Evaluation of Doppler ultrasound for renal transplant evaluation

ARRS meeting
2011-05-03

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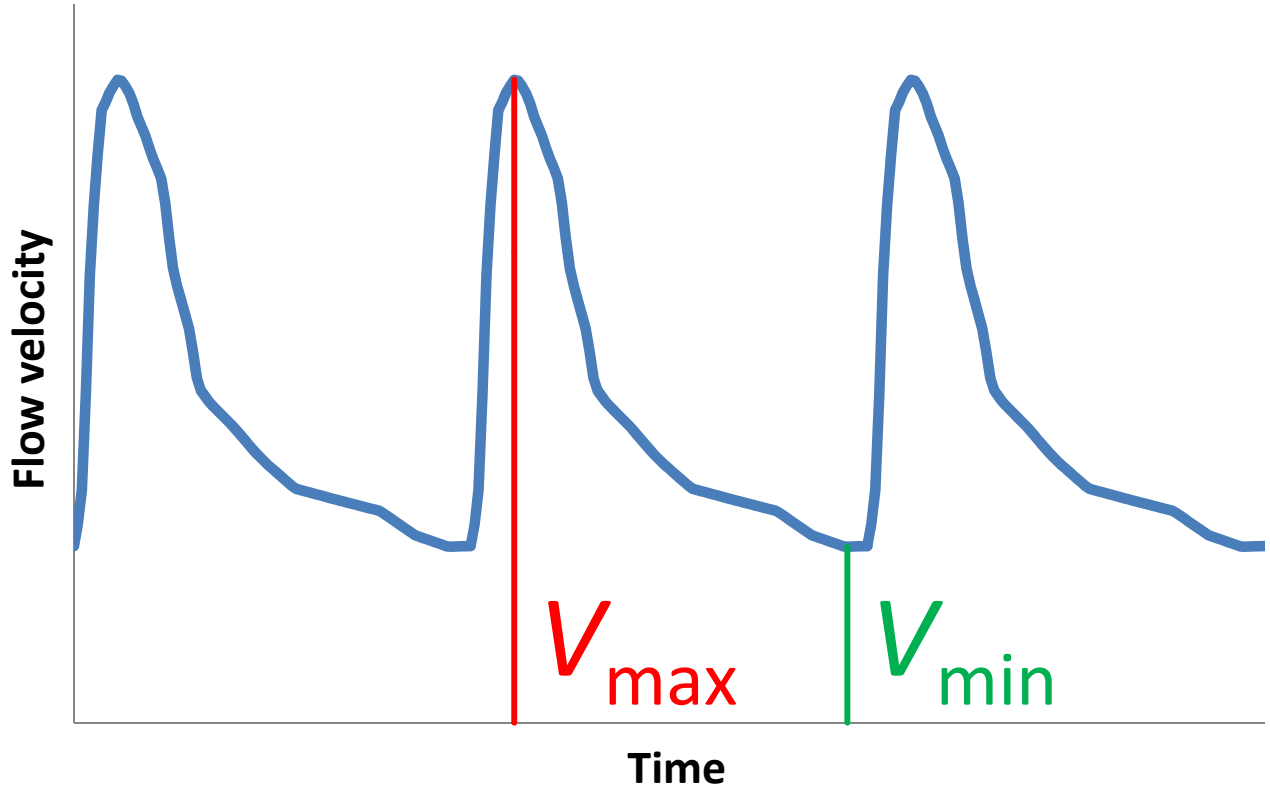
Disclosure of commercial interest

Neither I nor my immediate family members have a financial relationship with a commercial organization that may have a direct or indirect interest in the content.

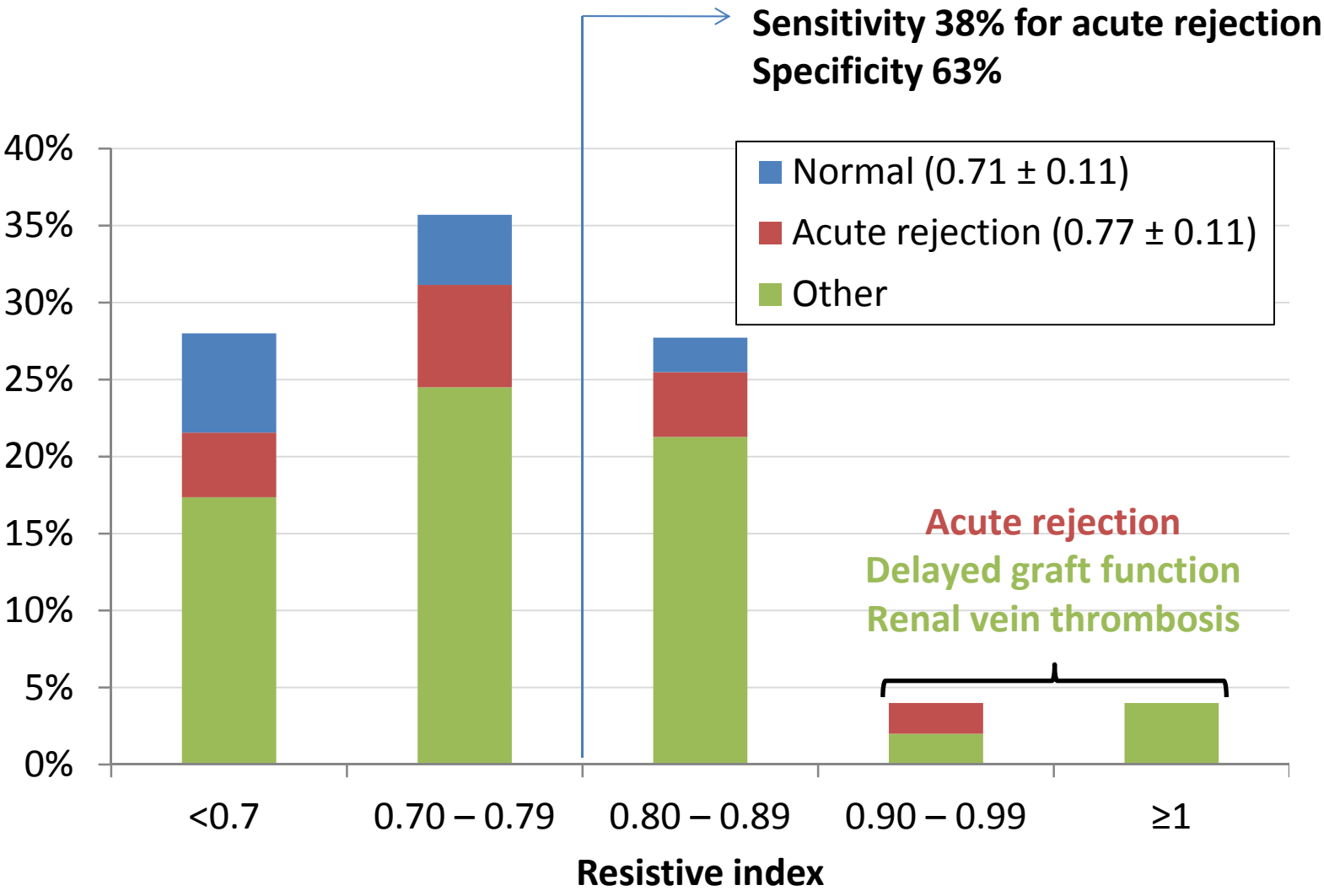
Diagnoses

Diagnosis	Number of patients
1. Normal, with creatinine ≤ 1.5	7
2. Delayed graft function post-operatively	6
3. Acute rejection	8
4. Chronic rejection, transplant glomerulopathy, or drug toxicity, creatinine > 1.5	5
5. Hydronephrosis	5
6. Renal vein thrombosis	2
7. Other	14
Total	47

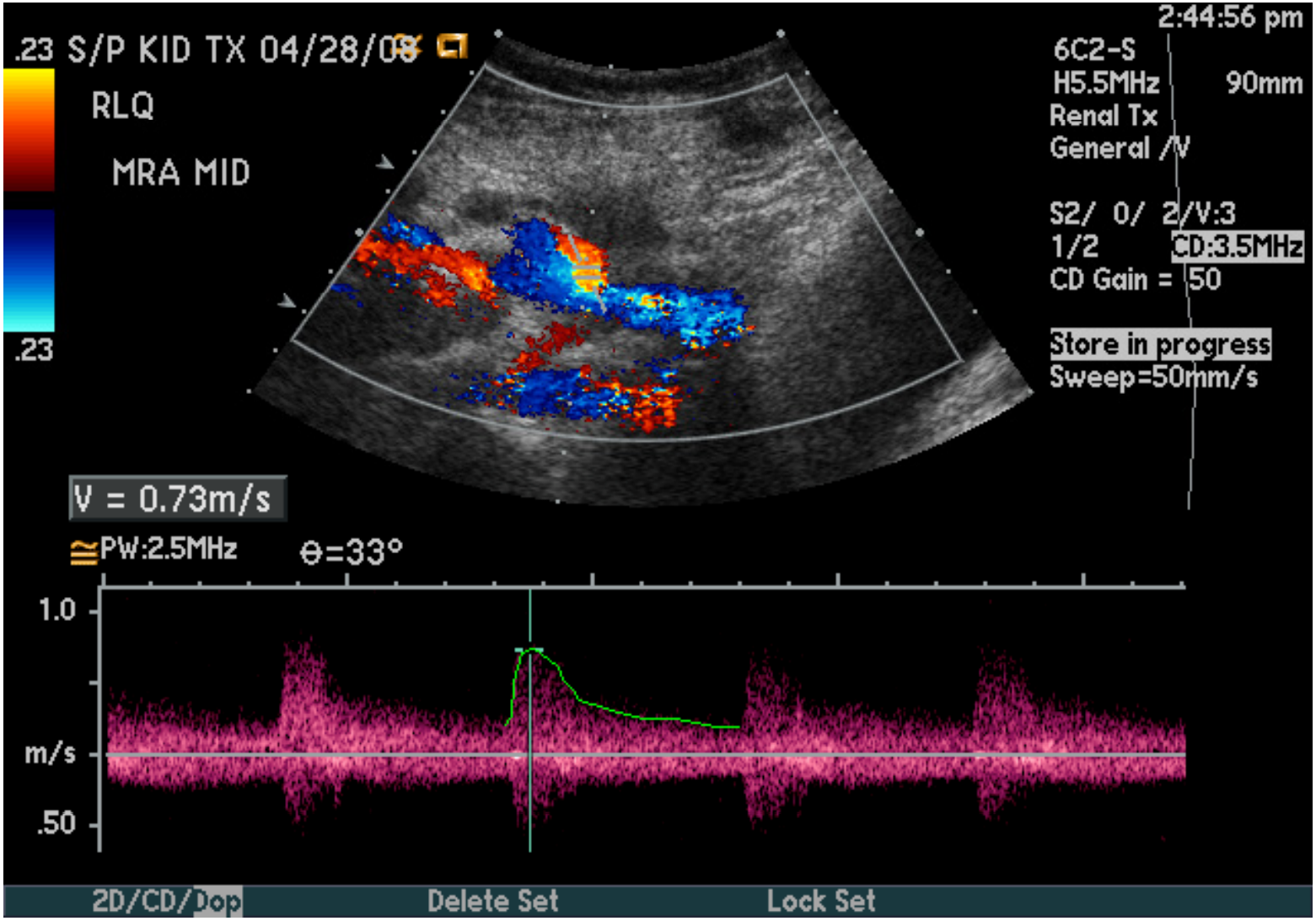
Resistive index = (V_{max}–V_{min})/V_{max}



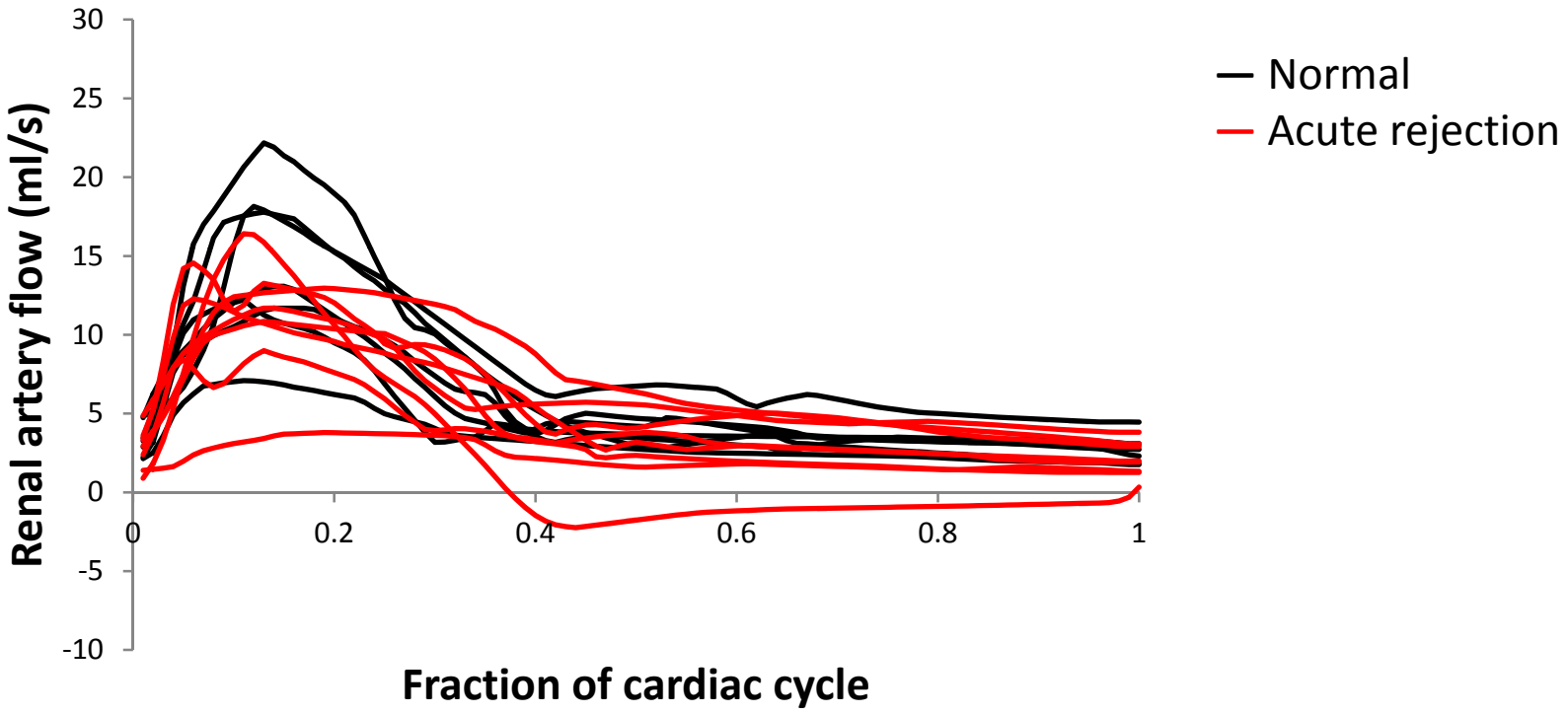
Resistive index



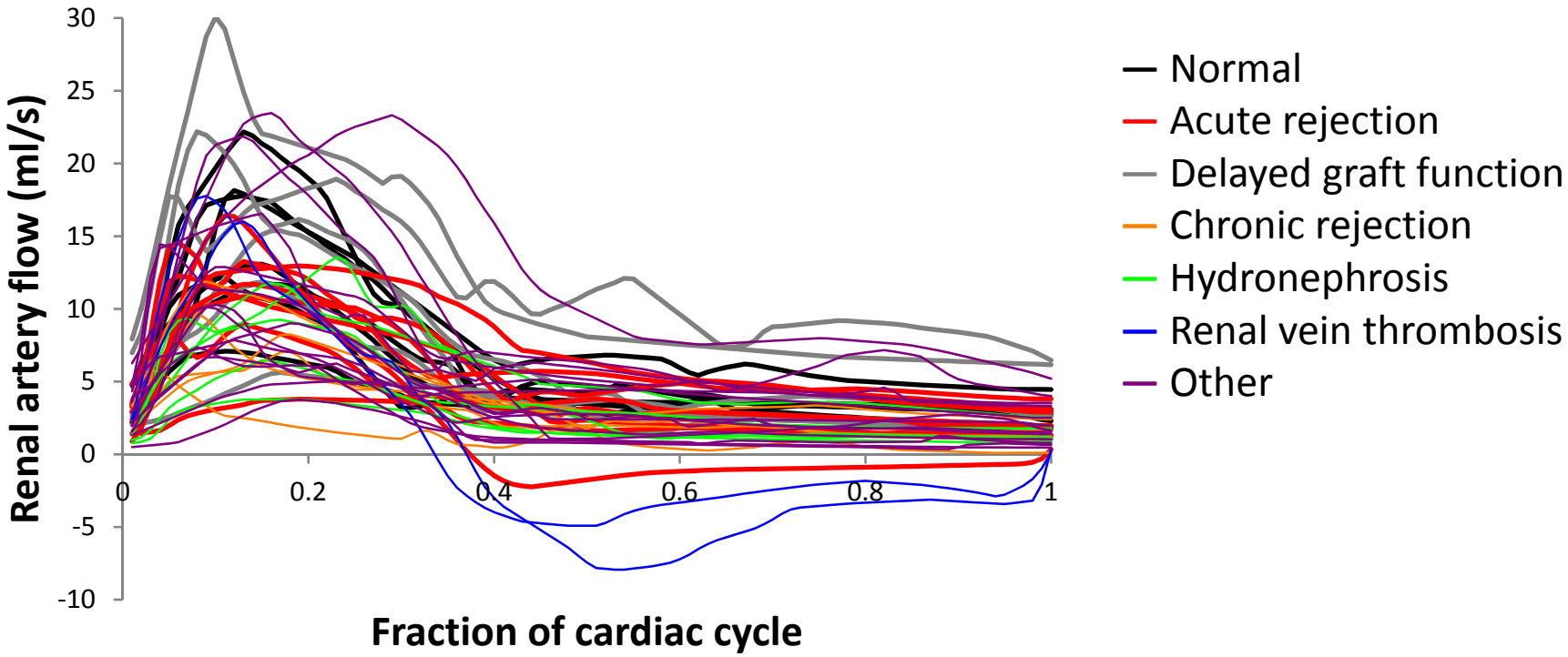
Mid renal artery velocity waveform



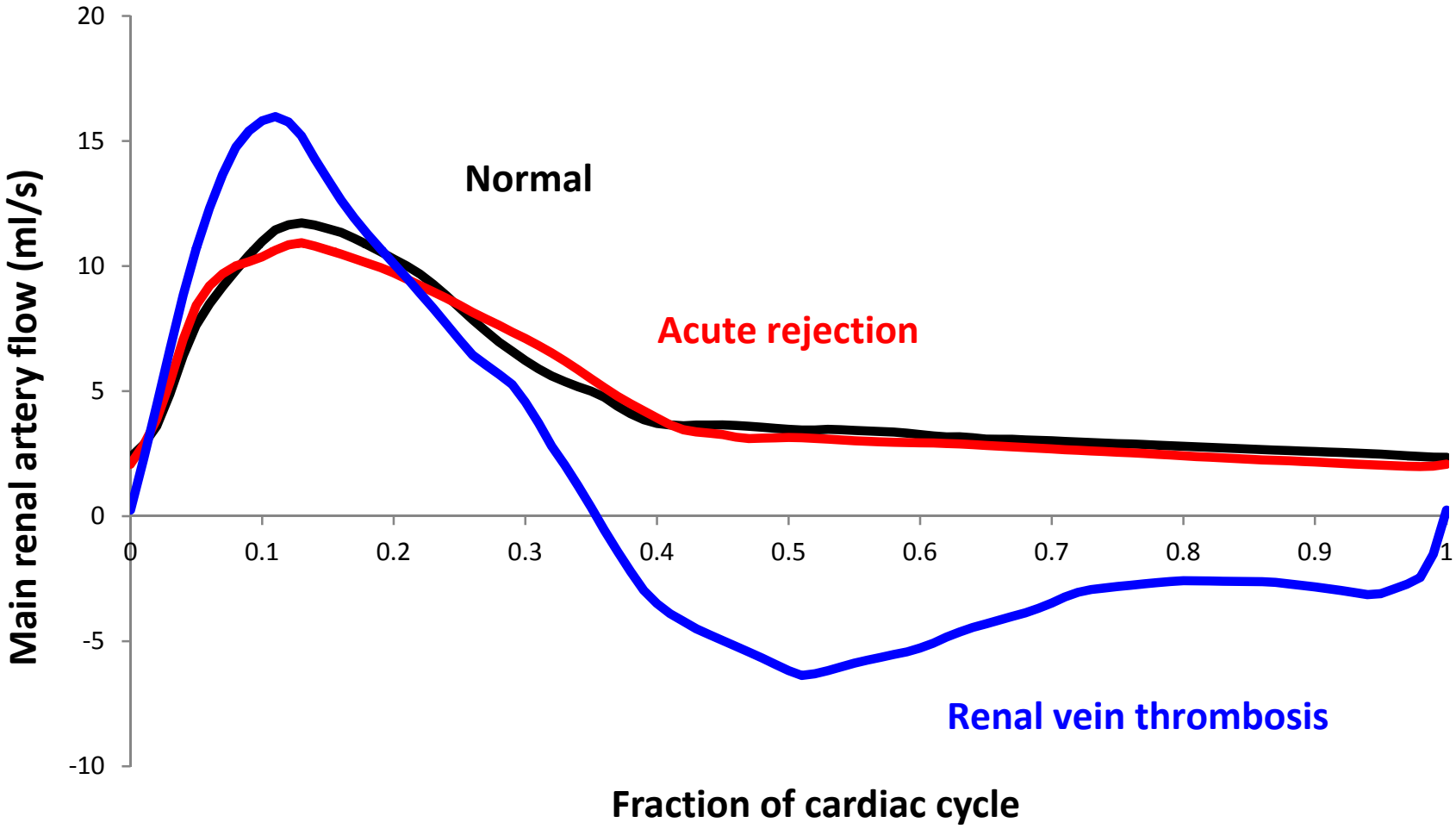
Velocity waveforms



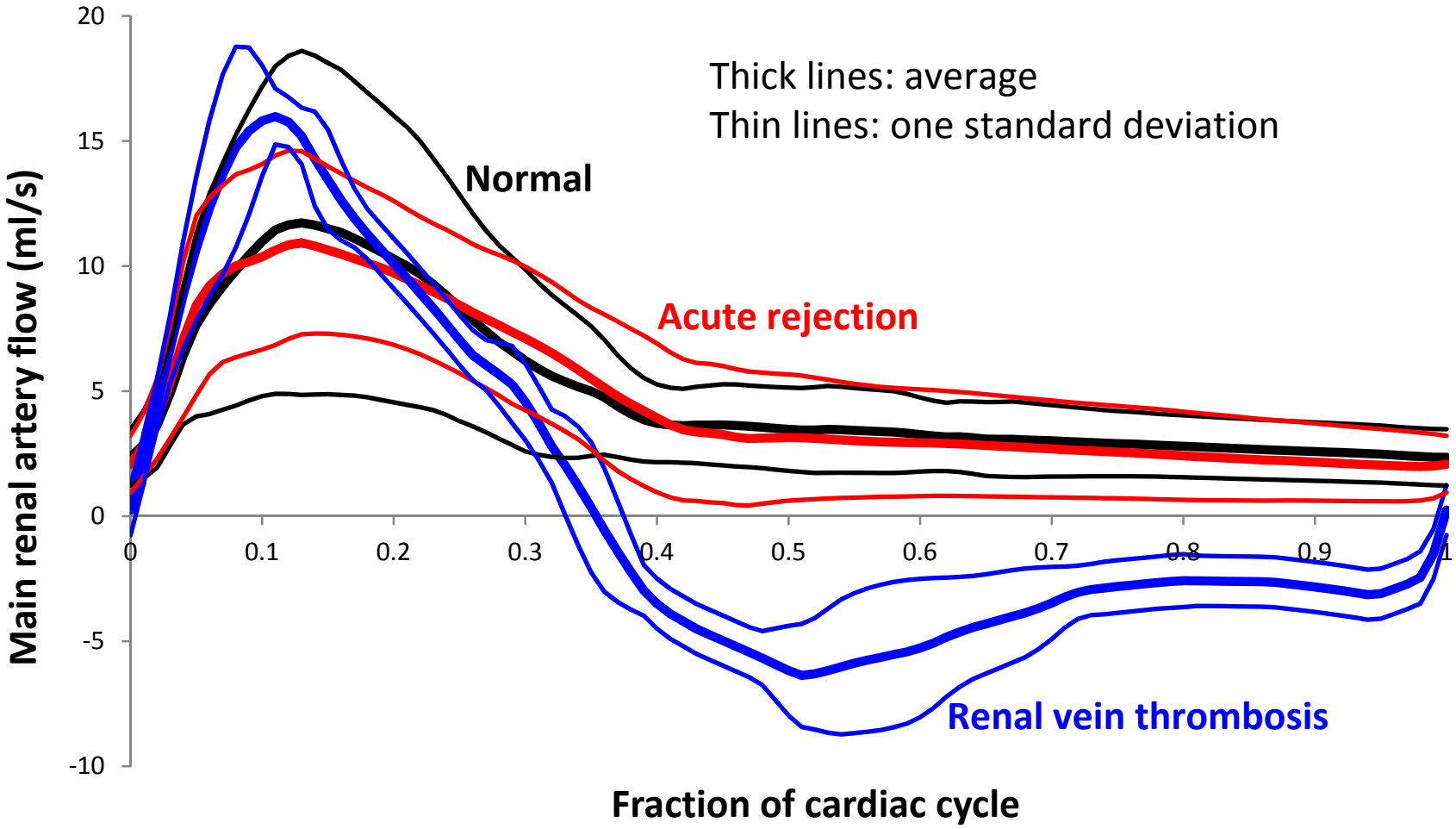
Velocity waveforms



Velocity waveforms (average)

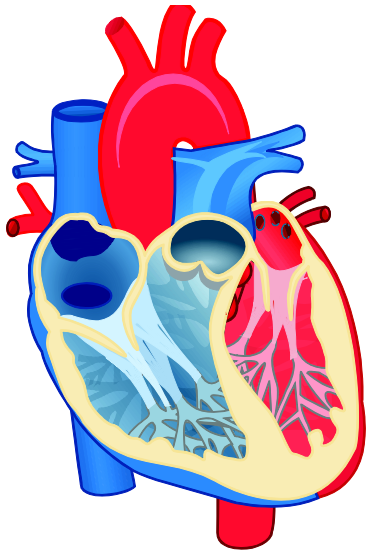


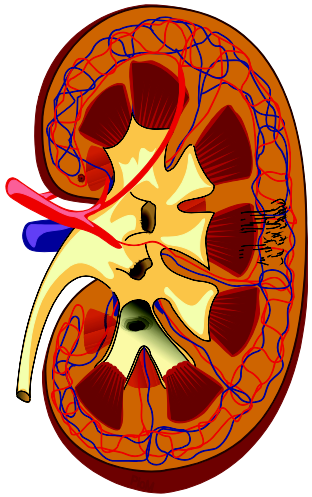
Velocity waveforms (Average ± stdev)



Windkessel model

Systole





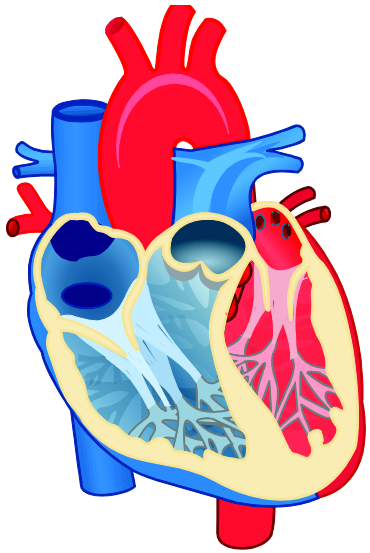
Pulsatile pump

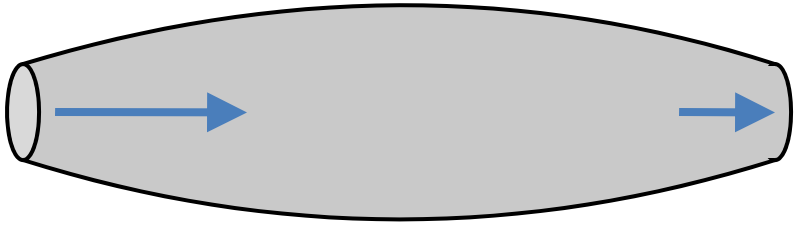
Continuous capillary flow

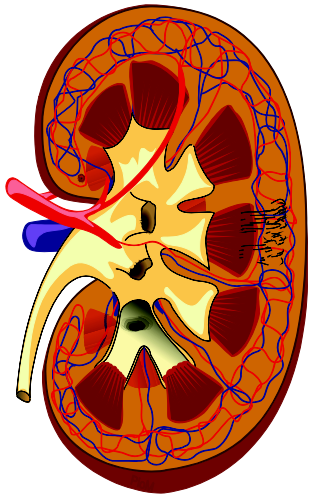
Image credits: Piotr Michał Jaworski (kidney) and User ZooFari on Wikipedia (heart). Creative Commons Attribution-Share Alike 3.0 Unported license.

Windkessel model

Systole







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Windkessel model

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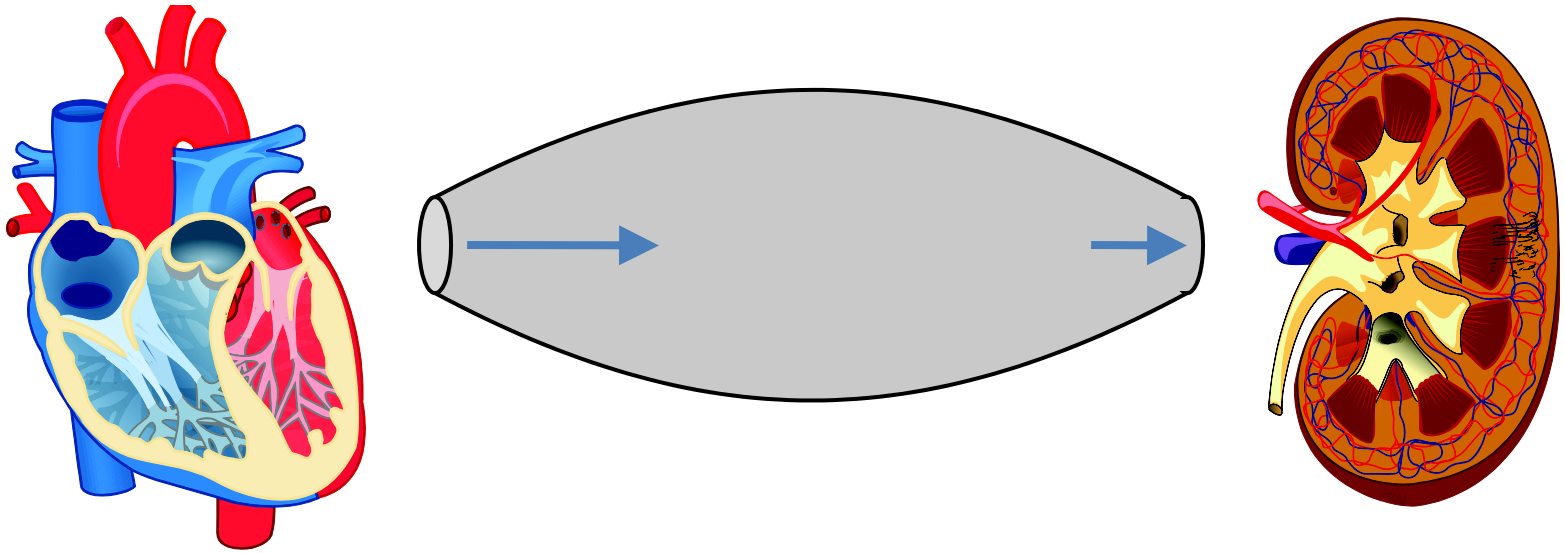

Pulsatile pump

Continuous capillary flow

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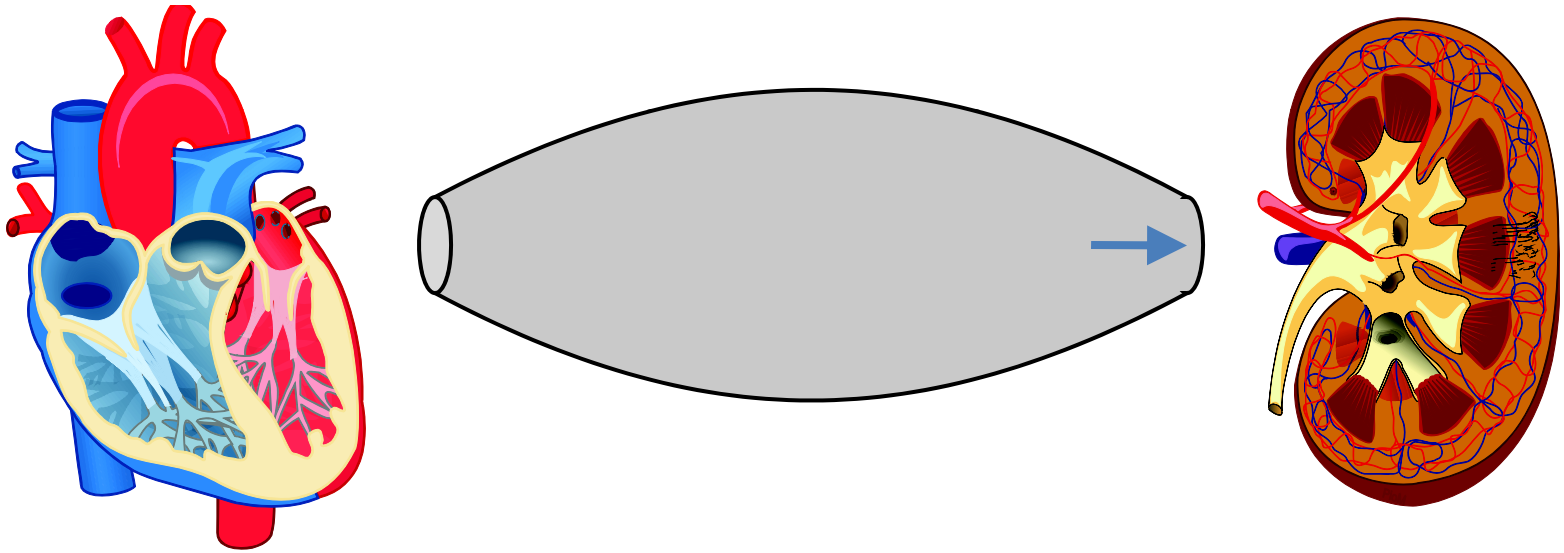
Windkessel model

Diastole



Pulsatile pump

Continuous capillary flow

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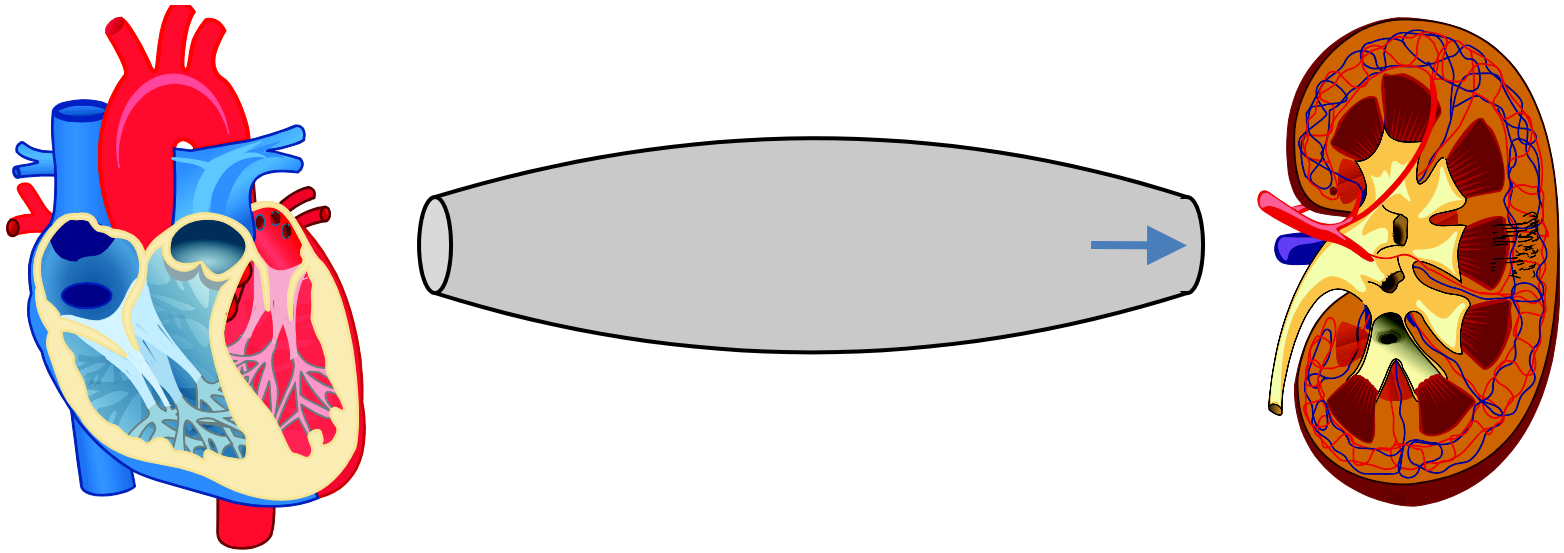
Windkessel model

Diastole



Pulsatile pump

Continuous capillary flow

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Windkessel model

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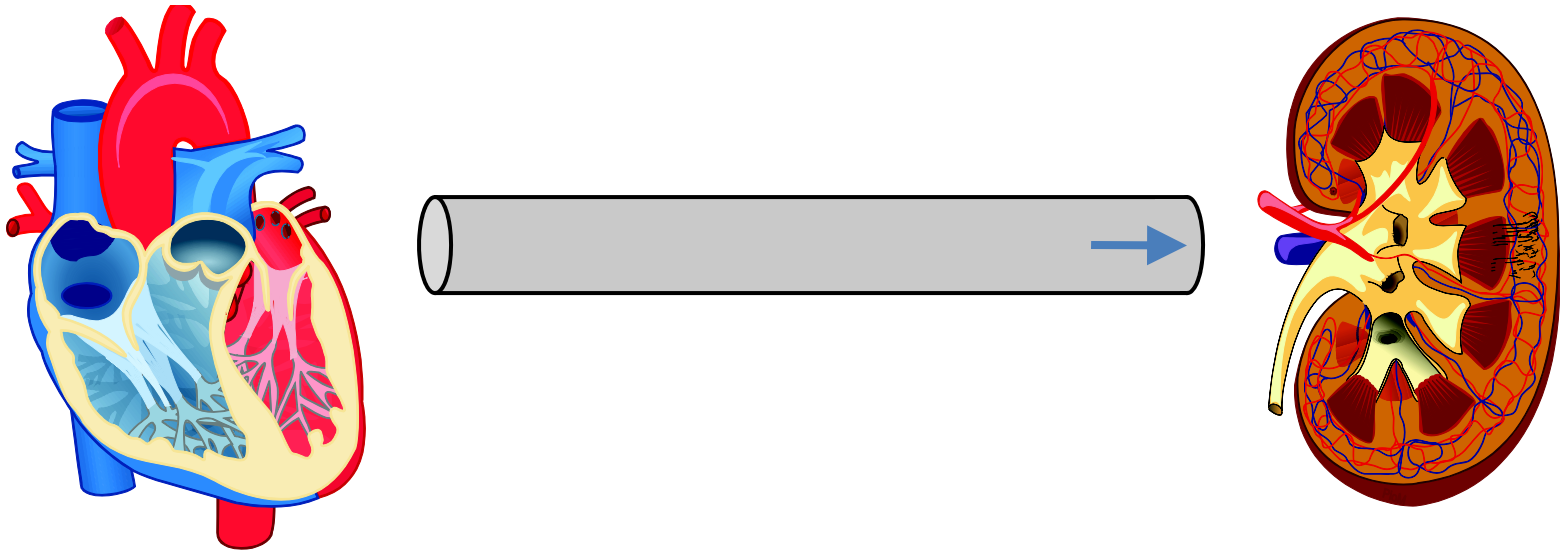

Pulsatile pump

Continuous capillary flow

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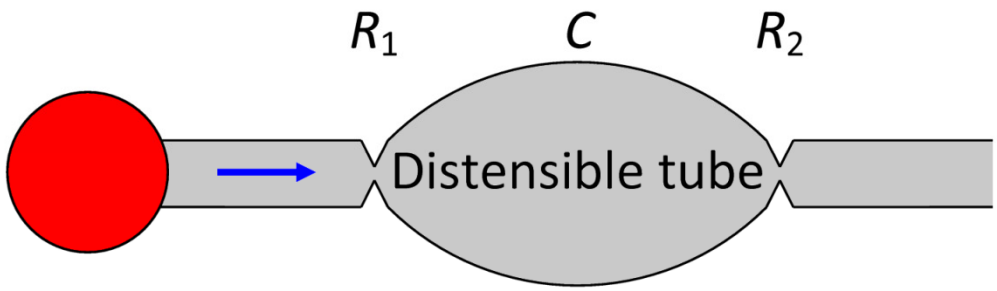
3-element Windkessel model

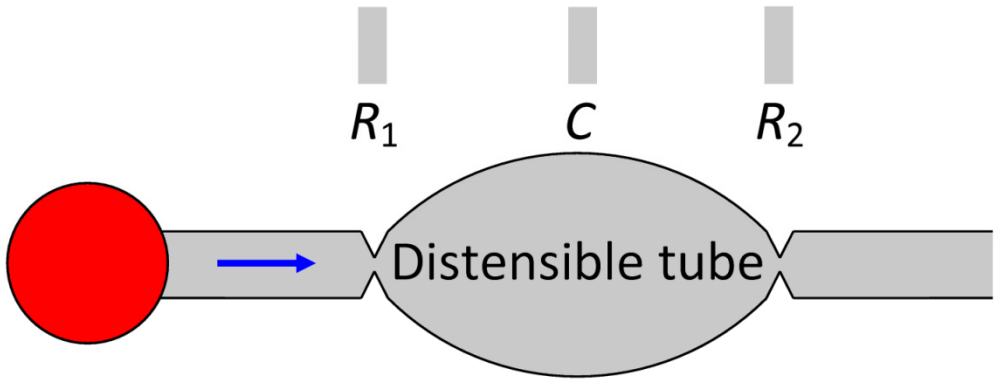


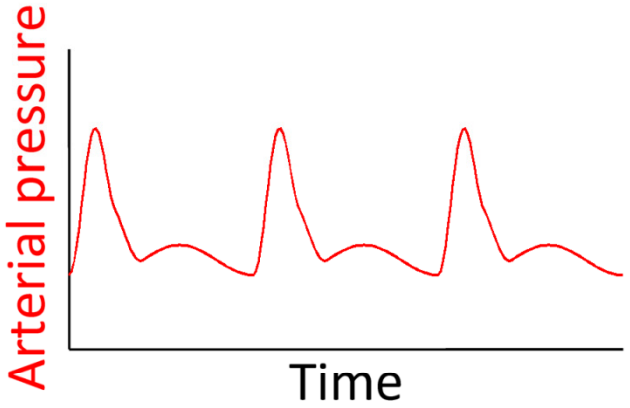
R_1 Pre-glomerular resistance (renal artery)

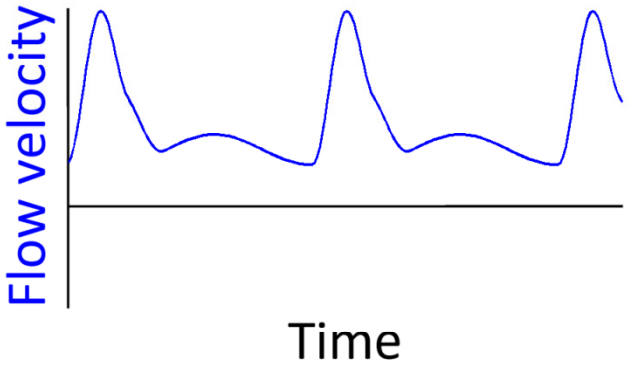
C Vascular compliance

R_2 Post-glomerular resistance (renal vein)

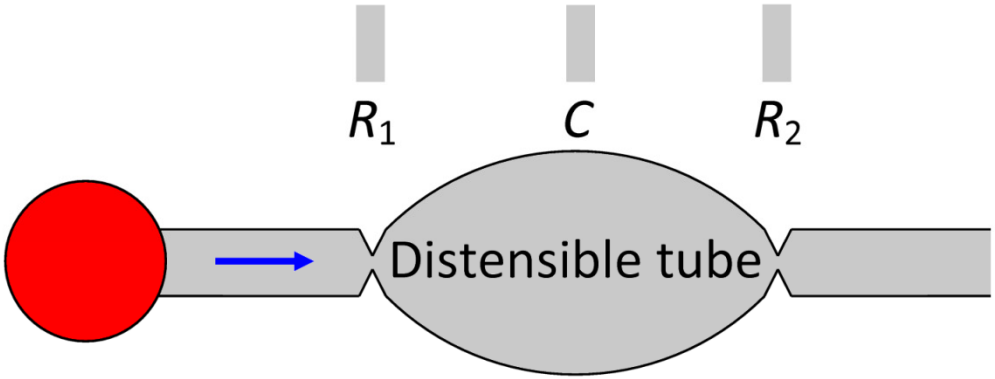
3-element Windkessel model

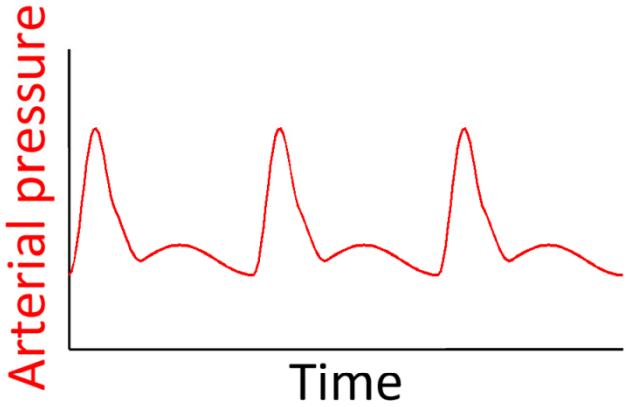


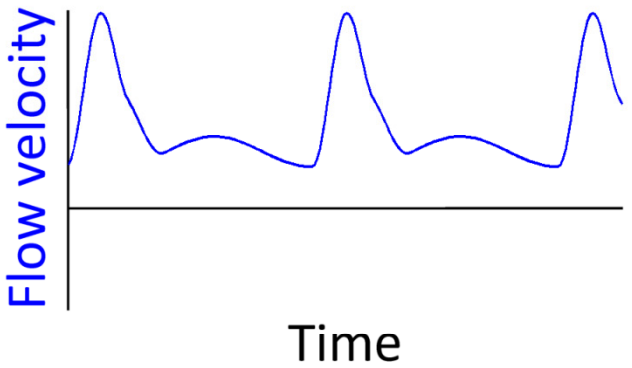




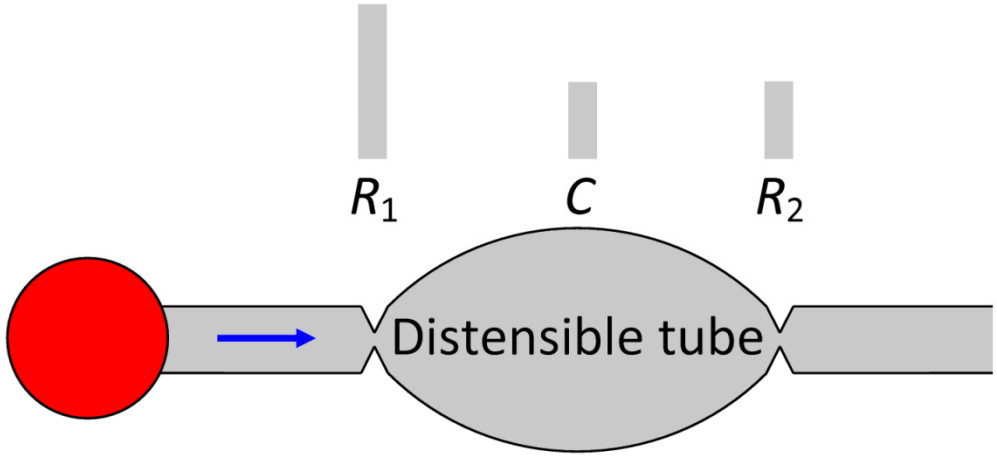
Normal

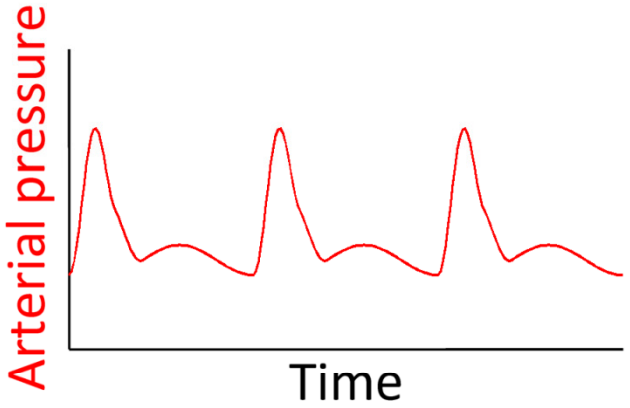

R_1
C
R_2
Distensible tube

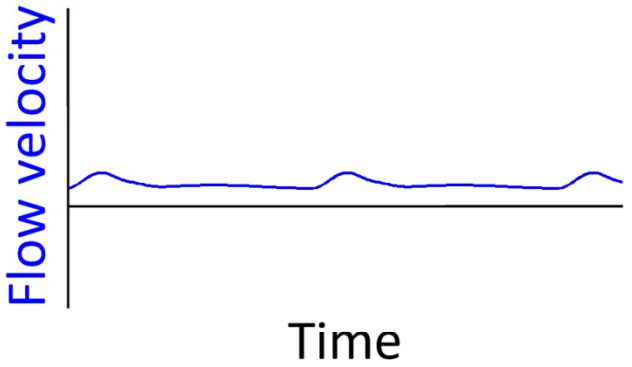

Arterial pressure
Time


Flow velocity
Time

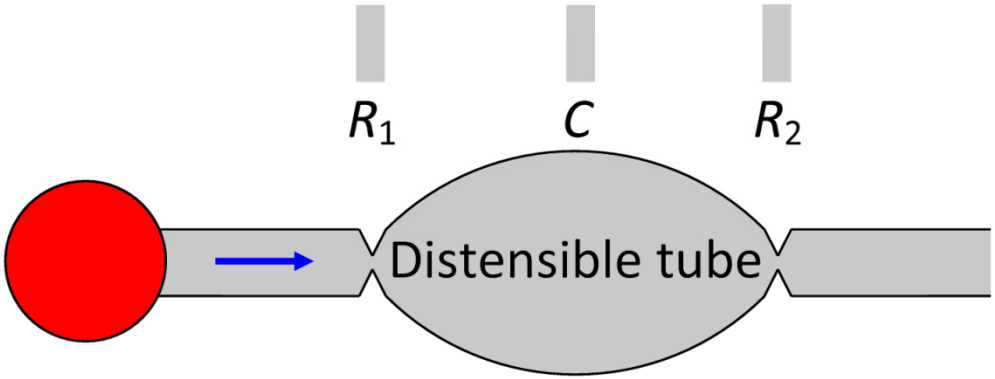
High R_1

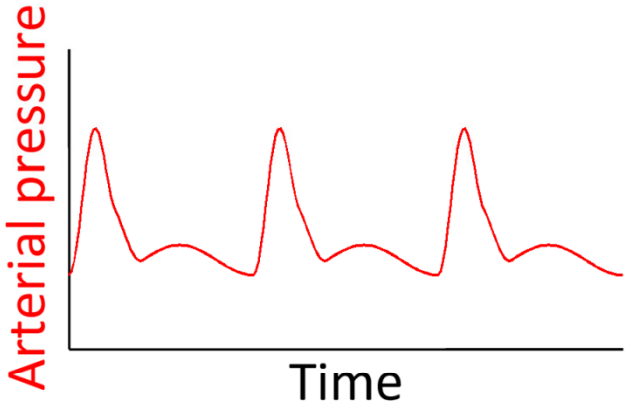

R_1
C
R_2
Distensible tube

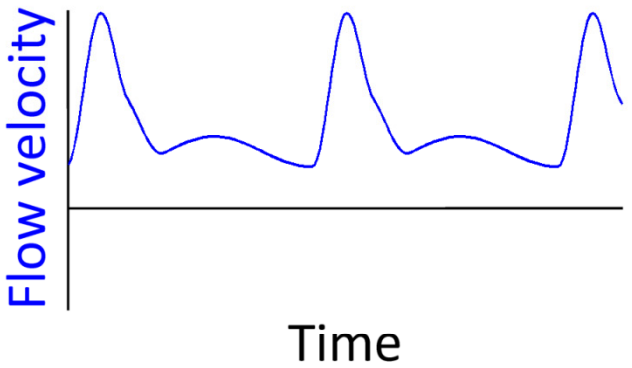

Arterial pressure
Time


Flow velocity
Time

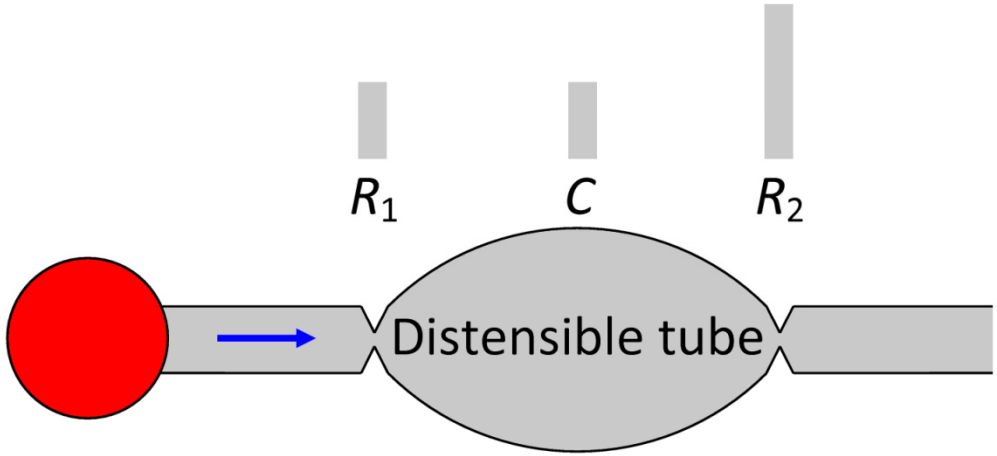
Normal

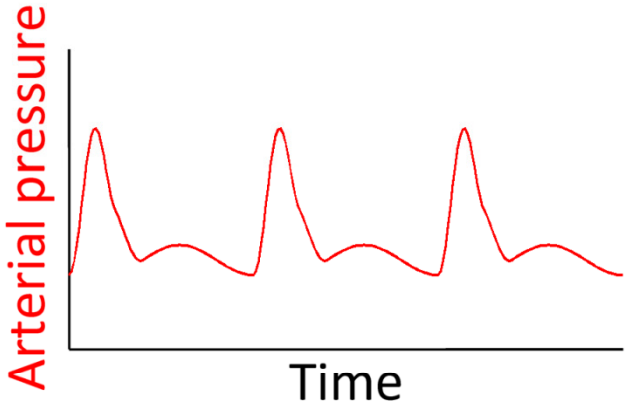

R_1
C
R_2
Distensible tube

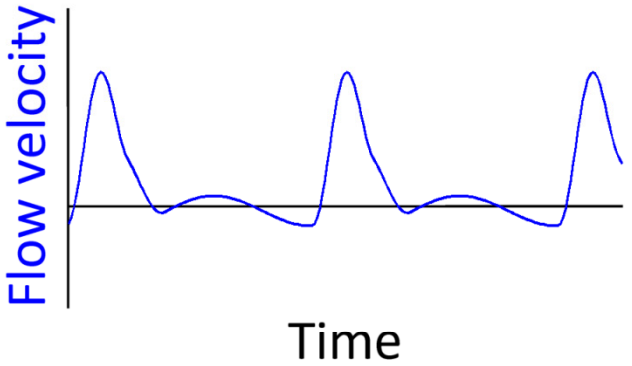

Arterial pressure
Time


Flow velocity
Time

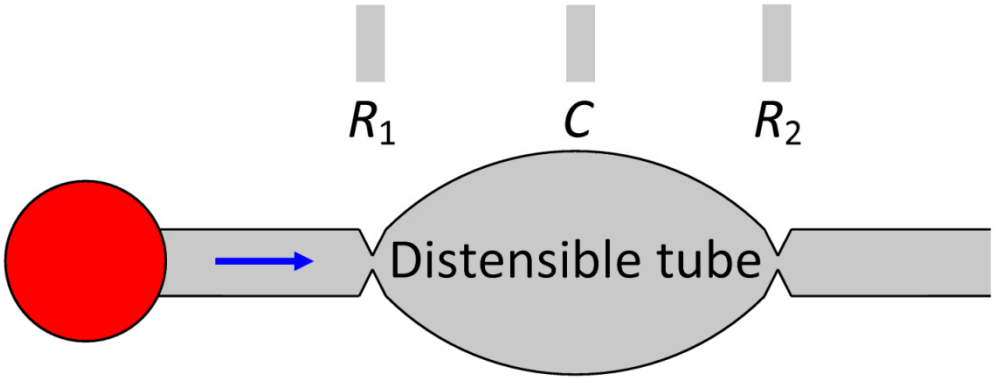
High R_2

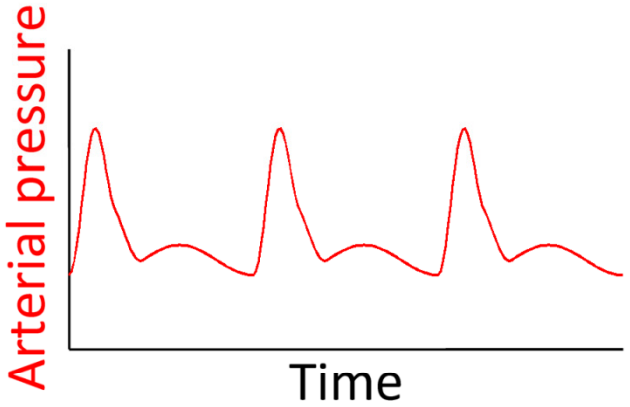

R_1
C
R_2
Distensible tube

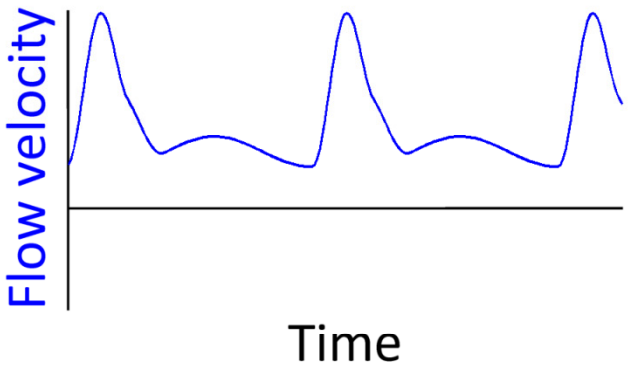

Arterial pressure
Time


Flow velocity
Time

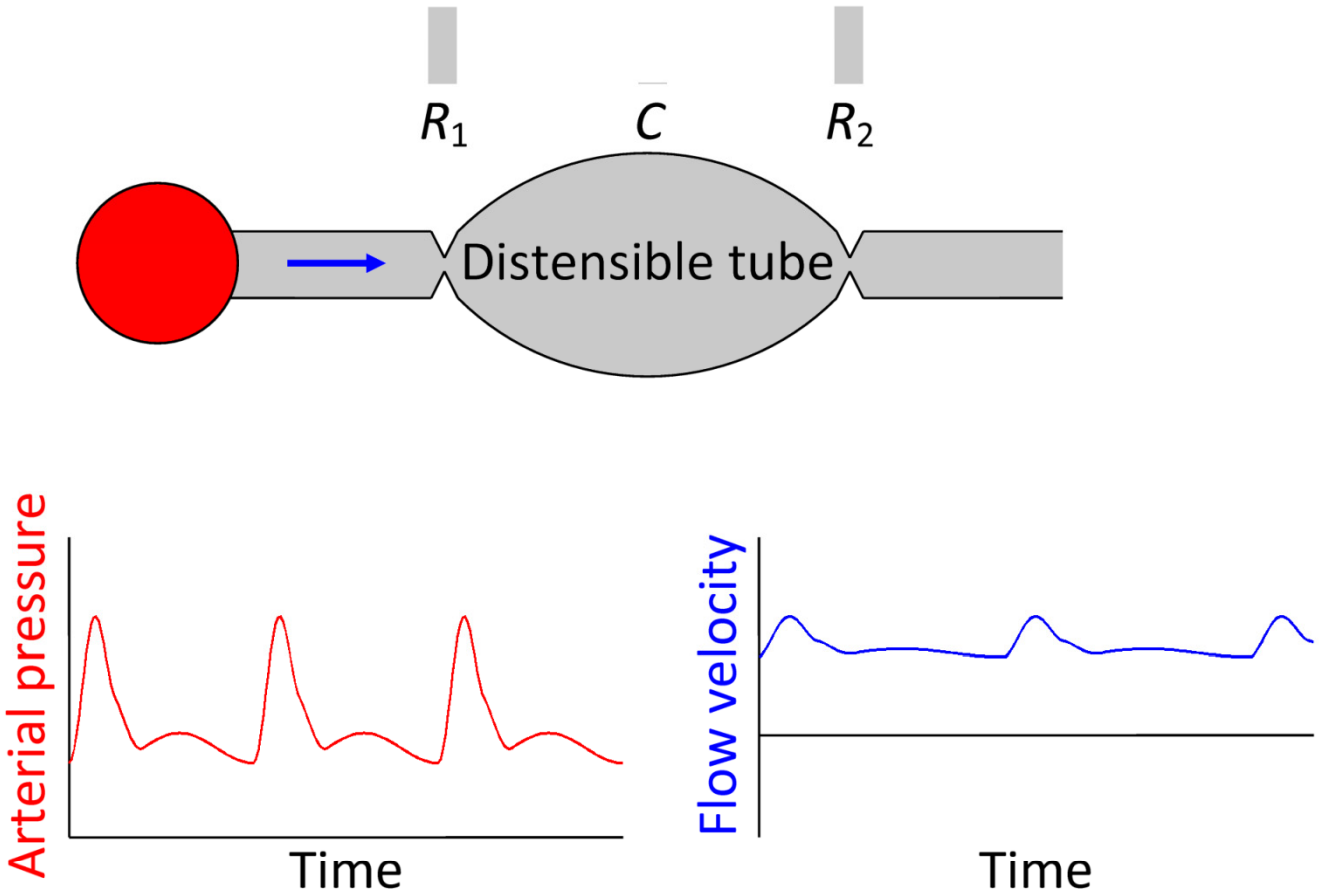
Normal


R_1
C
R_2
Distensible tube

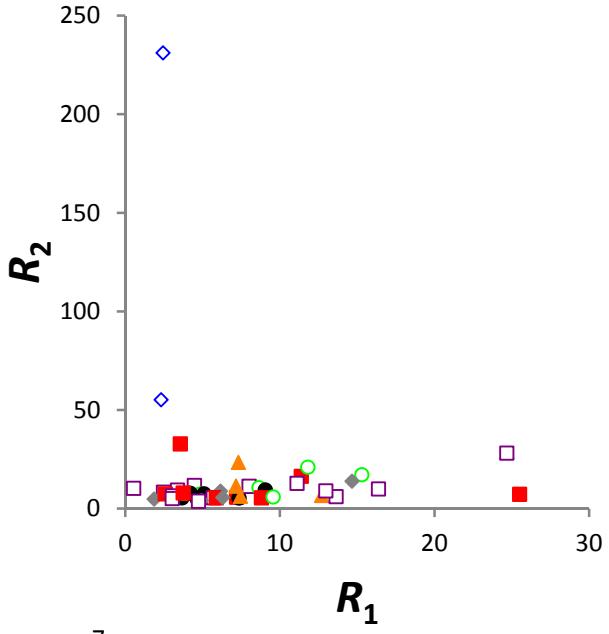

Arterial pressure
Time

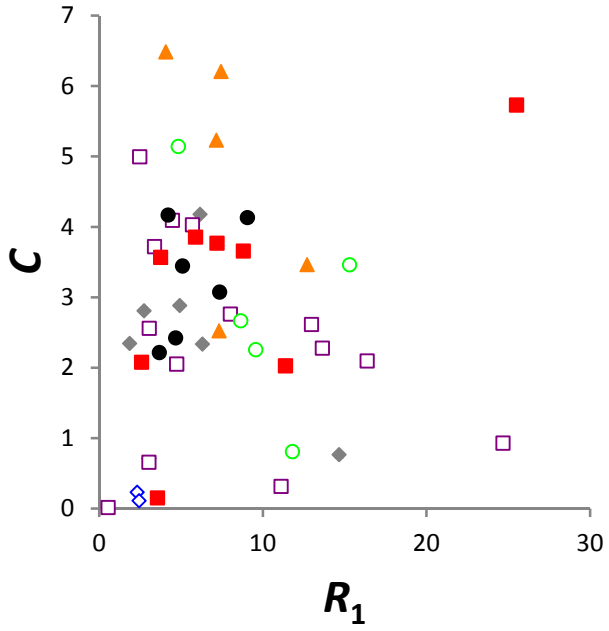

Flow velocity
Time

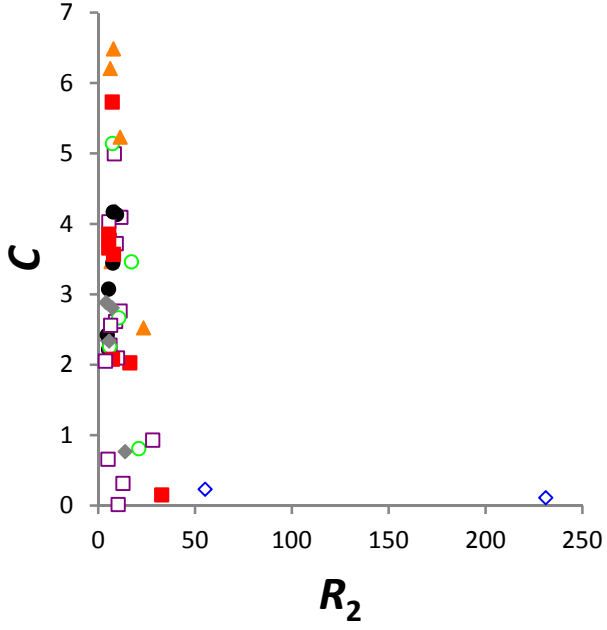
Low *C*

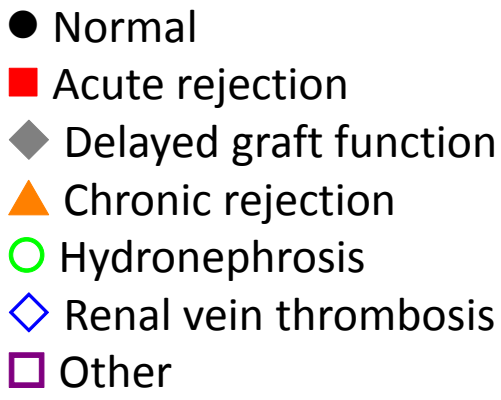

R_1
C
R_2
Distensible tube
Arterial pressure
Time
Flow velocity
Time

3-element Windkessel model

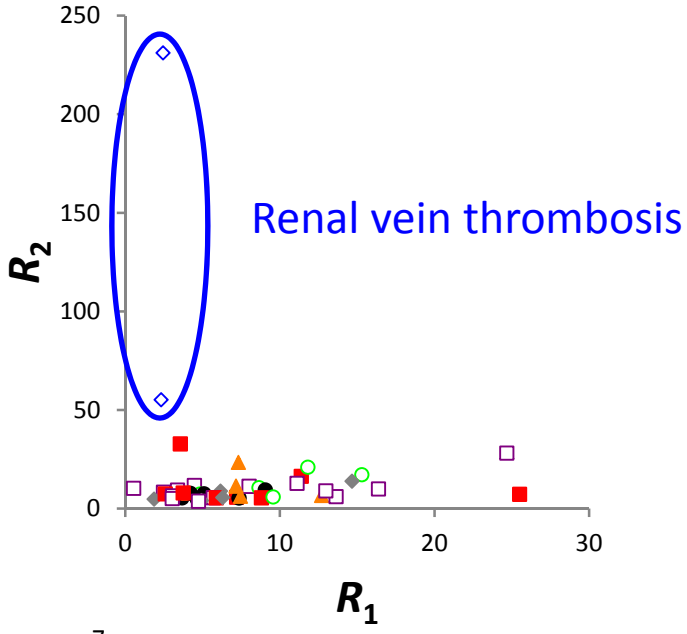


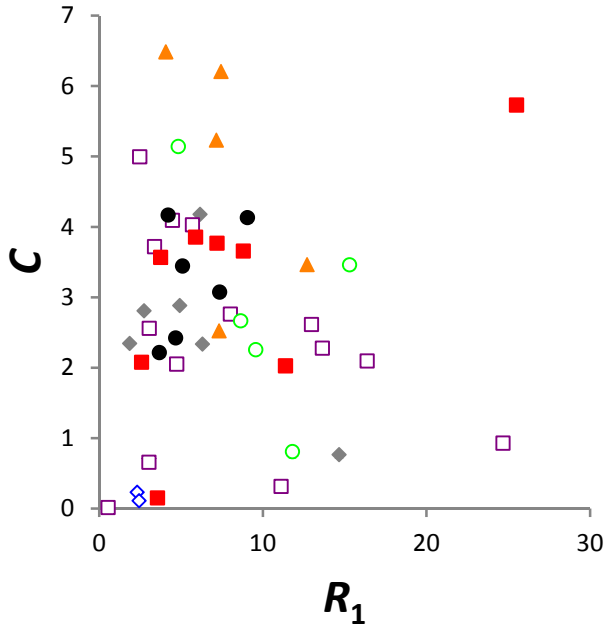


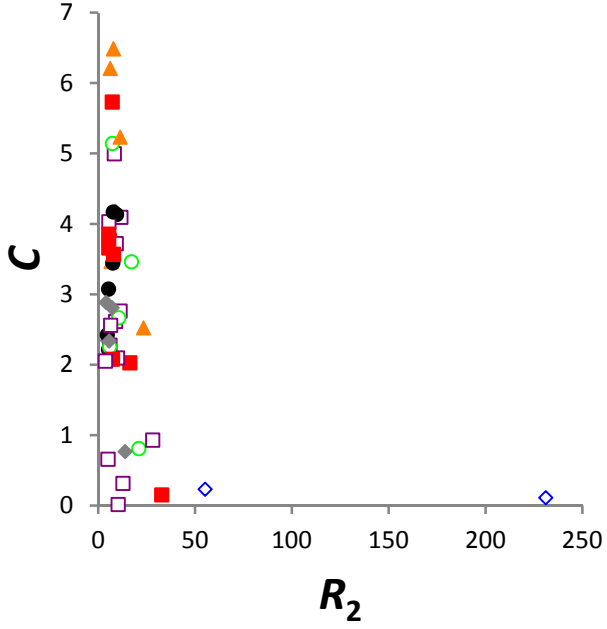


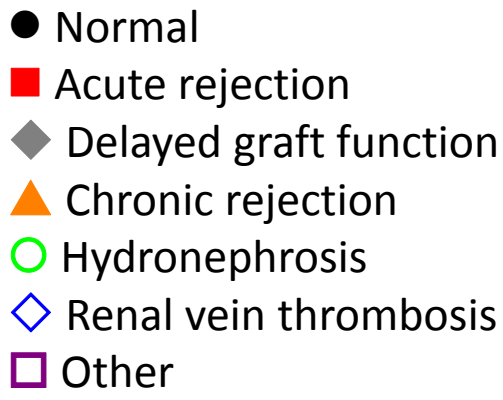


3-element Windkessel model









Doppler ultrasound

Acute rejection can’t be diagnosed using:

- resistive index (intra-renal)
- pre-glomerular resistance
- post-glomerular resistance
- vascular compliance
- the shape of the velocity waveform (mid renal artery)

Conclusions

- Doppler ultrasound of kidney transplants has limited value in diagnosing acute rejection.
- Resistive index > 0.9 is seen in acute rejection, delayed graft function, and renal vein thrombosis.
- The 3-element Windkessel model can be used to determine vascular resistance and compliance.

Additional slides

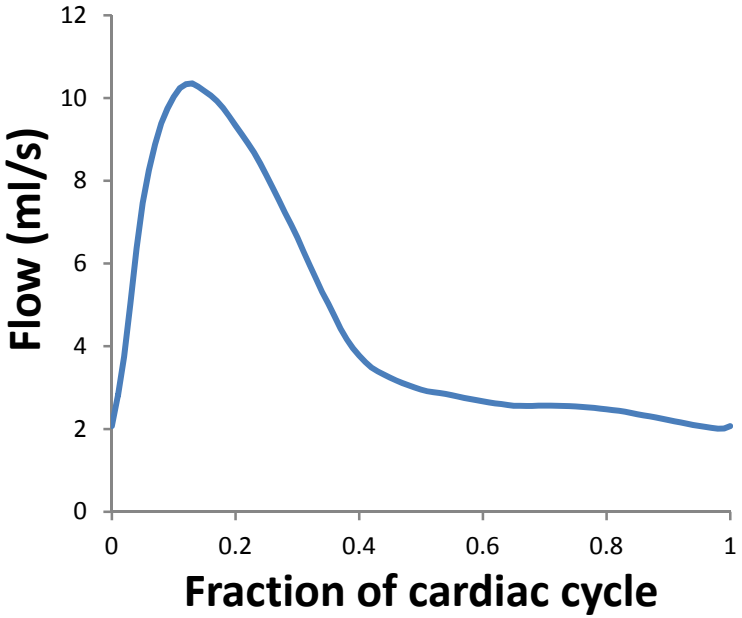
3-element Windkessel model

Resistive index is increased with:

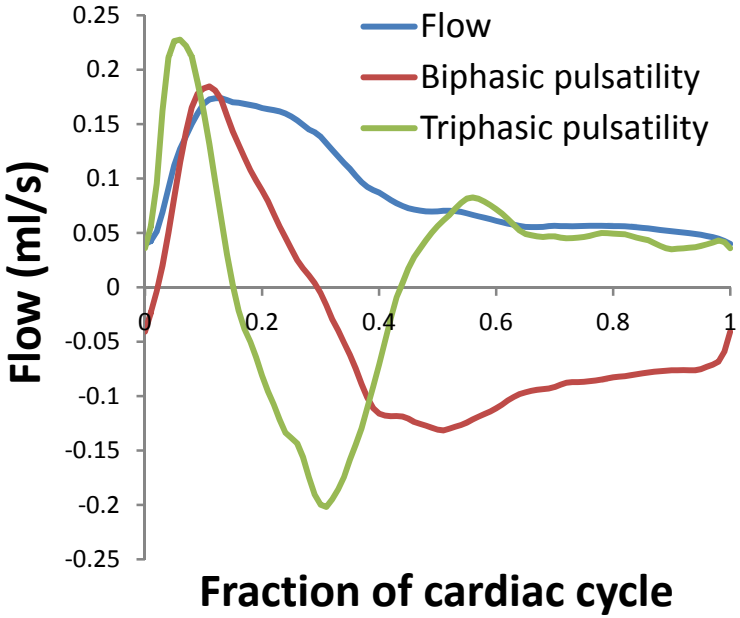
- Increased R_2 (post-glomerular resistance)
- Decreased R_1 (pre-glomerular resistance)
- Increased C (vascular compliance)
- Increased pulse pressure
- Increased heart rate

Principal component analysis

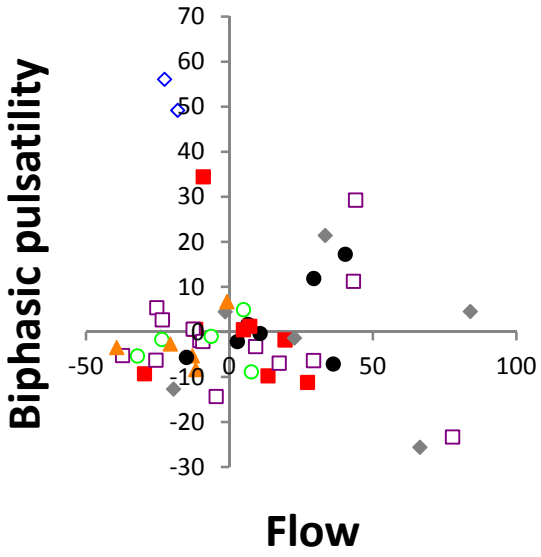
Average waveform

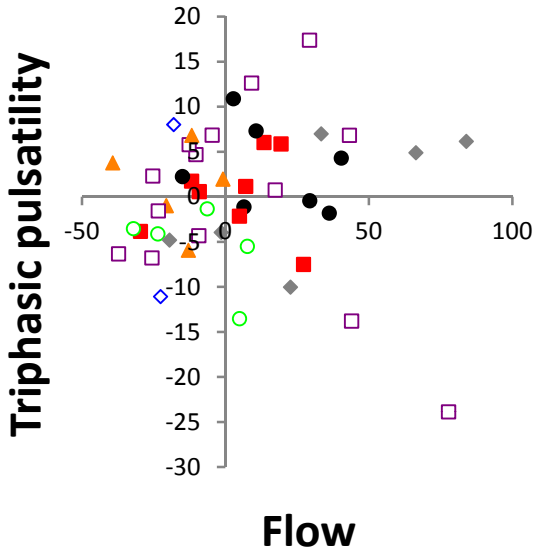


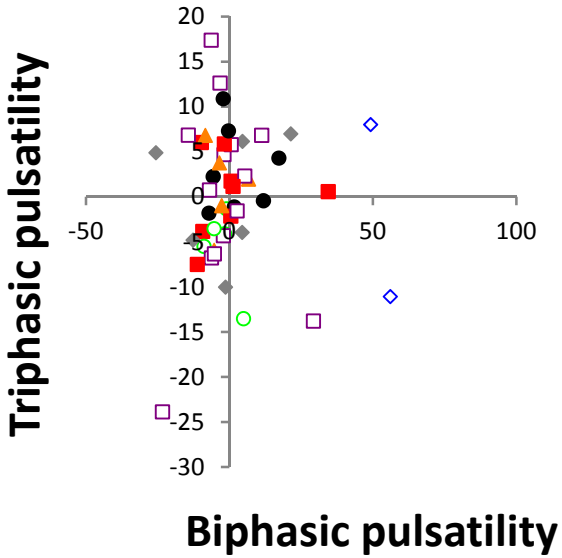
Principal components



Principal component analysis







- Normal
- Acute rejection
- Delayed graft function
- Chronic rejection
- Hydronephrosis
- Renal vein thrombosis
- Other