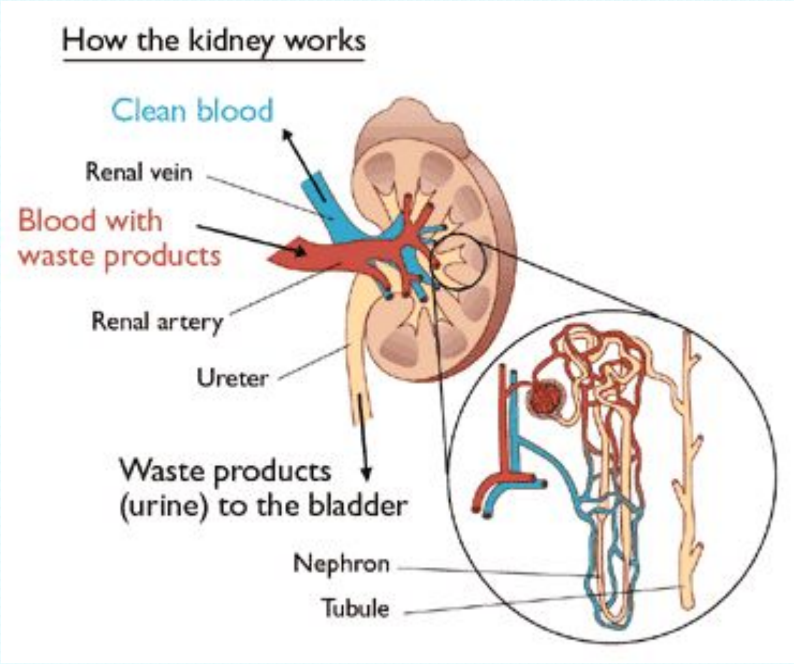
HEMODIALYSIS ACCESS ULTRASOUND

Lets review some basic facts about the normal kidney function, end stage renal disease(ESRD) and the role of dialysis you need to know before performing ultrasound on the very complex but essential dialysis access.

Kidney function - End stage renal disease (ESRD)

- Kidneys remove wastes, salts & fluid from the blood
- When the kidneys fail, they can no longer do this
- Dialysis takes over as an artificial kidney to keep the blood clean

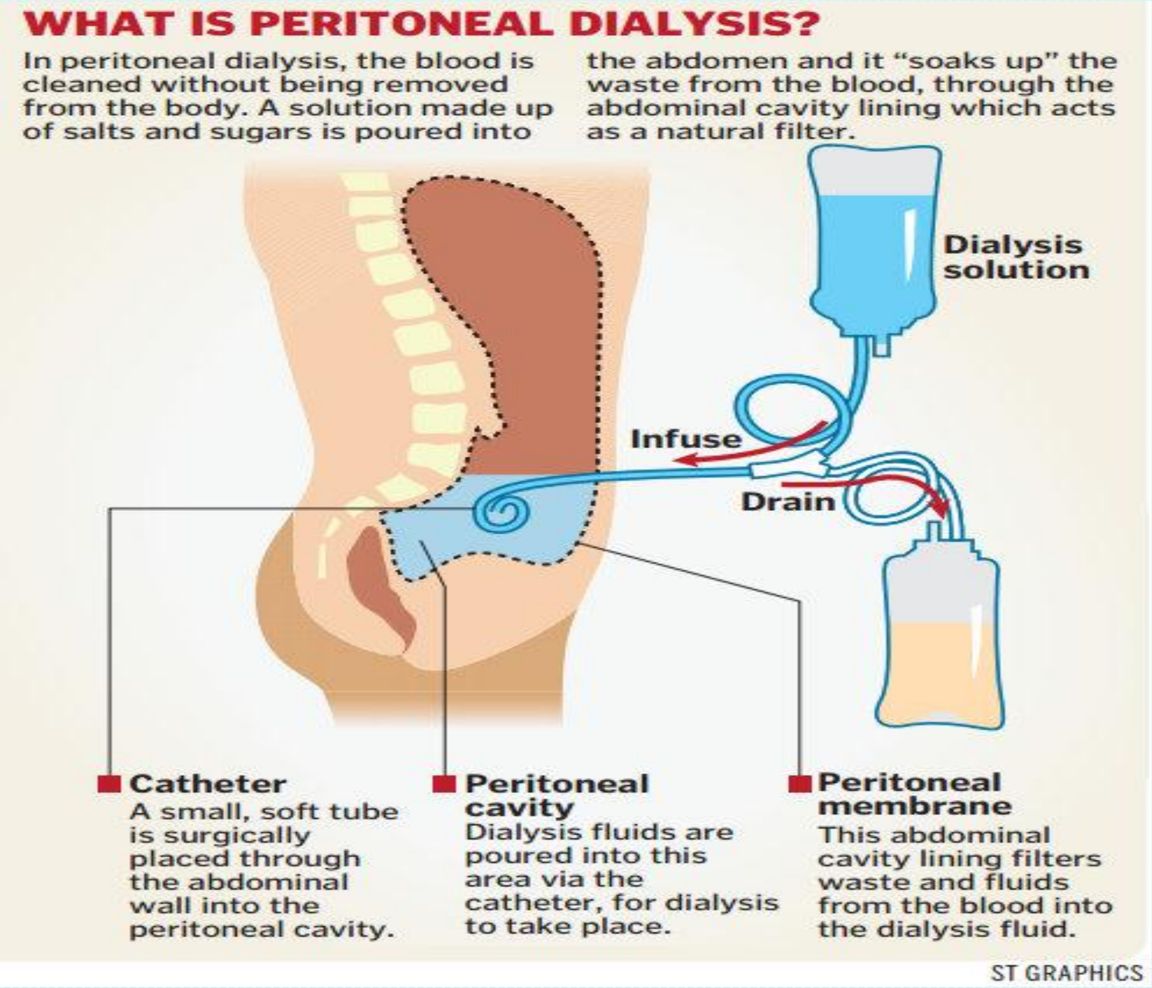
Dialysis is the “life-line” for patients with end stage renal disease.



Treatment options for ESRD

- Peritoneal dialysis
- Hemodialysis
- Kidney Transplant

PERITONEAL DIALYSIS



HEMODIALYSIS

The principle of hemodialysis is simple: remove blood from the patient's circulation, filter it in the dialysis machine and then return the dialyzed blood to the patient's circulation

Access options include:

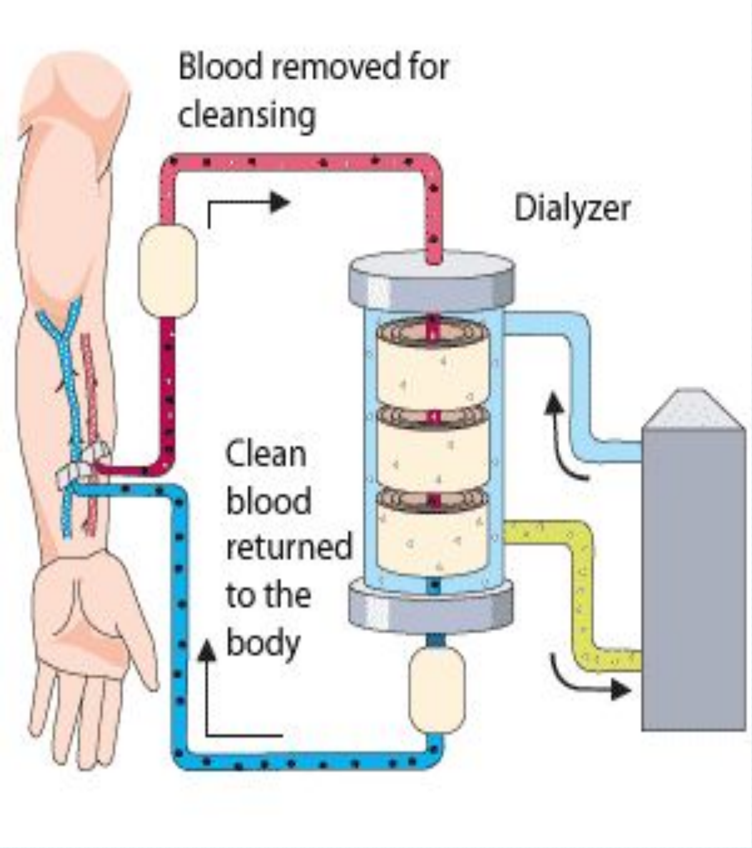
- Non-Tunneled Catheters
- Tunneled Catheters
- AV Fistula
- AV Graft

Hemodialysis-How it works

- During hemodialysis, two needles are inserted into the arm through the access or into a dialysis catheter and taped in place to remain secure.

- Each needle is attached to a flexible plastic tube that connects to a dialyzer. Through one tube, the dialyzer filters the blood a few ounces at a time, allowing wastes and extra fluids to pass from the blood into a cleansing fluid called dialysate.

- The filtered blood returns to your body through the second tube.



Central Venous Catheter

- DEFINITION:

A central venous access catheter is a long, slender, small flexible tube that is inserted beneath the skin so there is a simple, pain-free way to draw blood, or to give medication or nutrients. The catheter tip terminates in the superior venacava to obtain IV access.

Indications for Central Venous Catheter

Bridge for angio-access device is used:

- While the patient is awaiting living-related kidney donor transplantation
- Until maturation of an autologous fistula or graft

OR

As a permanent vascular access for patients with unsuitable vascular anatomy who have exhausted all other options

OR

If significant risks are present in situations of high output cardiac failure, myocardial ischemic events and steal syndrome.

Types of Central Venous Catheters

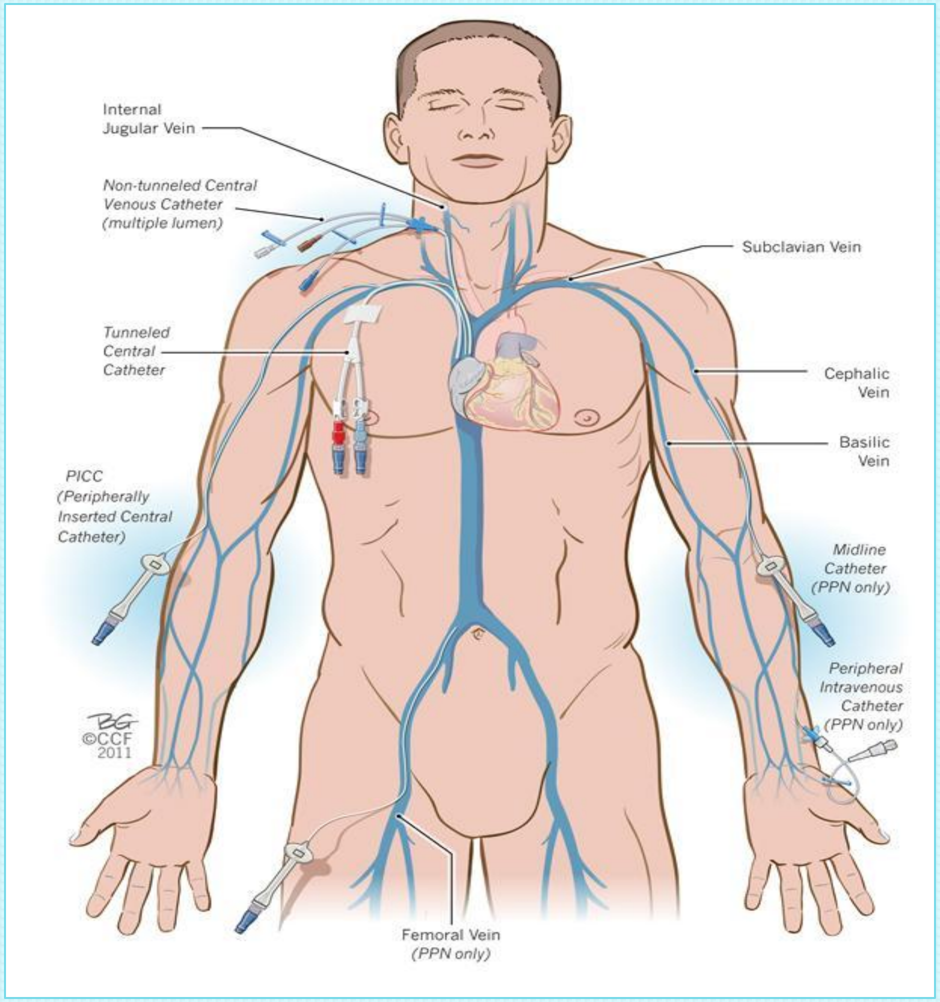
- **PICC line** is a peripherally inserted central catheter. It is similar to other central lines as it terminates into a large vessel near the heart. However, unlike other central lines, its point of entry is from the periphery of the body the extremities. And typically the upper arm is the area of choice, usually the basilic vein.
- **Non-tunneled central catheters** - Non-tunneled catheters are fixed in place at the site of insertion, with the catheter and attachments protruding directly. Commonly used non-tunneled catheters include Quinton catheters.
- **Tunneled small bore-catheters** - Tunneled catheters are passed under the skin from the insertion site to a separate exit site, where the catheter and its attachments emerge from underneath the skin. The exit site is typically located in the chest, making the access ports less visible than if they were to directly protrude from the neck. Hohn, Hickman, Broviac & Groshong are commonly used.
- **Tunneled dual-lumen catheters:** are placed in patients requiring stem cell transplant or for other indications that require larger flow volumes than can be provided by a small-bore catheter.
- **Tunneled dialysis catheters**: are placed in patients who require hemodialysis but do not have a functioning fistula or graft. These catheters are specially designed for rapid flow of blood to and from the dialysis machine. These are most frequently placed in the veins of the neck, although other sites can be used if necessary.
- **Implanted ports:** The port is surgically placed in a subcutaneous pocket in the patient's trunk. The surgeon threads the catheter into the central vascular system and positions the tip in the superior vena cava.

Disadvantages of tunneled catheters

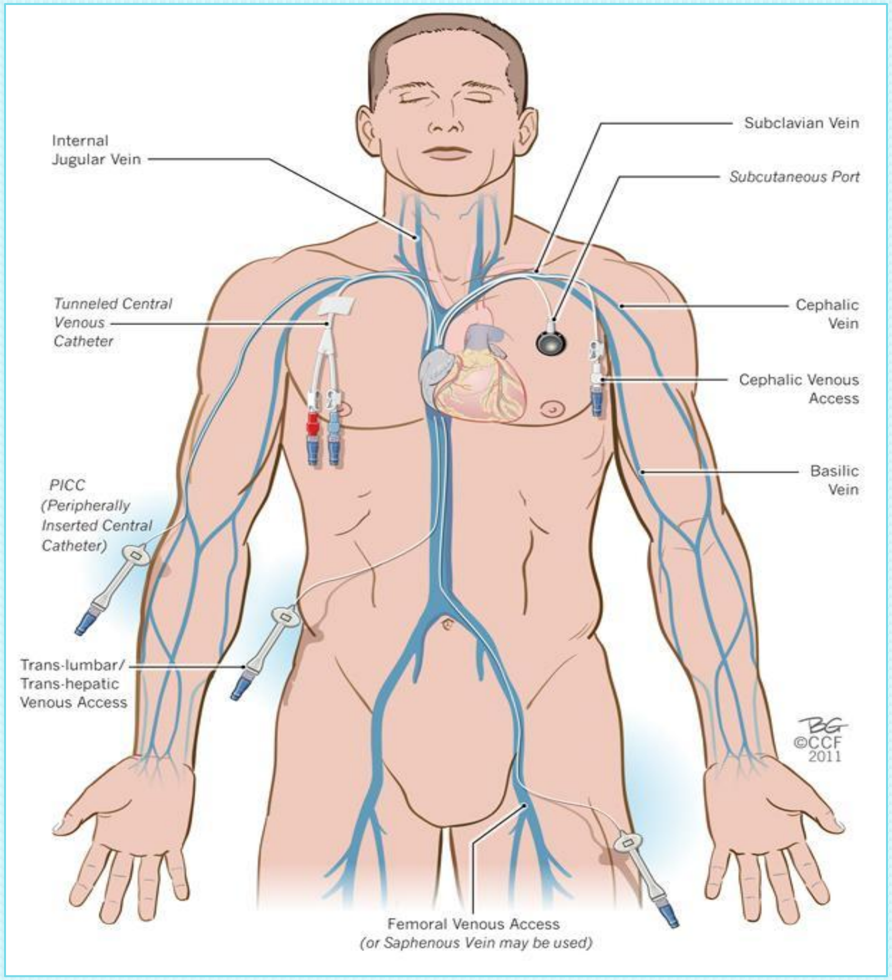
- Increased risk of luminal thrombosis & infection
- Unreliable blood flows
- Central venous stenosis
- Shorter use life
- Patient cosmetic concern

The development of a subcutaneous port, that is durable, offers a high blood flow and is fully implantable subcutaneously, may become an alternative for chronic use.

TEMPORARY IN HOSPITAL VENOUS ACCESS



LONG TERM AT HOME VENOUS ACCESS



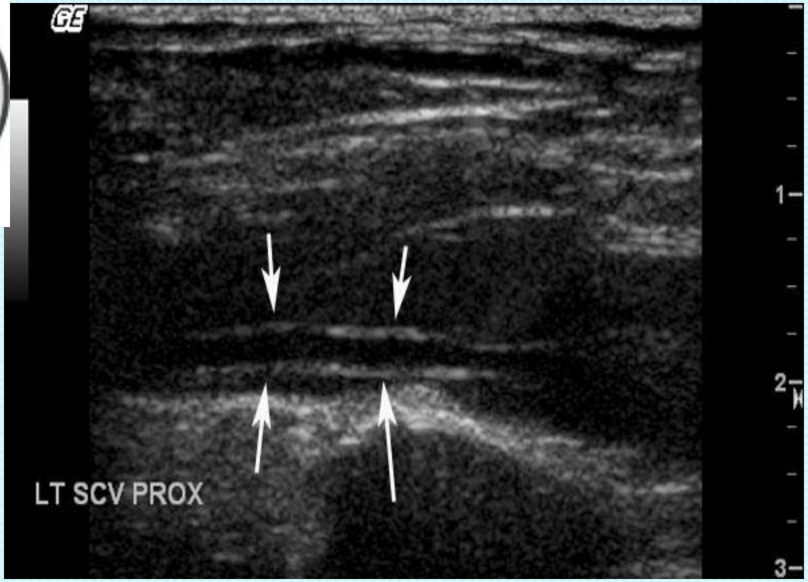
Fibrin sheath – complication of venous catheters

The formation of fibrin sheaths is considered the main culprit in the occlusion of central venous catheters.

The fibrin sheath formation starts as early as 24 hours after insertion of the catheter, with encasement of its entire length within 5 to 7 days.

The sheath begins as a thrombus containing some fibrin in the first few days and transforms to a cellular-collagen tissue after 1 week.

Upon catheter removal, the sheath tends to remain in the vein instead of attaching to the catheter.



Treatment

- Thrombolytic infusion
- Line stripping
- Catheter exchange
- Line replacement

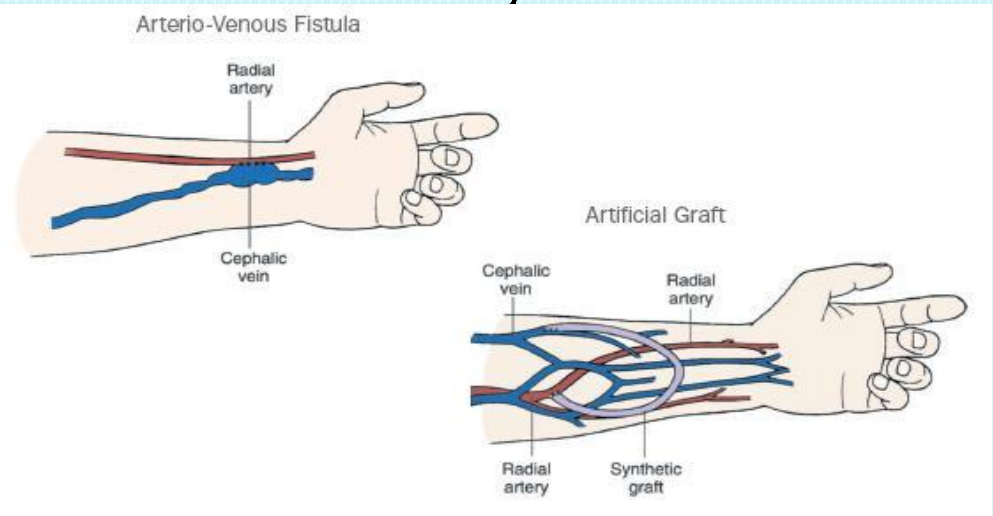
Echogenic signals in the vein of a patient who has recently had a catheter removed may represent a fibrin sheath. This is a sheath that forms around the catheter as it sits in the vein.

Arteriovenous fistula / graft

Hemodialysis access are surgically created communications between the native artery & vein in an extremity.

<u>TYPES:</u>

- AVFs - **<u>arteriovenous fistulas</u>** are direct communications between native arteries & veins.
- AVGs - **<u>prosthethic hemodialysis access arteriovenous grafts</u>** Polytetrafluoroethylene (PTFE) and other materials (Dacron, polyrurethane, bovine vessels, saphenous veins) are used as a communication between the artery & vein.



Arteriovenous fistulae

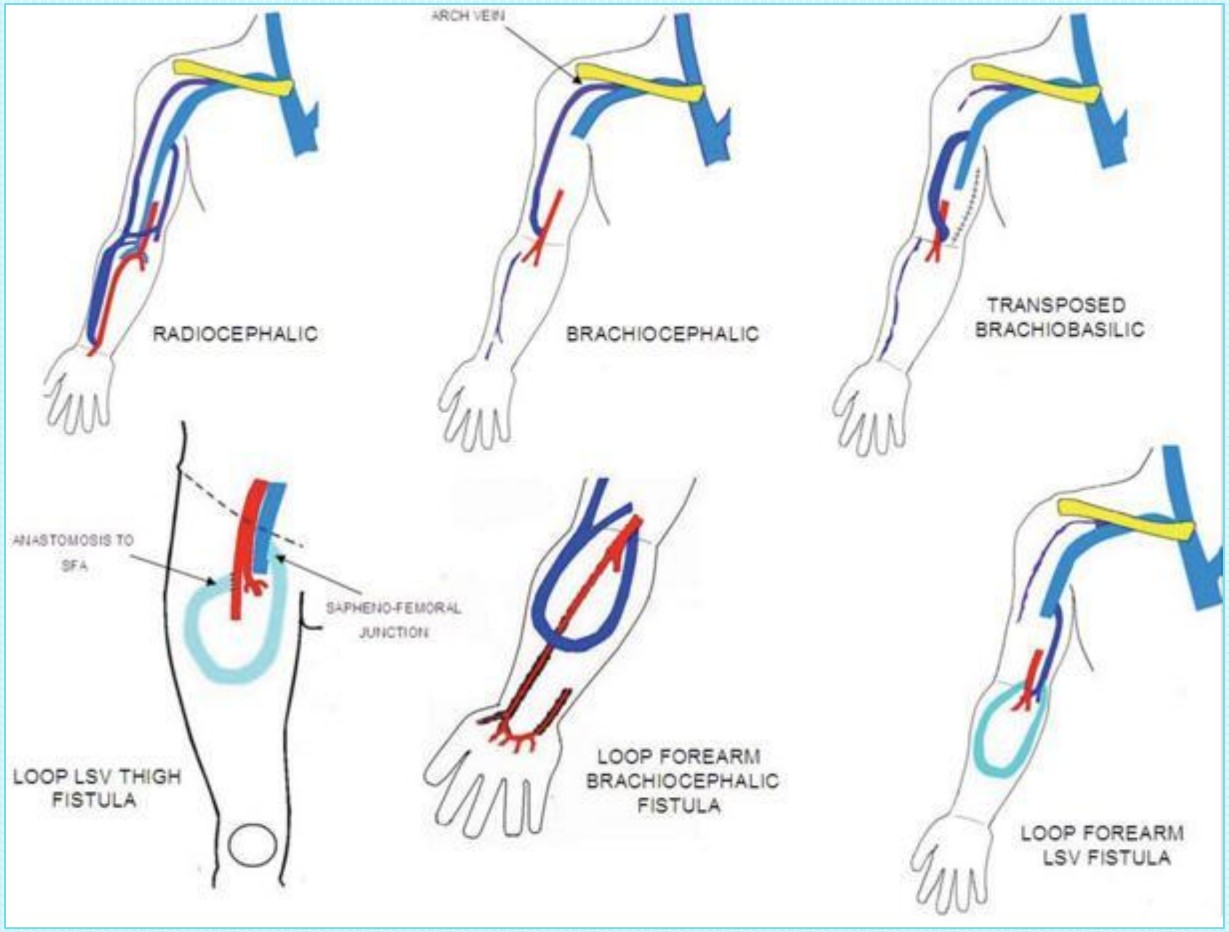
The most common native fistula is the radio-cephalic aka Brescio-Cimino Shunt.

- The majority of stenosis in the radio-cephalic fistula are found at the anastomosis followed by stenosis in the venous outflow with average PSV of 200 cm/sec in the patent fistula and PSV of >350 cm/sec in flow reducing lesions.

- Located at the wrist, these are the preferred site to preserve central vasculature for future access sites. Stenosis can occur at the juncture of principal run-off vessels, i.e. juncture of cephalic and subclavian veins in brachio-cephalic native fistulas.

- In contrast to grafts, thrombotic occlusions of AVFs often occur early because of inadequate flow resulting from small lumen of vessels or failure to dilate. For early diagnosis of access thrombosis, mainly postoperatively, indirect CDU parameters such as a triphasic Doppler waveform and low flow values at the access feeding artery give a rapid answer.

TYPES OF ARTERIOVENOUS FISTULA (AVF)



Straight and loop grafts

- In contrast to the Brescio-Cimino fistulae, peak systolic velocities of <150 cm/sec are common in non-stenotic graft segments of both straight and loop interposition graft.
- With both the straight and loop grafts, stenosis are most often found at the venous anastomosis with outflow lesions following in frequency. Gore-Tex grafts may become infected.
- With a loop graft (U shape), to differentiate between the arterial and venous sides of the access graft, gently compress the graft in the middle of the loop and check each side of the loop for an arterial pulsation. There will be pulsation on one side only and thus identify the arterial side, (inflow). There will be pulsation on one side only and thus identify the arterial side, (inflow). There would not be any pulsation palpated during compression on the venous side
- In PTFE grafts, thrombosis is primarily the result of progressive venous outflow stenosis.

Common AV graft locations:

- Straight forearm (brachial artery to cephalic vein)
- Straight upper arm (brachial artery to axillary vein)
- Looped upper arm (axillary artery to axillary vein).
- Looped forearm (brachial artery to cephalic vein)
- Leg grafts, looped chest grafts, axillary-axillary (necklace), and axillary-atrial grafts are unusual sites.

Thrills- AV access will typically have a thrill or vibration due to turbulent flow within the graft or vein.

Changes in the thrill may indicate a problem with the graft:

- A weak thrill can denote poor arterial inflow or arterial stenosis.
- Feeling a pulse rather than a thrill may signify high-grade stenosis at the outflow of an AVF or at the venous anastomosis of an AVG.
- Furthermore, significant increase in venous pressure during dialysis can indicate a stenosis at the venous anastomosis or outflow vein.

KNOW YOUR PATIENT!!

Review the patient's chart & obtain history from the patient:

- Type & location of <u>current</u> access
- Revision of current access
- Current or past DVT

<u>Indication/History/Symptoms:</u>

- Loss of thrill or decrease in strength of thrill
- Is it currently being used?
- Presence of venous hypertension or edema
- Difficult canulation by dialysis center
- Elevated recirculation time/venous pressure
- Aspiration of clot during dialysis
- Prominent pulsatility or aneurysmal dilatation

Long-term maintenance is required

- Maintaining continued patency of the dialysis access is an essential part of long-term treatment of these patients and has proven to decrease the mortality & morbidity of patients with chronic renal failure.

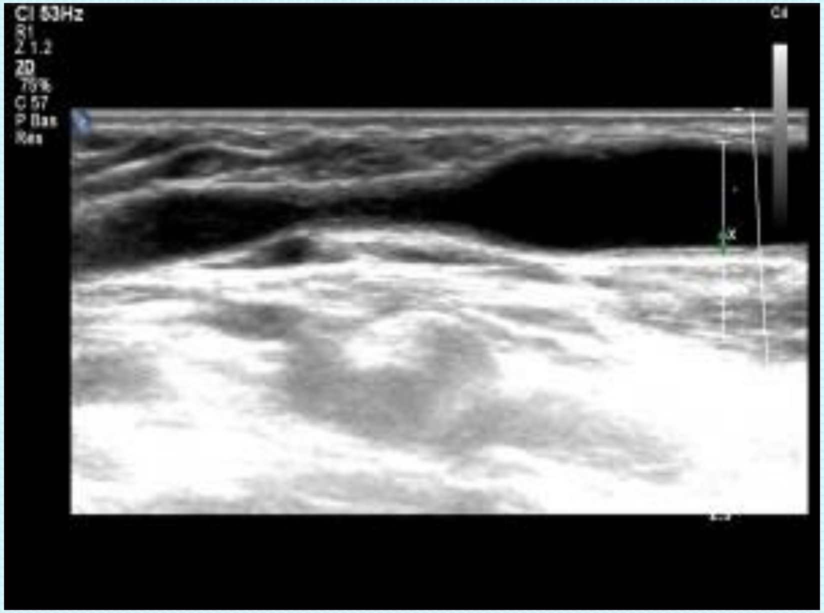
- Less than 15% dialysis shunts remain patent & can function without problems during the period of a patients dependence for dialysis.

- Eventually, stenosis of the graft, venous anastomosis or venous outflow will occur. After multiple interventions to treat underlying stenosis & thrombosis, the long-term secondary patent rates for native fistulas are reportedly 7 years for fistulas in the forearm & 3-5 years in the upper arm. Prosthetic grafts remain patent for up to 2 years.

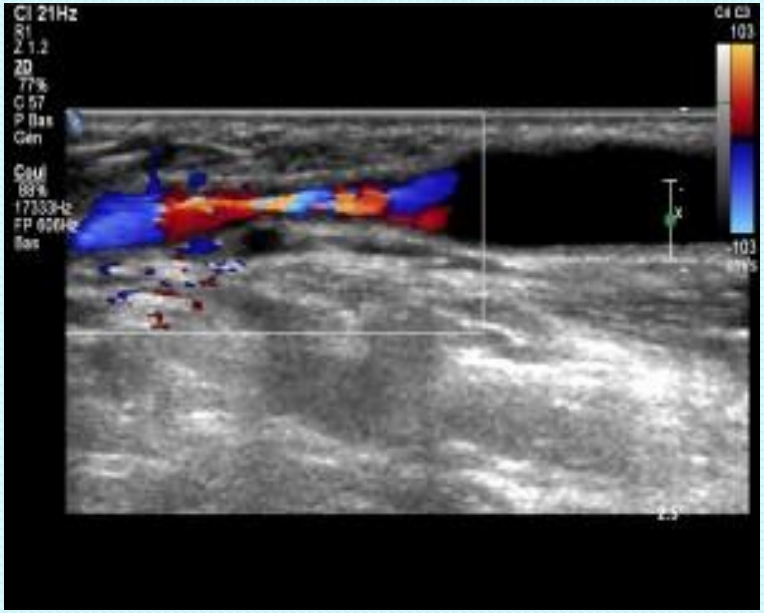
  Utilizing clinical monitoring and ultrasound can prolong the life of the access.

This stenosis may result in thrombosis, at the graft-vein anastomosis or in downstream or proximal vein.

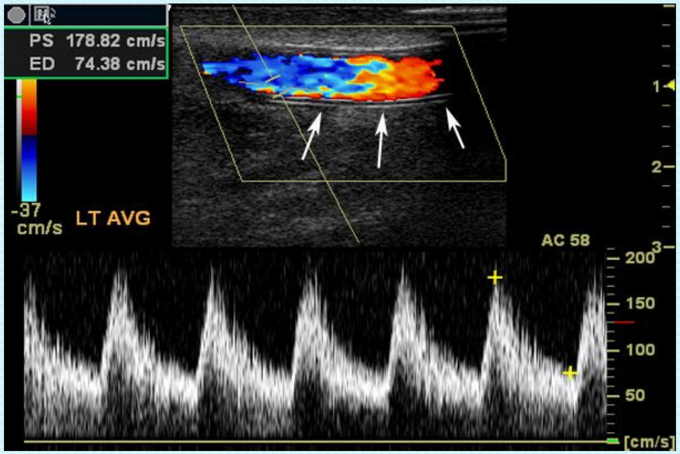
Neointimal hyperplasia



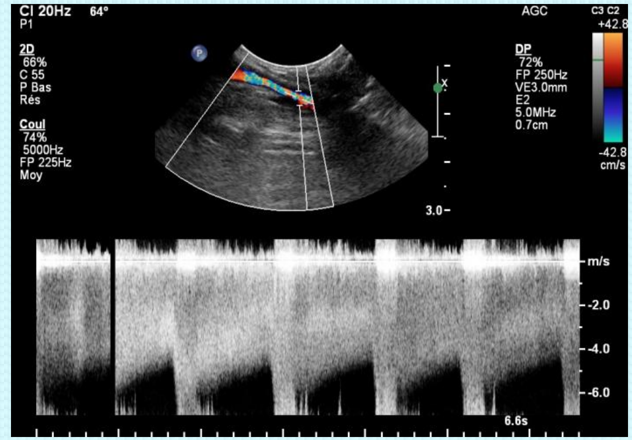
Color flow aliasing



Patent dialysis access



Narrowing of dialysis access w/increased velocities



Turbulence & velocity shift at confluence of subclavian & innominate veins indicate presence of outflow stenosis

Dialysis Fistula & Graft Criteria

<u>Normal flow characteristics:</u>

- Normal flow in a dialysis access graft is disorganized with PSV remaining fairly consistent throughout the graft.
- Inflow artery has low resistance flow with spectral broadening & PSV 100-250cm/s.
- AV access will typically have a thrill or vibration due to turbulent flow within the graft or vein.

<u>Mature fistula ultrasound findings:</u>

- Diameter ≥4mm
- Depth of no more than 5 mm from surface of the skin.

<u>Suggested findings and values to help determine if access if failing:</u>

- Loss of thrill replaced with prominent pulsatility
- Luminal diameter reduction >50% with the luminal diameter ≤2-3mm
- Peak systolic flow velocity >400 cm/s
- End diastolic velocity >250 cm/s
- PSV ratio >3
- Mid fistulae velocity of <150 cm/s (Note, velocities <150 cm/s may be normal in synthetic straight and loop interposition grafts.)
- High resistant inflow artery Doppler waveform may indicate an outflow venous stenosis.
- Inflow artery or outflow vein focal velocity increase with a doubling in the PSV.

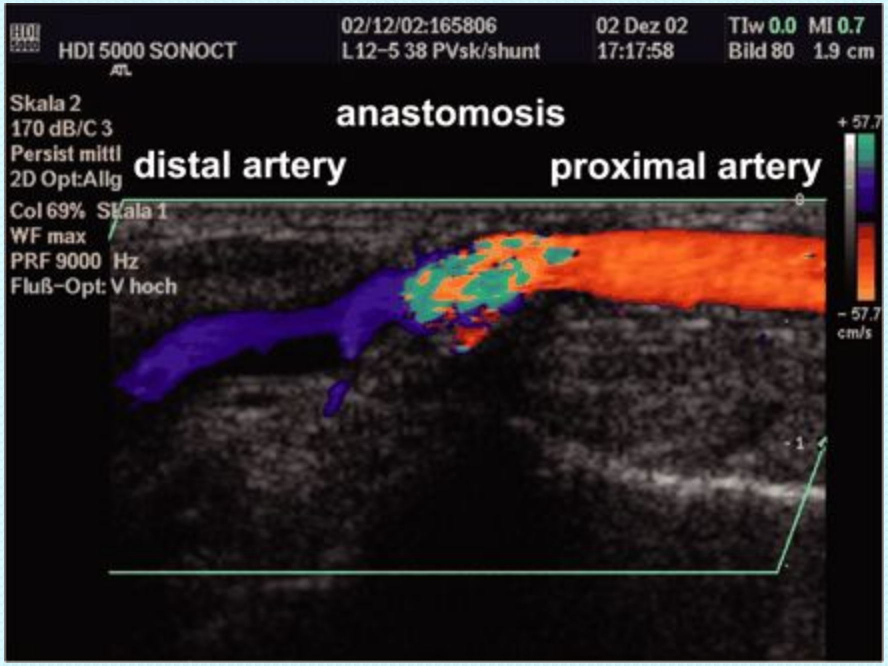
Steal phenomenon

Retrograde flow in the outflow radial artery of the mature fistula is present in 75-90% of patients, i.e. from the wrist to the fistula vein, effectively “stealing” blood from the ulnar artery via the palmer arch and can jeopardize adequate perfusion of the hand.

Usually, the steal phenomenon is clinically silent and the patient remains asymptomatic.

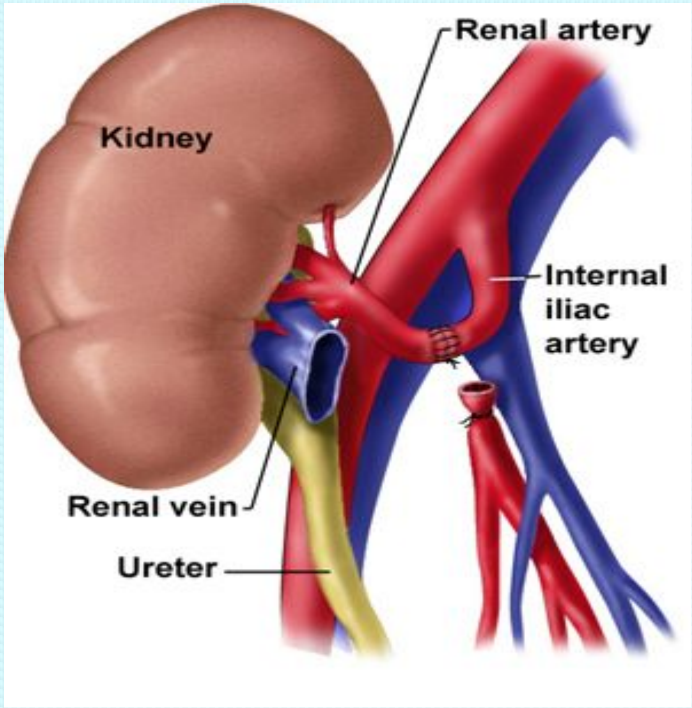
Steal syndrome is converted from a steal phenomenon when compensatory mechanisms to maintain peripheral arterial perfusion fails.

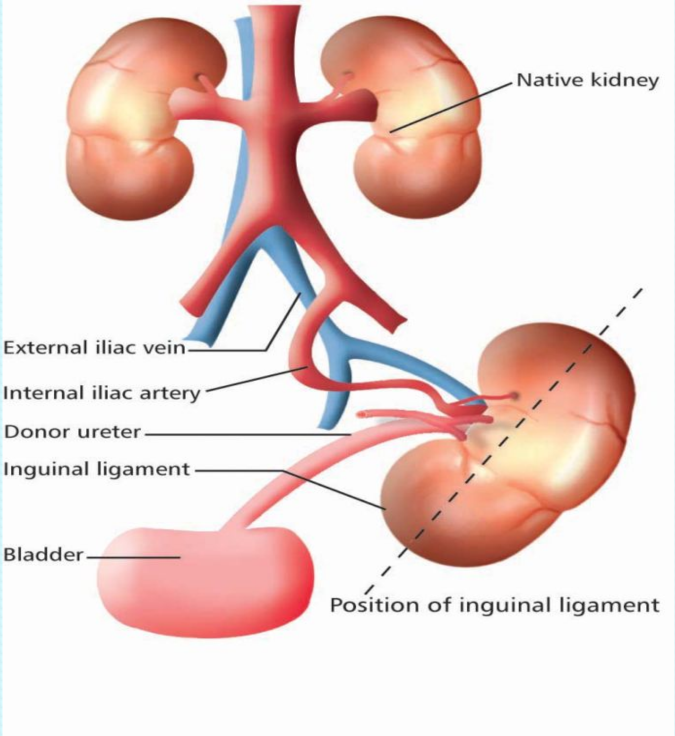
A steal may be diagnosed if PVR waveforms and/or digit pressures augment significantly during graft/fistula compression.



Retrograde inflow of blood into the access during diastole

RENAL TRANSPLANT





KNOWING THE TYPE OF KIDNEY DONOR IS HELPFUL:

- A kidney from a living donor will have an end to end or end to side anastomosis as the renal artery from the donor will be used
- A kidney from a cadaver will have part of the donor aorta for the renal artery so the main renal artery will be larger than normal.

WHERE DOES THE ANASTOMOSIS OCCUR:

- The arterial anastomosis for an end-to-side anastomosis is to the <u>external iliac artery.</u>
- The end-to-end anastomosis is to the <u>internal iliac artery.</u>

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