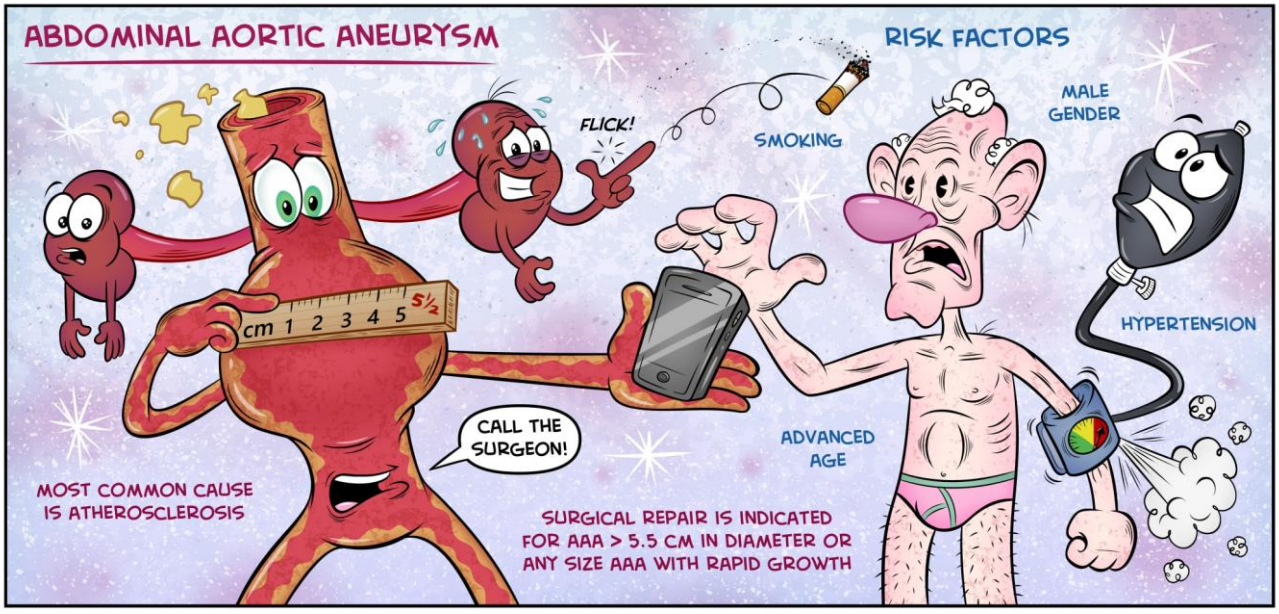
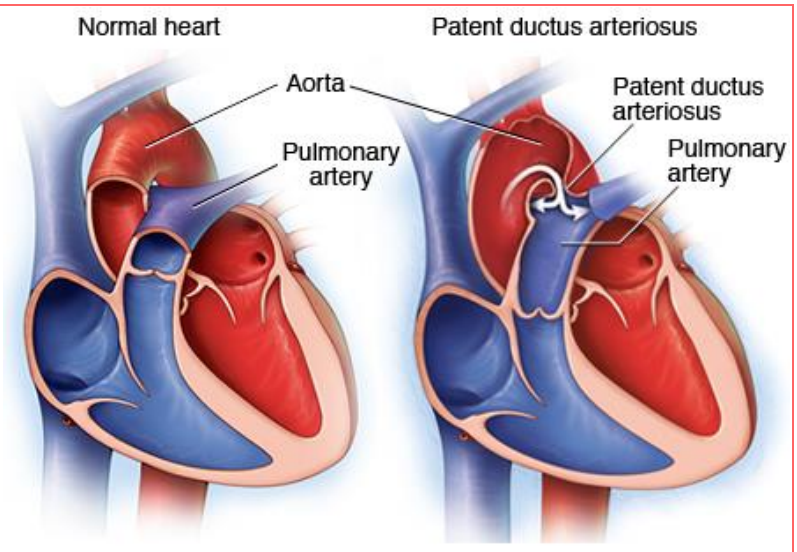
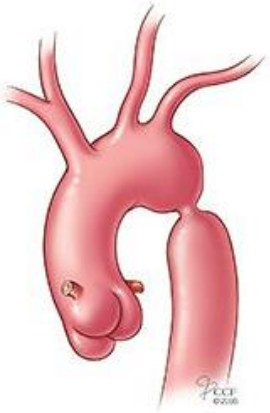
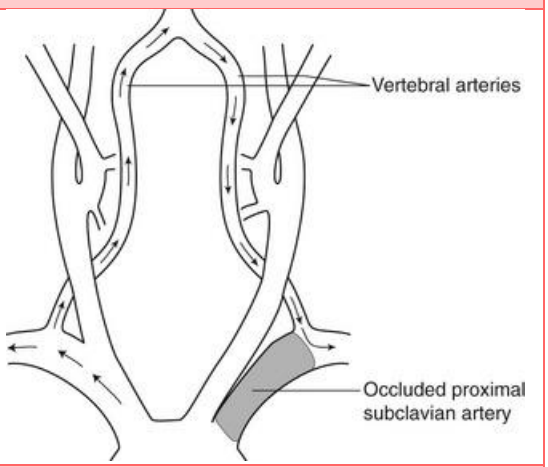


Vascular disease

Patent Ductus Arteriosus	• Ductus arteriosus is a normal fetal vessel that closes spontaneously after birth • Results in high pressure, oxygenated blood entering the pulmonary circuit • Untreated patients develop symptoms of congestive cardiac failure 
Cervical Rib	• Supernumerary fibrous band arising from seventh cervical vertebra • Incidence of 1 in 500 • May cause thoracic outlet syndrome • Treatment involves surgical division of rib
Coarctation of the Aorta	• Aortic stenosis at the site of the ductus arteriosus insertion • More prevalent in boys or females with Turners syndrome • Patients may present with symptoms of arterial insufficiency, such as syncope and claudication • Blood pressure mismatch may be seen, as may mismatch of pulse pressure in the upper and lower limbs • Treatment is either with angioplasty or surgical resection (the former is the most common) 
Takayasu's arteritis	• Large vessel granulomatous vasculitis • Results in intimal narrowing • Most commonly affects young Asian females • Patients present with features of mild systemic illness, followed by pulseless phase with symptoms of vascular insufficiency • Treatment is with systemic steroids
Subclavian Steal Syndrome	• Due to proximal stenotic lesion of the subclavian artery • Results in retrograde flow through vertebral or internal thoracic arteries • The result is that decrease in cerebral blood flow may occur and produce syncopal symptoms • A duplex scan and/ or angiogram will delineate the lesion and allow treatment to be planned 
Aortic Dissection *(see below)*	• Chest pain (anterior chest pain- ascending aorta, back pain - descending aorta) • Widening of aorta on chest x-ray • Diagnosis made by CT scanning • Treatment is either medical (Type B disease) or surgical (Type A disease)

Vasculitis

Vessel diameter and vasculitis classification

Aorta and branches	• Takayasu's arteritis • Buergers disease • Giant cell arteritis
Large and medium sized arteries	• Buergers disease • Giant cell arteritis • Polyarteritis nodosa
Medium sized muscular arteries	• Polyarteritis nodosa • Wegeners granulomatosis
Small muscular arteries	• Wegeners granulomatosis • Rheumatoid vasculitis

Specific conditions

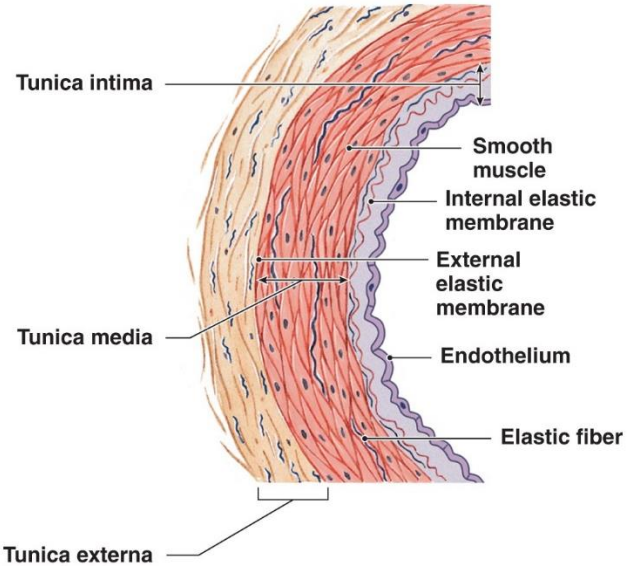
Takyasu's arteritis	• Inflammatory, obliterative arteritis affecting aorta and branches • Females> Males • Symptoms may include upper limb claudication • Clinical findings include diminished or absent pulses • ESR often affected during the acute phase
Buergers disease	• Segmental thrombotic occlusions of the small and medium sized lower limb vessels • Commonest in young male smokers • Proximal pulses usually present, but pedal pulses are lost • An acuter hypercellular occlusive thrombus is often present • Tortuous corkscrew shaped collateral vessels may be seen on angiography
Giant cell arteritis	• Systemic granulomatous arteritis that usually affects large and medium sized vessels • Females > Males • Temporal arteritis is commonest type • Granulomatous lesions may be seen on biopsy (although up to 50% are normal)
Polyarteritis nodosa	• Systemic necrotising vasculitis affecting small and medium sized muscular arteries • Most common in populations with high prevalence of hepatitis B • Renal disease is seen in 70% cases • Angiography may show saccular or fusiform aneurysms and arterial stenoses
Wegeners granulomatosis	• Predominantly affects small and medium sized arteries • Systemic necrotising granulomatous vasculitis • Cutaneous vascular lesions may be seen (ulceration, nodules and purpura) • Sinus imaging may show mucosal thickening and air fluid levels

Abdominal Aorta Aneurysm (AAA)

Vascular wall

- The innermost **tunica intima** consists of the endothelium and a thin subendothelial layer of loose connective tissue.
  In arteries and large veins, the intima includes a prominent limiting layer, the internal elastic lamina
- The **tunica media**, the middle layer, consists chiefly of concentric layers of helically arranged smooth muscle cells
- The outer adventitia, or **tunica externa**, consists principally of type I collagen and elastic fibers.
  The adventitia is continuous with and bound to the stromal connective tissue of the organ through which the blood vessel runs.

Smooth muscle fibers occur in the walls of all vessels larger than capillaries and are arranged helically in layers.

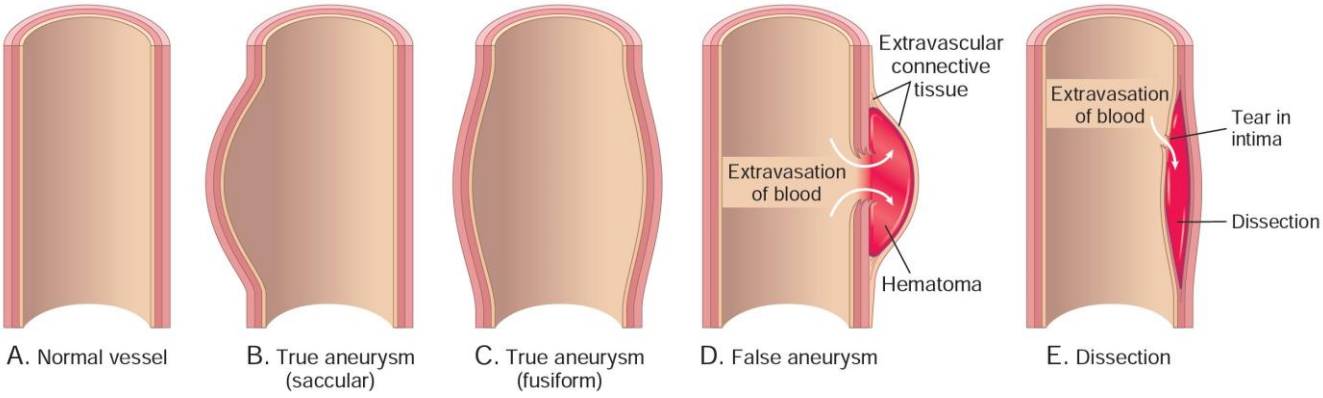


Definition of aneurysm

An aneurysm is a permanent and irreversible dilatation of a blood vessel by at least 50% of the normal expected diameter. Aortic aneurysms are classified as abdominal (the majority) or thoracic.

Aneurysm vs Dissection

True Aneurysm	False Aneursym (pseudoaneurysm)	Dissection
Segmental, full-thickness dilation of a blood vessel that is 50 percent greater than the normal aortic diameter	Breach in the vessel wall such that blood leaks through the wall but is contained by the adventitia or surrounding perivascular soft tissue	Separation of the arterial wall layers
• Atherosclerosis • *See other risk factors below*	• Trauma • Iatrogenic	• Trauma • Degenerative, Hypertension • Genetic (Marfan, Ehlers-Danlos)



Abdominal aortic aneurysms are a common problem in vascular surgery.

They may occur as either true or false aneurysm. With the former all 3 layers of the arterial wall are involved, in the latter only a single layer of fibrous tissue forms the aneurysm wall.

True abdominal aortic aneurysms have an approximate incidence of 0.06 per 1000 people. They are commonest in elderly men and for this reason the UK is now introducing the aneurysm screening program with the aim of performing an abdominal aortic ultrasound measurement in all men aged 65 years.

Pathology

Abdominal aortic aneurysms occur primarily as a result of the failure of elastic proteins within the extracellular matrix. Aneurysms typically represent dilation of all layers of the arterial wall. Most aneurysms are caused by degenerative disease. After the age of 50 years the normal diameter of the infrarenal aorta is 1.5cm in females and 1.7cm in males. **Diameters of 3cm and greater, are considered aneurysmal**. The pathophysiology involved in the development of aneurysms is complex and the primary event is **loss of the intima with loss of elastic fibres from the media**. This process is associated with, and potentiated by, **increased proteolytic activity and lymphocytic infiltration**.

Risk Factors

The risk factors associated with aneurysms include

- Older age
- Male gender
- Cigarette smoking
- Caucasian race
- Atherosclerosis
- Hypertension
- Family history of AAA
- Other large artery aneurysms (e.g. iliac, femoral, popliteal)
- Syphilis
- Connective tissue disease (Ehlers Danlos type 1 and Marfan syndrome) - *the extracellular matrix becomes disrupted with a change in the balance of collagen and elastic fibres.*

Decreased risk of AAA is associated with:

- Female gender
- Non-Caucasian race
- Diabetes

A CT reconstruction showing an infrarenal abdominal aortic aneurysm. The walls of the sac are calcified which may facilitate identification on plain x-rays

Management

- Most abdominal aortic aneurysms are an incidental finding.
- Symptoms most often relate to rupture or impending rupture.
- 20% rupture anteriorly into the peritoneal cavity. Very poor prognosis.
- 80% rupture posteriorly into the retroperitoneal space
- The risk of rupture is related to aneurysm size, only 2% of aneurysms measuring less than 4cm in diameter will rupture over a 5-year period. This contrasts with 75% of aneurysms measuring over 7cm in diameter.
- This is well explained by Laplace's' law which relates size to transmural pressure.
- For this reason, most vascular surgeons will subject patients with an aneurysm size of 5cm or greater to CT scanning of the chest, abdomen and pelvis with the aim of delineating anatomy and planning treatment. Depending upon co-morbidities, **surgery is generally offered once the aneurysm is between 5.5cm and 6cm.**

Indications for surgery

- Symptomatic aneurysms (80% annual mortality if untreated)
- Increasing size above 5.5cm if asymptomatic
- Rupture (100% mortality without surgery)

If no indication for surgery → f/u every 6 months (e.g. USS)
If planned for surgery → CT angio should be requested if not done already

Special groups

Ruptured AAA

Pre-operatively the management depends upon haemodynamic instability. In patients with symptoms of rupture (typical pain, haemodynamic compromise and risk factors) then ideally prompt laparotomy. In those with vague symptoms and haemodynamic stability the ideal test is CT scan to determine whether rupture has occurred or not. Most common rupture site is **retroperitoneal** 80%. These patients will tend to develop retroperitoneal haematoma. This can be disrupted if BP is allowed to rise too high so aim for BP 100mmHg.

Operative details are similar to elective repair although surgery should be swift, blind rushing often makes the situation worse. Plunging vascular clamps blindly into a pool of blood at the aneurysm neck carries the risk of injury the vena cava that these patients do not withstand. Occasionally a supracoeliac clamp is needed to effect temporary control, although leaving this applied for more than 20 minutes tends to carry a dismal outcome.

Supra renal AAA

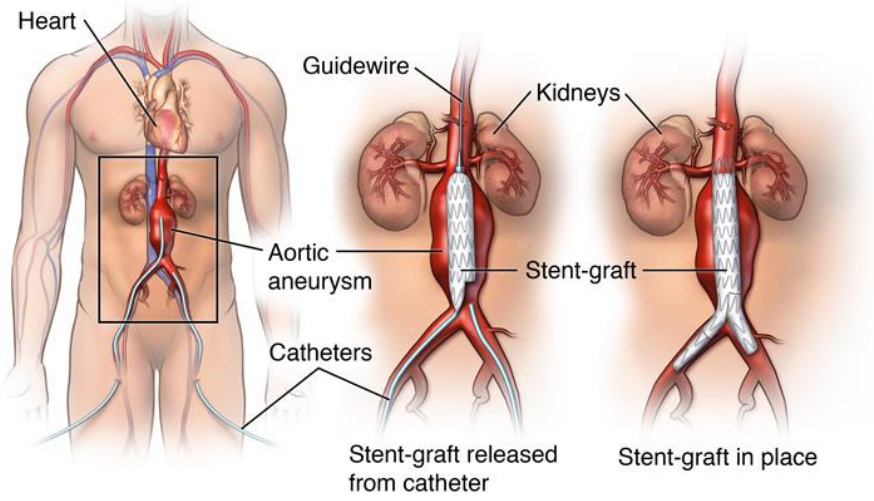
These patients will require a supra renal clamp and this carries a far higher risk of complications and risk of renal failure.

EVAR

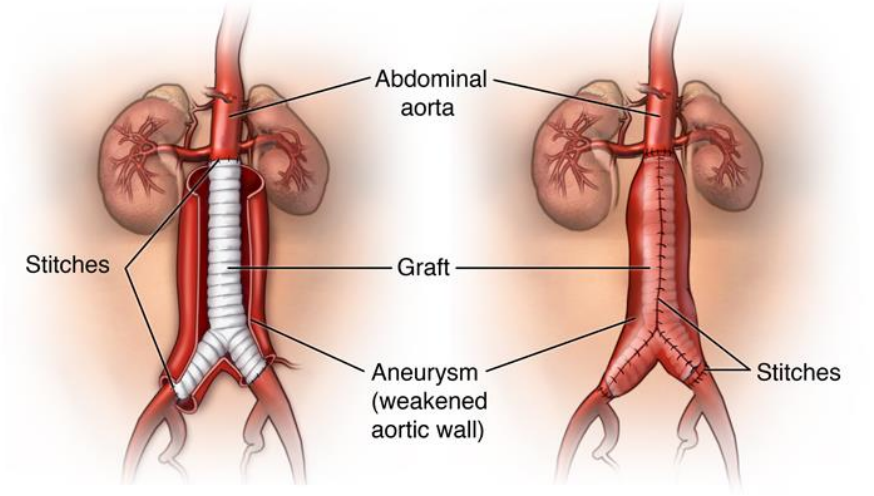
Increasingly patients are now being offered endovascular aortic aneurysm repair. This is undertaken by surgeons and radiologists working jointly. The morphology of the aneurysm is important and not all are suitable. Here is a typical list of those features favoring a suitable aneurysm:

- Long neck
- Straight iliac vessels
- Healthy groin vessels

Clearly few AAA patients possess the above and compromise has to be made. The use of fenestrated grafts can allow supra renal AAA to be treated.



Endovascular aneurysm repair (EVAR)



Abdominal aorta aneurysm open repair

Aortic dissection

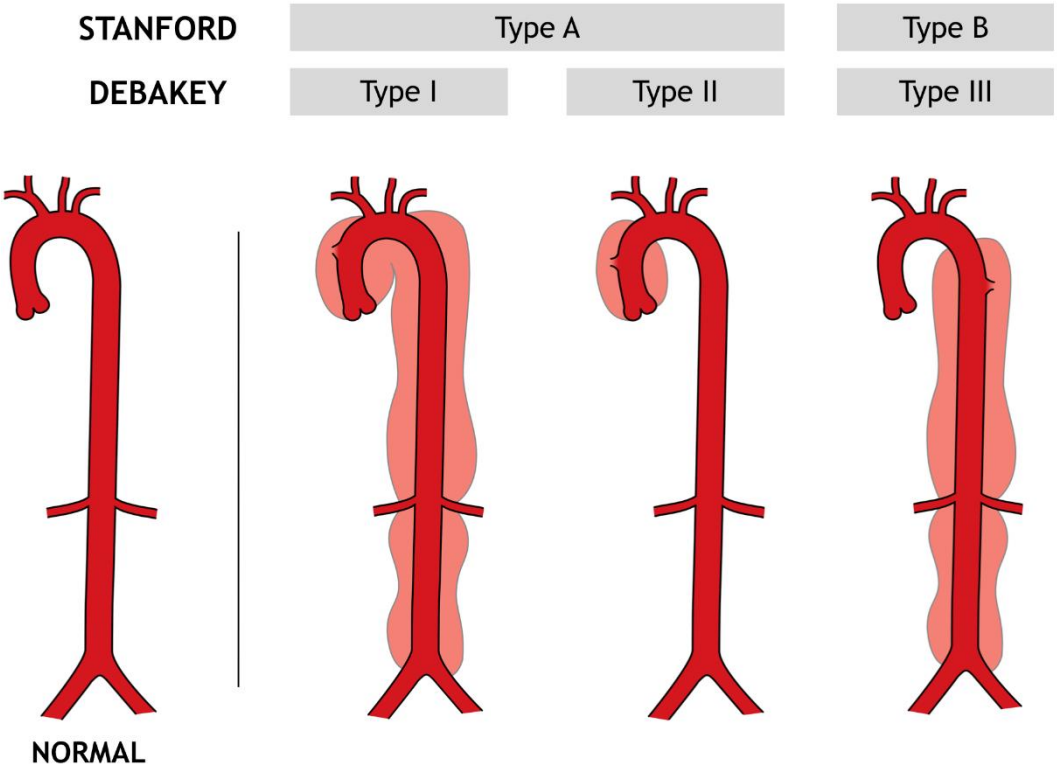
- More common than rupture of the abdominal aorta
- 33% of patients die within the first 24 hours, and 50% die within 48 hours if no treatment received
- Associated with hypertension
- Features of aortic dissection: tear in the intimal layer, followed by formation and propagation of a subintimal hematoma. Cystic medial necrosis (Marfan's)
- Most common site of dissection: 90% occurring within 10 centimetres of the aortic valve

Stanford Classification

Type	Location	Treatment
A	Ascending aorta/ aortic root	Surgery- aortic root replacement
B	Descending aorta	Medical therapy with antihypertensives

DeBakey classification

Type	Site affected
I	Ascending aorta, aortic arch, descending aorta
II	Ascending aorta only
III	Descending aorta distal to left subclavian artery

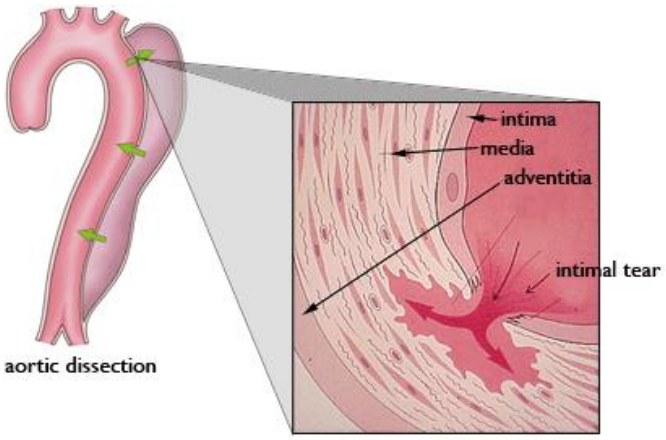


Clinical features

- Tearing, sudden onset chest pain (painless 10%)
- Hypertension or Hypotension
- A blood pressure difference (in each arm) greater than 20 mm Hg
- Neurologic deficits (20%)

Investigations

- CXR: widened mediastinum, abnormal aortic knob, ring sign, deviation of the trachea/oesophagus
- CT angiography of the thoracic aorta
- MRI angiography
- Conventional angiography (now rarely used diagnostically)



Management

- Beta-blockers: aim HR 60-80 bpm and systolic BP 100-120 mm Hg
- For type A dissections the standard of care is aortic root replacement

Vascular disorders of the upper limb

Upper limb arterial disease is less common than lesions causing symptoms in the lower limb. The upper limb circulation may be affected by embolic events, stenotic lesions (both internal and extrinsic), inflammatory disorders and venous diseases.

The anatomy of the collateral circulation of the arterial inflow may impact on the history and nature of disease presentation. In the region of the subclavian and axillary arteries the collateral vessels passing around the shoulder joint may provide pathways for flow if the main vessels are stenotic or occluded. During periods of increased metabolic demand the collateral flow is not sufficient and the vertebral arteries may have diminished flow. This may result in diminished flow to the brain with neurological sequelae such as syncope.

Vascular disease of the upper limb

Condition	Features
Axillary/Brachial embolus	• 50% of upper limb emboli will lodge in the brachial artery • 30% of upper limb emboli will lodge in the axillary artery • Sudden onset of symptoms; pain, pallor, paresis, pulselessness, paraesthesia • Sources are left atrium with cardiac arrhythmia (mainly AF), mural thrombus • Cardiac arrhythmias may result in impaired consciousness in addition to the embolus
Arterial occlusions	• Those resulting from atheroma are the most common, trauma may result in vascular changes and long term occlusion but this is rare • Features may include claudication, ulceration and gangrene. Proximally sited lesions may result in subclavian steal syndrome • The progressive nature of the disease allows development of collaterals, acute ischaemia may occur as a result of acute thrombosis
Raynaud's disease	• Idiopathic condition affecting young females • Usually affects hands > feet • Digits become: white → blue → red • Treatment is with calcium antagonists
Upper limb venous thrombosis	• Gradual onset of upper limb swelling and discomfort. • Sensation and motor function are normal • Condition may complicate pre-existing malignancy (especially breast cancer) or arise as a result of repetitive use of the limb in a task such as painting a ceiling • The condition is diagnosed with duplex ultrasound and treatment is with anticoagulation
Cervical rib	• 0.2-0.4% incidence • Consist of an anomalous fibrous band that often originates from C7 and may arc towards, but rarely reaches the sternum • Congenital cases may present around the third decade. Some cases are reported to occur following trauma. • Bilateral in up to 70% • Compression of the subclavian artery may produce absent radial pulse on clinical examination and in particular may result in a positive Adson's test (lateral flexion of the neck away from symptomatic side and traction of the symptomatic arm- leads to obliteration of radial pulse) • Treatment is most commonly undertaken when there is evidence of neurovascular compromise. A trans-axillary approach is the traditional operative method for excision

Axillary vein thrombosis

- 1-2% of all deep venous thrombosis
- Primary cause is associated with trauma, thoracic outlet obstruction or repeated effort in a dominant arm (young active individuals)
- Secondary causes include central line insertion, malignancy, pacemakers

Clinical features

- Pain and swelling (non-pitting)
- Numbness
- Discolouration: mottling, dusky
- Pulses present
- Congested veins

Investigations

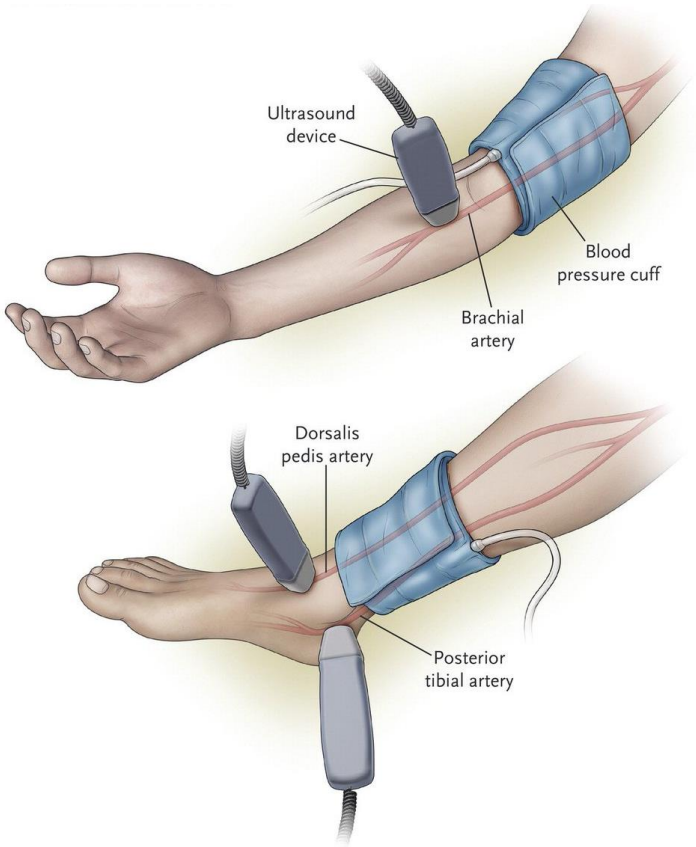
- FBC: viscosity, platelet function
- Clotting
- Liver function tests
- D-dimer
- Duplex scan: investigation of choice
- CT scan: thoracic outlet obstruction

Treatment

- Local catheter directed TPA
- Heparin
- Warfarin

Ankle-Brachial pressure index

- Measurement of ankle- brachial pressure index (ABPI) is a commonly performed vascular investigation.
- Calculated by dividing lower limb pressure by the highest upper limb pressure.



Results of ABPI

> 1.2	• Usually due to vessel calcification
1.0 – 1.2	• Normal
0.8 – 1.0	• Minor stenotic lesion • Initiate risk factor management
0.50 – 0.8	• Moderate stenotic lesion • Consider duplex • Risk factor management • If mixed ulcers present then avoid tight compression bandages
0.5 – 0.3	• Likely significant stenosis • Duplex scanning to delineate lesions needed • Compression bandaging contra indicated
< 0.3	• Indicative of critical ischaemia Urgent detailed imaging required

Thromboprophylaxis

See Peri-operative Care

Pulmonary Embolism

See Emergency Medicine

Acute limb ischaemia

- Thrombosis of a pre-existing site of atherosclerosis if the commonest cause of acute limb ischaemia
- Acute thrombosis of popliteal aneurysms poses the greatest threat to the limb
- Sudden occlusion of a large proximal vessel results in the typical appearances of acute limb ischaemia

Clinical appearances

- Less than 6 hours = White leg
- At 6 -12 hours = Mottled limb with blanching on pressure
- More than 12-24 hours = Fixed mottling

Management of acutely ischaemic leg

Clinical picture	Treatment
White leg with sensorimotor deficit	Surgery and embolectomy
Dusky leg, mild anaesthesia	Angiography
Fixed mottling	Primary amputation *(see later)*

Role of thrombolysis

- Intra-arterial thrombolysis is better than peripheral thrombolysis
- Mainly indicated in acute on chronic thrombosis
- Avoid if within 2 months of CVA or 2 weeks of surgery
- Aspiration of clot may improve success rate if the thrombosis is large

Surgery

- Both groins should be prepared
- Transverse arteriotomy is easier to close
- Poor inflow should be managed with iliac trawl- if this fails to improve then consider a femoro-femoral cross over or axillo-femoral cross over.
- A check angiogram should be performed on table and prior to closure
- Systemic heparinisation should follow surgery
- Fasciotomy should be considered if the time between onset and surgery exceeds 6 hours

Klippel-Trenaunay-Weber

Klippel-Trenaunay-Weber syndrome generally affects a single extremity, although cases of multiple affected limbs have been reported. The leg is the most common site followed by the arms, the trunk, and rarely the head and the neck

Signs and symptoms

The birth defect is diagnosed by the presence of a combination of these symptoms:

- One or more distinctive port-wine stains with sharp borders
- Varicose veins
- Hypertrophy of bony and soft tissues, that may lead to local gigantism or shrinking.
- An improperly developed lymphatic system

In some cases, port-wine stains (capillary port wine type) may be absent. Such cases are very rare and may be classified as "atypical Klippel-Trenaunay syndrome".

KTS can either affect blood vessels, lymph vessels, or both. The condition most commonly presents with a mixture of the two. Those with venous involvement experience increased pain and complications.

Varicose veins & Chronic Venous Insufficiency

Wide spectrum of disease ranging from minor cosmetic problem through to ulceration and disability. It is commoner in women than men and is worse during pregnancy. Varicose veins are best considered as being a saccular dilation of veins (WHO). Chronic venous insufficiency is a series of tissue changes which occur in relation to pooling of blood in the extremities with associated venous hypertension occurring as a result of incompetent deep vein valves.

The veins of the lower limb consist of an interconnected network of superficial and deep venous systems. Varices occur because of localised weakness in the vein wall resulting in dilatation and reflux of blood due to non-union of valve cusps. Histologically the typical changes include fibrous scar tissue dividing smooth muscle within media in the vessel wall.

Tissue damage in chronic venous insufficiency occurs because of perivascular cytokine leakage resulting in localised tissue damage coupled with impaired lymphatic flow.

Diagnosis

Typical symptoms of varicose veins include:

- Cosmetic appearance
- Aching
- Ankle swelling that worsens as the day progresses
- Episodic thrombophlebitis
- Bleeding
- Itching

Symptoms of chronic venous insufficiency include:

- Dependant leg pain
- Prominent leg swelling
- Oedema extending beyond the ankle
- Venous stasis ulcers

The typical venous stasis ulcer is:

- Located above the medial malleolus
- Indolent appearance with basal granulation tissue
- Variable degree of scarring
- Non ischaemic edges
- Haemosiderin deposition in the gaiter area (and also lipodermatosclerosis).

Left leg varicose veins in the distribution of an incompetent great saphenous vein (marked for intervention)

Differential diagnosis

- Lower limb arterial disease
- Marjolins ulcer
- Claudication
- Spinal stenosis
- Swelling due to medical causes e.g. CCF.

Exclusion of these differentials is by means of physical examination and ankle brachial pressure index measurement.

Examination

- Assess for dilated short saphenous vein (popliteal fossa) and palpate for saphena varix medial to the femoral artery
- Brodie-Trendelenburg test: to assess level of incompetence
- Perthes' walking test: assess if deep venous system competent

Investigation

- Doppler exam: if incompetent a biphasic signal due to retrograde flow is detected
- Duplex scanning: to ensure patent deep venous system (do if DVT or trauma)

Right leg varicose veins in the distribution of the small saphenous system with a recent episode of phlebitis

All patients should have a Doppler assessment to assess for venous reflux and should be classified as having uncomplicated varicose veins or varicose veins with associated chronic venous insufficiency. In the history establishing a previous thrombotic event (DVT/ lower limb fracture) is important and patients with such a history and all who have evidence of chronic venous insufficiency should have a duplex scan performed.

Owing to litigation patients with saphenopopliteal incompetence should have a duplex scan performed and the site marked by scan on the day of surgery.

Treatment *(see NICE Guidelines CG168)*
Indications for surgery:

- Cosmetic: majority
- Lipodermatosclerosis causing venous ulceration
- Recurrent superficial thrombophlebitis
- Bleeding from ruptured varix

Condition	*Therapy*
Minor varicose veins - no complications	Reassure / cosmetic therapy

Symptomatic uncomplicated varicose veins
or
Varicose veins with skin changes
	In those without deep venous insufficiency options include;
	• Endothermal ablation
	• Foam sclerotherapy *(if endothermal ablation is not suitable)*
	• Surgery *(if ultra-sound guided foam sclerotherapy is not suitable)*
	  ○ Saphenofemoral / popliteal disconnection
	  ○ Stripping and avulsions
	• Class I compression stockings *(if interventional treatment is not suitable)*

Chronic venous insufficiency or ulcers	Class 2-3 compression stockings (ensure no arterial disease).

- Application of formal compression stockings (usually class II/III). In patients who have suffered ulceration, compression stockings should be worn long term. Where ulceration is present and established saphenofemoral reflux exists this should be addressed surgically for durable relief of symptoms, either at the outset or following ulcer healing.
- Injection sclerotherapy (5% Ethanolamine oleate), foam is increasingly popular, though transient blindness has been reported. Endo venous laser therapy is another minimally invasive option
- Sapheno-femoral or sapheno-popliteal ligation, in the case of the LSV; stripping and multiple phlebectomies

Current best practice guidance
In the United Kingdom the National Institute of Clinical Excellence guidance on varicose veins suggests that for patients with symptomatic varicose veins the first line procedure of choice should be endothermal ablation (see reference for more information). Where this is unavailable or unsuitable then foam sclerotherapy should be the second line option. Surgery is currently the third line treatment option.

Trendelenburg procedure (sapheno-femoral junction ligation)

- Head tilt 15 degrees and legs abducted
- Oblique incision 1cm medial from artery
- Tributaries ligated (Superficial circumflex iliac vein, Superficial inferior epigastric vein, Superficial and deep external pudendal vein)
- SF junction double ligated
- Saphenous vein stripped to level of knee/upper calf. NB increased risk of saphenous neuralgia if stripped more distally

Lower leg ulcers

Venous leg ulcers

- Most due to venous hypertension, secondary to chronic venous insufficiency (other causes include calf pump dysfunction or neuromuscular disorders)
- Ulcers form due to capillary fibrin cuff or leucocyte sequestration
- Features of venous insufficiency include oedema, brown pigmentation, lipodermatosclerosis, eczema
- Location above the ankle, **painless**
- Deep venous insufficiency is related to previous DVT and superficial venous insufficiency is associated with varicose veins
- Doppler ultrasound looks for presence of reflux and duplex ultrasound looks at the anatomy/ flow of the vein
- **Management**
    - 4-layer compression banding after exclusion of arterial disease or surgery
    - If fail to heal after 12 weeks or >10cm^2 skin grafting may be needed

Venous Ulcer

Marjolin's ulcer

- Squamous cell carcinoma
- Occurring at sites of chronic inflammation e.g; burns, osteomyelitis after 10-20 years
- Mainly occur on the lower limb

If after many years an ulcer becomes heaped up and irregular, with rolled edges then suspect a SCC.

Marjolin's ulcer

Arterial ulcers

- Occur on the toes and heel
- Painful
- Punched appearance
- There may be areas of gangrene
- Cold with no palpable pulses
- Low ABPI measurements
- Poor blood flow associated with venous guttering

Arterial Ulcer

Neuropathic ulcers

- Commonly over plantar surface of metatarsal head and plantar surface of hallux
- The plantar neuropathic ulcer is the condition that most commonly leads to amputation in diabetic patients
- Due to pressure
- Management includes cushioned shoes to reduce callus formation

Neuropathic ulcer

Pyoderma gangrenosum

- Associated with inflammatory bowel disease/RA
- Can occur at stoma sites
- Erythematous nodules or pustules which ulcerate

Pyoderma gangrenosum

Management summary

Ulcer	Management
Venous ulcer	Compression if ABPI > 0.5. If failed → split-thickness graft
Infected ulcer	Swab for C&S + clean dressing + Systemic Abx
Necrotic Ulcer	Debridement + healing by 2ry intention
Thrombophlebitis	Elevation + NSAIDs + stocking

Summary of ulcers

	Venous	Arterial	Neuropathic / Diabetic	Pressure
Underlying	• Varicose veins • Previous DVT • Obesity • Pregnancy • Recurrent phlebitis	• Diabetes • Hyperternsion • Smoking • Previous peripheral vascular disease	• Diabetes • Trauma • Prolonged pressure	• Limited mobility • Prolonged pressure
Ulcer	• Area between lower calf and the medial malleolus	• Pressure points, toes and feet, lateral malleolus and tibial areas	• Planter aspect of foot, tip of the toe, lateral to fifth metatarsal	• Bony prominences, heel, sacrum
Ulcer Characteristic	• Shallow and flat margins • Moderate to heavy exudate • Slough at base with granulation tissue	• Punched out and deep • Irregular shape • Unhealthy wound bed • Presence of necrotic tissue • Minimal exudate unless infected	• Deep • Surrounded by callus • Insensate	• Deep • Often macerated
				
Condition of leg /	• Hemosiderin staining • Thickening and fibrosis • Eczematous and itchy skin • Limb edema • Normal capillary refill	• Thin shiny skin • Reduced hair growth • Cool skin • Pallo on leg elevation • Absent or weak pulses • Delayed capillary refill • Gangrene	• Dry • Cracked • Insensate • Calluses	• Atrophic skin • Loss of muscle mass
Treatment	• Compression therapy • Leg elevation • Surgical management	• Revascularization • Anti-platelet medication • Management of risk factors	• Off-loading of pressure • Topical growth factors	• Off-loading of pressure • Reduction of excessive moisture, shear, and friction • Adequate nutrition

Peripheral vascular disease & Intermittent Claudication

Indications for surgery to revascularise the lower limb

- Critical ischaemia
- Ulceration
- Gangrene
- ABPI < 0.4
- Rest pain or disabling intermittent claudication

Calf pain	Superficial femoral
Thigh pain	External Iliac
Buttock pain	Common Iliac
Buttock pain + Impotence	Aortoiliac (Leriche syndrome)

If occlusion at the site of bifurcation and sudden → saddle embolism

If pain is improving with going uphill or bending forward or riding bicycle → lumbar stenosis

Intermittent claudication that is not disabling may provide a relative indication, whilst the other complaints are often absolute indications depending upon the frailty of the patient.

Assessment

- Clinical examination
- Ankle brachial pressure index measurement *(see before)*
- Duplex arterial ultrasound
- Angiography (standard, CT, or MRI): usually performed only if intervention being considered.

Management

Initial Management

- Stop smoking
- Anti-platelets
- Statins
- Good diabetic control
- Regular exercises and weight loss

Surgery

- **Angioplasty**
  In order for angioplasty to be undertaken successfully the artery has to be accessible. The lesion relatively short and reasonable distal vessel runoff. Longer lesions may be amenable to sub-intimal angioplasty.
- **Bypass Surgery**
  Surgery will be undertaken where attempts at angioplasty have either failed or are unsuitable. Bypass essentially involves bypassing the affected arterial segment by utilizing a graft to run from above the disease to below the disease. As with angioplasty good runoff improves the outcome.
  - *In patients with major cardiac* ***co-morbidities the safest option is to choose an axillo-bifemoral*** *bypass graft. The long term patency rates are less good than with aorto-bifemoral bypass grafts, however, the operation is less major.*
  - *Femoro-femoral cross over grafts are an option for treatment of iliac occlusions in patients with* ***significant co-morbidities and healthy contralateral vessels.***
- **Amputation**
  (See below)

Some key concepts with bypass surgery:

Superficial femoral artery occlusion to the above knee popliteal

In the ideal scenario, vein (either in situ or reversed LSV) would the used as a conduit. However, prosthetic material has reasonable 5-year patency rates and some would advocate using this in preference to vein so that vein can be used for other procedures in the future. In general terms either technique is usually associated with an excellent outcome (if run off satisfactory).

Procedure

- Artery dissected out, **IV heparin 3,000 units given and then the vessels are cross clamped**
- Longitudinal arteriotomy
- Graft cut to size and tunneled to arteriotomy sites
- Anastomosis to femoral artery usually with 5/0 'double ended' Prolene suture
- Distal anastomosis usually using **6/0** 'double ended' Prolene

Distal disease

- Femoro-distal bypass surgery takes longer to perform, is more technically challenging and has higher failure rates.
- In elderly diabetic patients with poor runoff, **a primary amputation may well be a safer and more effective** option. There is **no point in embarking on this type of surgery in patients who are wheelchair bound.**
- In femorodistal bypasses vein gives superior outcomes to PTFE.

Rules

- Vein mapping 1st to see whether there is suitable vein (the preferred conduit). Sub intimal hyperplasia occurs early when PTFE is used for the distal anastomosis and will lead to early graft occlusion and failure.
- Essential operative procedure as for above knee fem-pop.
- If there is insufficient vein for the entire conduit, then vein can be attached to the end of the PTFE graft and then used for the distal anastomosis. This type of 'vein boot' is technically referred to as a **Miller Cuff** and is associated with better patency rates than PTFE alone.
- Remember the more distal the arterial anastomosis the lower the success rate.

Amputations

Amputations are indicated when the affected limb is one of the following:

- **Dead** non-viable
- **Deadly** where it is posing a major threat to life
- **Dead useless** where it is viable but a prosthesis would be preferable

Orthopaedic surgery

- Amputation is often undertaken as an option of last resort e.g. Limb salvage has failed and the limb is so nonfunctional that mobility needs would be best met with prosthesis.
- Chronic fracture nonunion or significant limb shortening following trauma would fit into this category. Occasionally following major trauma, a primary amputation is preferable. This would be the case in an open fracture with major distal neurovascular compromise and other more life threatening injuries are present.

Vascular surgery

- The first two categories are the most prevalent.
- Diabetic foot sepsis is often a major cause of sepsis which can spread rapidly in the presence of established peripheral vascular disease.
- As a general rule the main issue in vascular surgery is to optimise vascular inflow prior to surgery. The more distal the planned amputation is to be, the more important this rule becomes.
- In other situations, there has been something such as an embolic event that has not been revascularised in time. In this case the limb shows fixed mottling and an amputation will be needed.

Types of amputations

As the vast majority of commonly performed amputations affect the lower limbs these will be covered here.

The main categories of amputations are:

- Pelvic disarticulation (hindquarter)
- Above knee amputation (transfemoral)
- Gritti Stokes (through knee amputation)
- Below knee amputation (using either Skew or Burgess flaps)
- Syme's amputation (through ankle)
- Amputations of mid foot and digits

Gritti Stokes amputation

- *Femoral condyles are removed*
- *Patella is conserved and swung posteriorly to cover distal femoral surface*

Choosing a level of amputation depends on:

- The disease process being treated
- Desired functional outcome
- Co-morbidities of the patient

Above knee amputations

- Quick to perform
- Heal reliably
- Patients regain their general health quickly
- For this benefit, a functional price has to be paid and many patients over the age of 70 will never walk on an above knee prosthesis.
- Above knee amputations use equal anterior-posterior flaps

Below knee amputations

- Technically more challenging to perform
- Heal less reliably than their above knee counterparts.
- However, many more patients are able to walk using a below knee prosthesis.
- In below knee amputations the two main flaps are Skew flaps or the Burgess long posterior flap. Skew flaps result in a less bulky limb that is easier to attach a prosthesis to.

It is worth remembering that whilst it may be technically feasible to offer a below knee amputation there may be circumstances where an above knee option is preferable. For example, in **fixed flexion deformities of the lower limb**, little functional benefit would be gained from below knee amputation surgery.

Vascular Investigations

Venous disease

Venous Doppler

The simplest investigation for assessment of venous junctional incompetence is a Doppler assessment. This involves the patient standing and manual compression of the limb distal to the junction of interest. Flow should normally occur in one direction only. Where junctional incompetence is present reverse flow will occur and is relatively easy to identify.

Venograms and duplex scans

Structural venous information is historically obtained using a venogram. This is an **invasive test and rarely required in modern clinical practice. The most helpful test is a venous duplex scan** which will provide information relating to flow and vessel characteristics. Duplex is also useful in providing vein maps for bypass surgery.

Arterial disease

Ankle-brachial pressure

The ankle brachial pressure index measurement is an important investigation as it will allow classification of the severity of the flow compromise present. False readings may occur in those with calcified vessels such as diabetics and results in such settings should be interpreted with caution. When auscultating the vessel note should be made of the character of the signal. Monophasic signals are associated with a proximal stenosis and reduction in flow. Triphasic signals provide reassurance of a healthy vessel.

Arterial Duplex

As with the vein the duplex scan can provide a substantial amount of information about arterial patency and flow patterns. In skilled hands they can provide insight as to the state of proximal vessels that are anatomically inaccessible to duplex (e.g. Iliacs). Through assessment of distal flow patterns. It is an operator dependent test.
An arterial duplex should be performed first, before progression to an angiography.

Conventional angiogram

Vessel puncture and catheter angiography is the gold standard method of assessing arteries. High quality information can usually be obtained. Limitations of the technique include the risk of contrast toxicity and risks of vessel damage. Severely calcified vessels may be difficult to puncture and in this situation a remote access site (e.g. brachial) may be used. This technique is particularly useful in providing a distal arterial roadmap prior to femoro-distal bypass.

CT angiography

These tests provide a considerable amount of structural and flow information. They require contrast and thus carry the risks associated with this. They are particularly useful in the setting of GI bleeding as they are rapidly available and can be performed by a non-vascular radiologist. However, they lack the facility for endovascular intervention. In general they do not provide high enough resolution for distal arterial surgery.

Magnetic resonance angiography

This has the advantage of being non-invasive and not using nephrotoxic contrast. Movement artifact remains a problem in some sites and distal arterial resolution is imperfect.