Vascular Flow Patterns Assessment. Application in the Renal Transplant

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Why is this important?

- A relatively common procedure in the UK (3000-4000 per year)
- Most ultrasound centres will come into contact with patients who have a renal transplant.
- Many issues can be managed in secondary (rather than tertiary) care.
- Increase in mixed care models.
- Recognise when care needs to be transferred to a tertiary centre.
- Basic knowledge of flow patterns and interpretation enable accuracy of reporting and establish degree of urgency for management

Advantages of Ultrasound

Superficial Location

Minimal movement on respiration

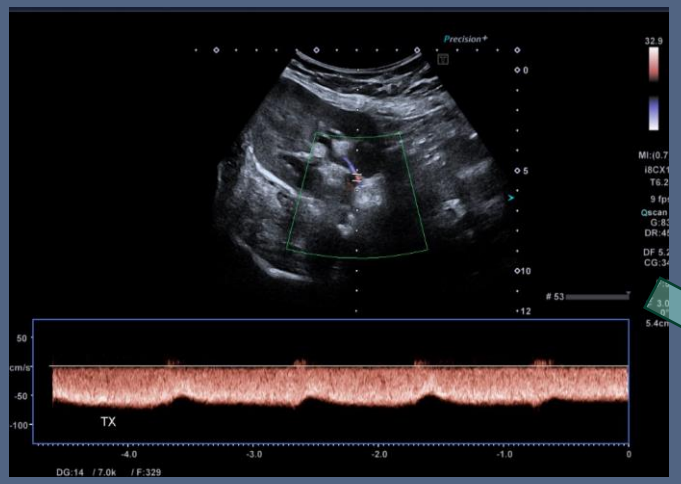
Repeated as often as needed

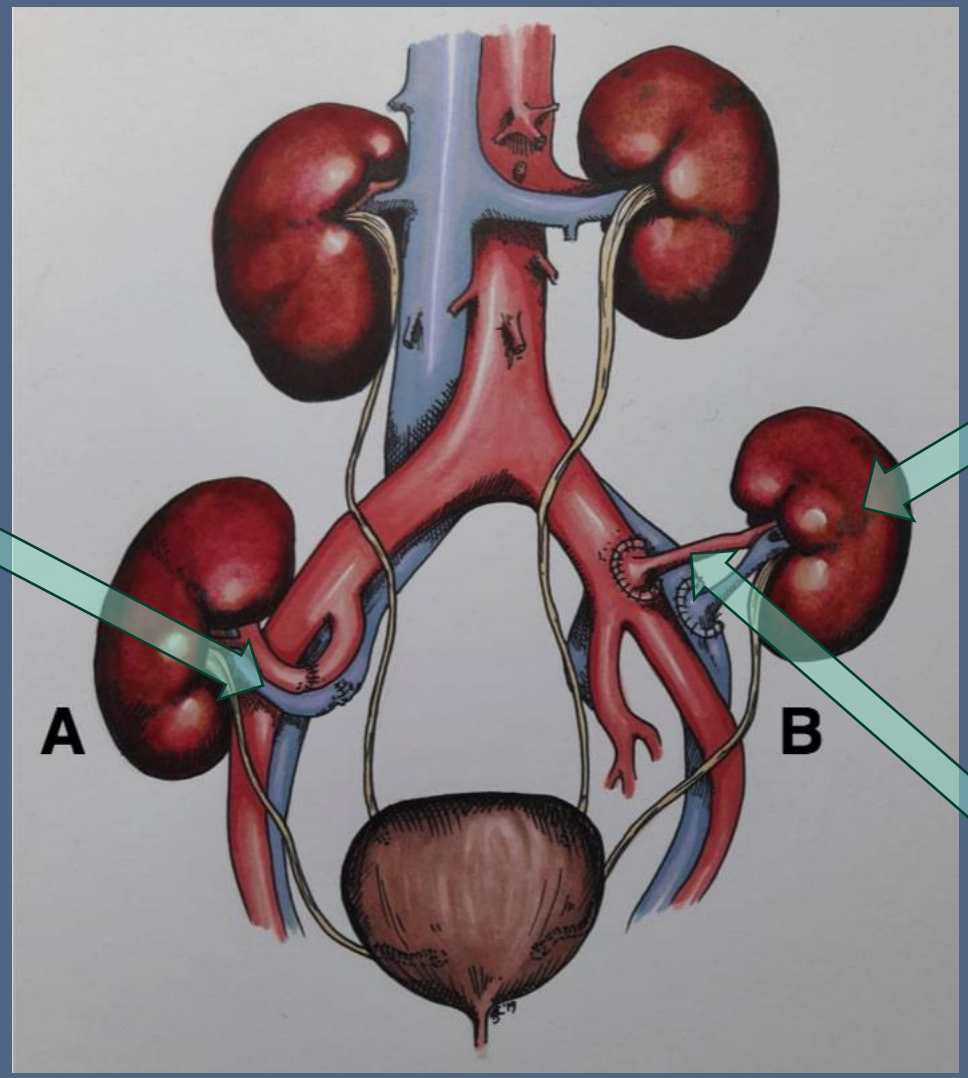
Can be performed at the bedside

Detailed information on both morphology and vascular characteristics

Cheap and accurate (in the right hands)

CEUS may be used without nephrotoxicity





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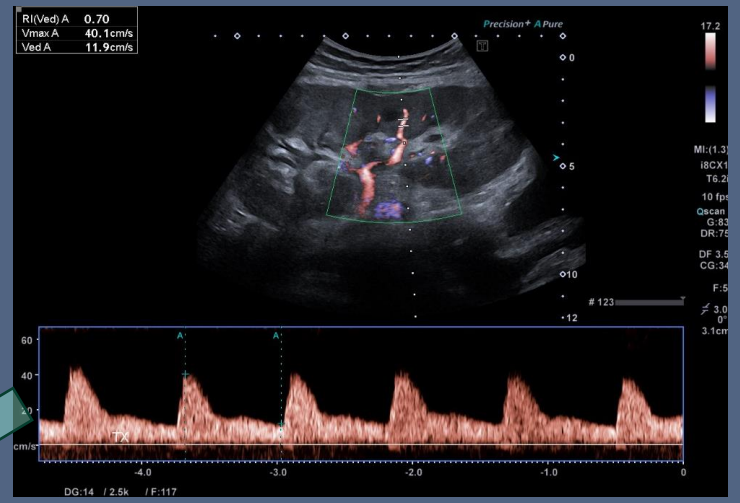
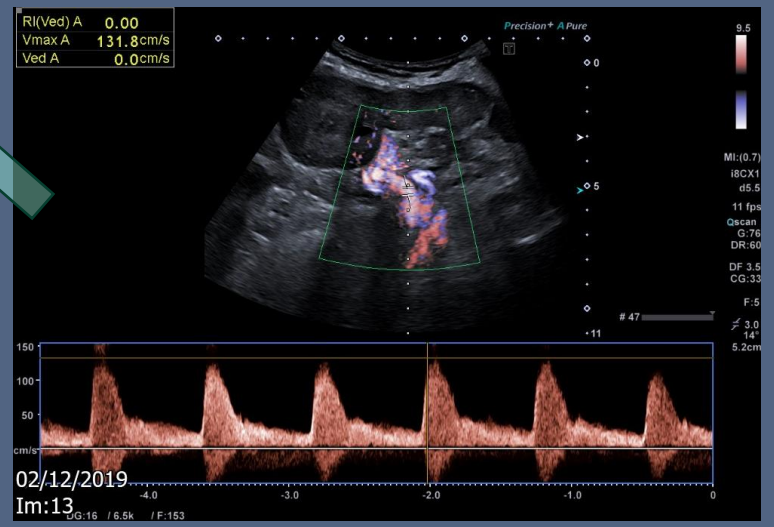


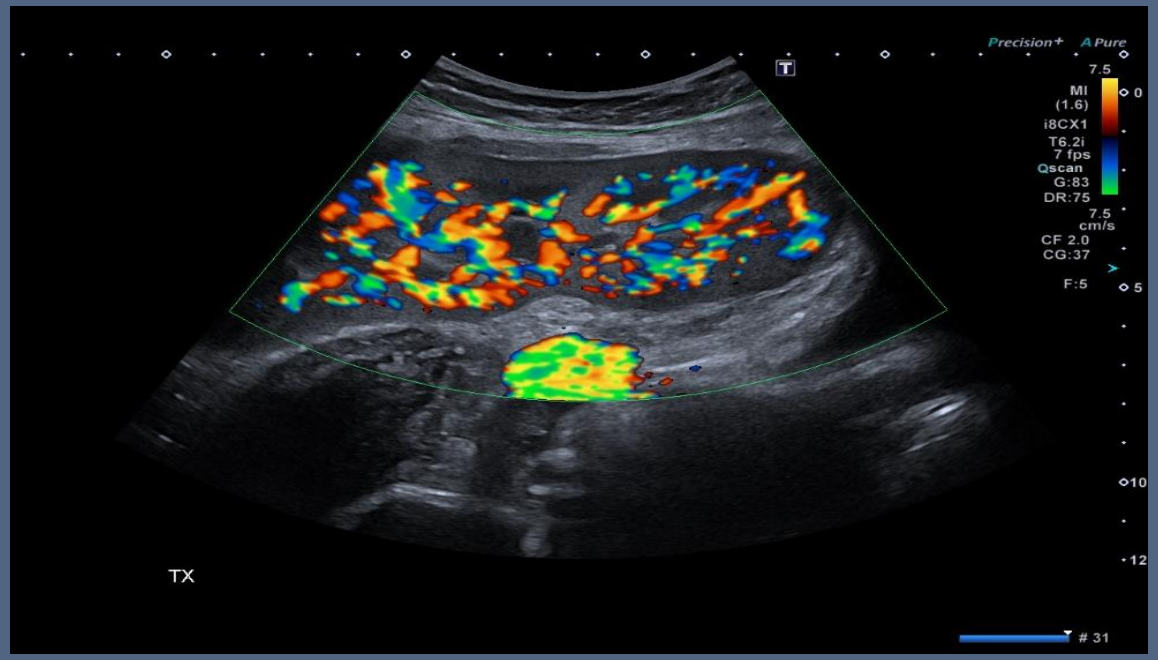


Before scanning....

- Previous imaging.
- Indication for ultrasound
- Donor
  - Live related or deceased donor
- Cold ischaemic time
- Numbers of major vessels
- Surgical difficulties/complications
- New transplants. Not usually necessary to remove surgical dressings. Remember to use sterile probe sleeve and gel when scanning over surgical wounds.

Approach to the renal transplant.

Vascular Assessment
Presence of intra-renal blood flow +/- CEUS where appropriate
Qualitative and quantitative assessment of intra-renal arterial blood flow patterns (interlobar vessels): Upper, mid and lower poles
Colour flow assessment of main renal artery/vein(s)
Quantitative assessment of major renal vessels/anastomoses (where possible)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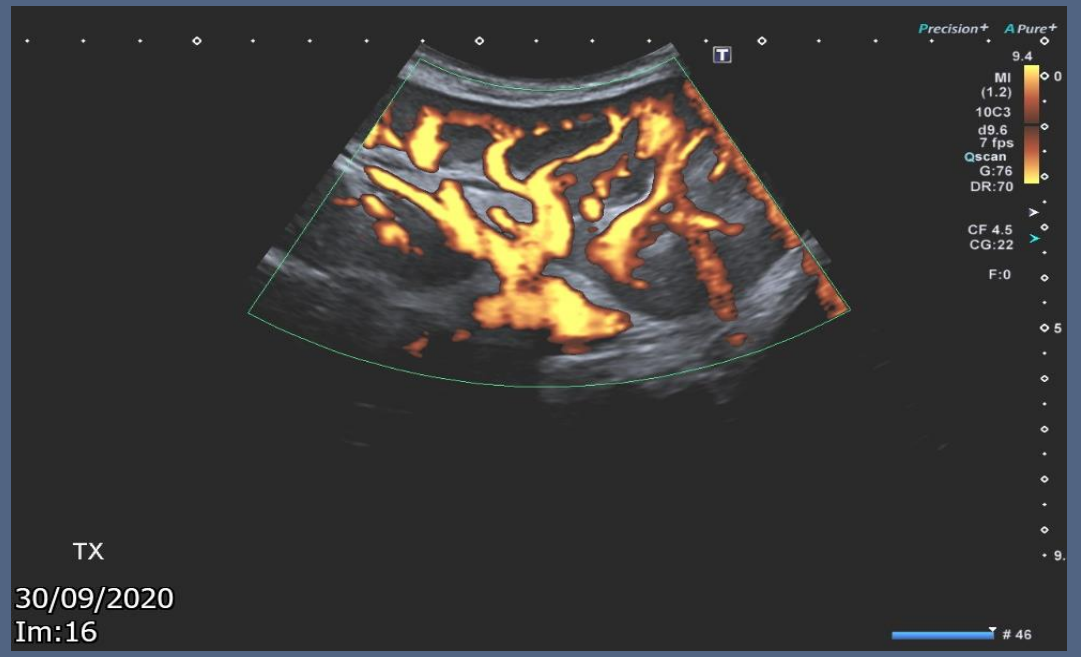
Qscan
G:83
DR:75
CF 2.0
CG:37
F:5
TX
31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30/09/2020
Im:16
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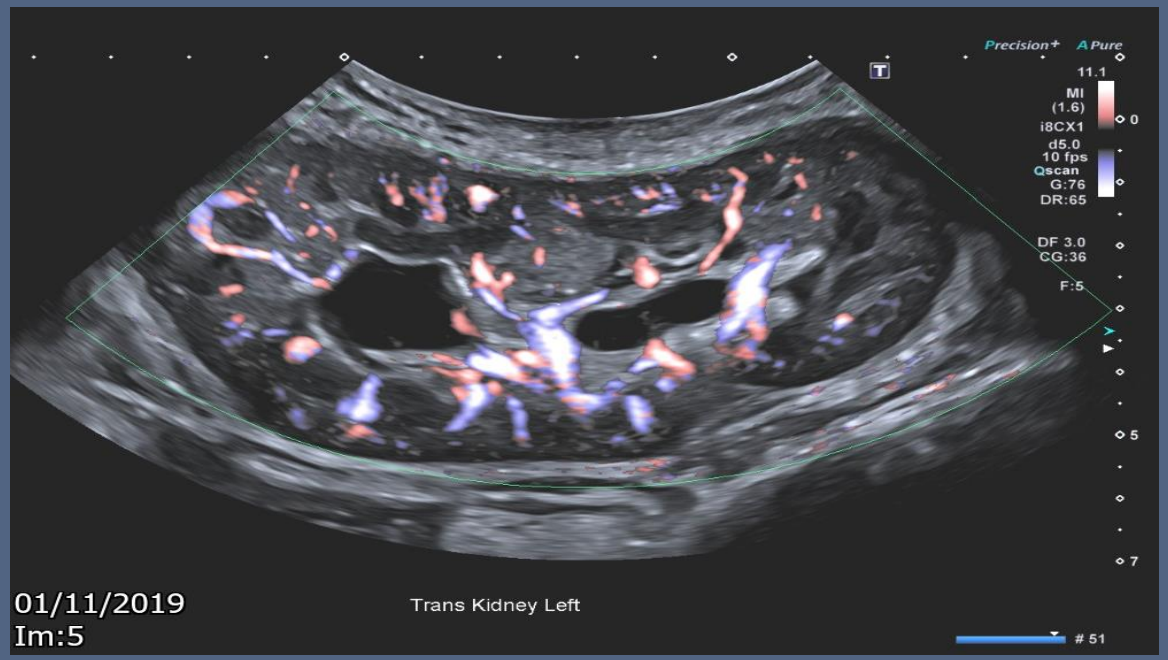
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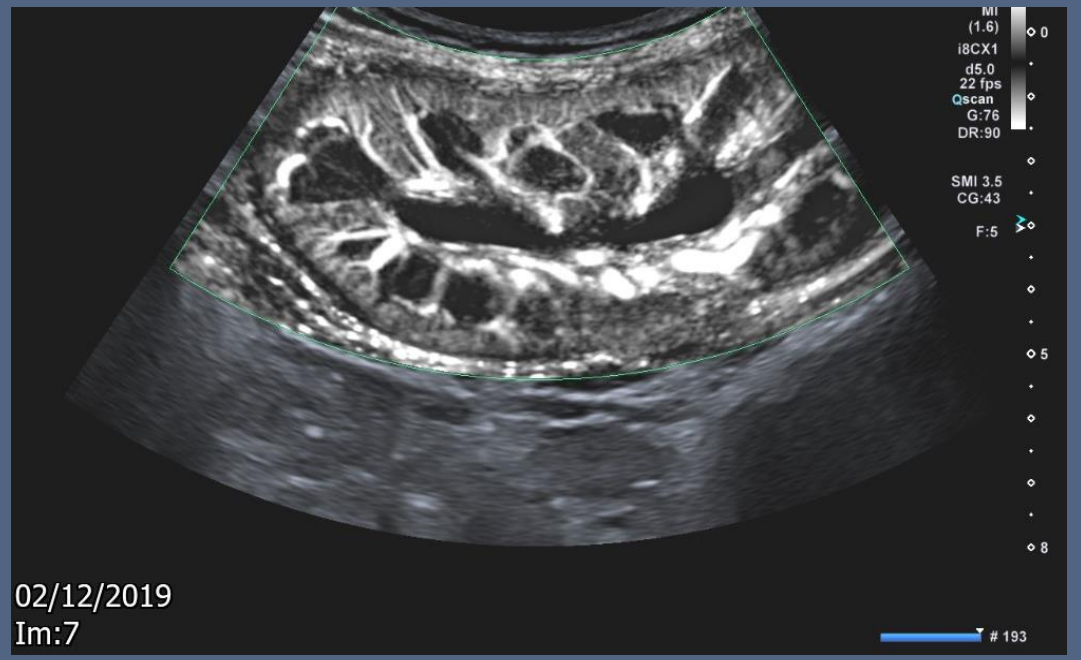
01/11/2019
Im:5
Trans Kidney Left
51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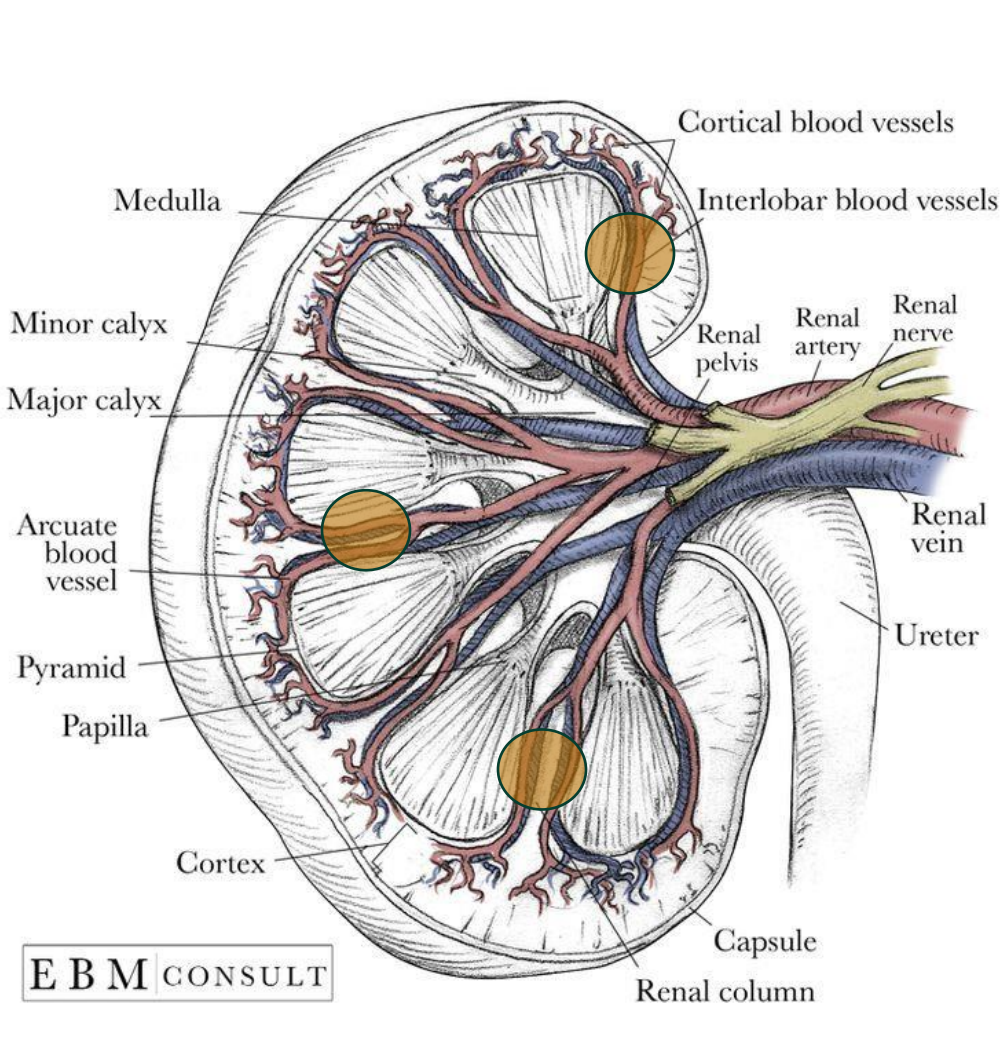
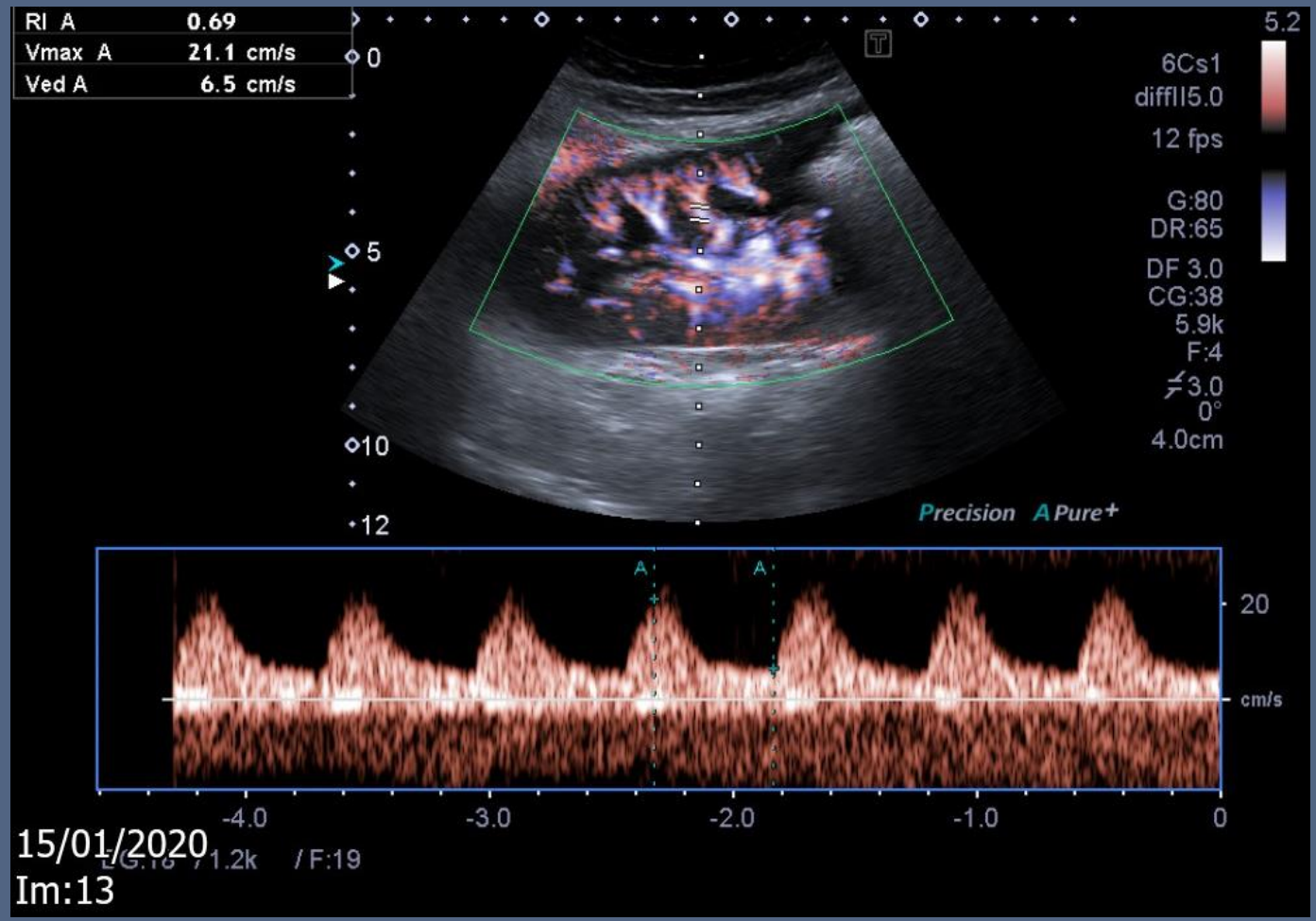
Spectral Doppler





EBM Consult. https://uk.pinterest.com/pin/480688960223331317/

Spectral Doppler

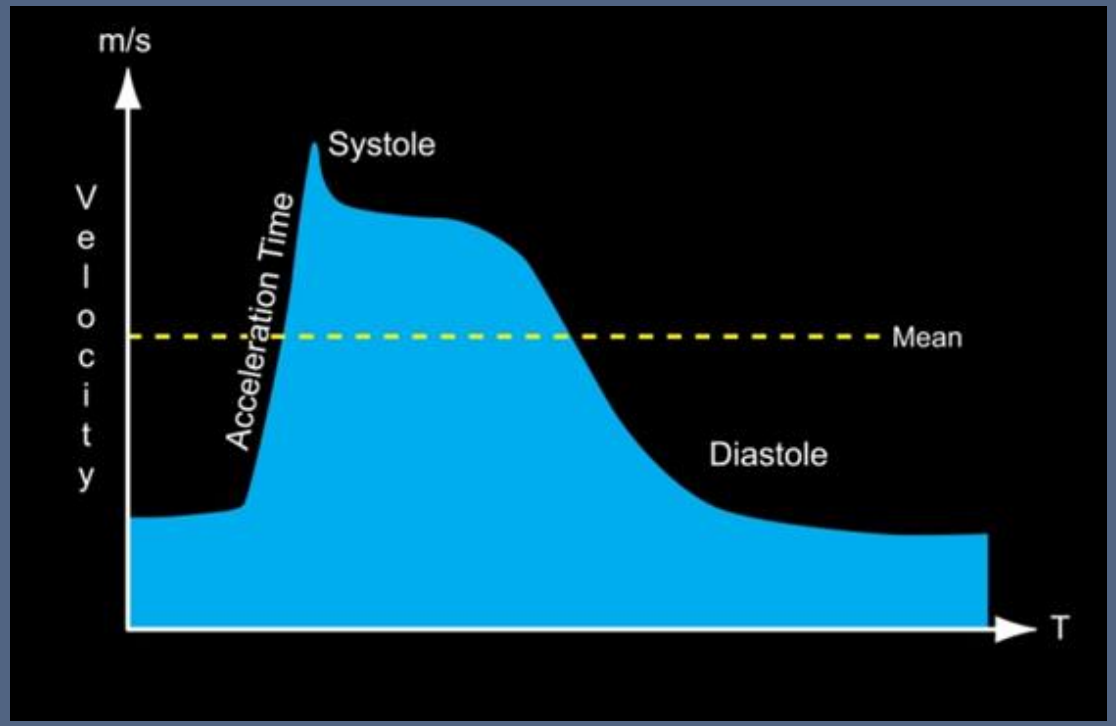
- RI= $(psv - edv)/psv$
- Normal Values

  RI= 0.56-0.7

  PI=0.63-1.5

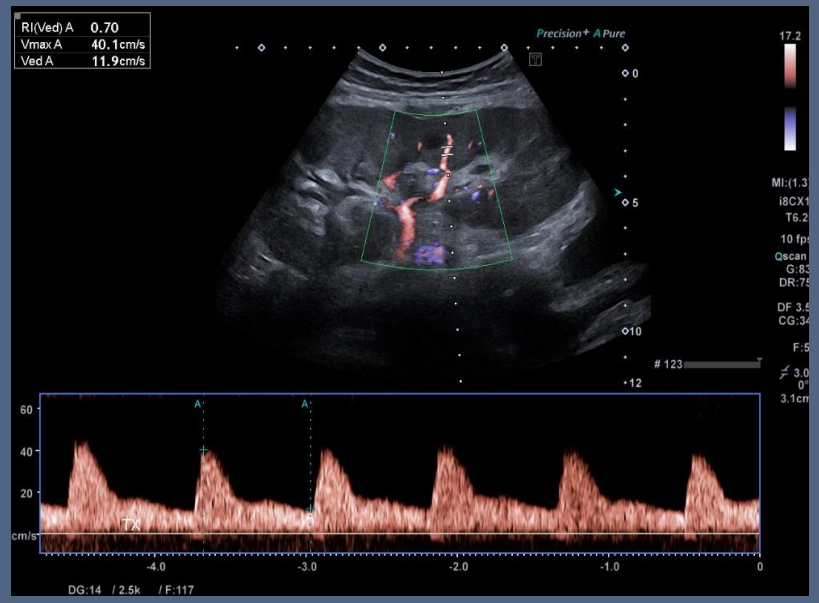
  AT <0.10s

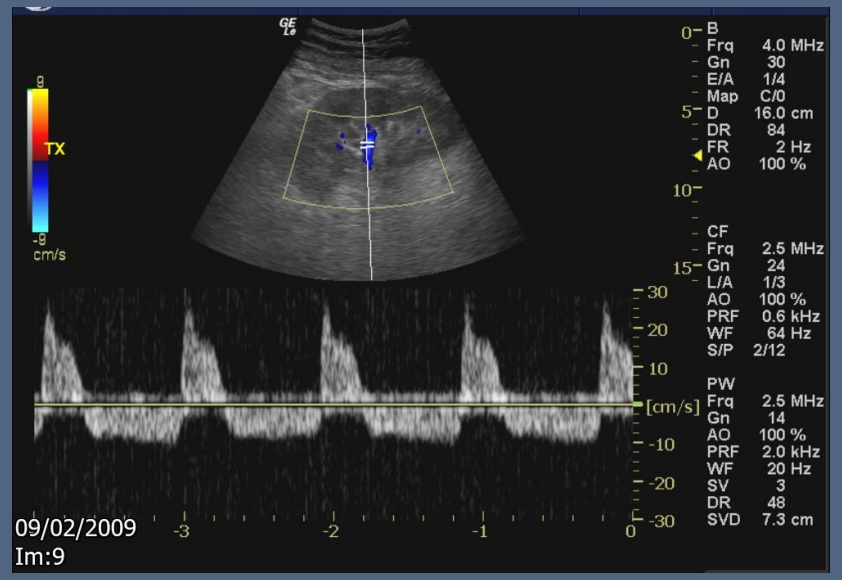
  PSV 2.5m/s



- RI will rise with ATN, acute rejection, ureteric obstruction, but can also reflect recipient factors.

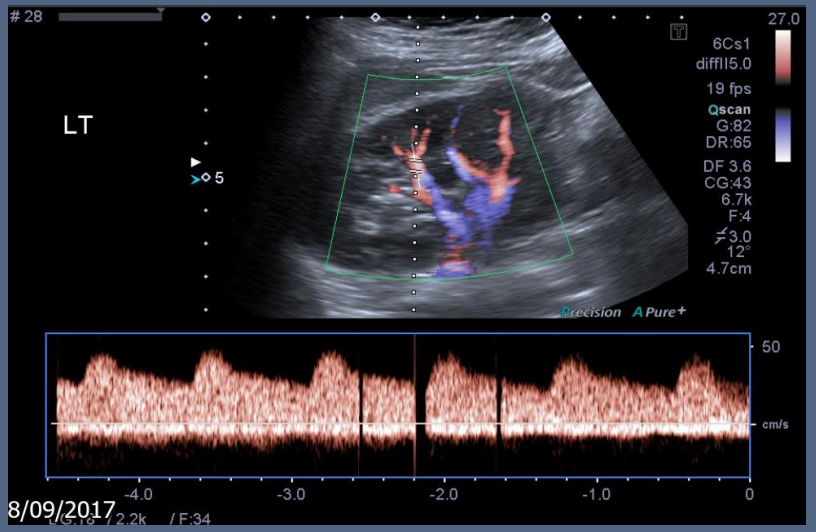
Flow Evaluation.

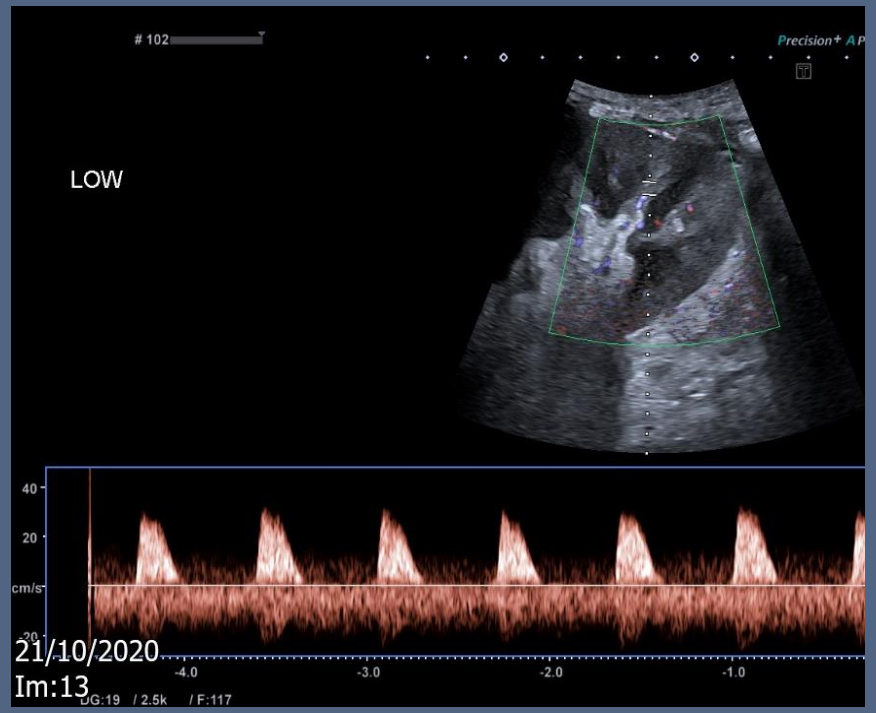




Undertake qualitative assessment of flow patterns before taking any measurements.

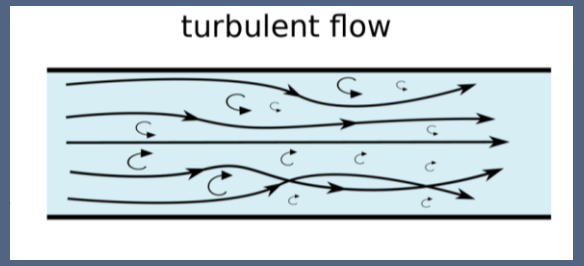
Use eyes and ears.

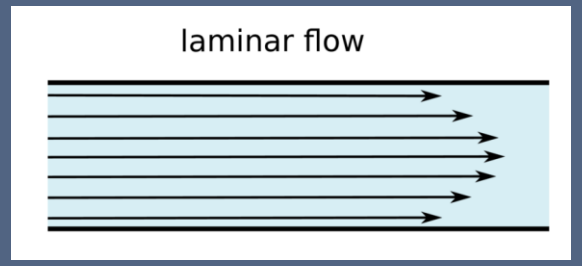


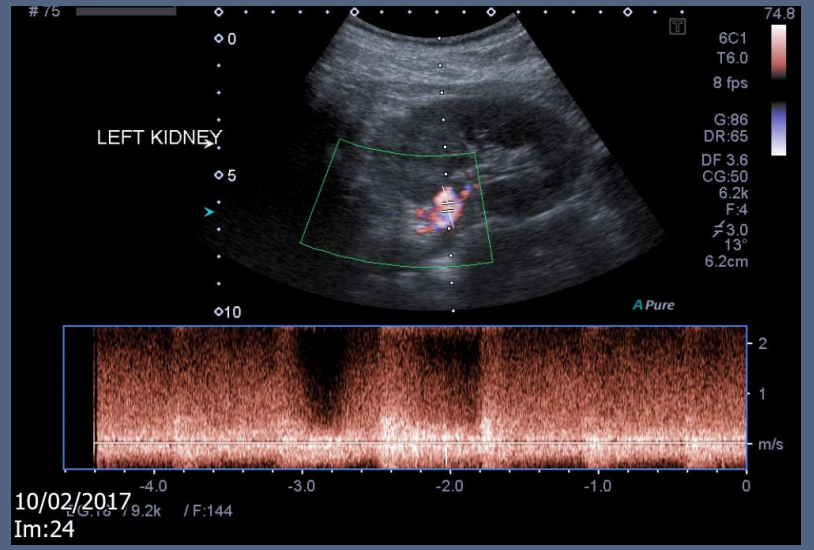


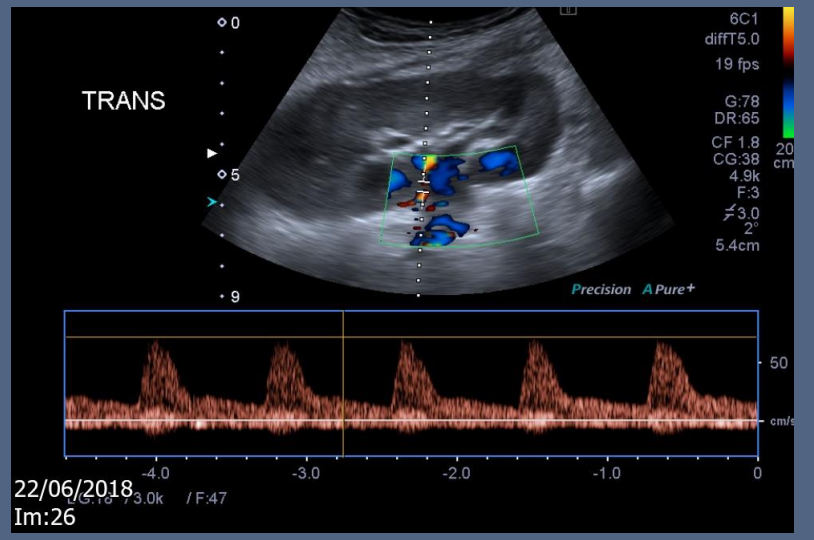
Laminar vs turbulent flow.

- $RN \propto \frac{Blood\ velocity\ x\ vessel\ diameter}{Viscosity}$

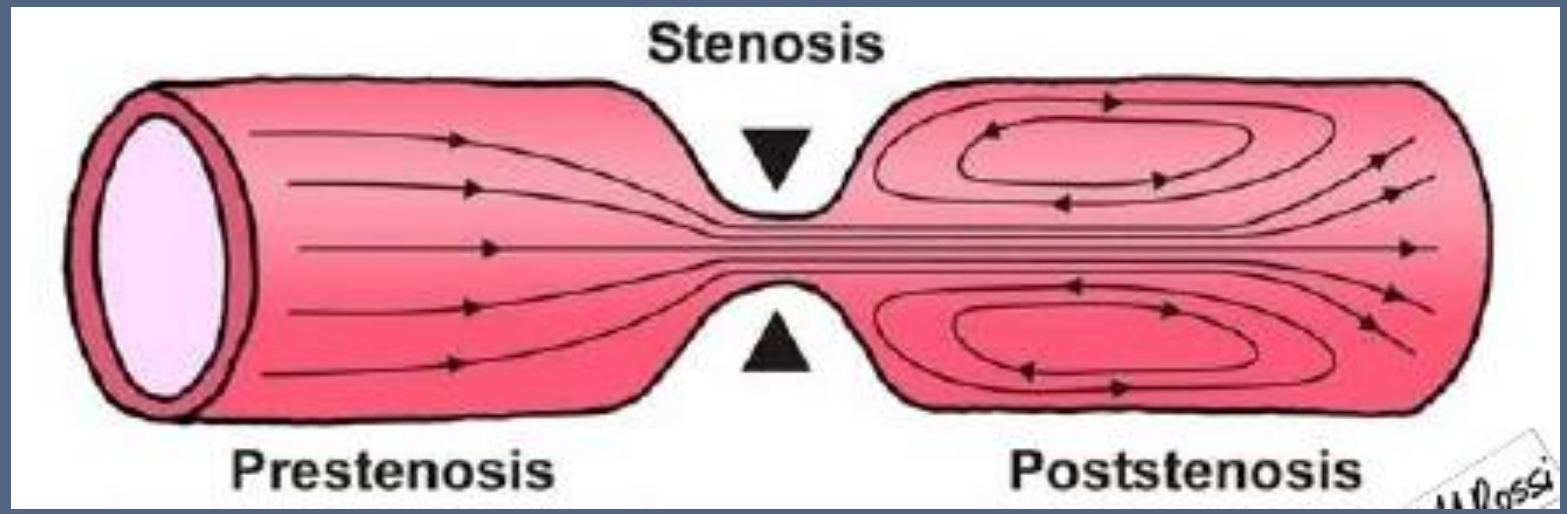








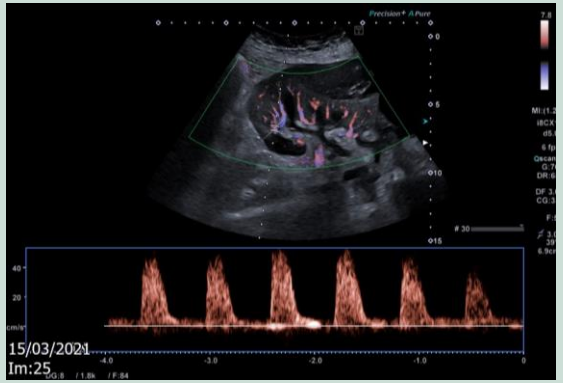
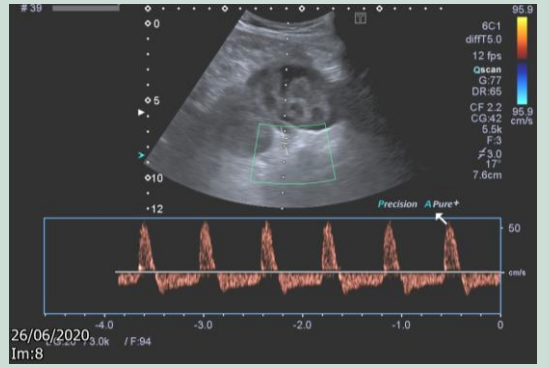
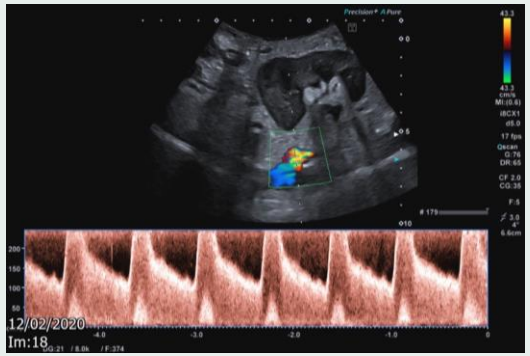
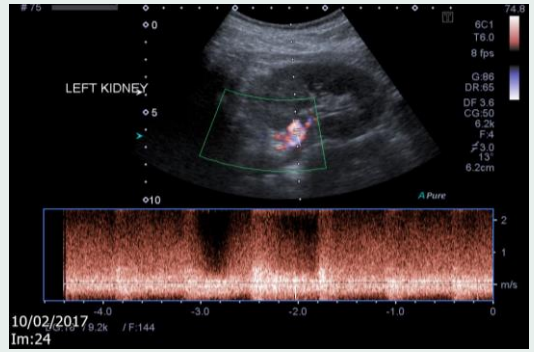
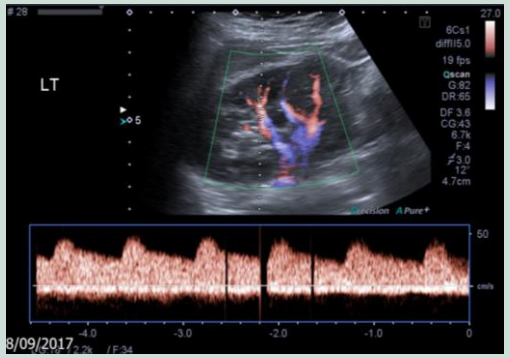
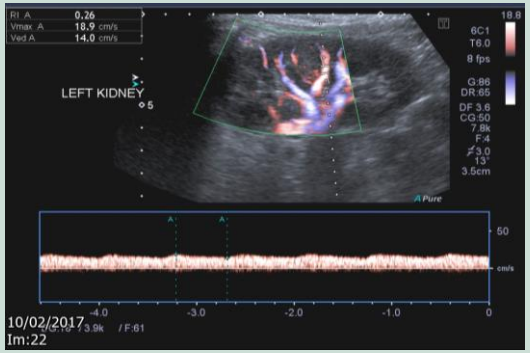
Flow Through Arterial Stenosis.



Pre-stenosis. ***Higher flow resistance (↑ RI)***

Stenosis: ***Stenotic jet +/- turbulent flow***

Post stenosis: ***Damped flow. 'Parvus-Tardus'***

Flow Pattern	Likely site of Abnormality.		
↑ *flow resistance (↑ RI)*	Look distally (downstream)		
Stenotic Jet and/or Turbulence.	At site of abnormality		
↓ *flow resistance (↓RI). Parvus-tardus pattern.*	Look proximally (upstream)		

Transplant Complications.

- Immediate
  - **Renal vein thrombosis**
  - **Renal artery thrombosis**
  - **Arterial kink**
- Early
  - **Renal vein thrombosis**
  - Acute Tubular Necrosis
  - Rejection
  - Drug toxicity
  - Ureteric issues (breakdown/stenosis)
  - Collections/haematoma
- Late
  - **Renal vascular stenosis**
  - Re-occurrence of original condition.
  - Malignancy
  - Calculi
  - Ureteric stenosis
- Any time
  - Infection
  - Trauma.

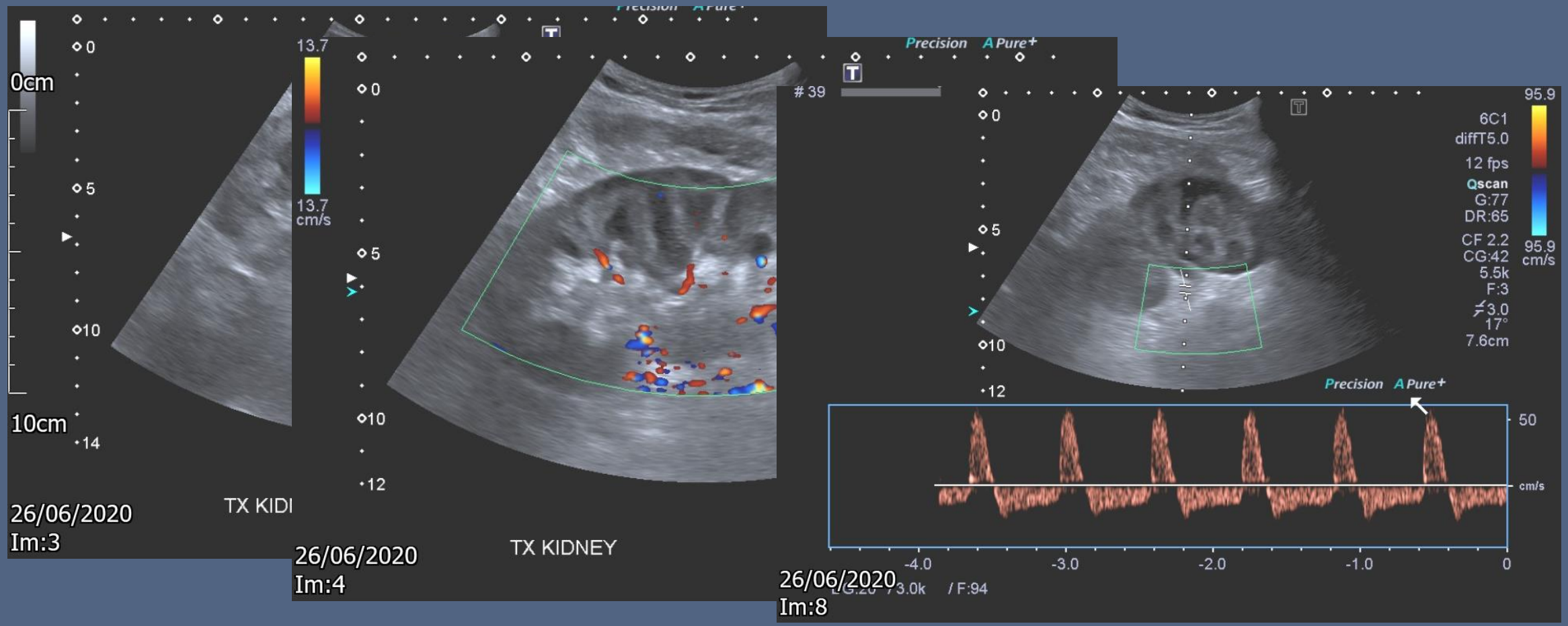
Renal Vein Thrombosis

- Prevalence of 0.1% -4.2%
- Most cases lead to loss of graft
- Several precipitating factors
  - Hypovolaemia
  - Venous Compression from collection
  - Slow flow due to rejection
- Prompt recognition essential

Ultrasound Findings

- Renal enlargement
- Loss of cortico-medullary differentiation
- Diastolic flow reversal of transplant artery
- No flow within the transplant vein.

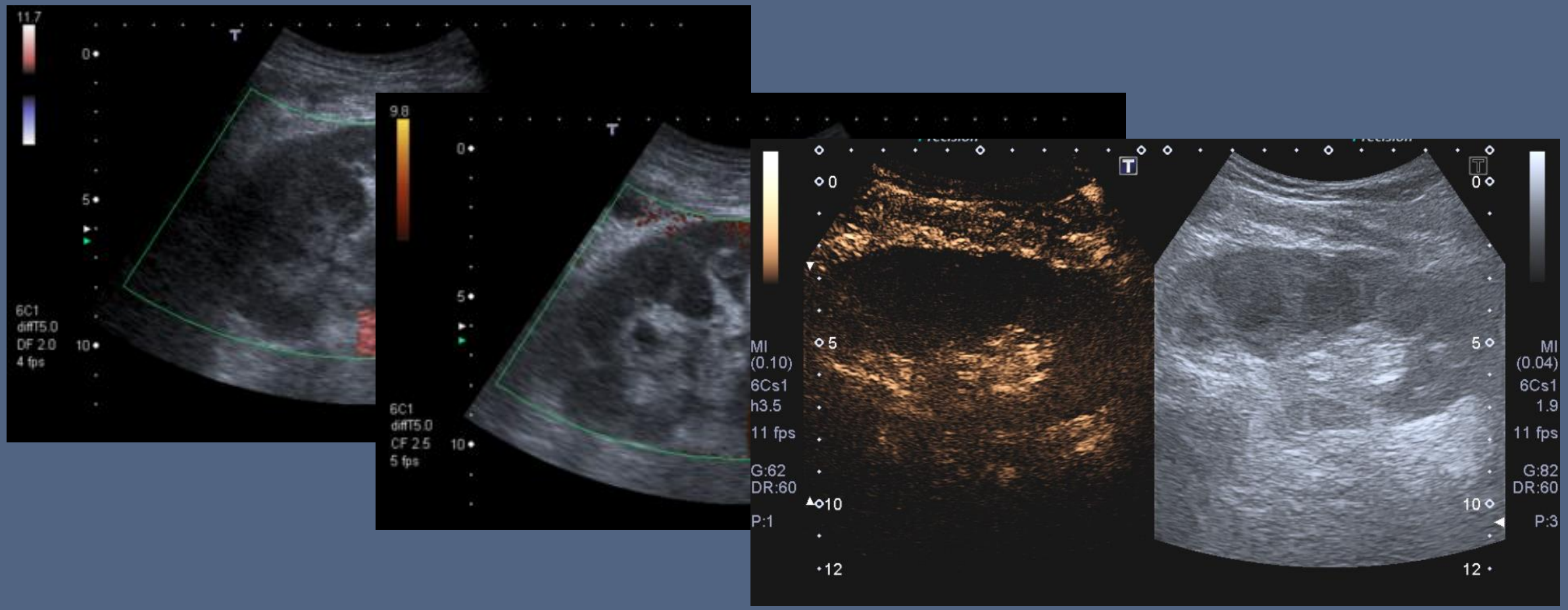
Renal Vein Thrombosis



Renal Artery Thrombosis

- Prevalence approx. 0.4%
- Multiple causes:
  - Hyperacute rejection
  - Anastomotic occlusion
  - Kinking of the renal artery
- May be segmental or global
- Abrupt cessation of urine output

Renal arterial thrombosis



Renal artery stenosis

- Late complication of transplantation
- Affects approx. 3% of renal transplants
- Refractory hypertension +/- graft dysfunction

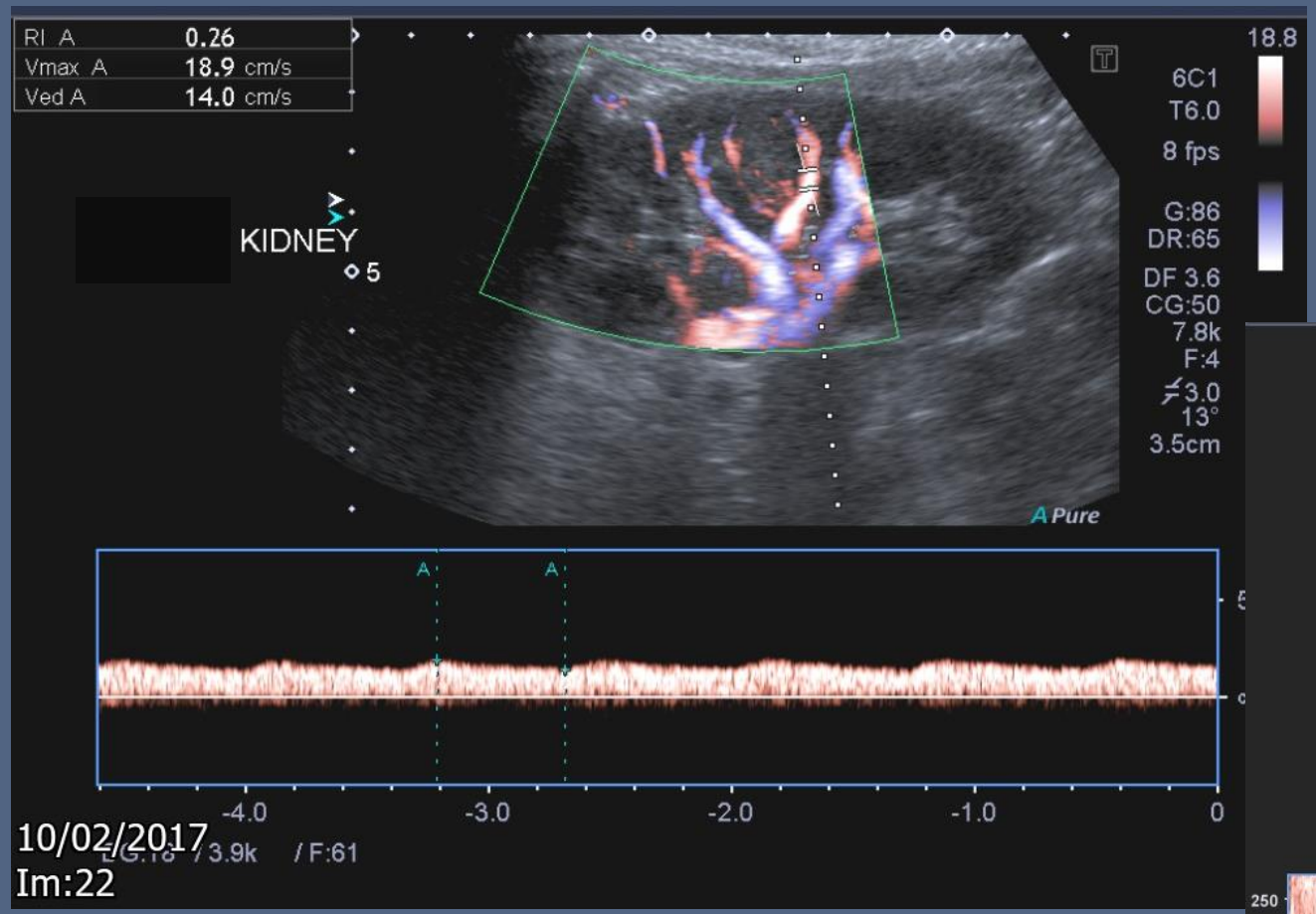
Direct Ultrasound Findings

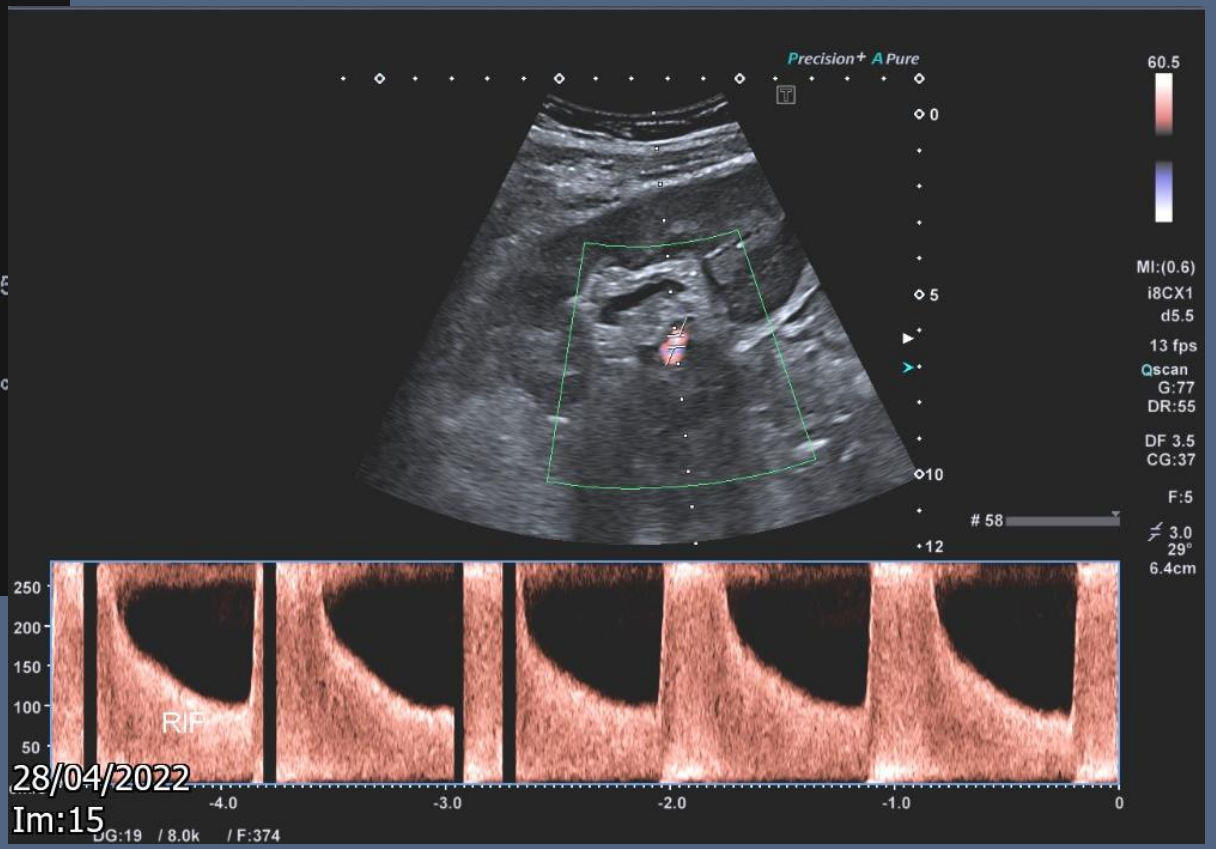
- Peak systolic velocity in main renal artery > 250 cm/s
- External iliac artery to main renal artery ratio > 1.8
- *Figures sensitive but not specific for renal artery stenosis*

Indirect Ultrasound Findings

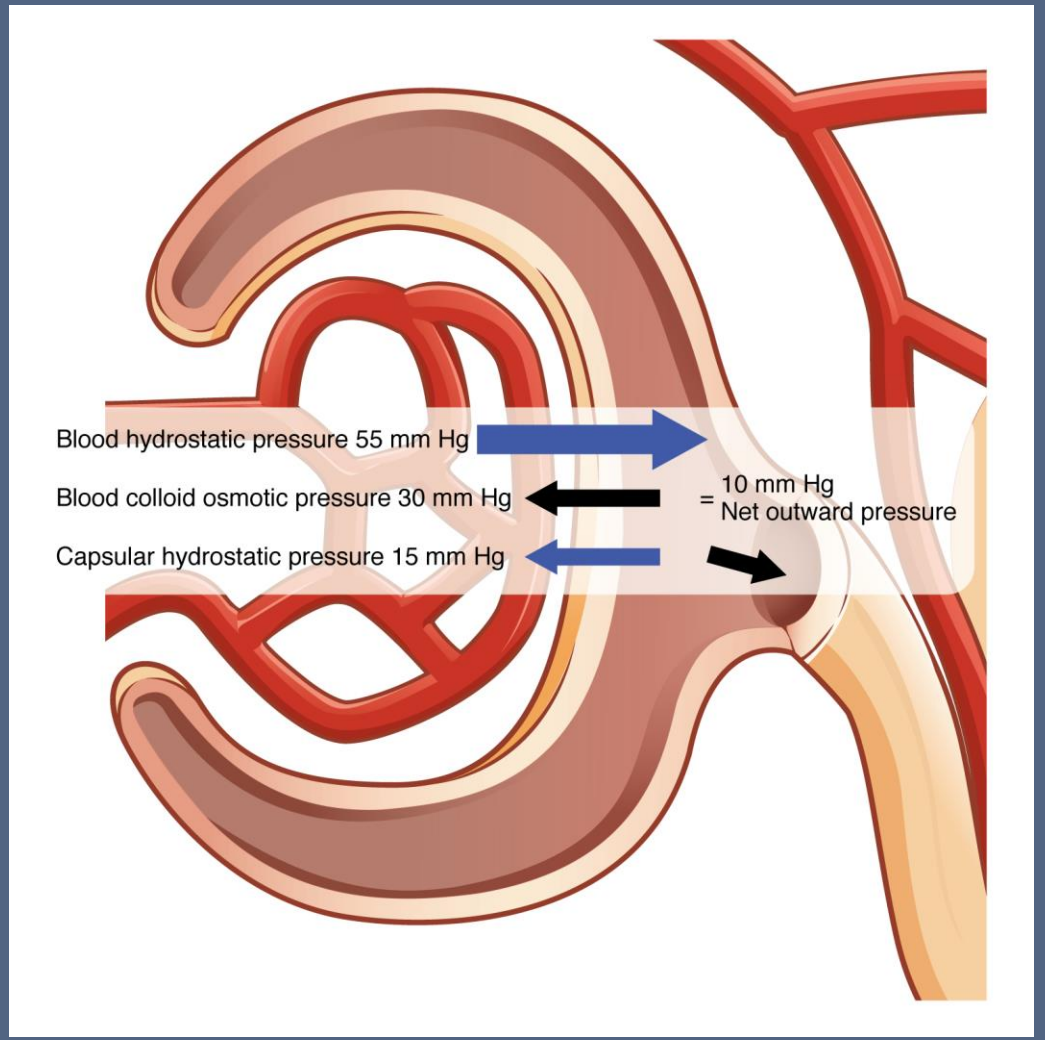
- Intra-renal Parvus-tardus waveform
- Acceleration time > 90ms (sens) >120ms(spec)
- If both direct and indirect signs present US 95% accurate

Renal arterial stenosis



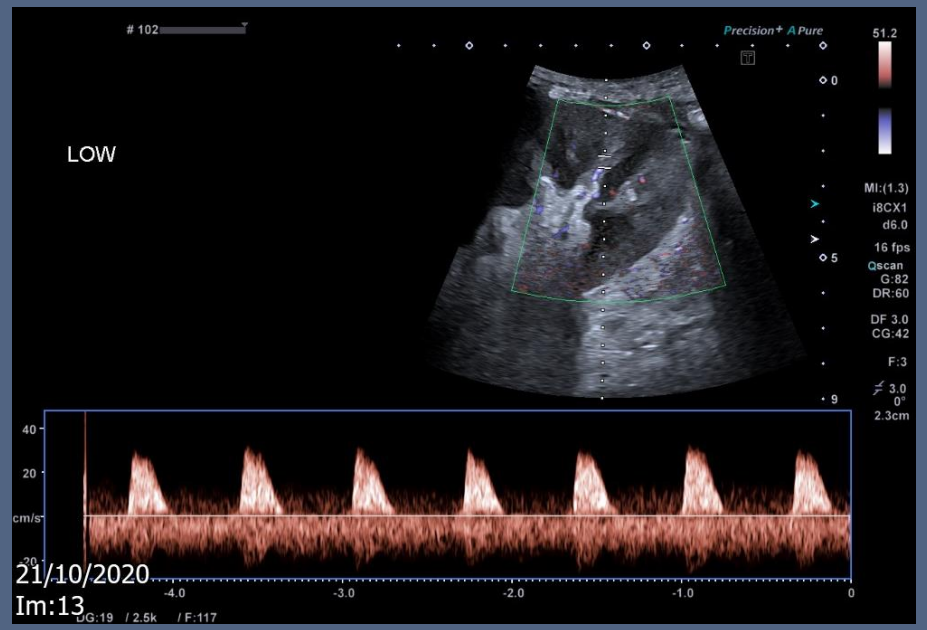


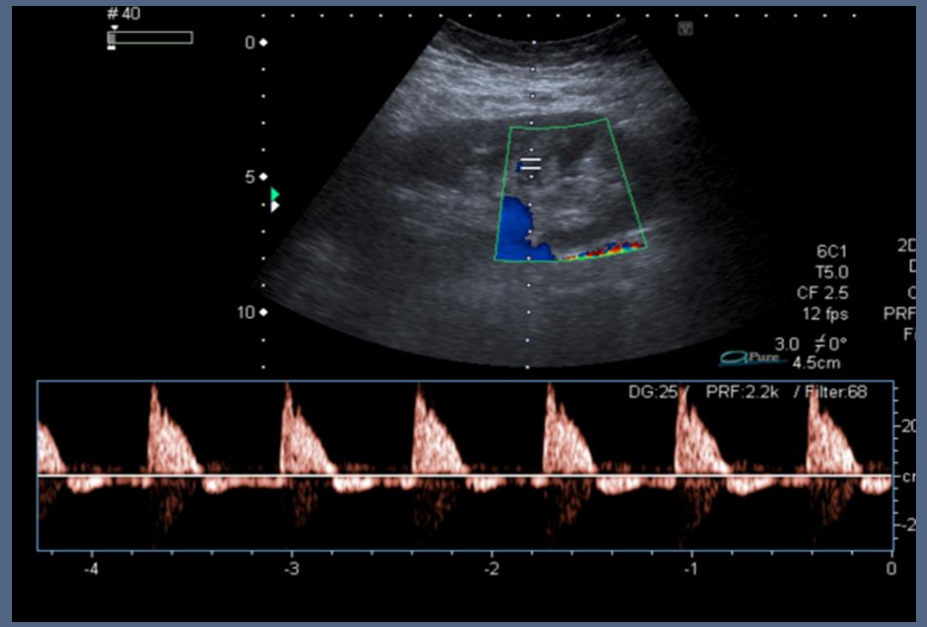
Renal arterial compromise



‘Medical’ complications

- ATN/rejection/drug toxicity
  - Can all have a similar presentation and appearance
  - ATN occurs in up to 20% (cadaveric)
  - Acute rejection in 20-40%
  - RI is non-specific but frequently elevated
  - Diastolic flow can be reversed in severe cases

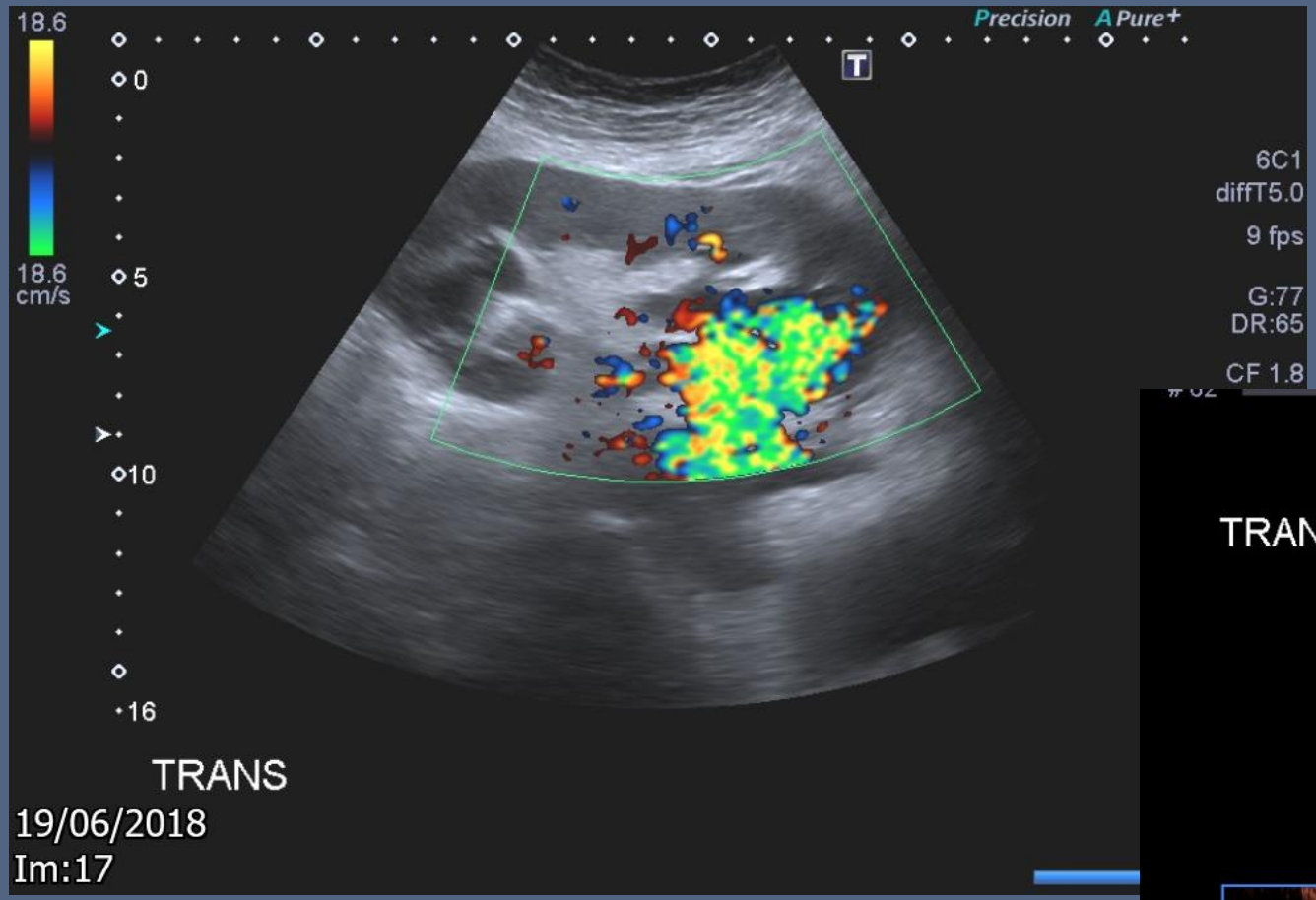




Arterio-Venous Fistula

- Usually post percutaneous transplant biopsy
- Variable incidence (1-18%)
- Most resolve spontaneously
- Selective embolisation an option if persistent haematuria or reduced graft function

Ultrasound Findings
Look for ‘steal’ from the rest of the kidney Look for an area of high velocity with turbulent flow Look for a tissue bruit within the kidney Look for large draining veins, or high velocity in the renal vein


18.6
18.6
cm/s
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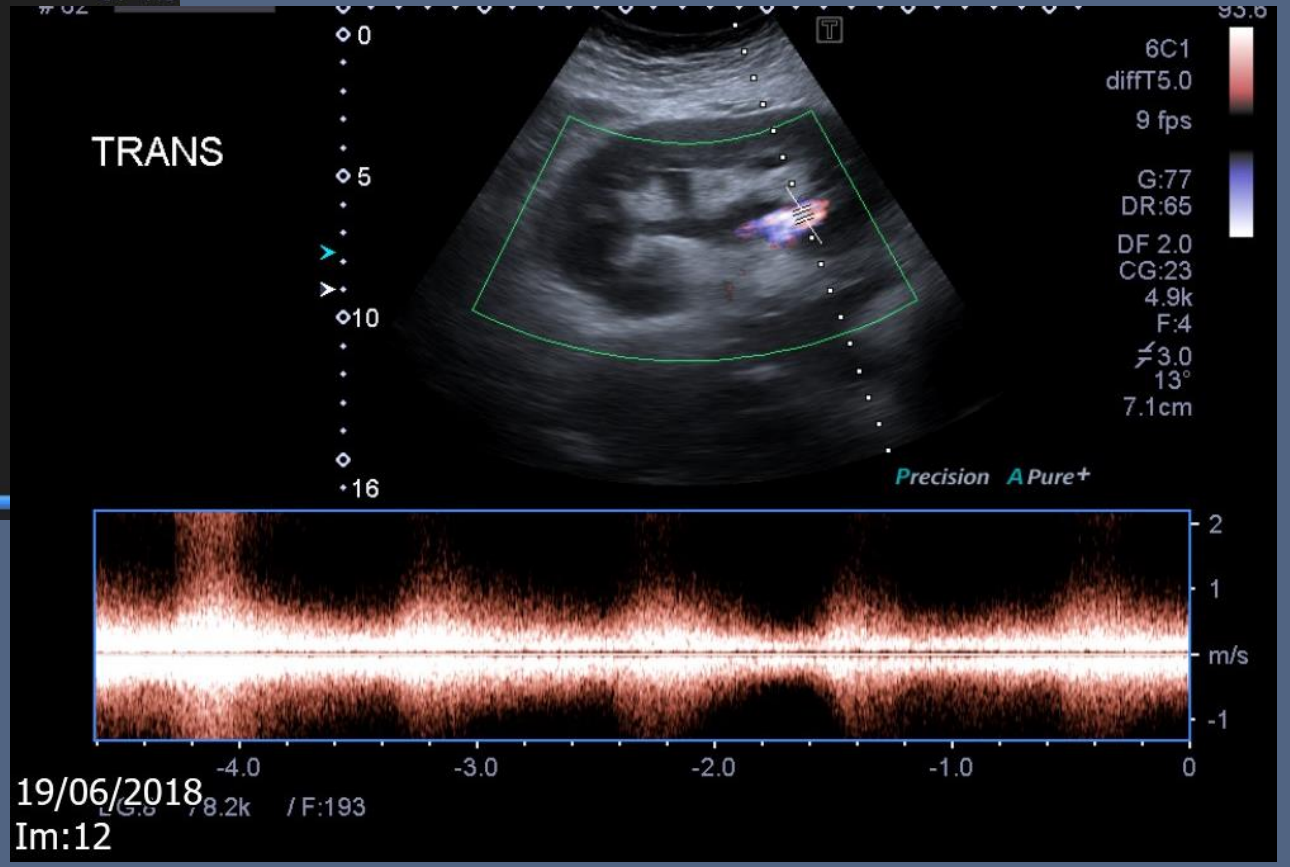
9 fps
G:77
DR:65
CF 1.8
TRANS
19/06/2018
Im:17


TRANS
6C1
diffT5.0
9 fps
G:77
DR:65
DF 2.0
CG:23
4.9k
F:4
3.0
13°
7.1cm
Precision
A Pure+
m/s
2
1
-1
-4.0
-3.0
-2.0
-1.0
0
19/06/2018
Im:12

In Summary:

- Ultrasound is the best modality for monitoring and frequently for guiding management decisions.
- A routine for assessing the transplant is important.
- Both B-mode and Doppler ultrasound important.
- Intra-renal arterial Doppler extremely useful.
- Basic fluid dynamics to problem solve abnormal flow patterns.
- Correlate ultrasound findings with clinical and biochemical findings.