

# Angiography and Vascular Interventional Radiology

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professor and chairman

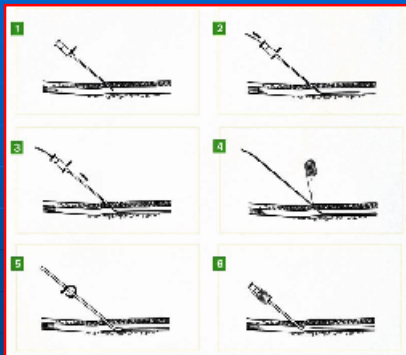


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## History

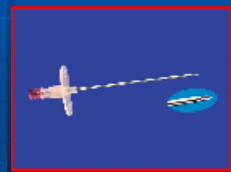
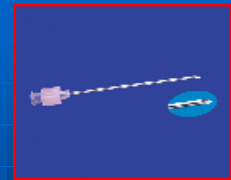
- 1929 Werner Forssman
  - Right heart catheterisation (ureter catheter)
- 1934 Dos Santos
  - Translumbar aortography
- 1953 Seldinger
  - „Seldinger-technique” – needle, guidewire, catheter

## Seldinger technique



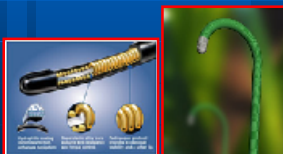
## Tools

- Puncture needle (18G)
  - One-part needle
  - Two-part needle



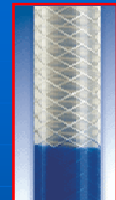
## Guidewire

- Atraumatic, non-thrombogenic
- Torque control
- Hydrophilic coating for difficult cases
- Diameter (inch)
  - 0.014, 0.018, 0.025, 0.032, 0.035, 0.038

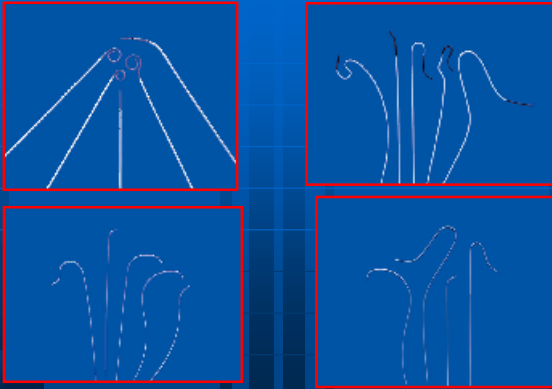


## Diagnostic catheters

- Braided plastic tube
  - Flexible
  - Kink-resistant
  - Torque response
- Outer diameter: French scale
  - 1 F = 1/3 mm



## Diagnostic catheters



- Non-selective (flush) angiography
- Selective angiography
  - Improved image quality, less contrast medium
  - Increased risk of complication



## Angiography

Conventional



DSA (digital subtraction)

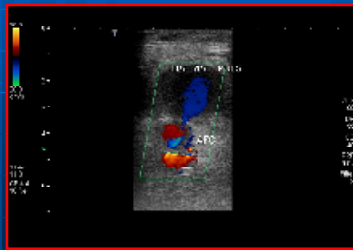


## Puncture sites

- Femoral – retrograde, antegrade, bilateral
- Brachial
- Radial
- Popliteal

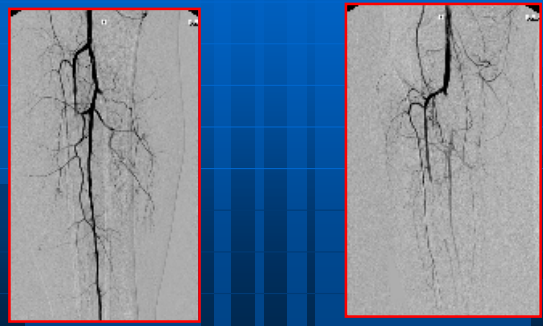
## Complications

- At the puncture site:
  - Bleeding, hematome
  - Pseudoaneurysm
  - AV fistule
  - Occlusion



## Complications

Embolisation



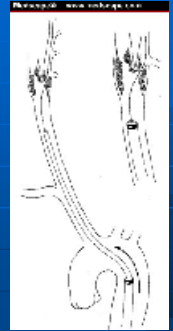
## Complications

### Dissection



## Complications

- Selective carotid angiography – 0.1-0.3% risk of stroke
- Non-selective, arch aortography – 0% (out of 311 patients\*) stroke
- CTA, MRA – No risk of stroke



- \* Berzi V, Randall M, Balamurugan R, Shaw D, Venables GS, Cleveland TJ, Gaines PA. Safety of arch aortography for assessment of carotid arteries. Eur J Vasc Endovasc Surg. 2006 31(1):3-7.

## Closure devices

- Estimated number of percutaneous catheter-based procedures is 8 million per year worldwide.
- Complication rates for diagnostic angiograms 0-1%, for therapeutic procedures (6-8F sheath, antiplatelets therapy) 1-9%.
- Manual compression should be used for small puncture sites.
- Closure devices have their place in the management of larger puncture sites especially in highly anticoagulated patients.

## Closure devices

- Suture – Perclose (Abbot Vascular Devices)
- Collagen plug – Angioseal (St. Jude Medical)
- Starshaped nitinol – Starclose (Abbot Vascular Devices)

## Perclose

- Suture-Mediated Closure
- Auto-Tie
  - Automated knot tying
  - Reduced procedure time



## Angio-Seal

- Absorbable collagen sponge
- Absorbable polymer anchor connected by an absorbable self-tightening suture.



## Starclose

- Easy to learn and use
- Automated Closure – nitinol clip instantly closes Arteriotomy
- Extravascular Closure
- Designed not to impact lumen diameter or distal bloodflow
- Mechanical Closure – hemostasis is not clot dependent
- Nitinol Clip – nothing remains in the artery
- Circumferential – provides 360° tissue apposition



## Vascular Interventional Radiology

- Image guided therapeutic procedures
- Minimal invasive technique
- How? (Technique, patient management)
- On whom? (Indication, patient selection)
- By whom? (radiologist, interventional radiologist, surgeon, vascular surgeon, angiologist, cardiologist, urologist, orthopedic surgeon, etc)

## Arterial interventions

- Percutaneous transluminal angioplasty (PTA), stent implantation
  - lower limb, subclavian, renal, aorta, mesenteric, carotid bifurcation, proximal CCA, innominate, coronary)
  - special balloons: cutting balloon, cryotherapy
  - stent types: balloon-mounted, selfexpandable, drug-eluting)
- Stent-grafts (TAA and AAA) and covered stents
- Thrombolysis, aspiration, thrombectomy devices,
- Embolisation (tumors, AVM, fibroid (UFE), bronchial artery, GI bleeding, bleeding from tumors, trauma, iatrogenic e.g. Orthopedic surgery)
- Dialysis fistule management (declotting, PTA)

## Venous procedures/interventions

- Venous
  - PTA/stent, TIPS
  - Varicocele embolisation
  - Radiofrequency or laser ablation of varicose veins
  - IVC filter placement and retrieval
  - Venous access, chronic venous lines (Hickman line)
  - Foreign body retrieval
  - Venous sampling

## Before getting access

- Examination of the patient
- Patient history, previous interventions, operations
- Pulse palpation
- Laboratory values
- Risk/benefit ratio
- Consenting the patient
- **PLANNING THE WHOLE PROCEDURE!!**

## Advantages of interventional radiological procedures over surgery

- Local anesthetics – lack of complications from general anesthesia
- Lack of surgical dissection (no surgical complications, such as wound infection, nerve injury, suture insufficiency)
- Small amount of blood loss.
- Minor burden for the patient, can be performed in severely ill condition and on the elderly.
- Following unsuccessful intervention, surgery is still an option
- Can be repeated numerous times

## Disadvantages of interventional radiological procedures over surgery

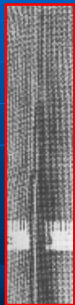
- Not all surgical procedures can be substituted by an interventional procedure
- Interventional radiological procedures are also not free of complications

## Percutaneous transluminal angioplasty (PTA) and stent implantation in peripheral arterial disease (PAD)

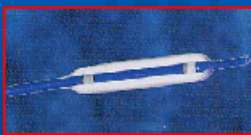
- Historical remarks
- PAD (Peripheral arterial disease)
- Luminal and subintimal angioplasty
- Stent implantation

## Historical remarks

1964: Dotter and Judkins PTA



1976: Grünzig balloon catheter

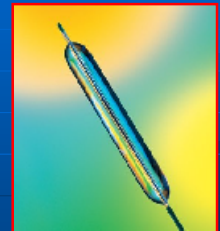


1987: Palmaz, Sigwart stents



## Balloon catheter

- ⌘ Shaft length
- ⌘ Balloon diameter and length
  - ☑ Length 1-12 cm
  - ☑ Diameter 1.5-20 mm
- ⌘ Semi-compliant
  - ☑ Nominal pressure
  - ☑ RBP



## Stents

- ⌘ Balloon mounted
  - ☑ Premounted, stainless steel
  - ☑ Easy positioning
- ☑ Rigid (external compression)
- ☑ Not conformable for different diameters (e.g. carotid bifurcation)

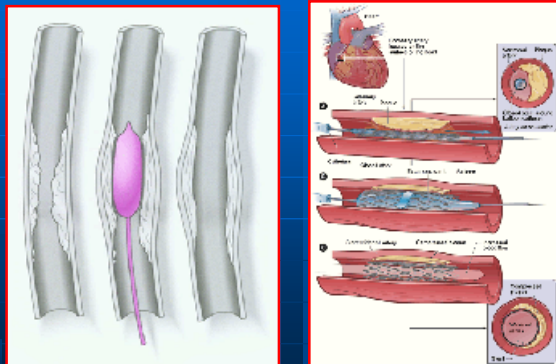


## Stents

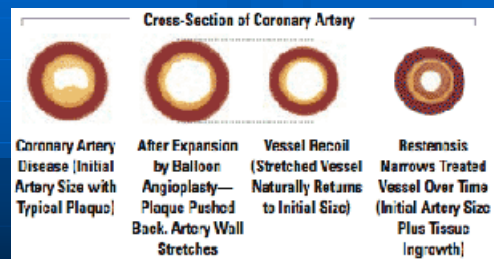
- ⌘ Self-expandable – nitinol (nickel-titanium alloy)
  - ☑ Continuous expanding force
  - ☑ Conforms to different diameters
- ☑ Positioning less precise
- ☑ Shortening – larger diameter, decreased length



## Mechanism and technique of PTA



## Elastic recoil and restenosis



## PAD – peripheral arterial disease

- Largest component to the workload
- Most patients chronic
  - Asymptomatic
  - Intermittent claudication (IC)
  - Critical limb ischemia (CLI)

## Non-surgical treatment for PAD

- IC patients
  - Exercise
  - Smoke cessation
  - Aspirin
  - Clopidogrel - CAPRIE study: small but significantly greater reduction in vascular morbidity and mortality than aspirin alone

## Non-surgical treatment for PAD

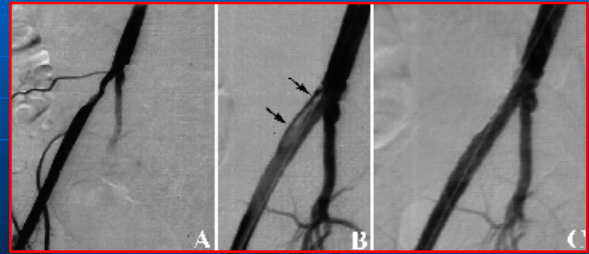
- CLI patients
  - Antiplatelet therapy
  - Prostanoids (PGE1, Iloprost)

## Peripheral arterial disease – treat the patient, not the lesion

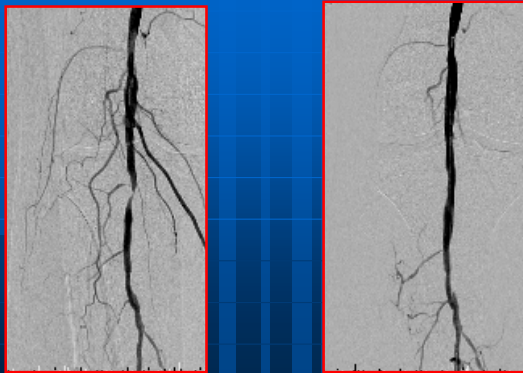
- Treat symptomatic lesions only (<200 m claudication, rest pain, gangrene) – vast majority of IC patients do not develop CLI
- Exception: femoropopliteal graft stenosis (US surveillance – treat lesions to prevent occlusion)
- Check femoral/popliteal/peripheral pulses before and after intervention

- General rule:
  - TASC A-B: endovascular treatment
  - TASC C: endovascular or surgical treatment
  - TASC D: surgical treatment

### Flow limiting dissection following PTA and stenting



### Popliteal PTA



### Distal embolisation - thrombolysis and aspiration

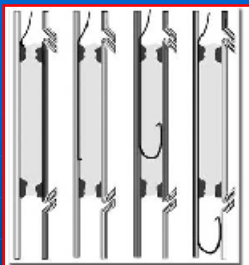


Figure 5. The subintimal space of superficial artery is considered anastomosis and a 4 or 5 Fr angled catheter (3.5 mm) is inserted. The catheter is inserted into the origin of the occlusion. Balloon is advanced into the origin of a hypotensive part (0.5-1.0 cm) and is inflated. The catheter is then pulled back and inflated in a distal part and connected together as a snare. Once in the subintimal space the guidewire is inserted, and can be manipulated to form a loop. Advancing the loop will cause re-entry in the true arterial lumen distal to the occlusion. After re-entry the snare is used to retrieve the catheter into the catheter and the "snare" is used for angioplasty.

### Subintimal angioplasty

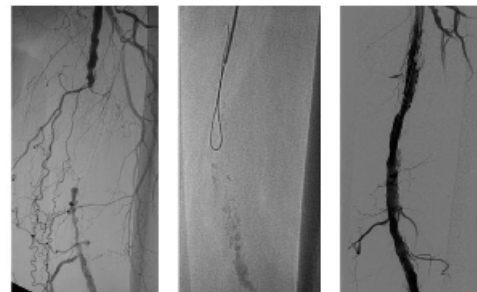
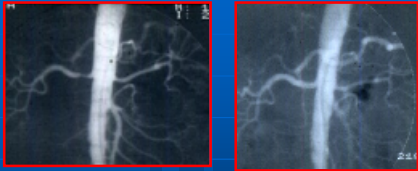


Figure 1. Subintimal angioplasty of a superficial femoral artery occlusion. (A) Angiogram demonstrating level of occlusion. (B) Subintimal guidewire advanced in "wide loop" configuration toward distal end. (C) Post-procedural angiogram demonstrates restoration of flow.

## Percutaneous Transluminal Renal Angioplasty (PTRA)



### Indications

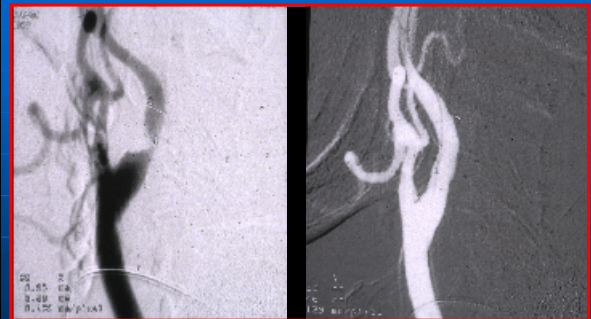
- Severe hypertension resistant to full medical therapy
- ACE-inhibitor induced uraemia
- Deteriorating renal function
- Flush pulmonary oedema
- Acute renal failure with a good sized kidney
- Severe stenosis in a single functioning kidney

## Carotid artery stenting (CAS)

- To decrease the risk of ipsilateral embolic stroke
- Indications:
  - Symptomatic (hemisymptoms, amaurosis fugax, aphasia) patients within 6 month; patients w symptoms within 4 weeks benefit most, >70% diameter stenosis
  - Periprocedure complication rate should be <6%, otherwise the patients do not benefit from CAS/CEA (carotid endarterectomy)

## Carotid artery stenting

- Relative indication:
  - Asymptomatic,
    - ??? >90% diameter stenosis
    - >80% stenosis and ipsilateral silent ischemia on CT
    - Rapid progression of carotid stenosis
    - >90% diameter stenosis and contralateral occlusion
    - Periprocedure complication rate should be <3%, otherwise the patients do not benefit from CAS/CEA (carotid endarterectomy)

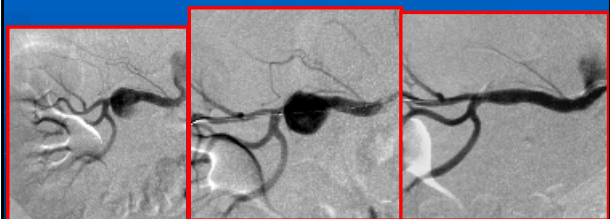


## Stent graft – covered stent

- Aneurysms
- Traumatic lesions
- To decrease the risk of restenosis
- To decrease the risk of distal embolisation

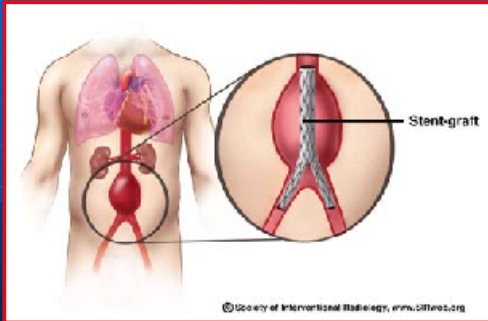


## Renalis aneurysm





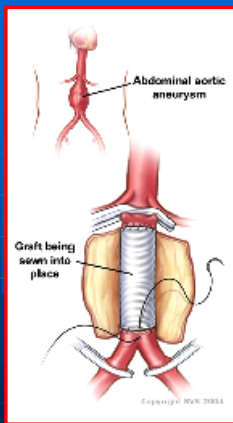
## Stent-graft for AAA



## Abdominal Aorta Aneurysm

Focal widening >3 cm  
Normal size of abdominal aorta >50 years of age: About 2 cm  
Prevalence: Increases with age, Greater with atherosclerotic disease  
Male predominance  
Whites: Blacks = 3:1  
Risk factors: male, age >75 years, white race, prior vascular disease, hypertension, cigarette smoking, family history, hypercholesterolemia

**Clinical**  
asymptomatic (30%)  
abdominal mass (26%)  
abdominal pain (37%)  
Location: infrarenal (91-95%) with extension into iliac arteries (66-70%)



## Open surgical repair of AAA

## Intraarterial thrombolytic therapy

The intravascular administration of thrombolytic agents originated in the 1960s with the intravenous (IV) treatment of pulmonary embolism.

Thrombolysis by means of selective catheter infusion for vascular occlusion entered the mainstream during the 1970s.

Since then, techniques for thrombolysis have branched in several directions with the treatment of thrombus and/or thrombosis in the coronary arteries, peripheral vascular and visceral arteries, dialysis grafts, veins, and IV catheters.

## Thrombolysis

### Streptokinase

Early thrombolysis efforts were with streptokinase, which is obtained from group c beta-hemolytic *Streptococcus bacillus*. It has no intrinsic enzymatic activity. After patients receive streptokinase, their antibody titers to the agent transiently increase. Should the patient receive streptokinase again before the titers returned to baseline, the residual circulating antibodies neutralize some of the dose administered and reduce the bioeffectiveness of the agent. These inactivating antibodies result from previous streptococcal infections.

### Urokinase

Urokinase is a 2-chain serine protease that contains 411 amino acid residues. Urokinase is extracted from human urine or long-term cultures of neonatal kidney cells. Like streptokinase, urokinase lacks fibrin specificity and induces a systemic lytic state. Urokinase is typically given with full heparinization (activated partial thromboplastin time [aPTT] 1.5-2 times control values). Titration of the dose of heparin dose is often difficult to achieve.

### Recombinant human tissue-type plasminogen activator (tPA)

Alteplase is a serine protease that is produced by recombinant DNA technology and that is chemically identical to human endogenous tPA. It acts by stimulating fibrinolysis of blood thrombi.

## Indications

Catheter-mediated thrombolysis is useful in the treatment of both acute and chronic vascular occlusion and thromboembolus, and it is an option for native bypass graft occlusions.

Thrombolysis is a reasonable option for patients with acute lower-limb ischemia for the prevention of amputation, with a mortality rate comparable to that of surgical interventions, with improved outcomes.

## Contraindication

- Intracranial or GI hemorrhage in patient history
- Any operation within 6 weeks

## Relative contraindication

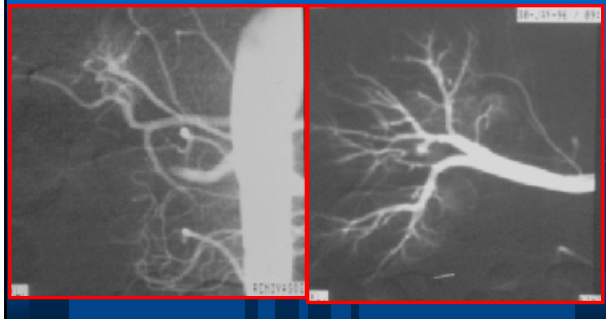
- Coagulopathy
- Gastric/duodenal ulcer
- Liver disease, portal hypertension
- Extreme hypertension
- Gravidity
- ICU care not possible
- Lack of cooperation of the patient

## Complications

Bleeding – may be fatal

- gastrointestinal 5-10%
- puncture site 12-17%
- hemorrhagic stroke 1-3%

## Selective arterial lysis



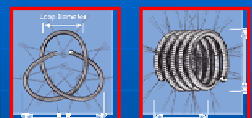
## Complication following Rotarex thrombectomy device

AV-fistule, treated with Hemobahn (Gore) covered stent

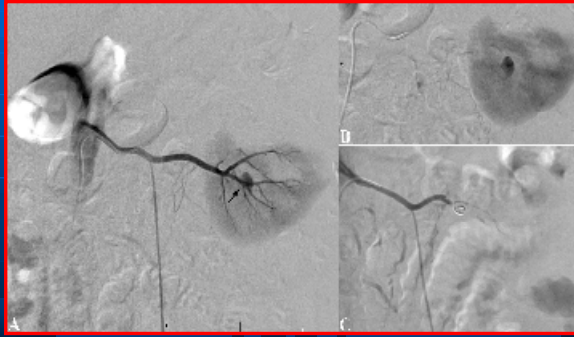


## Embolisation

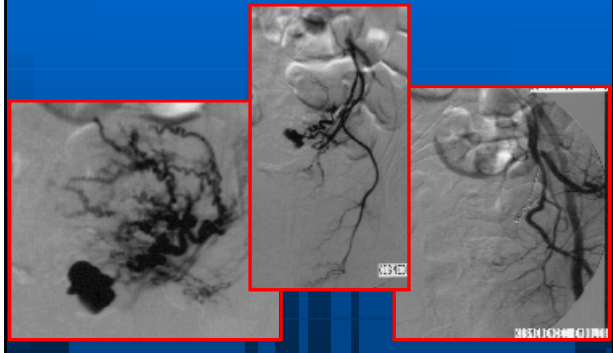
- Materials used for embolisation
  - Coils
  - PVA particles
  - Lipiodol
  - Alcohol
  - Tissue glue (cyanoacrylate)
  - Thrombin (for pseudoaneurysms)



### Embolisation with coil in renal bleeding following biopsy



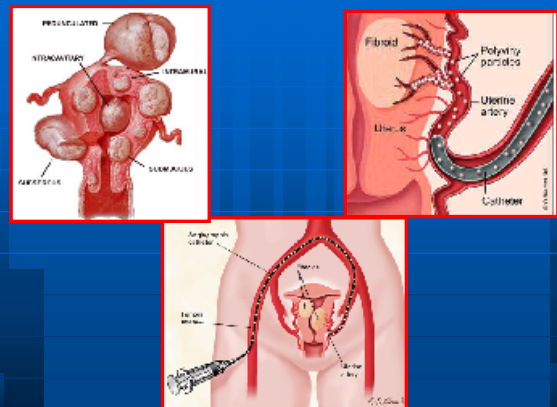
### Embolisation of hemorrhage from malignant uterus tumor



### Uterine fibroid embolisation (UFE)

- Indications: symptomatic leiomyoma
- „Ideal” candidate for UFE is
  - Symptomatic premenopausal women
  - Single or multifibroid uterus
  - In whom surgery is indicated
  - Who does not desire to preserve fertility
  - Who prefers minimal invasive treatment

### Fibroid embolisation



### 3. Description of the Procedure

#### • Description of the Step # 1

**Comments:**

Selective catheterism of the left uterine artery with a 5F cobra catheter (Cordis) showing the left sided predominant vascularisation of the fibromyoma.

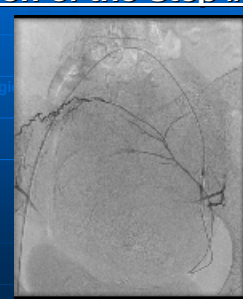


### 3. Description of the Procedure

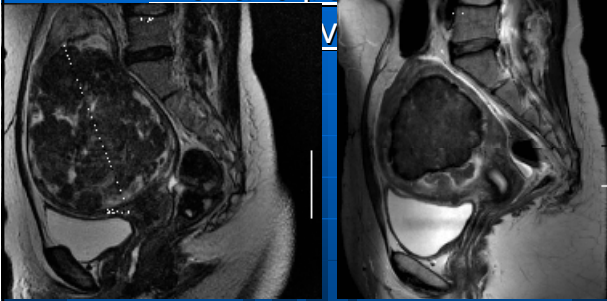
#### • Description of the Step # 2

**Comments:**

Control selective angiography of the left uterine artery after injection of 3 vials of 500µm and 1 vial of 700µm Embosphere Microspheres (microcatheter: SP, Terumo).

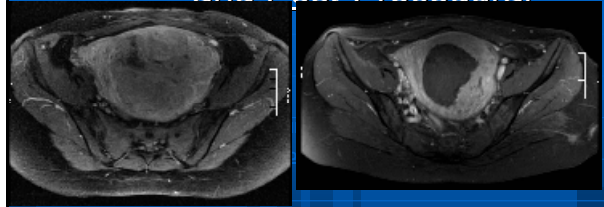


#### 4. MRI scan (T2, sagittal), Pre- and post-Procedural



**Comments:**  
T2 weighted sagittal view before (left panel) and 5 month after (right panel) embolisation

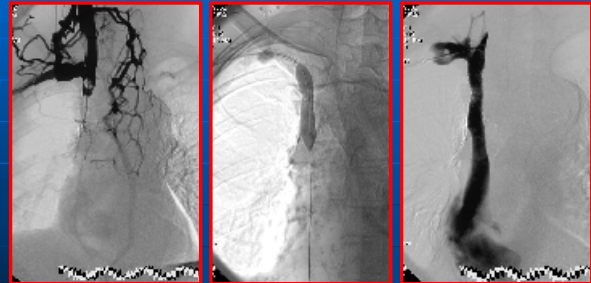
#### 5. MRI (T1 CE axial), Pre- and Post-Procedural



**Comments:**  
T1 weighted, contrast enhanced axial view before (left panel) and 5 month after (right panel) embolisation

### Venous interventions

### Occluded VCS (due to lung tumor - stent implantation)

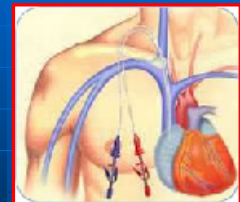


### Venous access I. – Historical points

1. 1900s - Early use of peripherally inserted central venous catheters (PICC)
2. 1952 - First reported use of central venous catheter (CVC) by Aubaniac
3. 1973 – Broviac developed a small-diameter silicone skin-tunneled catheter with a Dacron cuff
4. 1979 – Hickman modified the Broviac catheter for bone marrow transplant patients

### Venous access I.

1. Chronic infusion catheters
2. Peripherally inserted central infusion catheters (PICC)
3. Ports
4. Alternative vascular access techniques



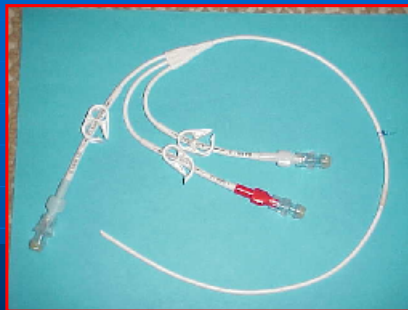
## Chronic infusion catheters

- Temporary (nontunneled)
  - No precise definition for time; planned duration more than 6 weeks considered long-term
  - Exit ports in close proximity to the venous puncture site
- Long-term (tunneled)

## Chronic infusion catheters (tunneled)

- Indications include
  - Chemotherapy
  - Long-term nutrition (Total Parenteral Nutrition, TPN)
  - Antibiotic-treatment
  - Hemodialysis
  - Plasmapheresis

## Chronic infusion catheters – Design



Hickman

single/double lumen

## Insertion techniques

- Right (or left) IJV
  - The most commonly used site
  - Higher success rate and lower complication rate than for subclavian vein access
  - US guidance recommended
  - UK NICE supports jugular approach
- Subclavian vein
  - Infraclavicular or supraclavicular (latter is rare, meticulous, risky)
- Femoral vein
  - Easiest but highest incidence of complications \*infection and thrombosis)

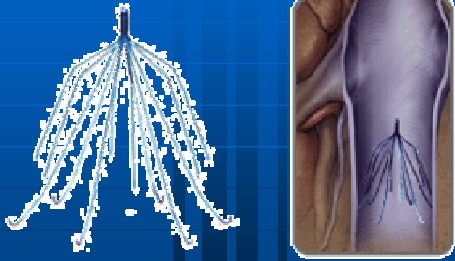
## Complications

- Immediate
  - PTX
  - Inadvertent great vessel puncture or perforation
  - Air embolism
  - Catheter malposition
- Delayed
  - Infection
  - Venous stenosis
  - Fibrin sheath and thrombus formation

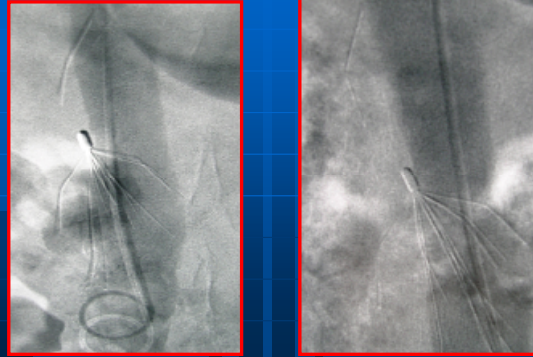
## IVC filter insertion

- Absolute indications
  - Deep venous thrombosis (DVT)
    - Contraindication for anticoagulation
    - Recurrent thromboembolic disease despite anticoagulation therapy
    - Significant complication of anticoagulant therapy
    - Inability to achieve adequate anticoagulation (despite patient compliance)

### IVC filter



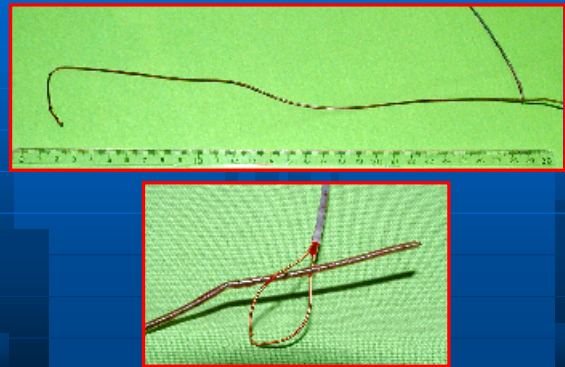
### Broken arm, arm penetration and filter tip embedded in cava



### Foreign body retrieval (broken PM electrode)



### Foreign body retrieval



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