Arterial injury

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Urban violence, collision of high-speed vehicles, acts of terrorism and military conflict continue to present difficult arterial injuries. The immediate threat of exsanguination, combined often with multiple trauma, and the challenge of limb salvage makes speedy effective management essential to improve the outcome for victims, who are frequently young adults.

Vascular repair as practised now has only been a reality during the last 60 years. An amputation rate during World War I of 72.5% (Ogilvie, 1944) fell during World War II to 35.8% (De Bakey and Simeone, 1946) because of the increasing success of limb salvage by vascular repair. In more recent years the experience of surgeons in busy trauma units and across the world has contributed significantly to the management of such injuries (Barros D'Sa, 1982; McKinley et al, 2000).

INITIAL MANAGEMENT

Standard resuscitation, as with all trauma victims, is essential, ensuring an adequate airway and generous intravenous access for resuscitation. It is worth exercising caution in transfusing large volumes of intravenous fluid, lest a rapid rise in blood pressure precipitate increased haemorrhage, particularly in those patients with intrathoracic or abdominal injury. Patients with penetrating injuries must be given antibiotic prophylaxis and tetanus toxoid.

TYPES OF INJURY

Penetrating

Arterial injuries in the neck, shoulder area and chest are frequently caused by a penetrating injury by stabbing or gunshot wound (McKinley et al, 2000). Characteristically, low velocity bullet wounds cause injury along the course of the track, while high velocity missile injury causes a wide area of tissue damage and often secondary injury as a result of shattered fragments of bone and foreign body that may be sucked into the wound.

Blunt

Traction injury to the vessels of the arm or leg, caused by sudden deceleration (e.g. a motorcyclist thrown from his/her bike), is frequently accompanied by similar injury to nerves and fracture and/or dislocation of bone and joint. Deceleration after head-on collision can cause injuries of the thoracic aorta, which are not always apparent on initial presentation (Katyal et al, 1997).

Crush

Entrapment in a vehicle or falling masonry may crush vessels, particularly in the limbs, and be associated with widespread soft tissue and skin damage.

The effect of injury on the artery wall

Penetrating injury to a vessel by a sharp instrument may cause complete transection or laceration with exsanguination through the wound or a rapidly enlarging and sometimes pulsatile haematoma. A vessel completely transected may be sealed by a plug of thrombus. An avulsion injury will result in initial rupture of the intima of the artery, which rolls back within the vessel, followed secondarily by rupture of the media and adventia. This has significant consequences when the vessel is repaired, for intimal damage may extend more proximally than is initially apparent. Injury of adjacent artery and vein may give rise to arteriovenous fistula associated with shunting and a high output cardiac state.

Spasm only is an uncommon cause of limb ischaemia following injury and in practice should not be considered likely in the presence of hard signs of arterial trauma.

LIMB TRAUMA

The attempts that have been made to predict the likelihood of saving a traumatized limb by use of scoring systems (Johansen et al, 1990) are not always easy to implement. Clearly time is an important factor. If the limb has become irreversibly ischaemic, it is not only pointless but also hazardous for the patient to attempt to revascularize the limb. A limb that is anaesthetic from nerve injury with bony and soft tissue damage may ultimately prove a liability. At the time of initial presentation this is often difficult to judge and an attempt at limb salvage is reasonable.

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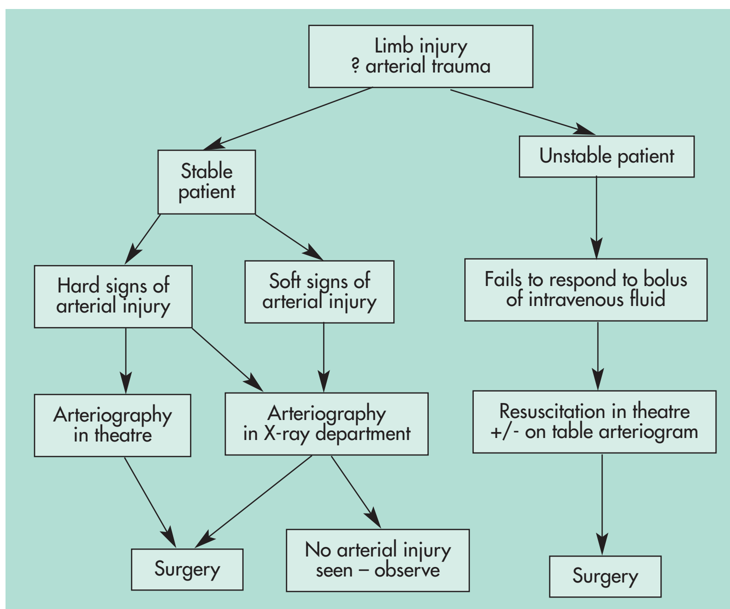
Initial assessment should first confirm the presence of an arterial injury. ‘Hard signs’ of ischaemia, e.g. absent pulses, cool anaesthetic limb, pallor or colour change, confirm the diagnosis. More difficult are the patients who present with a haematoma, which is not pulsatile or expanding, with minimal signs of ischaemia. In these patients preliminary angiography is recommended. Doppler ultrasound is an alternative investigation that can help detect the presence of localized injury to an artery, providing the soft tissue damage does not make the examination impractical. If the patient’s condition dictates urgent exploration, an on-table arteriogram can give all the information necessary. In injuries of the upper limb (particularly around the shoulder, where access to the vessels may be difficult) surgery can be helpfully preceded by an arteriogram to help plan the best incision (*Figure 1*).

Peroperative management and surgical techniques

Position on the operating table: In upper limb injury, the affected limb should be placed at right angles to the trunk on a board, with the neck and chest included in the operative field. A leg should be cleaned and draped to harvest a long saphenous vein if necessary. Similarly, both legs should be prepared when one is injured, to enable vein to be harvested from the healthy side.

Incisions for upper limb vessels: The proximal subclavian artery may need access through a median or limited sternotomy (Robbs and Baker, 1977). The distal subclavian or proximal axillary arteries are best exposed through supra- and infra-clavicular incisions. Exposure of the more distal axillary or brachial artery can be obtained by extending the incision along the delto-pectoral groove. Division of the clavicle results in significant morbidity and is best avoided.

Figure 1. Scheme for management of suspected limb arterial injury.



Incisions for lower limb vessels: Penetrating injuries to the groin may be best preceded by exposure of the external iliac artery through a muscle-splitting incision above the inguinal ligament first. Groin injuries can be explored through a longitudinal incision, exposing common, superficial and profunda femoris arteries. The popliteal artery can be approached through a medial incision giving good access to the vessels of the thigh, popliteal fossa and proximal vessels in the calf. A posterior approach to the popliteal fossa is an alternative.

The principles of arterial repair: The proximal and distal vessels should be exposed by sharp dissection and sufficient length of artery exposed to ensure that healthy vessel is reached. Frequently it is necessary to remove thrombus, both proximally and distally. Once proximal and distal flow are established, gentle irrigation with heparinized saline 20 units/ml helps wash the vessel edges clean. Frequently the artery will have sustained significant trauma, making direct repair impractical. Repair of artery ends under tension will result in stenosis and re-thrombosis. Similarly, repair of vertical injury, narrowing the vessel, will produce the same undesirable effect. Sharp injury to the wall of the artery may be repaired without stenosis using a vein patch.

In the majority of cases, an interposition graft will be needed and reversed long saphenous vein from the healthy leg is ideal. Cephalic vein from the arm may be a reasonable substitute. In some circumstances synthetic graft may be used with success, although in contaminated wounds its use is contraindicated. In a limb that has sustained significant surrounding soft tissue trauma, e.g. from a gunshot wound, an extra-anatomical bypass might be sensibly considered.

Management of associated fractures: Ideally the limb should be stable before an arterial reconstruction is carried out. However, lengthy delay with prolonged ischaemia of the limb is equally undesirable. This produces a conflict, which may be resolved by the application of a temporary shunt, as suggested by Barros D’Sa and Moorehead (1989). This technique buys time by restoring the circulation while bony stability is obtained. The good limb salvage results, using either a Brenner shunt or shunt of silicone or plastic tubing, make a strong argument for the use of this technique.

General wound care: It is essential that devitalized tissue and debris be removed from the wound. Contiguous nerve damage is a frequent finding. The contused or extensively damaged nerve is best left for later repair. If the debridement leaves graft or anastomosis exposed, the use of a muscle flap, e.g. sartorius, will protect the vessel from infection and secondary bleed.

The use of fasciotomy: After prolonged ischaemia and reperfusion, there is a risk of compartment syndrome. Decompression of the three compartments of the lower leg may be wise at the completion of the arterial reconstruction. More rarely, similar fasciotomies may be necessary in the forearm.

ARTERIAL INJURIES OF THE THORAX AND ABDOMEN

Patients presenting with arterial injury of the trunk have often sustained multiple trauma and present with a wide variety of different problems.

Deceleration injuries affecting the thoracic aorta may be difficult to detect initially (Simon and Leslie, 2001). A computed tomography scan may be helpful to identify a contained rupture. For patients with a free rupture, a grossly widened mediastinum combined with a haemothorax and transient haemodynamic instability are risk factors for sudden death from overwhelming haemorrhage and an indication for urgent thoracotomy.

Infra-abdominal injury of large vessels, in particular the aorta and iliac arteries, require proximal and distal control of the vessels. If such injuries are suspected before laparotomy, the surgeon must have in mind a plan for immediate proximal control, either exposing the aorta infrarenally or alternatively, exposing the supra-renal aorta via a left paracolic peritoneal incision.

IATROGENIC INJURY

After access for angioplasty and stenting of the coronary arteries, or the aorta and iliac arteries, a resulting false aneurysm at the site of cannulation can be satisfactorily controlled with pressure under Doppler ultrasound control with or without injection of thrombin (Vermeulen et al, 2000) (*Figure 2*). Rupture of the iliac arteries during angioplasty may on occasion require surgical intervention, but increasingly the use of covered stents to seal the leak is performed by the radiologist (*Figure 3*). HM

Conflict of interest: none.

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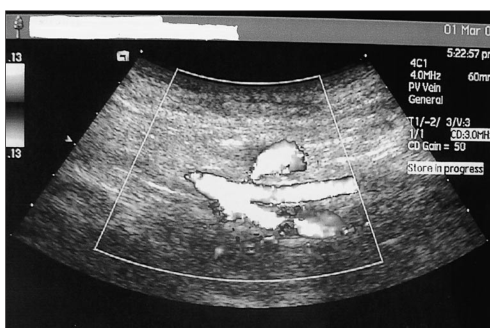

Figure 2. Femoral pseudoaneurysm following cardiac catheterization, as seen on Duplex scan.

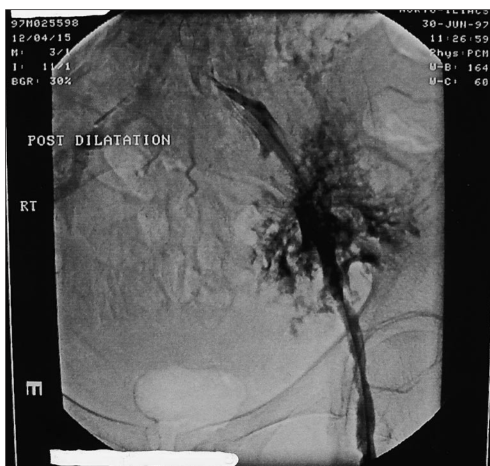

Figure 3. Rupture of artery during iliac angioplasty.

KEY POINTS

- Resuscitation should be undertaken with care in patients suspected of arterial injury.
- Is the limb viable?
- Consider a shunt to buy time while the patient, or bones and joints are stabilized.
- Avoid using a prosthetic graft if possible.
- Consider the possibility of laceration of the thoracic aorta in rapid deceleration injury, particularly head-on collision of vehicles.
- Consider stenting, particularly in radiologically-induced rupture at angioplasty.