Ultrasound – US Renal Transplant Doppler

PURPOSE:

To evaluate the parenchyma and vasculature associated with the renal transplant for structural or vascular pathology.

SCOPE:

Applies to all ultrasound renal transplant studies performed in:

- UT Southwestern William P. Clements Jr. University Hospital and Clinics, Imaging Services (UTSW Radiology)
- Parkland Health (Hospital and Clinics), Department of Radiology (PHHS Radiology)
- Applies to 2 renal transplant scenarios:
  - Renal Transplant Doppler – Immediately Post-Op / Baseline study
  - Renal Transplant Doppler – Follow-up, *not* immediately post-op

ORDERABLE:

- UTSW: US Doppler Kidney Transplant
- PHHS: US Renal Transplant
- If a native kidney evaluation is also requested, it is performed under a separate order. Please refer to that exam's protocol for image acquisition details.
  - UTSW: US Renal Complete
  - PHHS: US Renal

INDICATIONS:

- Baseline, Post-op Exam
  - Immediate post-operative status, to establish baseline

- Follow-up Exam
  - Signs (hypertension, renal failure) or symptoms (pain) associated with renal disease or transplant rejection;
  - Abnormal lab values (increased Cr, etc);
  - Suspicion for vascular complication (stenosis; thrombosis);
  - Suspicion for or follow-up of known fluid collection;
  - Suspicion for or follow-up of known hydronephrosis;
  - Clinical findings such as pain, fever, sepsis, hematuria, etc.
  - Abnormal findings on other imaging studies

CONTRAINDICATIONS:

- No absolute contraindications

EQUIPMENT:

- Linear transducer with a frequency range of 2-18 MHz that allows for optimal penetration and resolution depending on patient's body habitus
- Curvilinear transducer with a frequency range of 1-9 MHz that allows for appropriate penetration and resolution depending on patient's body habitus

PATIENT PREPARATION:

- Baseline, Post-op Exam
  - Pain medication should be administered as soon as available.
  - If the incision is stapled and not covered with a bandage, use a sterile probe cover and gel
- Follow-up Exam
  - Patient should be well hydrated.
  - If the incision is stapled and not covered with a bandage, use a sterile probe cover and gel

EXAMINATION:

GENERAL GUIDELINES:

A complete examination includes evaluation of:

- The main renal artery and branches (including interlobar).
- The main renal vein and branches (including interlobar).
- Iliac artery
- Iliac vein
- Additional image acquisition protocols based on orderable (above)

EXAM INITIATION:

- Review surgical history and reconstruction technique. Make note if multiple renal anastomoses are present.
  - For baseline, Post-op Exam, contact surgical team for guidance if OP note is not available or if number of vessels is unclear
  - For follow-up Exams, review any prior imaging and surgical reports, making note of abnormalities, prior velocity measurements, or other findings requiring further evaluation.
- Review prior imaging, if available and relevant
- Introduce yourself to the patient/family
- Verify patient identity using patient name and DOB
- Explain test
- Obtain patient history including symptoms. Enter and store data page
- Place patient in supine position

TECHNICAL CONSIDERATIONS:

Pre-Scan Review

- Review surgical history and reconstruction technique.
- Make note if multiple renal anastomoses are present.
- For **en bloc renal transplant**, the following images/measurements are needed for each kidney. Label kidneys “medial” and “lateral”, or “#1” and “#2”, being consistent with prior imaging, if applicable.

Graycale Imaging

- Optimize gain, depth, dynamic range, and focal zones on grey scale imaging first.
- For longitudinal renal images, include images without and with measurements.

Color & Power Doppler Optimization:

- Adjust scale and gain to fill the vessel lumen uniformly without artifacts.
- If “color bleed” occurs, adjust color scale and gain.
  - Use Power Doppler if flow is not visualized with standard color

    - Doppler For parenchymal perfusion, use Power Doppler, or microvascular flow imaging (eg. MFI; MVI; Slow Flow)
- For Stenosis, evaluate for:
    - Stenotic jet (i.e. aliasing)
    - Post-stenotic turbulence
    - Soft tissue color "bruit" may be present in severe stenosis

Spectral Doppler Optimization:

- Place sample gate centrally within the vessel.
- Adjust sweep speed to include approximately 3-5 waveforms only
- Adjust velocity scale to adequately display waveform amplitude.
- Eliminate aliasing for high-flow evaluation by increasing velocity range and/or lowering the baseline.
- Use angle correction of ≤ 60^{o}, always parallel to the vessel wall.
    - A decreased Doppler angle correction is allowed and preferred, if in line with flow
    - Try alternate windows if anatomy limits angle optimization.
- External Iliac Artery: Assess proximal to (cranial to), at, and distal to (caudal to) the anastomosis.

Renal Artery Evaluation:

- Survey for multiple renal arteries: use color Doppler along the iliac artery.
- For multiple renal arteries, measurements should be repeated for each artery.
- Main Renal Artery Velocities: Obtain spectral Doppler at the anastomosis, proximal, mid, and distal (hilum) segments.
- If stenosis suspected (often where color aliasing appears), measure peak systolic velocity with proper **angle correction**.
    - Most renal artery stenoses occur at the anastomosis (ostium).

Intrarenal Interlobar Artery Evaluation (eSAT & RI):

- Obtain early systolic acceleration time (eSAT or AT) and Resistive Index (RI) from Interlobar arteries upper pole, mid segment, and lower pole.
- Multiple waveforms may be required to capture a clear early systolic peak (ESP). **Be patient!**
    - Be aware of ESP variants (see "Renal Doppler Complete" Protocol).
    - Adjust sweep speed to show only 3-5 waveforms – this will improve spectral Doppler caliper placement
- Special Considerations:
    - Immediate post-op: if normal, obtain mid-pole AT only; **if abnormal**, then obtain AT at upper and lower poles
    - If **multiple renal arteries** are present: obtain AT at all segments

Venous Evaluation:

- Using color Doppler, survey the entire main renal vein for thrombus.
    - Obtain spectral Doppler without velocity measurement at MID MRV.
    - If stenosis suspected (eg. color Doppler aliasing), waveforms and velocities proximal, at, and distal to narrowing is needed.
- Evaluate iliac vein with color
    - Obtain spectral Doppler cranial to the anastomosis

Complications:

- Arteriovenous Fistula (AVF)

- Investigate any transplant with hematuria for AVF (common post-biopsy, usually lower pole).
- Look for:
  - High-flow aliasing in interlobar artery
  - High-velocity, pulsatile flow in draining vein
  - "Color bruit" of "color thrill" indicating turbulent high flow

- Pseudoaneurysm
  - If cystic structure is seen, use color Doppler to exclude pseudoaneurysm (another biopsy-related complication).
- Soft Tissue & Bladder
  - Scan soft tissues of the perinephric space between the transplant kidney and bladder for fluid collections
    - Document still images and cine sweeps in Long and Trans only if fluid collection is visualized
  - Evaluate bladder for urinary stent and annotate on image if present.
- Hydronephrosis
  - If hydronephrosis is present:
    - Obtain pre- and post-void bladder volumes.
    - Include pre- and post-void renal hilum images to assess for persistence or resolution

DOCUMENTATION:

For **en bloc renal transplant**, the following images/measurements are needed for each kidney. Label kidneys "medial" and "lateral", or "#1" and "#2", being consistent with prior imaging.

IMMEDIATE POST-OPERATIVE STATUS FOR BASELINE ESTABLISHMENT

Anatomy	Grey Scale	Color Doppler	Wave form	PSV	RI	eSAT
Longitudinal TX kidney: medial	x					
Longitudinal TX kidney: mid w/ and w/o measurement	x					
Longitudinal TX kidney: lateral	x					
Transverse TX kidney: superior pole	x					
Transverse TX kidney: superior mid	x					
Transverse TX kidney: mid	x					
Transverse TX kidney: mid inferior	x					
Transverse TX kidney: inferior pole	x					
% TX Renal artery: proximal	%x	%x	%x	%x		
% TX Renal artery: distal	%x	%x	%x	%x		
$ TX Interlobar artery: middle pole	$x	$x	$x		$x	$x
*TX Renal vein: Mid	*x	*x	*x			
Iliac artery: proximal to ostium	x	x	x	x		
Iliac artery: at ostium	x	x				
Iliac artery: distal to ostium	x	x	x	x		
Iliac vein: cranial to ostium	x	x				
**Transverse Bladder (w/ Foley)	**x					
Survey of perinephric space	x	x				
Survey collecting system for hydro	x	x				

Baseline, Post-op Exam Documentation Footnotes:

% Main Renal Artery (MRA): If abnormal, evaluate complete MRA including ostium and mid; repeat for each artery, if applicable

$ If mid interlobar artery is abnormal OR there are multiple renal arteries, evaluate superior and inferior pole interlobar arteries.

***** If stenosis suspected (eg. color Doppler aliasing), waveforms and velocities proximal, at, and distal to narrowing is needed.

****** Bladder: One still Trans mid image to identify foley balloon placement and determine distention level of bladder.

FOLLOW-UP EXAMS ONLY

Anatomy	Grayscale	Color Doppler	Wave form	PSV	RI	eSAT
Longitudinal TX kidney: medial	x					
Longitudinal TX kidney: mid w/ and w/o measurement	x					
Longitudinal TX kidney: lateral	x					
Transverse TX kidney: superior pole	x					
Transverse TX kidney: superior mid	x					
Transverse TX kidney: mid	x					
Transverse TX kidney: mid inferior	x					
Transverse TX kidney: inferior pole	x					
Longitudinal TX Kidney Perfusion: Representative images; cine loop		x				
^TX Renal artery: ostium	^x	^x	^x	^x		
^TX Renal artery: proximal	^x	^x	^x	^x		
^TX Renal artery: mid	^x	^x	^x	^x		
^TX Renal artery: distal	^x	^x	^x	^x		
TX Interlobar artery: Superior pole	x	x	x		x	x
TX Interlobar artery: middle pole	x	x	x		x	x
TX Interlobar artery: Inferior pole	x	x	x		x	x
*TX Renal vein: Mid	x	x	x			
Iliac artery: proximal to ostium	x	x	x	x		
Iliac artery: at ostium	x	x				
Iliac artery: distal to ostium	x	x	x	x		
Iliac vein: cranial to ostium	x	x				
Survey collecting system for hydro	x	x				
+Longitudinal bladder	+x					
+Transverse bladder	+x					
++Bladder pre- and post-void volumes	++x					
%Survey of perinephric space	%x	%x				

Follow-up Exam Documentation Footnotes:

^ Multiple Renal Arteries: Repeat images for each MRA Bladder

***** If stenosis suspected (eg. color Doppler aliasing), waveforms and velocities proximal, at, and distal to narrowing is needed.

+ w/o Foley: Obtain multiple longitudinal and transverse images of the bladder as per Renal Protocol.

++ Obtain post void residual if there is TX renal hydro.

- Data page(s)

PROCESSING:

- Review examination data
- Export all images to PACS/Sectra
- Export all measurements to Imorgon
- Confirm data Imorgon (where applicable)
- Note any study limitations (in PACS or Epic Study Note, or Imorgon, per local workflow)

APPENDIX:

DIAGNOSTIC CRITERIA:

Transplant Kidney Intrarenal Measurements

RI	Category
0.6 – 0.7	Normal range
>0.8	Elevated (increased vascular resistance)
<0.5 – 0.6	Suspicious for renal artery stenosis

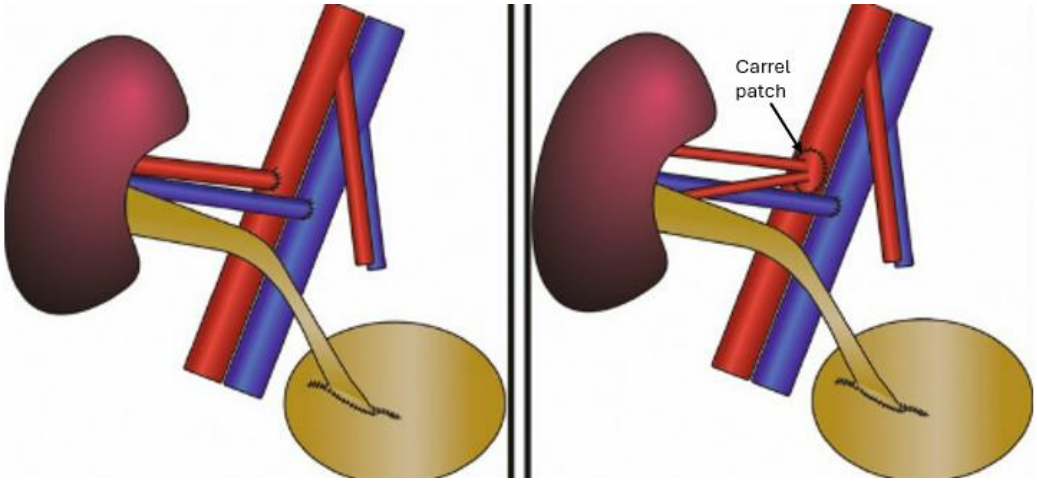
Criteria for Severe (60-80%) Renal Artery Stenosis

SAT	>0.07 sec
PSV	>200 cm/sec (150-300 cm/sec) • Post stenotic turbulence (color Doppler) and spectral broadening distal to stenosis • Consider >300 cm/sec for initial post-surgery, then >250 cm/sec for surveillance
RA/IA ratio	2.0 (PSV of Iliac Artery (IA) at Renal Artery (RA) anastomosis)
RI <0.5	Not a primary criteria

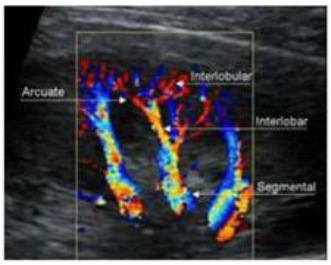
Renal Transplant Anatomy:

- Extraperitoneal, usually RLQ
- Arterial Anastomosis:
  - Renal Artery on a Carrell patch anastomosed end-to-side to External Iliac Artery
    - Deceased-donor TX only
    - Can be one MRA or multiple on a single patch
  - End-to-side Renal Artery to Internal Iliac Artery
    - Living-related TX
- Venous Anastomosis:
  - End-to-side Renal Vein to External Iliac Vein

Donor MRA and MRV end-to-side anastomosis (LEFT) vs. Donor MRA on a Carrel patch and MRV end-to-side techniqe (RIGHT)



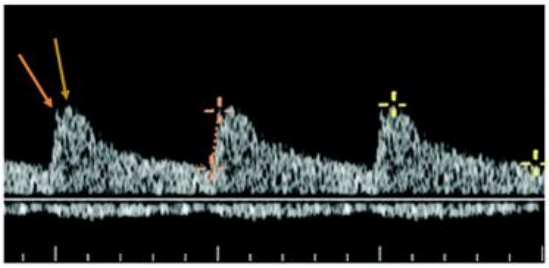
Intra-Renal Arteries, Resistive Index & Acceleration Time



Goal is to obtain "segmental" waveforms from distal segmental, proximal interlobar arteries, at approximately the level of artery insertion into the renal cortex

+ Acceleration Time, (orange arrow) measured from systolic inflexion point to first systolic peak (ESP, early systolic peak)

+ RI, (yellow arrow) measured from highest systolic peak to lowest diastole



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- Langdon, Jonathan & Sharbidre, Kedar & Garner, Matthew & Robbin, Michelle & Scoutt, Leslie. (2024). Renal transplant ultrasound: assessment of complications and advanced applications. Abdominal Radiology. 50. 2558-2585. 10.1007/s00261-024-04731-9.

CHANGE HISTORY:

DATE:	SUBMITTED BY: (NAME, TITLE)	APPROVED BY: (NAME, TITLE)	SUMMARY:
11/25/2015	David Fetzer, MD, Director		Submitted
01/31/2016	David Fetzer, MD, Director		Approved
11/14/2018	Anthony Setiawan, MD		Reviewed
07/25/2016	David Fetzer, MD		Segmental renal artery waveform descriptions
05/31/2020	David Fetzer, MD		Updates based on 2020 AIUM Practice Parameters update
03/31/2025	Thoa Bui, RDMS, RVT, R.T.(S)(ARRT)		Updates based on 2024 AIUM Practice Parameters
11/10/2025	Jana Smith, RDMS, RVT	David Fetzer, MD, Director	Added requirements for pre and post void bladder/kidney images with hydro. Updated facility logos. Minor grammatical changes.
06/16/2026	Jana Smith, RDMS, RVT; Skye Sayarath, RDMS, RVT	Pending	Added immediate post-op requirements. Applied accessibility features. Minor reformats. Re-structured techniques and documentation sections; switched out the renal artery anatomy image