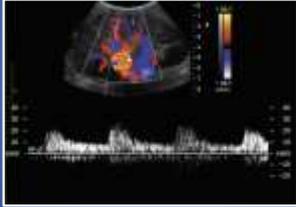


Renal transplant Doppler: vascular complications of renal transplants



Rosalie Vis BS, RDMS, RVT

Introduction

- Indications for renal transplant Doppler
- Surgical techniques
- Renal Transplant Protocol – AIUM
- Intrarenal Doppler waveforms
 - Normal & Abnormal Findings
- Extrarenal Doppler waveforms
 - Normal & Abnormal findings
- Post biopsy vascular complications

Indications for Renal Tx Doppler:

- Baseline after transplantation
- Decreased urine output
- Evaluate vascular patency
- BUN or creatinine: significant/rapid increase
- Hypertension (RAS) or bruit (AVF)
- Pain, fever, sepsis (pyelonephritis)
- Possible fluid collection
- Hematuria (post biopsy AVF, hydronephrosis)
- Follow-up of abnormal findings seen on prior

Surgical Techniques:

Deceased Donor:

- A portion of the donor aorta & IVC are left attached to the MRA and MRV
- Called a Carrel patch



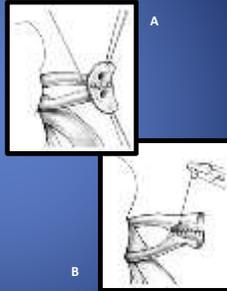
Live Donor:

- Donor MRA and MRV are attached **directly** to the recipient artery and vein.
- End-to-end or an end-to-side anastomosis



Variant anatomy: two renal arteries

- A. If from a **deceased donor**: Carrel patch
See two anastomoses with the recipient artery
- B. If from a **live donor**:
The individual arteries can be joined such that there is essentially a single donor vessel at the anastomosis with recipient artery



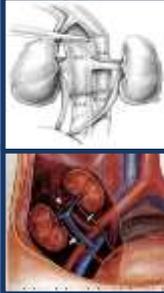
Donor Kidney- Multiple arteries



It is helpful to read the surgical report prior to scanning a transplant.

En Bloc Renal Transplant:

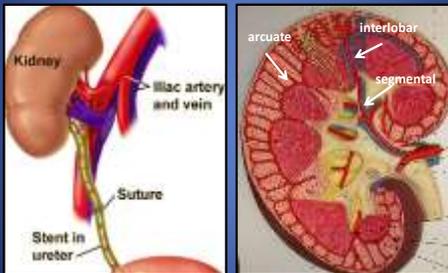
- En bloc = together at the same time.
- Kidneys obtained from donors <5 years of age
- Involves transplantation of both donor kidneys into a single recipient and using the donor aorta and vena cava for vascular anastomosis.
- The donor aorta functions as the main renal artery.
- The donor IVC functions as the main renal vein.
- Full evaluation on both kidneys



Renal Transplant Protocol - AIUM

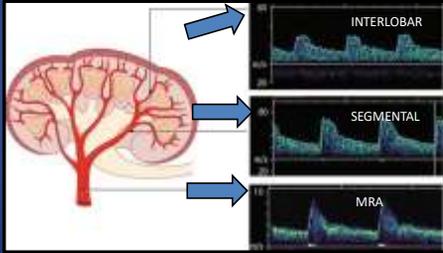
- **Intrarenal arteries (RI):**
 - (PW) interlobar- sup, mid, inf
 - (PW) segmental- sup, mid, inf
 - color/power Doppler of parenchyma for a global assessment of perfusion
- **Intrarenal veins:** multiple
 - color and/or spectral
- **Main Renal Artery (PSV):**
 - Evaluate the entire length
 - Especially at areas with focal aliasing and anastomosis
 - Multiple angle corrected velocity measurements
- **More than one MRA?**
 - Complete evaluation on each
- **Main renal vein:**
 - entire vein + anastomosis
 - color and spectral
- **External Iliac Artery/CIA:**
 - cephalad to anastomosis
 - Color and spectral
- **External Iliac Vein/CIV:**
 - cephalad to anastomosis
 - color and spectral
- **Complete grayscale evaluation**
 - Transplant, perirenal area
 - Bladder and color of jet

Vascular Anatomy



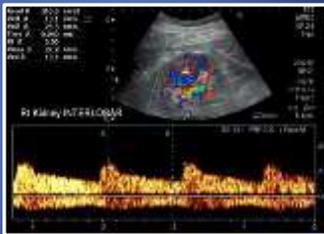
Normal Waveform Examples

Adjust the color and spectral Doppler scale throughout exam.



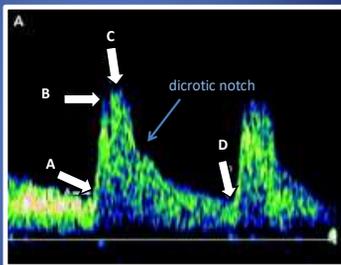
Normal Intrarenal Doppler Waveform:

- Sharp early systolic peak
- Short acceleration time (<70 msec)
- Forward flow throughout diastole
- Low RI (<0.7)

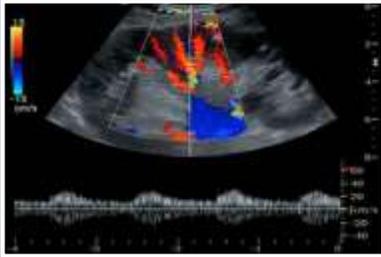


Anatomy of a Spectral Doppler Waveform:

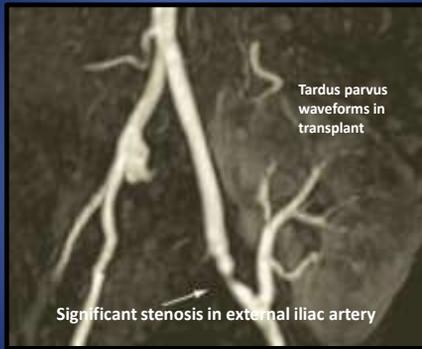
- A. Point A indicates the beginning of systole
- B. Point B, early systolic peak
- C. Point C, peak systole
- D. Point D, end of diastole.



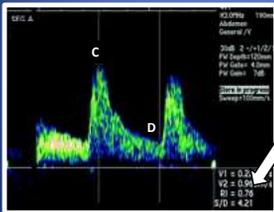
Tardus Parvus Waveform:



Intrarenal tardus parvus waveforms can add specificity to the diagnosis when a MRA stenosis is identified.



Measuring Resistive Index



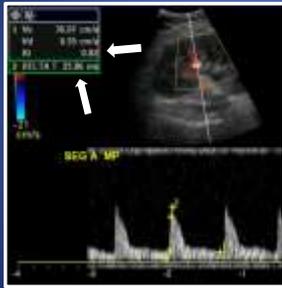
Indicator of renal dysfunction and downstream resistance

Caliper Placement:
Point C - Peak Systole
Point D - End Diastole

Low resistive index is normal (<.7)

Elevated resistive index (>.75)

Elevated Resistive Indices:



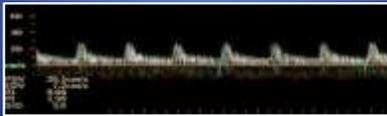
- Normal acceleration time (< 70 msec)
- Elevated Resistive Index (RI) (> .75)

Pulsatility Index/Tissue Pulsatility Index

Pulsatility Index is also an indicator of downstream renal resistance.

$$PI = \frac{PSV - EDV}{MeanV}$$

Normal values: 1.36–1.56



Increased Resistive Indices (or PI):

- Increased RI is an indicator of:
 - Acute/Chronic transplant rejection
 - ATN (acute tubular necrosis)
-
- Renal vein thrombosis (a specific waveform)
 - Graft infection
 - Compressive perinephric fluid collections
 - Obstructive hydronephrosis.

Acute Rejection:

Develops within 1 to 3 weeks after transplantation

Symptoms:

- o Flu-like symptoms
- o Low-grade fever
- o Graft site tenderness
- o Asymptomatic
- o Rapid rise of creatinine (frequent blood draws)

Ultrasound Findings:

- o Swelling of the graft
- o Decreased parenchymal blood flow (arcuate, interlobar)
- o Elevated Resistive Index / Pulsatility Index

Treatable if caught early – adjust immunosuppression

Requires biopsy to confirm (differential diagnosis = ATN)

Chronic Rejection:

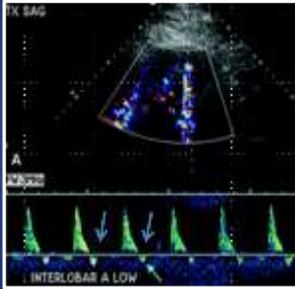
- A progressive decline in renal function beginning 3 months or more after surgery
- May ultimately lead to renal failure
- Decrease in kidney length, thinned cortex
- Doppler features:
 - Elevated RI
 - No diastolic flow
 - Early diastolic flow reversal
- Requires biopsy



Acute Tubular Necrosis (ATN)

- Delayed function after renal transplant.
- This condition is seen more frequently when the transplant is from a cadaver.
- Delayed graft function can occur as a result of factors such as low blood pressure during CPR.
- Expect to see ATN for 10 days to a few weeks in a kidney from a deceased donor.
- Kidney may not make urine for days.

Acute Tubular Necrosis:

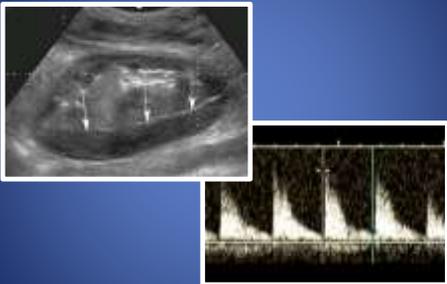


- Elevated resistive index
- Absent diastolic flow
- Early diastolic flow reversal
- **Cannot be differentiated from rejection**

Compressive perinephric fluid collections

- Page kidney phenomenon – increased resistance due to compression of the renal parenchyma by structures.
- Leads to absent or reversed diastolic flow
- Severe acute tubular necrosis can develop
- Graft loss can result if not caught early.
- May require decompression
- Example: subcapsular hematoma

Subcapsular hematoma

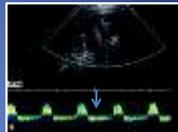


Renal Vein Thrombosis (RVT):

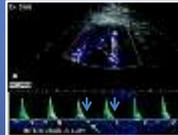
- Onset: within the first post-operative week
- Symptoms: Abrupt onset of oliguria
- Grayscale:
 - graft enlargement
 - decreased echogenicity
- More often with left renal transplants
- Arterial waveforms have a specific appearance.

Renal Vein Thrombosis:

- Reversal of flow from early diastole to end diastole (below the baseline)
 - Causes of RVT:
 - Surgical difficulty
 - Compression of the renal vein
 - Prolonged bed rest
 - Coagulation disorders
 - Propagation from extremity
- Reversal of flow limited to early diastole is seen with severe rejection or acute tubular necrosis of the graft.



Renal Vein Thrombosis

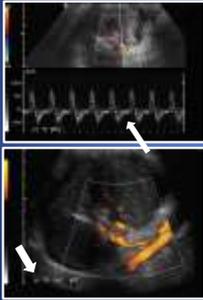


Transplant Rejection/ATN

Transplant Renal Vein Thrombosis - Left CIV Compression:

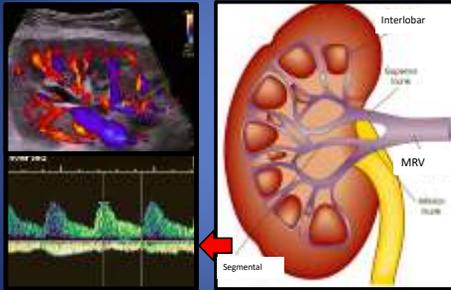


Renal Vein Thrombosis:



- Reversal of flow throughout diastole in main renal artery (holodiastolic flow reversal)
- The additional finding of absent venous flow is diagnostic for RVT.

Intrarenal Veins:



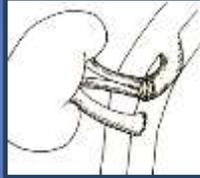
Normal Main Renal Artery (MRA)



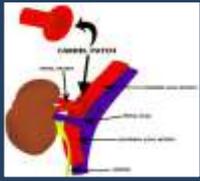
- Sharp systolic upstroke
- Forward flow throughout diastole.
- Peak Systolic Velocity < 200 cm/sec

Main Renal Artery Stenosis (RAS)

Common complication
>Three months post transplant
Symptom: severe hypertension
Deceased Donor: less common

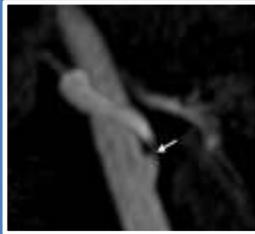


Live donors: renal artery stenosis occurs at anastomosis
Pediatric donors or recipients: due to the small size of the MRA



Main Renal Artery Technique:

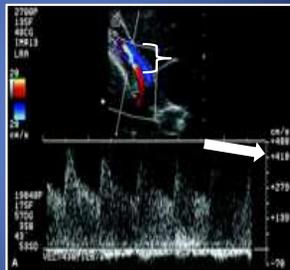
- Increase the color Doppler scale so that the majority of the vessel is displayed in a solid color.
- Look for focal areas of aliasing (mosaic pattern on color image)
- Doppler angle less than 60 degrees
- Obtain multiple samples
- Record highest velocity



Main Renal Artery Stenosis:

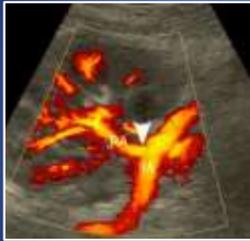
- Obtain multiple velocities with good angle correction throughout the area of aliasing.
- Look for elevated velocities greater than 200 cm/sec.

9 times out of 10 will be over calling stenosis if only the PSV is used





MRA/CIA Ratio



PSV at MRA Stenosis <2.0 is normal
PSV Iliac Art

Significant MRA Stenosis:

PSV MRA > 200 cm/s
(and)

Velocity Ratio of the MRA/CIA \geq 2.0
(and)

Kidney has tardus parvus waveforms

Not significant stenosis:

If MRA is >200 cm/s (but) Ratio < 2.0 (and) no tardus parvus

Elevated MRA Velocity – Stenosis?



- 1) Is the velocity in MRA >200 cm/sec? **Y/N**
 - 2) Is the PSV in the MRA twice that of the proximal vessel (EIA or CIA) **Y/N**
 - 3) Do we see tardus parvus waveforms in the intrarenal arteries? **Y/N**
- (Tardus parvus is seen when proximal stenosis is > 80%)

Other Considerations - MRA

- Transplant renal arteries are more tortuous than native renal arteries.
- Flow normally accelerates around curves or kinks.
- Velocity is elevated when there is a small angle at the anastomosis.



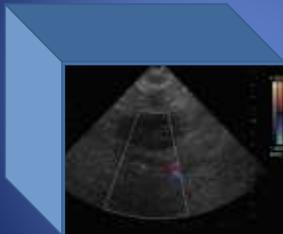
Suspect that increased velocity is due to tortuosity when:

- PSV of MRA > 200 cm/s
- MRA/CIA ratio ≥ 2.0
- Curvy vessel/small angle
- & absent tardus parvus

Renal Artery Thrombosis (RAT)

- Rare less than 1%
- Immediately post-op/intraoperative
- Requires immediate diagnosis - thrombectomy or thrombolysis to prevent graft loss
- More common in:
 - live donor transplant recipients
 - complex arterial anastomoses
 - pediatric transplants due to the small size of the main renal artery.

Renal Artery Thrombosis

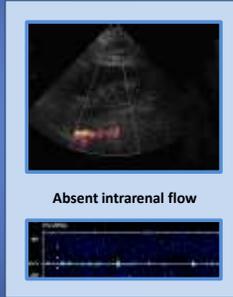


Also caused by:
severe rejection
acute tubular
necrosis

Doppler US shows absent arterial and venous flow.

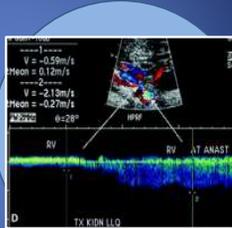
Renal Artery Thrombosis

- Doppler Technique: Increase sensitivity for detecting slow blood flow.
 - Use **power Doppler**
 - **low pulse repetition frequency (scale)**
 - **Increase color gain**
 - **low wall filters**
- **Pulsed wave Doppler** is more sensitive than either color or power Doppler when determining if flow is present.



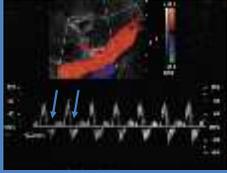
Renal Vein Stenosis:

- Renal vein stenosis is **uncommon** and can occur at the anastomosis
- May result from extrinsic compression
- Doppler US of the renal vein shows focal aliasing with a **three- to fourfold increase in velocity compared to distal segments** indicating a significant stenosis or kinking .





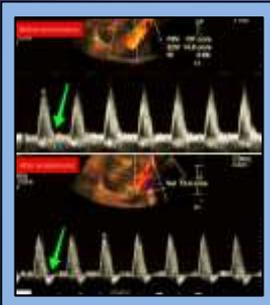
External Iliac Artery:



This is a normal waveform when obtained inferior to the renal artery anastomosis.

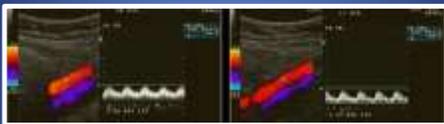
Inferior to the anastomosis we should see a high resistance waveform because at this point the vessel is only supplying the lower extremity.

EIA Waveforms with Renal Tx



*Superior to the anastomosis the EIA is supplying both the kidney and the lower extremity so we get a combination Renal/ extremity waveform with forward flow throughout the cardiac cycle.
 *If the kidney becomes high resistance the waveform superior to the anastomosis will reflect that and become high resistance.

Iliac Arteries

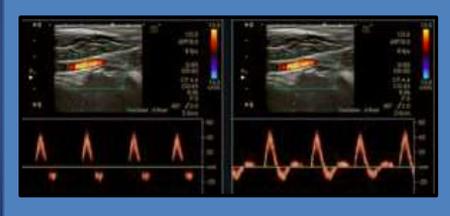


If the Rt EIA looks like this >>> Look at the left EIA

Tardus parvus in both external iliac arteries from a proximal stenosis in the aorta.

Technique – Spectral Wall Filter

Use a low wall filter (color and Duplex) for slow flow.



Wall filter too high

Wall filter just right

Five-Year Survival Rate

Possible Kidney Donors:

- Parents
- Spouses
- Living unrelated donors
- Other living related
- Identical siblings
- Other siblings
- Cadavers

- Living unrelated donor kidney transplants had superior outcomes compared with cadaver transplants



Vascular Complications of Percutaneous Transplant Biopsy:

- Hemorrhage
- Hematoma
- Arteriovenous fistula
- Pseudoaneurysm
- Infarction

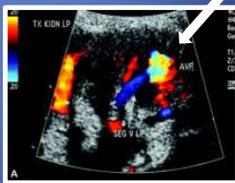
Hematoma:



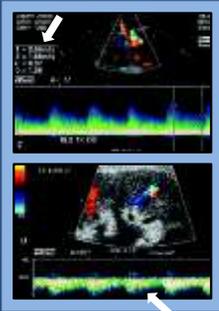
Look for peritransplant fluid/bleeding after biopsies

Arteriovenous fistula:

- Abnormal connection between an artery and vein which can be created by a biopsy needle.
- Always obtain a post biopsy color Doppler image at site of needle tract.
- Relatively common
- Majority are small and insignificant
- Mosaic pattern
 - disorganized flow
 - tissue vibrations
- **Can cause infarct**



Arteriovenous Fistulas:



- Feeding artery will have high velocity, low-resistance waveform.
- The draining vein will become pulsatile – called arterialization
- Can cause hematuria when blood goes into the collecting system
 - may lead to obstruction of the ureter

Arteriovenous Fistulas:



- The abnormal connection between the artery and the vein can also cause a steal which may lead to ischemia and infarct.
- Color or power Doppler will show lack of vascularity
- Similar findings can be seen in severe pyelonephritis

Pseudoaneurysm:

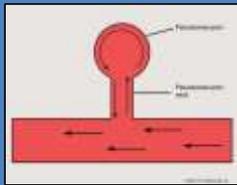
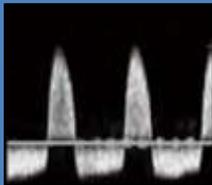


- Grayscale findings similar to a simple renal cyst.
- Yin Yang sign



Pseudoaneurysm Neck:

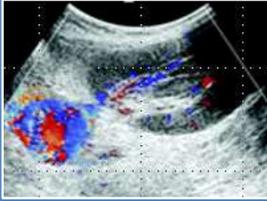
The pseudoaneurysm neck waveform will have a specific appearance.



To-and-fro flow when the sample gate is placed in neck

Pseudoaneurysms:

- Can be intrarenal or extrarenal
- Patient may have hematuria & low hematocrit



Conclusion:

- Renal transplant surgeons can be very creative in their approaches to surgery
- Cadaver kidney transplants have different issues than live donor transplants
- Obtaining quality Doppler waveforms is important:
 - Acceleration time/tardus parvus waveforms
 - Resistive Index/pulsatility Index
 - Flow reversal – early diastolic or holodiastolic
- Sometimes renal transplant Doppler exams truly are “stats”
- Be aware of post biopsy vascular complications
- Early detection enables earlier treatment and a better chance of saving the transplant.

Keep Calm &
Fill Out Your Donor Card.

References:

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