# Dialysis Access Management

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# Contents

# Brief Introduction of Hemodialysis and Vascular Access

1

Ru Yu Tan and Chieh Suai Tan

## Introduction

Three main treatment options exist to replace the kidney function of patients with end-stage renal disease (ESRD): hemodialysis (HD), peritoneal dialysis (PD) and renal transplantation. Hemodialysis is an extracorporeal renal replacement therapy that uses counter-current dialysate flow across a semipermeable membrane to achieve uremic toxins and fluid removal. It is now established as a mature therapy worldwide and has been the mainstay of treatment for ESRD patients. In the United States, a steady increase in ESRD prevalence was observed between 1980 and 2016, and the majority of patients used HD as their renal replacement therapy [1].

## The First Hemodialysis

The first successful HD was described and performed by Kolff in 1943 [2]. Kolff's rotating drum dialyzer was made of cellulose membrane tubes which were filled with blood and wrapped around a wooden drum that rotated through the dialysate for removal of uremic toxins during treatment. Since then, the concept was further refined and improved to provide a safe, reliable and effective therapy for patients suffering from ESRD. Modern dialyzers are made of more biocompatible or synthetic membranes with clearly defined characteristics and the ability to provide quantitative clearance of uremic toxins.

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## The First Arteriovenous Access

Maintenance HD is only possible in the presence of a vascular access. There are three main types of vascular accesses used to perform maintenance HD: arteriovenous fistula (AVF), arteriovenous graft (AVG) and central venous catheter (CVC). The initial form of vascular access was called the Scribner shunt. It was implanted for the first time in a human in 1960 [3]. The surgical technique to create the autogenous AVF was described by Brescia and Cimino in 1966. The use of synthetic graft for arteriovenous (AV) access creation began in the 1970s while hemodialysis catheters started in the 1980s [4, 5].

## Trends in Hemodialysis

Hemodialysis is now established as a mature therapy worldwide and has been the mainstay of treatment for patients with ESRD. In 2017, 86.9% of incident ESRD patients began renal replacement therapy with HD in the United States. Of all prevalent ESRD patients, 62.7% were treated with HD [1].

AVF provides the best outcome when compared to AVG and CVC. Patients with AVF have the lowest rates of infection, morbidity and mortality. However, the use of AVF in hemodialysis patients was extremely low in the 1990s. To increase the appropriate use of AVF, the Fistula First Initiative was started in 2003 [4]. Although there was a substantial increase in the rate of AVF placement, the primary failure rates remained high. Driven by the changing demographics in patients with ESRD, placement of AVF is increasingly challenging as ESRD patients entering dialysis are older and more likely to suffer from multiple comorbidities including diabetes mellitus, coronary artery disease and peripheral arterial disease. This highlights the need to individualize patient care when planning for vascular access placement.

Over the past decade, there has been a growing interest in home HD and intensive HD where patients receive either long-hours nocturnal dialysis or short daily dialysis. Home HD encourages patients' independence and allows patients the freedom to schedule dialysis at their own convenience. Intensive HD is demonstrated in many studies to result in a better quality of life, cost-saving in healthcare and better clinical outcomes [6]. Although home HD was only used by 2% of all prevalent patients receiving maintenance hemodialysis in 2017, the proportion was increased by 120% compared to 2007 [1]. A known adverse outcome to more frequent hemodialysis is the competing risks of vascular access-related complications.

Research is currently underway to develop lightweight, easy to use wearable dialysis devices and implantable hemodialysis devices that would allow patients to receive dialysis without restricting their daily activities. The successful development of these new dialysis devices could potentially improve the outcomes and quality of life of patients with ESRD. Similarly, improvement in AVF creation techniques and the use of novel devices such as drug-coated balloons for endovascular intervention are exciting developments in dialysis access management.

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# Angiographic Imaging Equipment

2

Chieh Suai Tan, Robert M. Sheridan, and Steven Wu

## Introduction

Since the accidental discovery of X-rays in 1895, technology has evolved so rapidly that minimally invasive endovascular interventions are routinely performed under radiological guidance.

Having high-quality fluoroscopic imaging is pivotal for endovascular intervention. Hence, it is essential to know your machine well and understand some of the common terminologies.

## Angiographic Imaging System

Interventional suites may be equipped with either a stationary (Fig. 2.1) or a mobile fluoroscopic imaging system (Fig. 2.2). The common features of these systems are the presence of a C-arm, an angiographic procedure table and a console or computer system to process and project the images for viewing on a screen. As the name suggests, C-arm consists of a C shaped metal mount equipped with an X-ray generator

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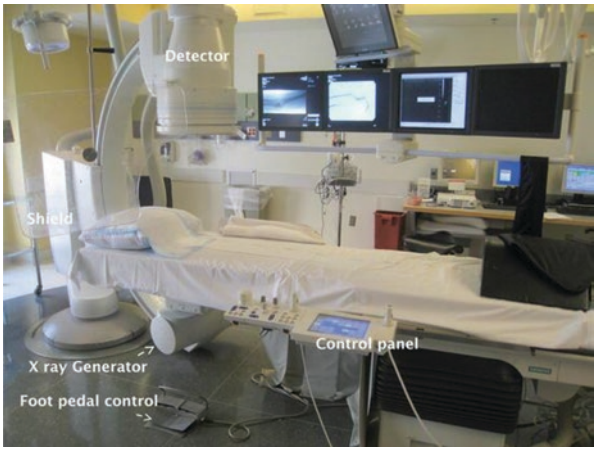


**Fig. 2.1** The layout of an angiography suite with a stationary fluoroscopic imaging system

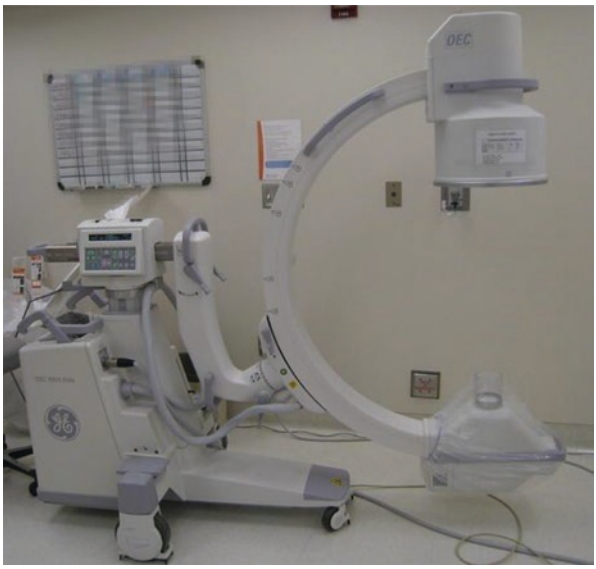


**Fig. 2.2** The portable C-arm of a mobile fluoroscopic imaging system. The radiographer has to manually position the C-arm over the area of intervention

at one end and an X-ray receptor at the opposite end of the C-arm. The patient is placed on a radiolucent procedure table, between the X-ray tube and the receptor.

A stationary fluoroscopy system consists of a ceiling or floor mounted C-arm, ceiling mounted monitors and floor mounted procedure table. The entire set up is fully mechanized and the patient is positioned within the fluoroscopy field by either moving the motorized procedure table or the C-arm. The stationary system usually has a larger generator that can provide higher image resolution than a mobile system. In addition, the stationary system has excellent C-arm mobility to allow imaging of the target area at different angulations.

A mobile fluoroscopy system consists of a portable C-arm and monitor that can be moved from room to room. The angiographic procedure table is usually stationary and the radiographer manually positions the C-arm over the area of intervention. They are usually less expensive and have smaller X- ray generators and lower heat capacity than stationary systems. Some new generation portable C-arm systems can produce high quality images and have image processing capability similar to that of the stationary systems.

## C-arm

The C-arm consists of an X-ray generator and an X-ray receptor (Fig. 2.3a, b). The X-ray beam that is generated travels through the patient and is captured by the receptor, which is either an image intensifier or a digital flat-panel detector. The current that is required to generate X-rays is measured in milliampere/second (mAs). It ranges from 0.5–5 mA for fluoroscopy and is triggered when the fluoroscopy pedal

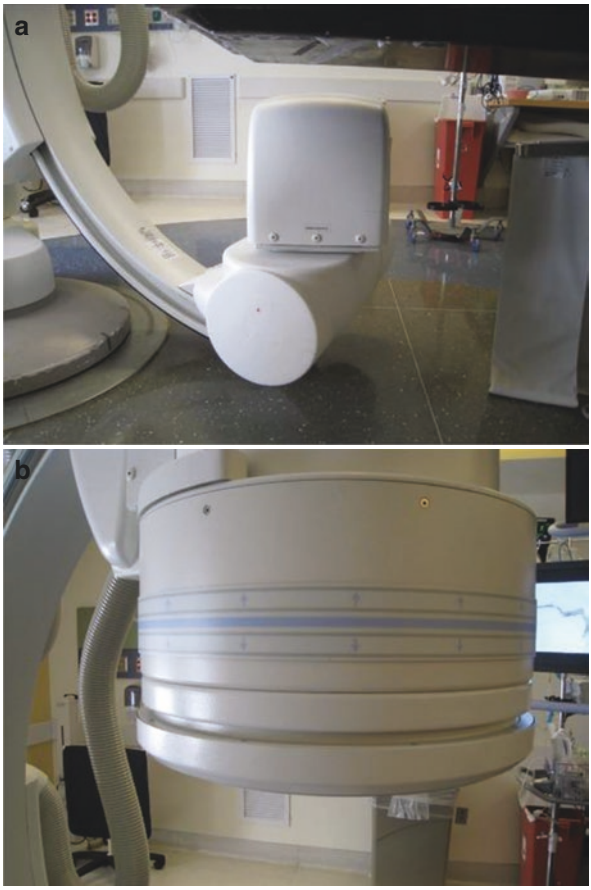


**Fig. 2.3** (**a**) The generator is mounted on the lower end of the C-arm and is located under the table. (**b**) The X-ray detector is mounted on the top end of the C-arm

is pressed. The current determines the density of the image. Peak kilo-voltage (kVp), which is a measure of the potential difference across the anode and cathode, determines the maximum kinetic energy of the X-ray beam. The kinetic energy of the X-ray beam impacts the penetrability of the X-ray beam and the contrast of the image. In an automated system, the interaction between the mAs and kVp is determined by the computer to provide the best image quality at the lowest radiation dose to the patient.

## Foot Switch

A foot switch control is used to start the generation of X-rays by the C-arm (Fig. 2.4). The pedals are programmed to begin imaging using fluoroscopy or digitally subtracted angiography when depressed respectively. X-rays are generated once the pedal is depressed and continued until the pedal is released.

## Monitor Console

The monitor console usually has two or more computer screens to display the images (Fig. 2.5). The screen on the left shows the "active" or "live" images, while the one on the right displays the last recorded image frame or replay the image sequences.

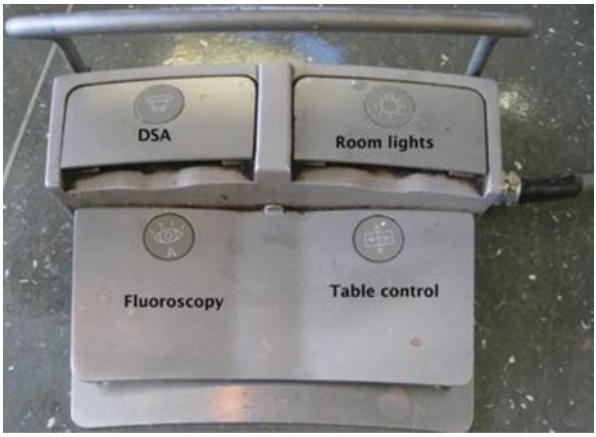


**Fig. 2.4** The pedals on the foot switch can be programmed based on user preference

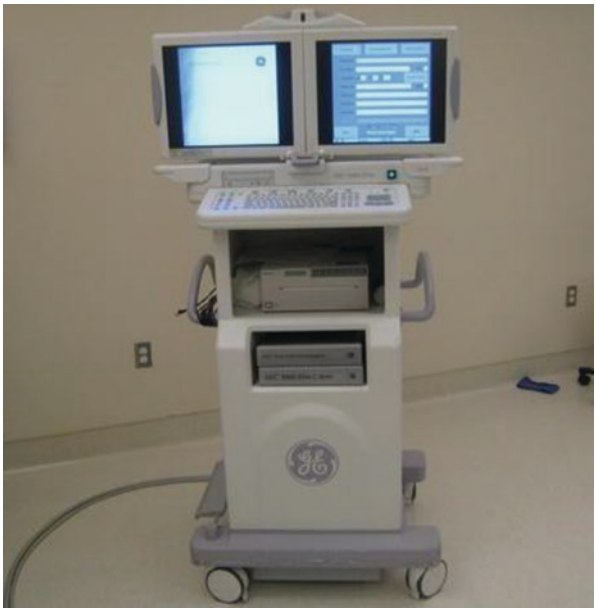

**Fig. 2.5** The monitor console in a mobile fluoroscopic imaging system is mounted on wheels and can be moved together with the mobile C-arm from room to room

## Table and Control Panel

The procedure table is made of carbon fiber to allow easy penetration of the X-ray beam. The stationary system may be equipped with two control panels; one located at the side of the procedure table, and another may be found within the control room (Fig. 2.6a–c).

## Imaging Options

### Pulsed Fluoroscopy

Variable rated pulsed fluoroscopy is an important feature in a digital angiographic imaging system (Fig. 2.7a, b). In pulsed mode, the X-ray beam is not generated continuously but delivered intermittently in synchrony with the image display to produce the appearance of a smooth continuous image. The use of pulsed fluoroscopy can significantly reduce X-ray dose, but "flickering" of the images can occur when it is set too low. The default setting in our center is 15 pulses per second although in general, 4 pulses per second is sufficient for dialysis access intervention. The X-ray dose at 30 pulses per second is equivalent to that of continuous fluoroscopy.

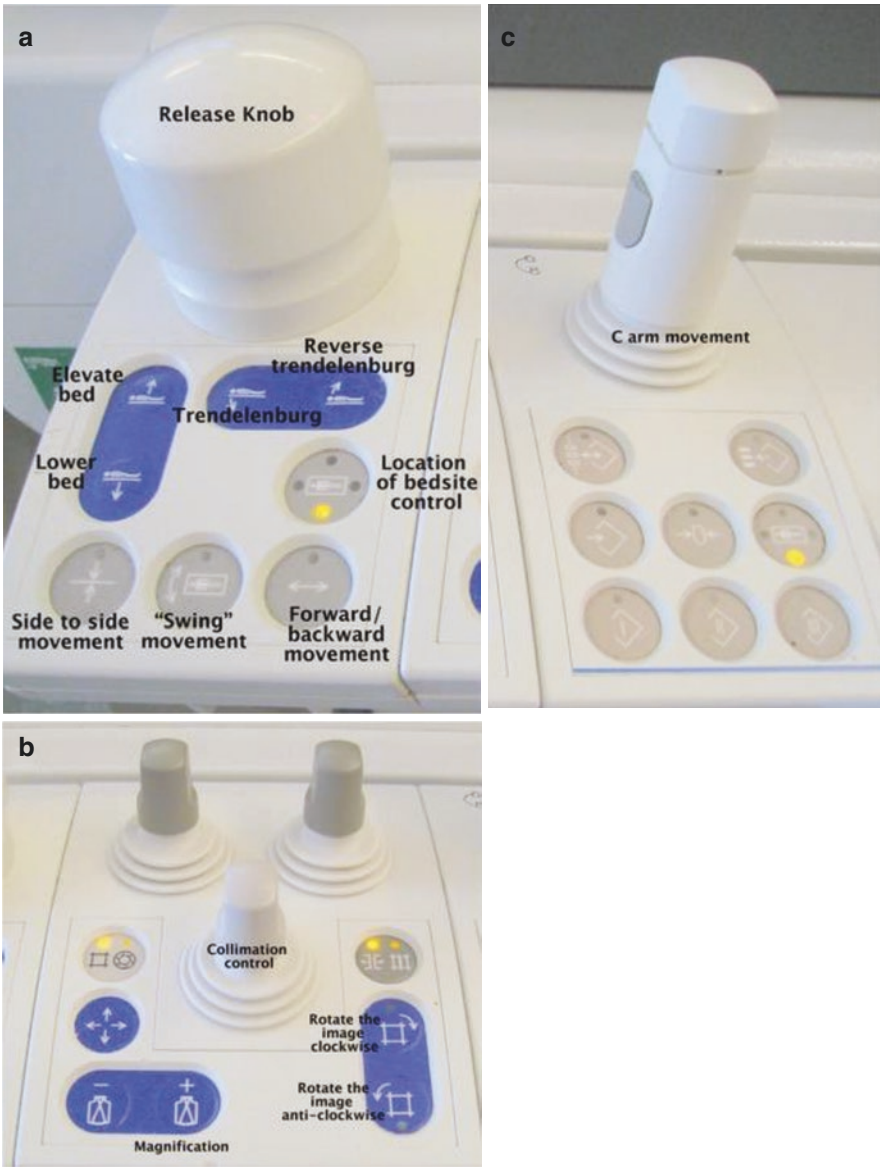


**Fig. 2.6** (**a**) Horizontal movement of the table in all directions is possible once the release knob is depressed. The three grey colored buttons are used when the restriction in a particular direction of the table movement is required. (**b**) This panel controls the generation of images by the C-arm. Collimation is used to restrict the field of view to the area of interest. Magnification is used to magnify the area of interest for detailed examination. The images can also be rotated clockwise or anti-clockwise. (**c**) This control stick controls the movement of the C-arm. It is used to move the C-arm around the patient

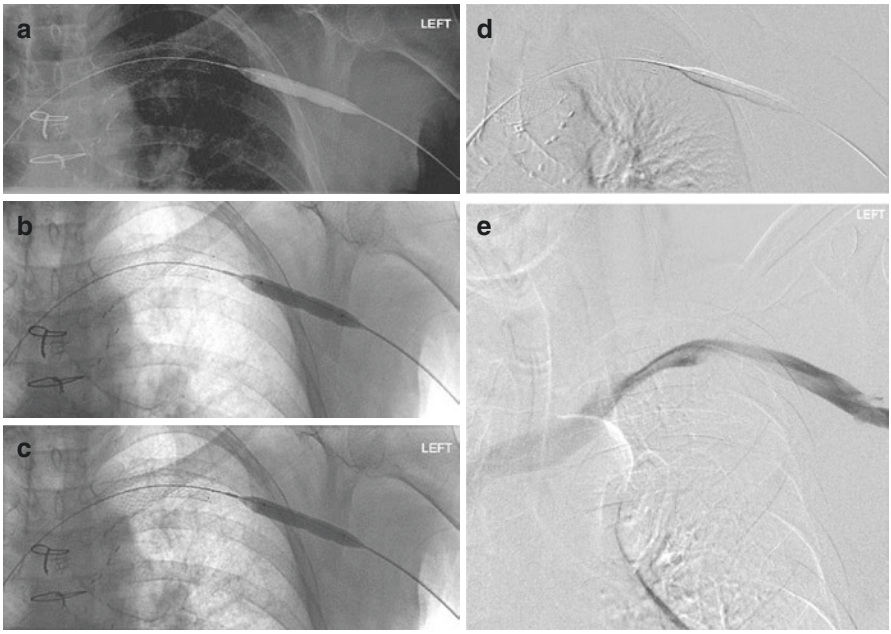


**Fig. 2.7** (**a**) Fluoroscopy with a "white on black" setting. The angioplasty balloon which is filled with radiopaque contrast material will appear white. (**b**) Fluoroscopy with a "black on white" setting. The angioplasty balloon which is filled with radiopaque contrast material will appear black. (**c**) In digital subtraction angiography, a "mask" of the area is first created. (**d**) Using the "mask" that was initially acquired, background tissues or structures are then digitally removed from the subsequently acquired images. (**e**) The injected contrast will appear black on a "white-out" background that has been digitally subtracted or modified using the "mask" image as the reference image

## Fluoroscopy Versus Digital Subtraction Angiography (DSA)

In standard fluoroscopy, electron dense objects such as bones and iodinated contrast materials absorb more energy and appear white on a black background. This is usually reversed digitally such that bone and contrast will appear black on a white background.

In digital subtraction angiography (DSA), a "mask" of the area of interest is first taken and used as a reference to digitally remove or subtract the "background" tissues or structures from the images that are subsequently acquired during contrast material administration. Vessels that are filled with the contrast material appear black on a "white-out" background. Subtraction angiography improves the contrast resolution of the images (Fig. 2.7c–e).

Acquisition of DSA images is described in "frames per second". The image acquisition frame rate can be adjusted as per the target vasculature. While a slow acquisition frame rate may not adequately capture the flow of contrast material, a high frame rate may be unnecessary and may result in a high radiation dose. In

general, 3 frames per second is sufficient when imaging the central veins (to compensate for chest movement artifact), while 1–2 frames per second is adequate for peripheral dialysis access interventions.

## Collimation versus Magnification

Collimation is used to limit the size of the field of view to the area of interest. It helps to decrease the radiation dose to the patient and improve image quality by reducing scattered radiation.

Magnification is used to magnify or enlarge the area of interest. Magnification results in an increase in the patient's radiation dose and should be used only when fine detail is needed.

## Optimizing Image Quality

The quality of the images will have an impact on the ability to make an appropriate interpretation. While obtaining the best image possible is essential, one must be mindful of the potential adverse effects of radiation. Some of the techniques to improve image quality are as follows:

1. Minimize the distance between the X-ray detector (image receptor) and the patient. This improves image quality and decreases scatter radiation.
2. Remove radiopaque objects such as oxygen tubing and ECG leads from the field of view (Fig. 2.8).

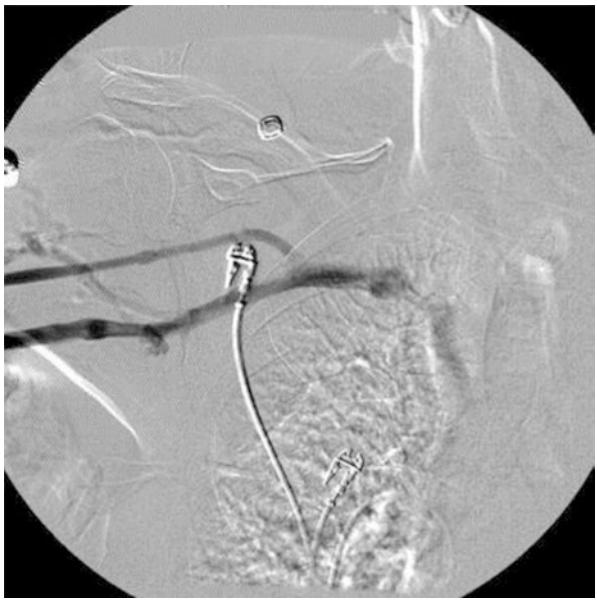

**Fig. 2.8** ECG leads should not be placed within the fluoroscopic field

3. Minimize patient's movements to decrease movement artifacts, e.g., instructing the patient to breath-hold during imaging of the central veins will improve image quality.
4. Position the patient and X-ray detector before starting imaging.
5. Keep the area of interest in the center of the image.
6. Use collimation to "remove" unnecessary areas.
7. Use magnification to see details in a specific area when necessary.
8. Increase the number of pulses per second or frames per second where necessary.
9. Use full strength iodinated contrast material rather than diluted contrast material, especially when imaging the proximal or central vessels.
10. Oblique views may be necessary to delineate overlapping vessels and detecting eccentric vascular disease.

# Endovascular Tools

3

Chieh Suai Tan, Zubin D. Irani, and Steven Wu

## Introduction

The Seldinger technique, first described in 1953, revolutionized the way angiography was performed. It overcomes the traditional need for surgical exposure of a blood vessel before catheterization by using a guidewire to introduce devices into a blood vessel via a percutaneous puncture. The technique involves percutaneous puncture of a blood vessel with a hollow needle, introduction of a guidewire through the needle into the blood vessel lumen, removal of the needle while maintaining the guidewire in position, followed by advancement of a catheter over the guidewire.

The refinement of this technique by the placement of a sheath over the puncture site allows devices to be introduced via the same vascular access site without the need for multiple punctures. The tools for endovascular interventions are outlined in this chapter.

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## Access Needle

All endovascular intervention begins with the insertion of a vascular access needle. There is a great variety of access needles that can be used. Examples include the micropuncture needle, introducer needle, sheath needle and angiocath (Fig. 3.1a–c). Their common feature is the presence of a central channel for the introduction of a guidewire. The diameter of a needle is described using the stubs iron wire gauge system in "gauge" or "G". The maximum guidewire diameter that an 18-G and

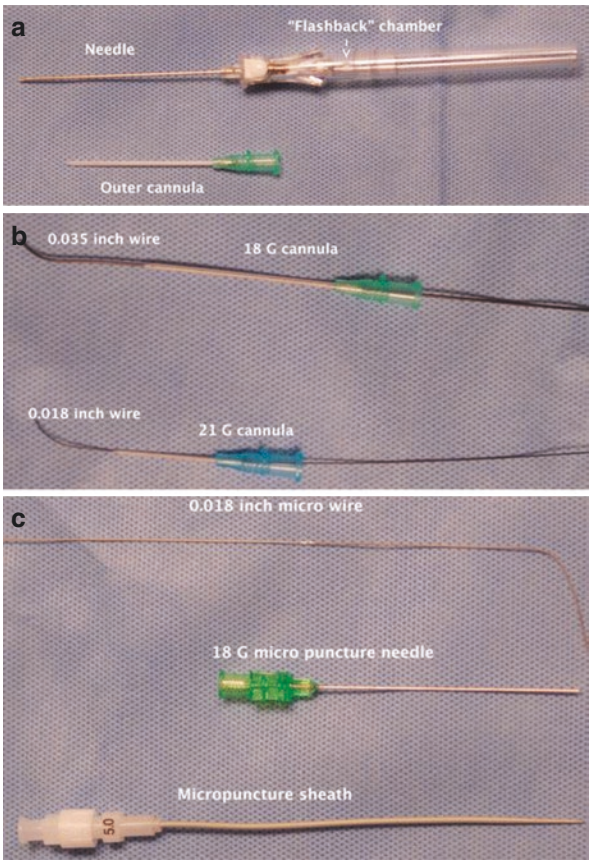


**Fig. 3.1** (**a**) An angiocath consists of a hollow core needle with an outer sheath. The "flashback" chamber allows visualization of blood once the needle punctures the vessel. (**b**) An 18G cannula can accommodate a 0.035 in. guidewire while a 21G cannula can accommodate a 0.018 in. guidewire. (**c**) A micropuncture set consists of a micropuncture needle, a guidewire and a transitional sheath. The transitional sheath consists of an inner 3 Fr sheath and an outer 5 French sheath. The needle is used to puncture the vessel. The wire is threaded through the needle after a successful puncture. The needle is then removed, and the sheath inserted over the guidewire. The inner 3 Fr sheath can accommodate the 0.018 system while the outer 5 Fr sheath is able to accommodate the 0.035 system. The design of the transitional sheath permits upsizing from the 0.018 to 0.035 system when required

21-G needle can accommodate is 0.035 and 0.018 in. respectively. An 18G angiocath is routinely used to obtain access to an arteriovenous fistula or a graft in our institution. A fistulogram or graftogram can also be performed through the 18G angiocath via injection of contrast material. The 18G cannula can be exchanged for a vascular sheath over a 0.035 in. guidewire.

## Sheath

Sheaths are used to secure the puncture site for vascular intervention. They are plastic tubes that are open on one end and capped with a hemostatic valve at the other (Fig. 3.2a). The hemostatic valve prevents bleeding and air embolism during the procedure and allows wires, catheters and other devices to be introduced into the vessel. The valve end usually has a short sidearm that can be used for flushing, contrast material administration and medications.

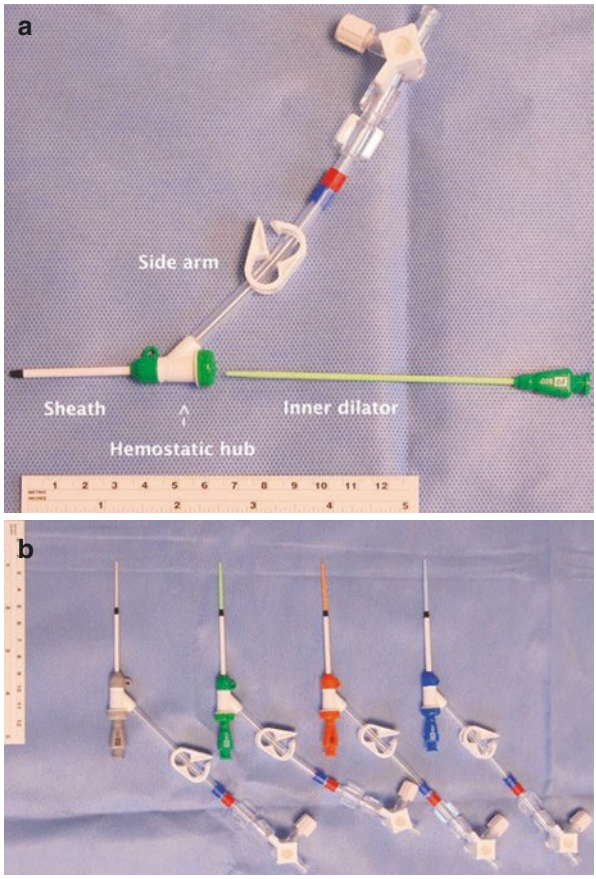


**Fig. 3.2** (**a**) Components of a vascular sheath. (**b**) In general, short sheaths (4 cm) are used for dialysis access interventions. Sheaths are described by their inner diameters. The different sheath sizes are shown here. The 6 F sheath is frequently used as the routine sheath for dialysis access interventions

Sheaths are sized by their inner diameter described using the "French" (Fr) system, which is based on "π". The diameter of the sheath is obtained by dividing the "Fr" by "π" or approximately 3. For example, a 6-Fr sheath is approximately 2 mm by the inner diameter. The outer diameter for a sheath is 1.5–2 Fr larger; hence a 6 Fr (2 mm) sheath will create an 8 Fr (2.5 mm) hole in the vessel wall.

The size of the sheath to be inserted is determined by the diameter of the catheter or angioplasty balloon or device to be used (Fig. 3.2b). The product insert of the catheter or angioplasty balloon or device will specify the size of the sheath that is required.

Sheaths also come in different lengths. For AV access interventions, a short sheath (4 cm) is routinely used. In general, a 4 cm 6 Fr short sheath is often used as the routine sheath for intervention. The sheath can be "up-sized" over a guidewire for a larger sheath if a larger angioplasty balloon or stent deployment is required.

## Dilator

Dilators are used to enlarge the puncture tract to facilitate the placement of sheaths, catheters or devices. Dilatation is done by sequentially passing larger dilators over a guide wire till the tract is adequately sized to accept the intended sheath, catheter or device (Fig. 3.3). Unlike sheaths that are sized by their inner diameter, dilators are sized by their outer diameter. Hence, a 7–8 Fr dilator is needed to enlarge the

**Fig. 3.3** Dilators come in different diameters and lengths. The common feature is the presence of a tapered end

tract for a 6 Fr sheath. In general, sheaths come together with their appropriately sized dilators in a pack and extra dilators are not required unless you are planning to upsize the sheath by 2 Fr or more.

## Catheter

Similar to dilators, catheters are sized by their outer diameter using the Fr system. Again, there is a huge variety of catheters available for diagnosis and intervention. Broadly, catheters can be classified based on their intended use. The material, shape of the catheter tip, end hole diameter, configuration of side holes (location, size and number) of each catheter are designed to fulfill its specific purpose.

## Non Selective or Flush Catheter

A flush catheter is used for diagnostic angiography. It has an end hole and multiple smaller side-holes to allow for uniform dispersion of contrast material during administration. The "pigtail" catheter is a typical flush catheter with a curled tip that is used for aortography.

## Selective Catheter

Selective catheters are used to seek the orifice of vessels and direct guidewire into a specific location. For this reason, they come in many different shapes. They have less or no side holes and generally have end hole design for angiography to perform angiography. The tip of the catheter may be angled like a hockey stick, such as a Kumpe catheter (Cook Medical, Bloomington, Ind) or have complex curvatures such as the "Cobra" catheters (Cook Medical, Bloomington, Ind).

## Guiding Catheters

These are hybrid between diagnostic catheter and sheath. They are typically used in place of sheaths to access vessel of interest and to deliver tools for intervention. They are non-tapered and come in different tip configurations and lengths. Their French size refers to their outer diameter. Some guiding catheters have special hydrophilic coatings to enhance the trackability of the catheter over occluded vessels.

In summary, every catheter has its own unique characteristics and purpose. The best catheter is one that you are familiar with and is versatile enough to meet your expectations and requirements most of the time. A 65 cm long 4F Berenstein catheter or Kumpe catheter is routinely used for AV access intervention in our institution (Fig. 3.4a–d).

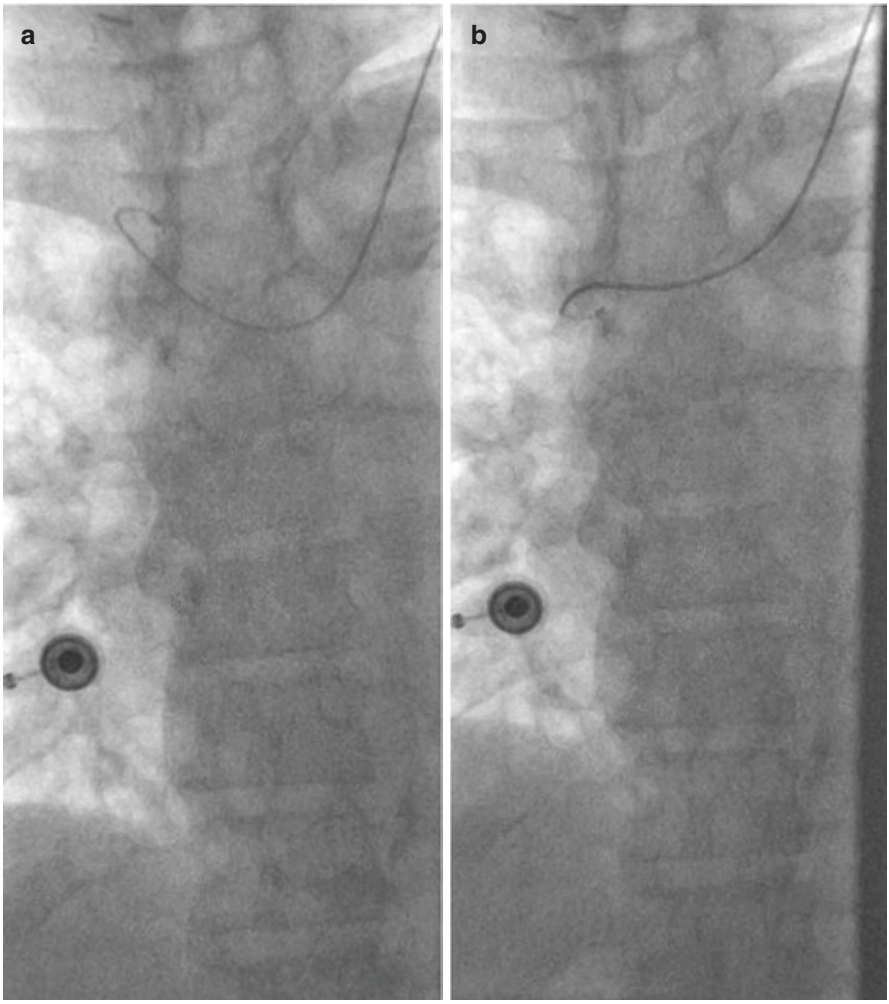


**Fig. 3.4** (**a**) The guidewire repeatedly curled upward while attempting to maneuver it into the inferior vena cava. (**b**) A Kumpe catheter was introduced to "stiffen" the wire and exert more control over its movement. (**c**) The guidewire was navigated towards the IVC with the aid of the Kumpe catheter. (**d**) The guidewire finally passed into the inferior vena cava

## Guidewire

Guidewires come in different thicknesses, lengths, stiffness, coating and tip configurations (Fig. 3.5). The diameters of a guidewire are measured in inches and are available in sizes ranging from 0.008 to 0.038 in.. The common sizes in everyday use are the 0.018 and 0.035 in. wires. Guidewires may have a

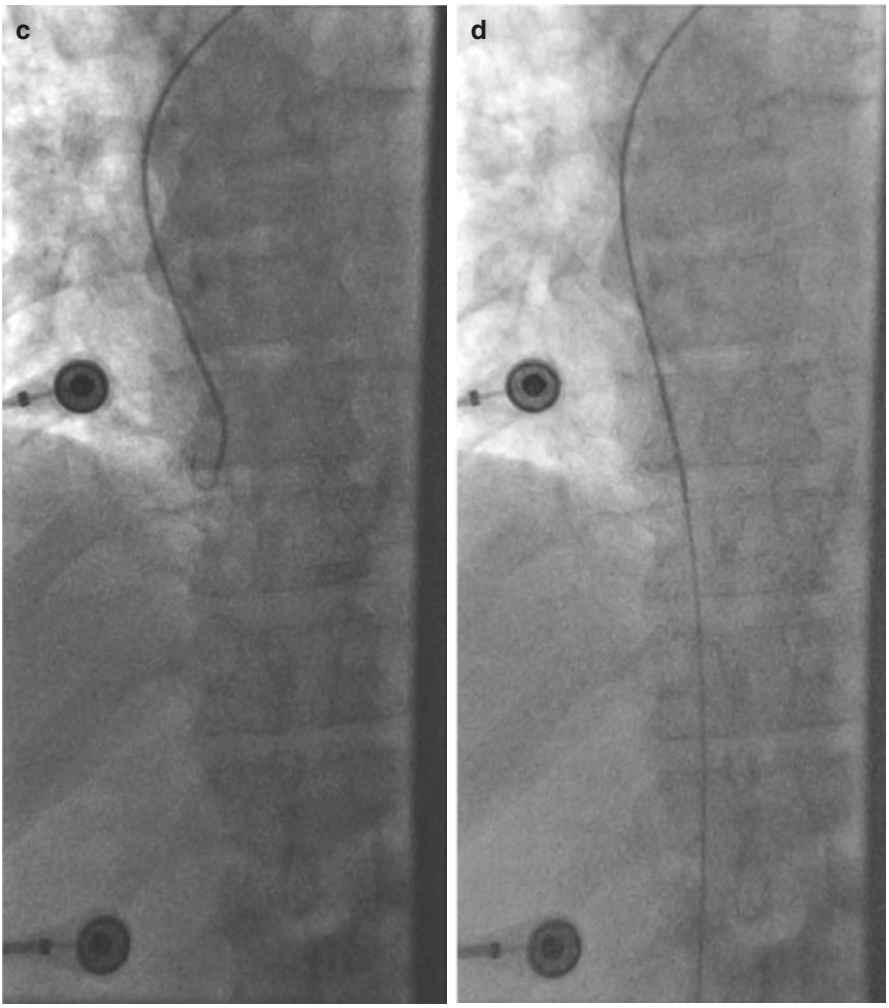


**Fig. 3.4** (continued)

hydrophilic coating to enhance their maneuverability. The hydrophilic or "water seeking" coating enables the wire to be advanced easily within the vessels. Hydrophilic wires with steerable or angled tip designs are especially useful in crossing critically stenotic lesions. However, the hydrophilic coating makes the wire feel slippery and can give an impression of movement when it is stationary. A 180 cm 0.035 in. regular angled tip hydrophilic wire is routinely used for dialysis access intervention in our institution.

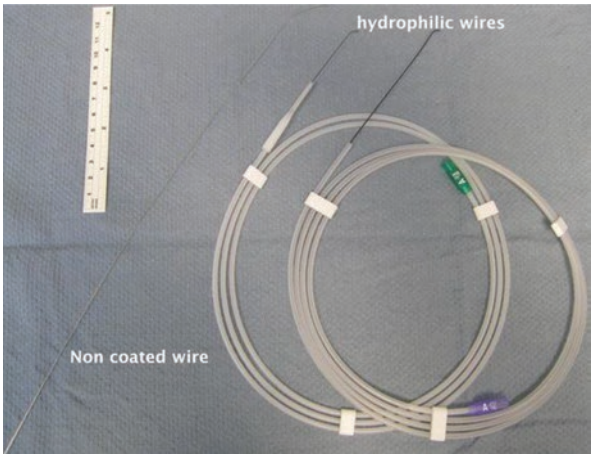


**Fig. 3.5** Guidewires can come in different lengths, tip designs and coating

## Balloon Catheter

There are two basic types of balloons. A non-compliant balloon is used for angioplasty while a compliant balloon (e.g. Fogarty balloon) is used for embolectomy or temporary vascular occlusion. These balloons are mounted on catheters and the shaft of the balloon catheter is described using the Fr system (Fig. 3.6a–g) and the length of the shaft in centimeters.

The size of the balloon, on the other hand, is described by its diameter in millimeters when inflated; followed by its length in centimeters. For example, an "8 by 4" balloon has an 8 mm diameter and a 4 cm length when inflated and may be mounted on a 5 Fr shaft. The balloon is tightly wrapped around the balloon catheter before inflation. After use, the deflated balloon will not return to its original size and can be larger in diameter than the shaft that it is mounted on. As such, an 8 mm balloon that is mounted on a 5 Fr balloon catheter will require a 6 Fr sheath to permit smooth removal of the balloon catheter. The size of the sheath required to permit the passage of the balloon catheter is usually described in the product insert.

A "cutting" or "scoring" balloon is a non-compliant balloon with atherotomes or blades mounted on its surface to "cut" or "score" the stenotic lesion during inflation. It is useful in the treatment of stenotic lesions that are resistant to balloon angioplasty.

The angioplasty balloons that are used for dialysis access intervention are usually non-compliant and can be inflated to "high pressure". It is important to know the nominal pressure and the rated burst pressure of the balloon when performing an angioplasty procedure. These pressures are usually indicated on the product insert of the angioplasty balloon. The nominal pressure is the inflation pressure at which the stated diameter of an angioplasty balloon is achieved. The rated burst pressure (RBP) is the pressure at which 99.9% of balloons can maximally withstand before rupture with 95% confidence. It is advisable not to inflate beyond the rated burst pressure as rupture of the angioplasty balloon can result in embolism of the balloon fragments and retrieval of a ruptured balloon may be difficult.

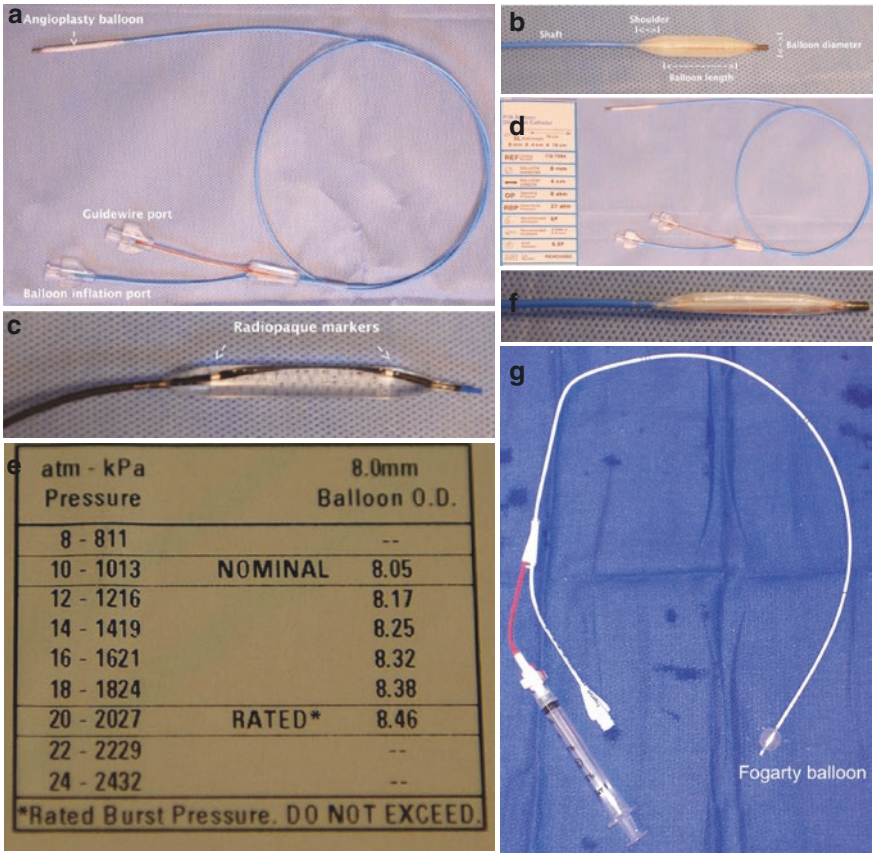


**Fig. 3.6** (**a**) Components of an angioplasty balloon catheter. This is an example of a high pressure, non-compliant balloon. (**b**) The size of an angioplasty balloon is described by its diameter in millimeters when inflated; follow by its length in centimeters. The balloon is mounted on the tip of a catheter. (**c**) Radiopaque markers are present to mark the position of the balloon during fluoroscopy. (**d**) The characteristics of the angioplasty balloon catheters are described in the product insert. Information on the recommended sheath size, guidewire and rated burst pressure of the balloon is indicated. (**e**) The nominal pressure and rated burst pressure are usually indicated in the product insert. The nominal pressure is the inflation pressure at which the stated diameter of an angioplasty balloon is achieved. The rated burst pressure (RBP) is the pressure at which 99.9% of balloons can maximally withstand before rupture with 95% confidence. (**f**) The deflated angioplasty balloon will not return to its pre-inflated size after being used and is bigger than the diameter of the balloon catheter that it is mounted on. Therefore, even though it is mounted on a 5 Fr balloon catheter, a 6 F sheath is required to permit smooth removal of the entire balloon catheter after use. (**g**) The Fogarty balloon (Edwards Lifesciences, Irvine, CA) is an example of a low pressure, compliant balloon

The angioplasty balloon can be inflated either using an inflation device or a syringe assembly. The inflation device looks like a huge syringe with an attached manometer. It has a locking mechanism to maintain pressure and allow inflation of an angioplasty balloon to a precise pressure. These devices are designed for one-time use and may be costly. An alternative is to manually inflate the balloon using a syringe assembly consisting of a 3 and 10 mL syringe connected via a 3-way stopcock. The balloon is first inflated using the 10 mL syringe. The 3-way stopcock is then turned and pressure is maintained using the 3 mL syringe. The pressure should be maintained for approximately 3 min to ensure adequate dilatation and effacement of the stenosis.

## Stents

Stents are broadly classified into balloon-expandable or self-expanding balloon stents. Balloon expandable stents require balloon dilatation to increase their diameter from the compressed state. They have greater radial strength and can be over dilated but they will not return to their deployed shape when crushed or compressed; hence they are less suitable to be used in peripheral vessels in the limbs. However, they are preferred when accurate positioning of the stent is of paramount importance. One such example is during the treatment of subclavian artery ostial stenosis, where the stent has to be positioned accurately across the stenosis with minimal protrusion of the stent into the aortic lumen. Self-expanding stents will conform to the vessel wall and expand to its designed diameter. They have greater flexibility and will return to the original shape after bending or compression.

The flexibility and strength of a stent are dependent on the construction material, design and configuration of its "cells". A stent is made up of multiple cells that are connected by struts. A closed-cell design is one where struts support every cell. In comparison, in a stent with open-cell design, some cells are not in contact with any struts at all. By varying the cell designs and number of struts, the flexibility and radial strength of a stent can be altered.

Stents can be constructed with stainless steel or alloys such as Nitinol and Elgiloy (Fig. 3.7a). Nitinol exhibits shape memory, allowing it to regain its shape after compression. Stents that are constructed using Nitinol provide better long-term patency compared with stainless steel stents in the treatment of hemodialysis graft related stenosis [1].

Stents may also be "bare" or "covered" with relatively inert polymeric covering such as expanded polytetrafluoroethylene (PTFE) (Fig. 3.7b). The intention of the covering is to decrease the high restenosis rates associated with bare-metal stents that are caused by neointimal hyperplasia. The covering is postulated to work by providing a barrier to prevent the migration of smooth muscle cells and separate the thrombogenic wall surfaces from the luminal blood flow. The characteristics of the four types of self-expanding covered stents that are available in the United States are summarized in Table 3.1 [2]. Covera and viabahn stents are approved by the FDA for the treatment of venous anastomotic stenosis in arteriovenous grafts.

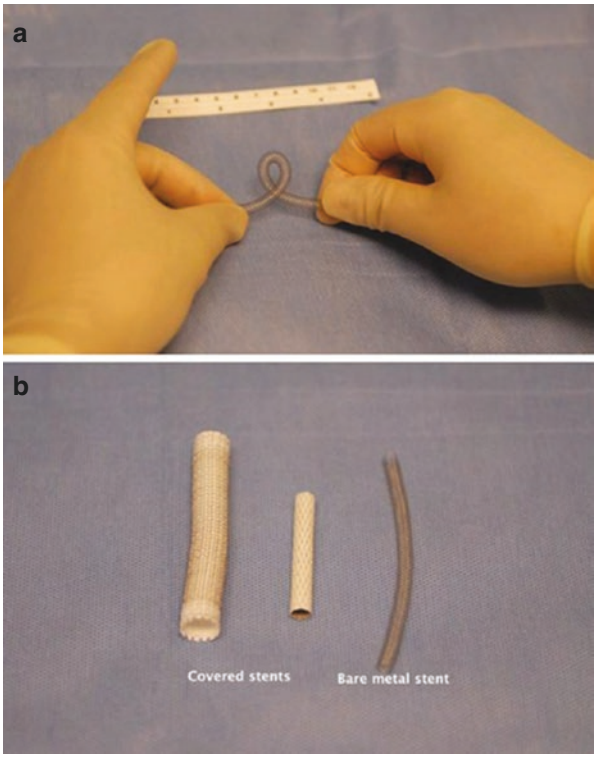


**Fig. 3.7** (**a**) Bare nitinol stents exhibit great flexibility and return to their original shape after compression. (**b**) Different types of stents

**Table 3.1** Types of stents used in dialysis vascular access intervention

| Name of stents | Wallgraft | Viabahn | Fluency plus | Covera |
|---|---|---|---|---|
| Stent material | Elgiloy | Nitinol | Nitinol | Nitinol |
| Covering | Polyethylene terephthalate | Expanded PTFE | Expanded PTFE | Expanded PTFE |
| Characteristics | Relatively rigid with poor contourability | Very flexible | Stiffer than Viabahn | Very flexible, available in a straight or flared configuration |

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# Basic Endovascular Skills and Techniques

4

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## Introduction

Performing interventional procedures requires a different skillset not traditionally associated with nephrology training. It involves developing cognitive skills and understanding indications for different interventional procedures, their limitations and potential complications, mastering fluoroscopic eye-hand coordination, understanding the behaviors and properties of various guidewires and catheters and acquiring fine motor skills in manipulating these devices. These skills are essential to perform interventional procedures safely and effectively. Competencies can be achieved with the right attitude and adequate hands-on procedural and clinical training.

## Preparation for Intervention

1. History and physical examination aid in determining the site of lesions and treatment planning. Always examine the patient, understand the indications for intervention and review the ultrasound images and images from any previous

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