Femoral Artery Injuries

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Injury/Disease Demographics

- In civilian series 50% to 60% of extremity arterial injuries occur in the femoral or popliteal arteries
- Femoral artery injuries include intimal injuries (flaps, disruptions or sub-intimal/intra-mural hematomas), complete wall defects with pseudoaneurysms or hemorrhage, complete transections with hemorrhage or occlusion, arteriovenous fistulas or vascular spasm.

Clinical Presentation

- Patients can present with hard or soft signs of vascular injury.
- Any patient presenting with penetrating injury to the groin or medial thigh should be considered to be at risk for a femoral artery injury.
- Blunt trauma resulting in femoral head, femoral neck or complex femoral shaft fractures should be considered to be at risk for a femoral artery injury.
- Motor or sensory deficits may be an early sign of arterial injury due to ischemia.

Evaluation/Diagnostics/Imaging

- If an associated fracture is present, it should be realigned before definitive vascular examination.
- Clinical evaluation of the extremity should determine if "hard" or "soft" signs of vascular injury are present.
- "Hard" signs of injury include:
    - pulsatile bleeding
    - a rapidly expanding hematoma
    - a palpable thrill/audible bruit
    - classical signs of arterial occlusion (pulselessness, pallor, paresthesias, pain, paralysis).
- There is a high correlation between these clinical findings and the presence of arterial injury.
- "Soft" signs of arterial injury include:
    - a cool limb
    - change in color
    - nonexpanding hematoma
    - non-pulsatile bleeding
    - thrill/bruit
    - associated nerve injury
    - injury proximity to vasculature.
- The prevalence of arterial injury is lower when only soft clinical signs are present so these patients should undergo further evaluation for vascular injury.
- Initial screening with an ankle brachial index (ABI) is paramount. Any patient with an ABI < 0.9 should undergo vascular imaging.
    - An ABI is performed by measuring the systolic blood pressure from both brachial arteries and from both the dorsalis pedis (DP) and posterior tibial (PT) arteries. Both should be measured with a handheld 5- or 10-mHz hand held Doppler. To measure the brachial pressure, place the blood pressure cuff on the arm, with the limb at the level of

the heart. Position the transducer of the Doppler to maximize the intensity of the signal. Inflate the cuff until the doppler signal disappears. Then deflate the cuff slowly until the doppler signal re-appears, the pressure of the cuff is equal to the brachial systolic pressure. This should be measured in both arms.

- To measure the ankle pressures, place the blood pressure cuff immediately proximal to the malleoli. Again, using a standard hand-held Doppler probe locate the signal from the DP. Inflate the cuff until the signal re-appears. Then slowly deflate using the same technique used in the arms until the Doppler signal re-appears. Repeat the same procedure with the PT and then repeat both measurements on the opposite leg.
- The ABI value is determined by taking the higher pressure of the 2 arteries at the ankle, divided by the brachial arterial systolic pressure. In calculating the ABI, the higher of the two brachial systolic pressure measurements is used. In normal individuals, there should be a minimal (less than 10 mm Hg) interarm systolic pressure gradient during a routine examination.

Imaging

- Use of duplex ultrasonography for diagnosis of vascular injury is not recommended because of its lower sensitivity than arteriography and its operator dependent accuracy.
- High-resolution multidetector helical CTA is the first line screening test for femoral artery injury.
  - CTA signs of arterial injury include active extravasation of contrast material, pseudo-aneurysm formation, abrupt narrowing of an artery, loss of opacification of an arterial segment, and arteriovenous fistula formation.
  - CT angiograms may be rendered non-diagnostic by motion artifact, lack of opacification of the arteries, and metallic streak artifact.
- Digital subtraction angiography or on-table angiography are alternatives for CTA.

Role of Conservative Management

- Patients with non-occlusive injuries from either a blunt or penetrating injury may be managed non-operatively if they fulfill the following criteria: <5 mm intimal disruption; small pseudoaneurysms, small arteriovenous fistulas, adherent intimal flaps; intact distal circulation; and no active hemorrhage.
  - Serial follow-up imaging with vascular duplex ultrasonography should be performed to confirm healing. Initial follow up at 4 weeks, then every three months until healed.
- Should lesions worsen (distal flow is no longer intact, development of active hemorrhage, increased size of intimal disruption, increased size of arteriovenous fistula or pseudoaneurysm expansion), as detected by routine vascular duplex ultrasonography scan, CTA, or serial angiography, surgical repair is warranted. Vasospasm can be managed medically and exam should be followed closely using hourly clinical exams for the first 24 hours to evaluate for improvement/resolution. If clinical exam worsens or fails to improve re-imaging with repeat CTA should be performed to evaluate for potential thrombosis.

Indications for Operative Intervention

- Documented flow-limiting femoral artery injury or vessel disruption is an indication for surgical intervention.
    - Complete transections of proximal vessels are better served by open repair
    - Vessel thrombosis, intimal disruptions, and partial lacerations may be addressed with endovascular techniques.
- Both penetrating and blunt traumatic lesions have been successfully treated with covered stents in the common or superficial femoral arteries.

Pre-Operative Preparation

- The patient should be positioned on the operating table to allow for on-table angiography of the affected region and distal perfusion.
- The entire area from the umbilicus to the feet should be prepped and draped.
    - An entire uninjured limb should be prepped for potential vein graft harvesting.
    - The lower abdomen should also be prepped to allow for vascular control to be gained more proximally if needed.
- Manual compression at a bleeding site will have to be temporarily prepped into the operative field until scrubbed personnel can take over.
- Arterial access for on-table angiography can be obtained percutaneously with a standard arterial catheter, via femoral vessel exposure and direct cannulation.

Impact of Associated Injuries

- Associated fractures should be stabilized prior to definitive vascular repair.
    - The vascular injury should be identified and an intraluminal shunt placed to restore flow to the extremity. Orthopedics may then stabilize the extremity with external fixation.
    - Ideally limb length should be restored prior to definitive vascular repair.
- Associated venous injuries:
    - Repair of concomitant venous injuries (particularly the common femoral vein and popliteal vein) should be undertaken if the clinical status of the patient allow as this can decrease the incidence of postoperative venous hypertension and associated chronic venous insufficiency as well as improve arterial flow.
    - Success of more distal arterial repair in patients with *blunt* injury, is diminished when ligation of the concomitant venous injury is required. (15% amputation rate in those individuals.)
    - Vein repair is associated with a high likelihood of postoperative deep vein thrombosis, therefore postoperative antiplatelet and/or antithrombotic treatment is recommended
        - Prophylactic dosing of low molecular weight heparin in addition to aspirin is adequate initially.
        - A heparin drip at standard DVT treatment dosing should be used if a DVT develops

- Associated significant soft tissue defects
    - Adequate/viable soft-tissue coverage of vascular repairs with viable tissue can be challenging in patients with complex soft tissue defects.
    - Rotational or free flap coverage may be required

Operative Techniques/Intraoperative Considerations

- A longitudinal incision should be made over the area of the peripheral vascular injury.
- Proximal and distal control around a peripheral vascular injury is appropriate when arterial occlusion is present
- A proximal tourniquet may be employed either pre-op or at the time of the operation.
- If hemorrhage cannot be controlled, it is appropriate to enter the area of injury and digitally control the vessel; vascular clamps may then be directly applied to the injury. Alternatively, balloon occlusion can be used to control blood loss while proximal and distal control are obtained. Adequate suction devices and appropriate retractors are mandatory to limit blood loss during this approach.
- With proximal and distal vascular control, the magnitude of the vascular injury can be assessed.
- Small vascular clamps, bulldog clamps, or vessel loops for can be used proximal and distal control.
- Debride back the end of the vessel to healthy intima.
- For an isolated femoral artery injury operative repair, is dependent on length and type of vascular injury.
    - Segmental loss
        - Short segment defect
            - Mobilize ends and perform primary repair if no tension.
                - Consider using a spatulated end to end anastomosis to minimize stenosis.
        - Long segment (>2cm) defect
            - Bypass graft with reverse saphenous vein from contralateral leg
            - Either with an end-to-end or end-to-side proximal anastomosis and an end-to-end distal anastomosis.
            - PTFE may be used in fields that are not contaminated
    - Incomplete transection or branch vessel injury (Transection of less than 100% of the circumference of the vessel or avulsion of a branch vessel)
        - Primary repair.
        - Consider endovascular approach
        - Potential ligation of branch vessel if adequate collaterals present
- A Fogarty balloon catheters should be passed both proximally and distally to ensure the absence of thrombus if forward or back flow appears impaired
    - Heparinized saline (50U/ml) can be used to prevent recurrence.
- After repair or bypass graft, completion on table angiogram ensures adequacy of flow. To perform an on table angiogram obtain proximal control and make a small arteriotomy allow the introduction of an 18 gauge catheter. A 50/50 dilution of intravenous contrast is used. Twenty to 50 mls of intravenous contrast solution is injected rapidly, and the arteriogram film obtained. A delay of 10 to 15 seconds should be used where distal vessels are being imaged. Fluoroscopy

and digital subtraction angiography avoid many of the pitfalls associated with plain film radiography in the operating room

- Low threshold for performance of 4-compartment calf fasciotomies.
    - Patients with combined arterial/venous injury.
    - Patients with ischemic periods greater than 6 hours.

Postoperative Management/Complications

- Close monitoring of vascular exam (hourly distal pulse/doppler checks) in the immediate postoperative period.
    - Any change in exam should raise concern for thrombosis of the repair/graft or development of compartment syndrome.
- If prophylactic fasciotomies are not performed, one must closely monitor for the development of compartment syndrome.
- Postoperative use of antithrombotics and anti-platelet agents is individualized in both duration and type is based upon the repairs required and the concomitant injuries. For example, anti-platelet agents should be utilized if vein or synthetic graft was required for vascular repair.
- The majority of patients will require anti-platelet agents for some time.

Considerations for Special Populations

- Abnormal ABI measurements in older patients may be reflective of atherosclerotic disease rather than acute injury. A/A indices comparing the affective limb to the contra-lateral limb is more appropriate.
- Small vascular diameter in children makes diagnostic studies and interventions more challenging than in adults.

Suggested Readings

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