfusion is important in reducing the incidence of neurologic sequelae thus further preserving the quality of life.

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