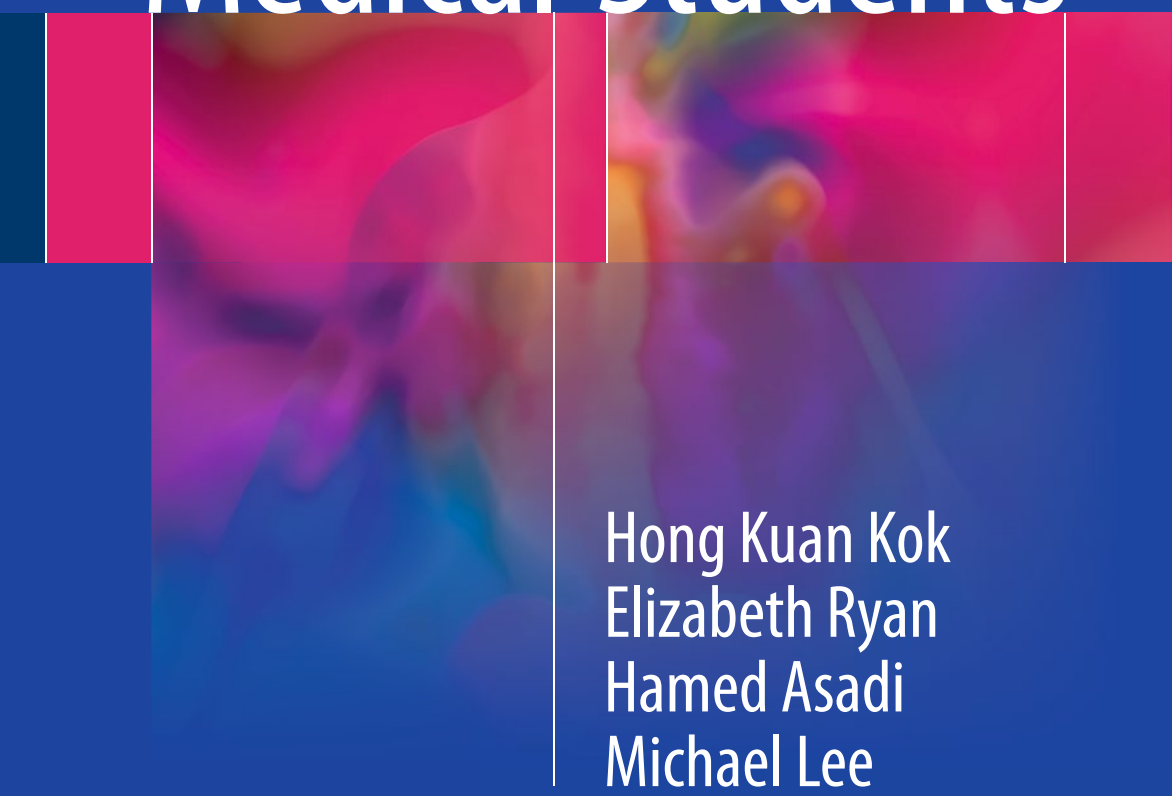
Interventional Radiology for Medical Students



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To my parents, Sonny and Karen; my wife, Limy; and my family, Adrian and Tiffany

– Hong Kuan Kok

To my family and colleagues for their much valued support and to all students of the wonderful field of Interventional Radiology

– Elizabeth Ryan

To my beautiful wife Anousha and our lovely Tara and Daniel

– Hamed Asadi

To Aoife, Ronan, Daire and Sarah

– Michael Lee

Foreword

IR has grown over the last forty years from a small cadre of enthusiasts who were on the outside of mainstream medicine to the current situation where IR is now an essential part of modern healthcare delivery. For any specialty, teaching the next generation of doctors is vitally important. It has been shown that medical students are much more likely to choose a career in a specialty if they have been taught or mentored by doctors within that specialty. As interventional radiology comes of age, dedicated IR teaching is a must for all medical schools so that qualified doctors are familiar with the scope of IR and can refer appropriately. This is even more important in the current era because of the rapid growth in the breadth and depth of IR procedures, which are used to treat a diverse group of diseases and conditions.

This book covers the main topics of interventional radiology in a case-based format for optimal learning and retention. Biopsy and drainage, angioplasty and stenting, embolisation, musculoskeletal IR and neuro intervention, including stroke thrombectomy, are all covered. The book has been edited and written by IR experts who have delivered the IR teaching programme at Beaumont Hospital over a number of years. It is our hope that this book will familiarize medical students, general practitioners and other interested parties with the dynamic specialty of IR and what IR can contribute to patient care.

We hope that you enjoy the book and through reading this book you will gain an understanding of modern IR practice and where it fits in hospital practice.

Dublin Ireland — Michael Lee

Preface

Interventional radiology or "IR" has been practiced since 1954 when a Swedish radiologist called Sven Seldinger devised a system to puncture the femoral artery and gain access with a catheter to perform diagnostic angiography. This simple invention provided safe access to the arterial system and diagnostic radiology morphed into interventional radiology. IR has grown and matured since its inception, and in the last twenty years has become a vitally important part of patient care. In fact, for many diseases, one cannot receive appropriate care without using IR services.

As IR moves to becoming a specialty in its own right, it is important that IR take up its teaching duties and teaches the next generation of doctors. We decided to write this book because of the enthusiastic reception of IR teaching by medical students attached to RCSI (Royal College of Surgeons in Ireland) medical schools in Dublin, Bahrain and Malaysia. We have been teaching IR to our medical students in a dedicated curriculum for the past four years and this book is based on that experience. The book is in a case-based format, which we believe enhances the learning experience for medical students. All of the important topics in modern IR are covered.

As IR grows and attains specialist status in its own right we hope that IR teaching in medical schools will become the norm rather than the exception.

Dublin Ireland — Michael Lee

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Introduction to Interventional Radiology

1

Mark Sheehan and Michael Lee

1.1 Introduction

- The field of medicine is constantly changing, evolving and outcomes for patients are improving with the increasing use of minimally invasive surgical techniques. Interventional Radiology (IR) or image guided minimally invasive surgery has demonstrated enormous innovation over the last 20 years and has developed multiple new minimally invasive alternatives to traditional surgical procedures.
- IR is now a must in all reasonably sized hospitals to ensure optimal patient care.
- The competent medical student needs to know:
  - The basic principles of IR.
  - The role of IR within clinical practice.
  - Image guidance techniques used in IR.
  - Consent and patient preparation for IR procedures.
  - Importance of radiation protection.

1.2 History of Interventional Radiology

- Since the Seldinger technique was first developed in 1953 by a Swedish radiologist of the same name, IR has made significant advancement. Some of the common procedural terms used in IR are listed below:
  - Angioplasty (opening an artery, vein or other tubular structure with a balloon),

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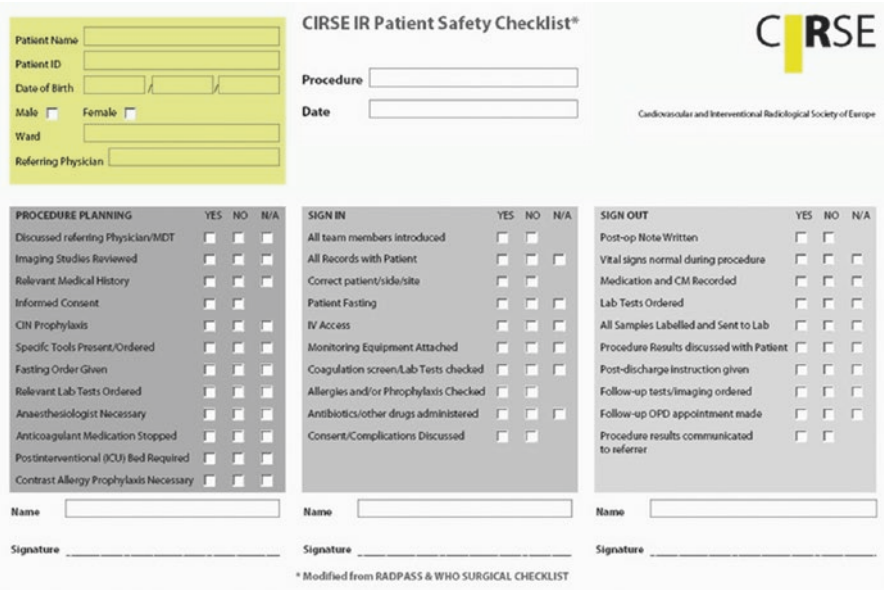
  - Stent placement (using a stent in an artery, vein or tubular structure to support angioplasty)
  - Biopsy and Drainage - using image guidance to obtain a tissue or fluid sample to aid diagnosis or drain an abscess, obstructed biliary system (biliary drainage) or obstructed renal (nephrostomy) system
  - Embolisation (blocking an artery that is bleeding, delivering payload to an artery supplying a tumor)
  - Tumor ablation or Interventional Oncology (ablating or destroying tumours by using thermal energy).
- Charles Theodore Dotter, also known as the "Father of interventional radiology" performed the first angioplasty in 1964. Dr. Dotter later went on to receive a Nobel prize nomination in 1978 for the development of this procedure.
- In 1966 the first embolisation techniques were pioneered to treat tumours and spinal cord vascular malformations.
- In the 1970s embolisation of the arteries supplying the gastrointestinal (GI) tract was used to treat massive GI bleeds.
- In the 1980s, Transjugular Intrahepatic Portosystemic shunt (TIPS) was first used to treat life threatening variceal bleeding in patients with portal hypertension.
- In the early 90s, Endovascular aneurysm repair (EVAR) was first used to treat abdominal aortic aneurysms (AAA) and is now the preferred treatment for elective AAA repair.
- In the late 90s, the use of radiofrequency ablation for the treatment of varicose veins first began and its use is now widespread.
- The training of Interventional Radiologists has also evolved greatly over this time. Typically an IR trainee undertakes 3–4 years of basic Radiology training followed by at least two higher training (also known as Fellowship) years in IR.
- Training follows a national or supranational curriculum such as the CIRSE (Cardiovascular and Interventional Radiology Society of Europe) curriculum where trainees are expected to gain competency in the imaging, technical and clinical aspects of IR and patient management.
- Assessment of competency of IR training is now available in most jurisdictions through the European Board of Interventional Radiology (EBIR) in Europe, Australia and New Zealand, the Certificate of Added Qualification in Vascular & Interventional Radiology (CAQ in VIR) exam in the USA and examinations or continuous appraisal in other countries.

1.3 Patient Preparation and Safety Checklist

- Patient preparation for IR procedures is similar to patient preparation for surgical procedures.
- Informed consent must be obtained form all patients, preferably form the doctor performing the procedure or a delegate with suitable knowledge of IR.



CIRSE IR Patient Safety Checklist*

CIRSE
Cardiovascular and Interventional Radiological Society of Europe

Patient Name
Patient ID
Date of Birth
Male ☐ Female ☐
Ward
Referring Physician

Procedure
Date

PROCEDURE PLANNING	YES	NO	N/A
Discussed referring Physician/MDT	☐	☐	☐
Imaging Studies Reviewed	☐	☐	☐
Relevant Medical History	☐	☐	☐
Informed Consent	☐	☐	
CIN Prophylaxis	☐	☐	☐
Specifc Tools Present/Ordered	☐	☐	☐
Fasting Order Given	☐	☐	☐
Relevant Lab Tests Ordered	☐	☐	☐
Anaesthesiologist Necessary	☐	☐	☐
Anticoagulant Medication Stopped	☐	☐	☐
Postinterventional (ICU) Bed Required	☐	☐	☐
Contrast Allergy Prophylaxis Necessary	☐	☐	☐

Name
Signature

SIGN IN	YES	NO	N/A
All team members introduced	☐	☐	
All Records with Patient	☐	☐	☐
Correct patient/side/site	☐	☐	
Patient Fasting	☐	☐	☐
IV Access	☐	☐	☐
Monitoring Equipment Attached	☐	☐	☐
Coagulation screen/Lab Tests checked	☐	☐	☐
Allergies and/or Phrophylaxis Checked	☐	☐	
Antibiotics/other drugs administered	☐	☐	☐
Consent/Complications Discussed	☐	☐	

Name
Signature

SIGN OUT	YES	NO	N/A
Post-op Note Written	☐	☐	
Vital signs normal during procedure	☐	☐	☐
Medication and CM Recorded	☐	☐	☐
Lab Tests Ordered	☐	☐	☐
All Samples Labelled and Sent to Lab	☐	☐	☐
Procedure Results discussed with Patient	☐	☐	☐
Post-discharge instruction given	☐	☐	☐
Follow-up tests/imaging ordered	☐	☐	☐
Follow-up OPD appointment made	☐	☐	☐
Procedure results communicated to referrer	☐	☐	

Name
Signature

* Modified from RADPASS & WHO SURGICAL CHECKLIST

Fig. 1.1 Typical patient safety checklist used in IR which includes a pre-procedure checklist, time out and post procedure checklist

- Routine blood investigations such as a full blood count, renal profile and a coagulation screen are usually required for most procedures.
- Occasionally and subject to local guidelines, blood investigations may not be required for some simple procedures such as superficial biopsies or venous procedures where haemostasis is easily achieved by local compression.
- The awareness of iodinated contrast material (CM) allergy is crucial before any proposed procedure where CM is used (endovascular procedures).
- A safety checklist (Fig. 1.1) has been developed and is now in routine use to ensure patient safety.

1.4 IR Practice

- IRs work in Interventional suites or 'angiographic laboratories' with the support of dedicated specialist nursing staff and radiographers or technologists (Fig. 1.2).
- These procedure suites are designed like operating theatres and most contemporary rooms have a clean air designation to improve procedure sterility.
- Many IRs also now lead a clinical service where they see patients in outpatient clinics, admit patients for many procedures and perform ward rounds on patients post-procedure. Collaboration and teamwork with referring clinicians and disciplines are essential.

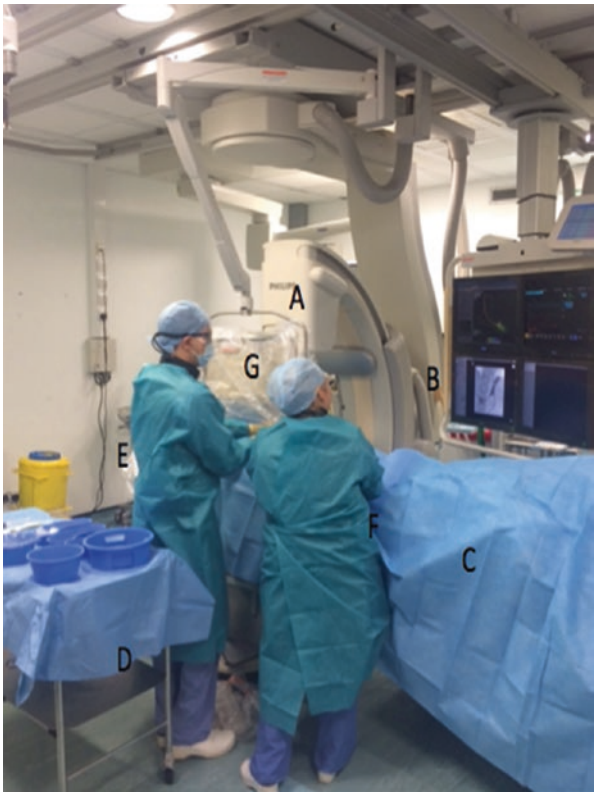


Fig. 1.2 Example of a percutaneous nephrostomy procedure being performed in an Interventional Radiology suite. *A* C-arm, *B* Monitor displaying live images, *C* Bed/ Patient, *D* Sterile trolley and IR equipment, *E* Interventional Radiologist, *F* Scrub Nurse, *G* Radiation protection screen

Key Points

- IR is a relatively new minimally invasive, image-guided specialty that has grown from Radiology.
- IR is often termed "Pinhole Surgery"
- IR is mandatory for modern healthcare delivery.
- IRs train in diagnostic and interventional radiology with some years of clinical practice also desirable.

Suggested Reading

1. European Board of Interventional Radiology. www.cirse.org.
2. IR curriculum and syllabus. www.cirse.org.
3. Patient safety checklist. www.cirse.org.

Principles, Signs and Symptoms of Peripheral Vascular Disease

2

Mark Sheehan, Hong Kuan Kok, and Michael Lee

2.1 Introduction

- Peripheral arterial disease (PAD) includes a group of conditions of different aetiologies which can affect the vessels of the upper and lower limb. PAD is most commonly used to describe atherosclerotic disease of the lower extremity arteries.
- PAD can be divided into acute and chronic presentations; the principal pathology being a compromised supply of oxygenated blood to the extremities leading to tissue ischaemia and necrosis if severe.

2.2 Risk Factors

- Smoking
- Hyperlipidemia
- Hypertension
- Age
- Diabetes Mellitus
- Male
- Family history
- Homocysteinemia

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2.3 Chronic Lower Limb PAD

2.3.1 Symptoms

- The symptoms of PAD depend on the extent of arterial stenosis or occlusion and the presence or absence of collateral supply to the ischaemic limb.
- PAD is often classified into three categories, each indicating progressively more severe disease – intermittent claudication, rest pain and critical limb ischaemia.
- The Rutherford and Fontaine classifications are used to grade the symptoms of PAD:

Rutherford		Fontaine	
Stage	Clinical	Stage	Clinical
0	Asymptomatic	I	Asymptomatic
1	Mild claudication	IIa	Mild claudication
2	Moderate claudication	IIb	Moderate to Severe claudication
3	Severe claudication	III	Ischaemic rest pain
4	Ischaemic rest pain	IV	Ulceration or gangrene
5	Minor tissue loss		
6	Ulceration or gangrene		

2.3.1.1 Intermittent Claudication (IC)

- Defined as cramping muscular pain that develops on physical exertion and is relieved by rest. This pain typically occurs because there is an imbalance between the arterial supply and the metabolic demands of the muscles in the lower limb. The distance walked to onset of symptoms is quite consistent in each individual and is referred to as the claudication distance.
- Age adjusted prevalence of 12%, 20% of those presenting are over 70 years.
- 25% deteriorate – 7–9% in the first year and 2–3% thereafter
- Amputation rate is 1–3.3% over a 3 year period
- 5, 10, 15 year mortality rates are 30%, 50% and 70% respectively

2.3.1.2 Rest Pain

- Severe pain that typically affects the toes and forefoot without exertion (Rutherford 4 or Fontaine III). Symptoms often occur at night or when patient is at rest with the limbs elevated due to reduced gravity perfusion.
- Patients often report relief of pain by standing or when the leg is positioned over the edge of the bed. This is related to the gravitational effects of dependence on limb blood pressure.

2.3.1.3 Critical Limb Ischaemia (CLI)

- CLI is defined as severe arterial compromise in patients with peripheral arterial disease, often resulting in tissue loss. It includes severe rest pain, limb ulcers or gangrene (Rutherford 4–6 or Fontaine III–IV).

- There is a 20% mortality at 1 year and continues at the same rate. Mortality at 12 months is worse than many cancers.
- High risk of amputation with limb and mobility loss.
- Also associated with a high risk of cardiovascular events including myocardial infarction and death.

2.4 Clinical Signs

- Inspection:
  - Hair loss
  - Dystrophic skin and nail changes
  - Pallor
  - Arterial ulcers – Punched out, painful, deep, pressure points
  - Gangrene
  - Previous amputation
- Palpation (comparing both sides):
  - Cool peripheries
  - Reduced capillary refill time
  - Reduced or absent peripheral pulses: femoral, popliteal, dorsalis pedis and posterior tibial pulses
  - Blood pressure measurement
- Auscultation
  - Arterial bruits over the aorta, femoral, carotid arteries
- Special tests:
  - Buerger's test: Straight leg lift causing pallor in the foot and toes of a patient with PAD lying in the supine position. The angle when the signs are observed is known as Buerger's angle. Reactive hyperaemia is seen when the limb has been positioned dependently off the edge of the bed.

2.5 Investigations

- **Ankle-Brachial Index (ABI)**: This is a non-invasive measurement of the ratio of systolic blood pressure in the lower limb compared to that of the upper limb. Interpretation of ABI results is as follows:
  - Ratio of >1.2 – Associated with calcified non compressible arteries such as those occurring in patients with diabetes mellitus.
  - Ratio of 0.9–1.2 – Normal
  - Ratio of 0.4–0.9 – Mild to moderate PAD
  - Ratio < 0.4 – Severe PAD, usually associated with tissue loss
- **Toe Pressures**: This is another non-invasive measure of arterial insufficiency. It is particularly useful in diabetic patients with calcified non compressible vessels

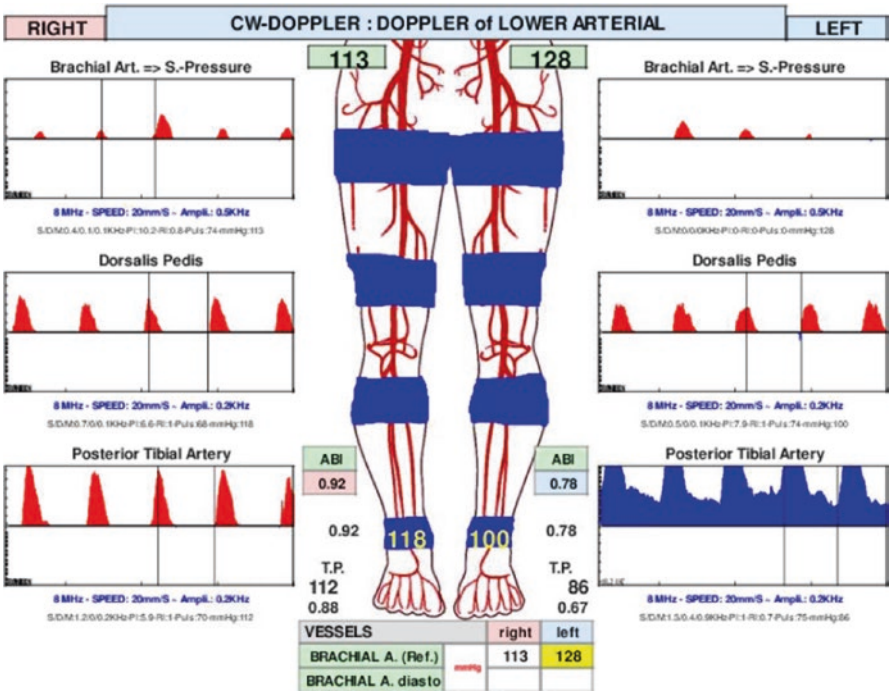

Fig. 2.1 Example of a report from the non-invasive Vascular Laboratory including Doppler measurements of arterial flow in the upper and lower limb arteries as well as ankle-brachial index (ABI) and toe pressure (TP) measurements in a patient with mild left lower extremity PAD (ABI 0.78 and Toe pressure of 86 mmHg)

and gives a more accurate representation of the arterial compromise in comparison to ABI measurements.

- Toe pressures <30 mmHg suggests severe PAD.
- A toe-brachial index (TBI) can also be calculated and interpreted in a similar manner to ABI (Fig. 2.1).
- **Duplex Ultrasound**: This is a non-invasive imaging study which combines the anatomic assessment of a blood vessel using ultrasound with the ability to assess blood flow using the Doppler technique.
- The extent and impact of a stenotic lesion on the flow of blood within a vessel can be accurately assessed.
- Duplex ultrasound does not involve ionising radiation and is a useful tool for both the diagnosis and follow-up of PAD.
- Disadvantages of duplex ultrasound include operator variability and a relatively long exam time (30–60 min) (Fig. 2.2).
- **CT Angiography (CTA)**: Non-invasive angiographic imaging of the aorta, visceral and peripheral arteries without the need for arterial catheterisation.

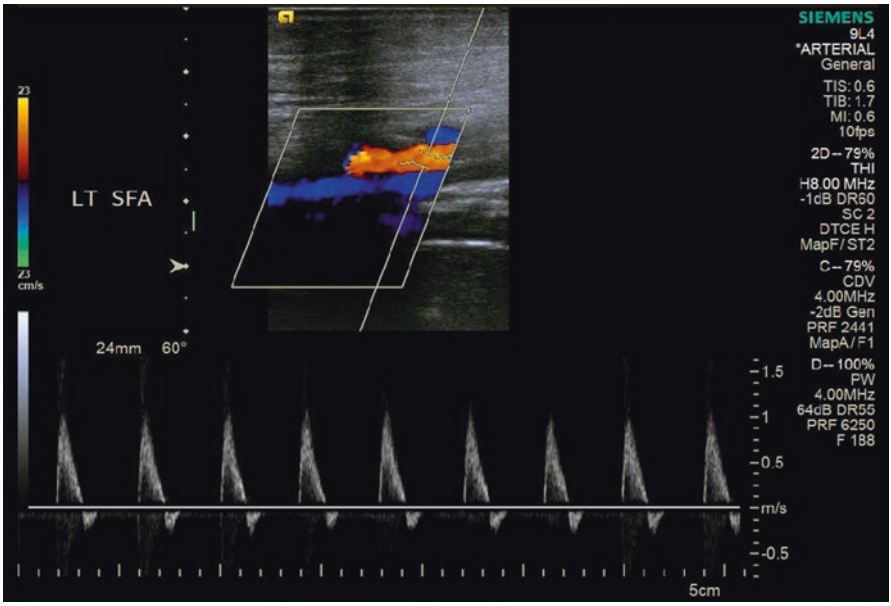

Fig. 2.2 Duplex ultrasound of the left superficial femoral artery demonstrating normal triphasic flow in the artery (*arrow*) consistent with patency

- Iodine-based contrast media is injected through a peripheral intravenous cannula followed by acquisition of high-resolution images with the contrast opacification timed to the arterial phase using a multidetector CT scanner.
- Modern CT scanners allow images to be reconstructed in multiple planes such as the coronal, sagittal or oblique planes to aid interpretation. Volumetric 3D reconstructions can be performed to aid pre-procedural planning.
- The advantages of CTA is the rapid acquisition of high-resolution images (seconds) and its non-invasive nature.
- Disadvantages include exposure to ionising radiation, risk of contrast induced nephropathy in patients with chronic renal impairment and reduced accuracy in the assessment of heavily calcified arteries due to 'blooming' artifacts (stenosis and occlusions may be overestimated) (Fig. 2.3).
- **Magnetic resonance angiogram (MRA)**: Non-invasive imaging technique, which is similar to CTA but does not involve ionising radiation and is therefore safer.
- Image acquisition generally involves administration of a gadolinium-based contrast agent through a peripheral intravenous cannula followed by imaging in an MRI scanner, consisting of a superconducting magnet (commonly at 1.5 or 3.0 Tesla field strength) and radiofrequency coils to obtain high-resolution images.
- However, MRA is contraindicated in patients with certain cardiac pacemakers, loose metal within or on the body and certain intracranial clips. Image quality is