BNMS Boot Camp
Birmingham, April 2016

Renogram Processing: Dos and Don'ts

Richard Lawson

Retired Medical Physicist, Central Manchester Nuclear Medicine Centre
Honorary Professor, University of Salford
Honorary Senior Lecturer, University of Manchester

Richard.Lawson@physics.org

Central Manchester University Hospitals NHS
NHS Foundation Trust

Overview

- Based on BNMS Clinical Guidelines
  - Dynamic Renal Radionuclide Studies (Renography)
    http://www.bnms.org.uk/procedures-guidelines
  - Section 9 – Data Analysis
  - Section 10 – Hard copy or PACS output

"This guideline will assist individual departments in the development and formulation of their own local protocols."

- Local protocols still matter
  - Junior staff must follow local protocols
  - Senior staff may wish to review local protocols against these guidelines
- Local nuclear medicine software matters
  - You may be constrained by what facilities are available in your local renogram processing program
  - Or this may influence you in future system purchases

View dynamic data

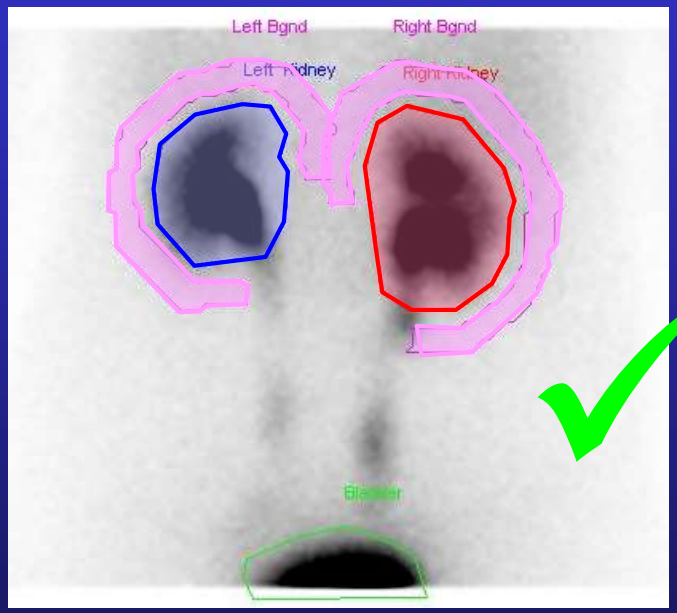
9.1. The dynamic data should be reviewed to check that there has been no patient movement……

- **DO**
  - Look for movement of the kidneys
  - Check for any unusual kidney position
    Such as pelvic kidney
  - Check whether bladder is seen
    Or any special plumbing
- **DON'T**
  - Forget to correct for significant movement by shifting relevant frames

Richard Lawson
Richard.Lawson@physics.org

Draw Regions of Interest

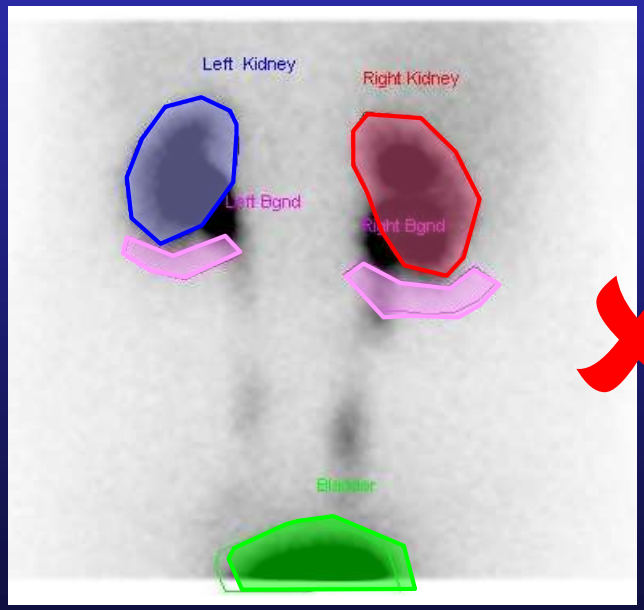
9.2. Regions of interest should be drawn over each kidney….., background areas…. and over the bladder.



- **DO**
  - Include renal pelvis in kidney ROI
  - Make kidney regions big enough to include any small movement
    Too big is better than too small
  - Use mixture of blood and tissue in background ROI
    eg perirenal or Rutland method

Draw Regions of Interest

9.2. Regions of interest should be drawn over each kidney….., background areas…. and over the bladder.

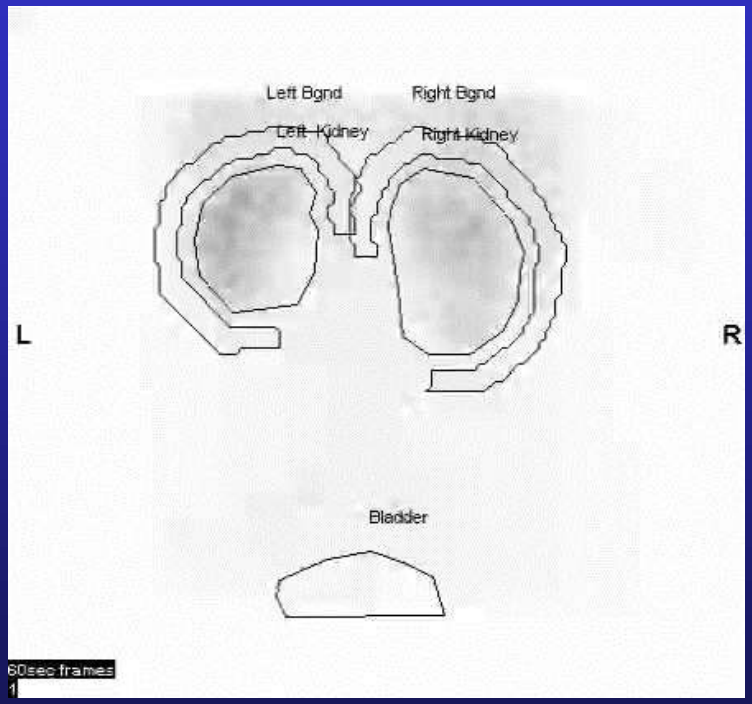


- **DO**
  - Include renal pelvis in kidney ROI
  - Make kidney regions big enough to include any small movement
    Too big is better than too small
  - Use mixture of blood and tissue in background ROI
    eg perirenal or Rutland method
- **DON'T**
  - Cut off the renal pelvis
  - Let background cross ureters
  - Make background ROIs too small
    Low counts → large uncertainty
- **Doesn't matter**
  - Whether separate L & R backgrounds
  - If some of bladder is missing

Richard Lawson
Richard.Lawson@physics.org

Review Regions of Interest

9.3. The regions of interest should be reviewed on a cine display of the dynamic study……



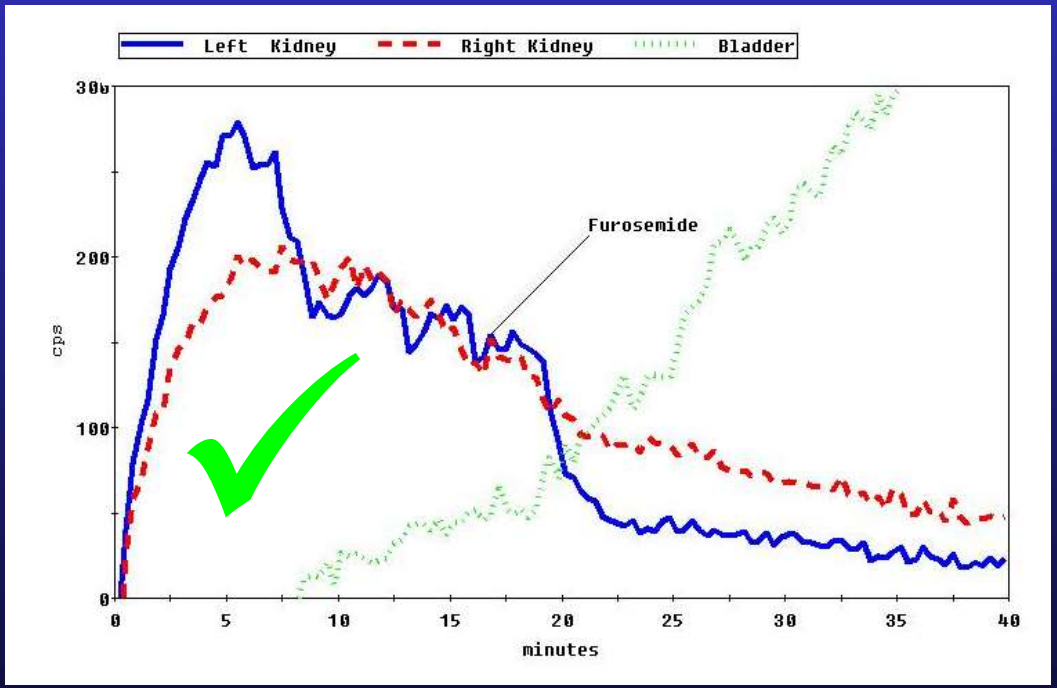
- **DO**
  - Check that kidneys stay within kidney ROIs on all frames
    Small movements are OK
- **DON'T**
  - Let kidneys stray into background ROIs
  - Let ureters cross background ROIs
- **Doesn't matter**
  - If bladder isn't perfect

Produce background corrected curves

9.4. Background-corrected activity-time curves should be derived from each kidney.

The computer analysis program will subtract background cps from kidney cps, allowing for different sizes of regions

This should give curves showing only kidney activity



DO

- Check that kidney curves rise smoothly from zero

Richard Lawson

Richard.Lawson@physics.org

Produce background corrected curves

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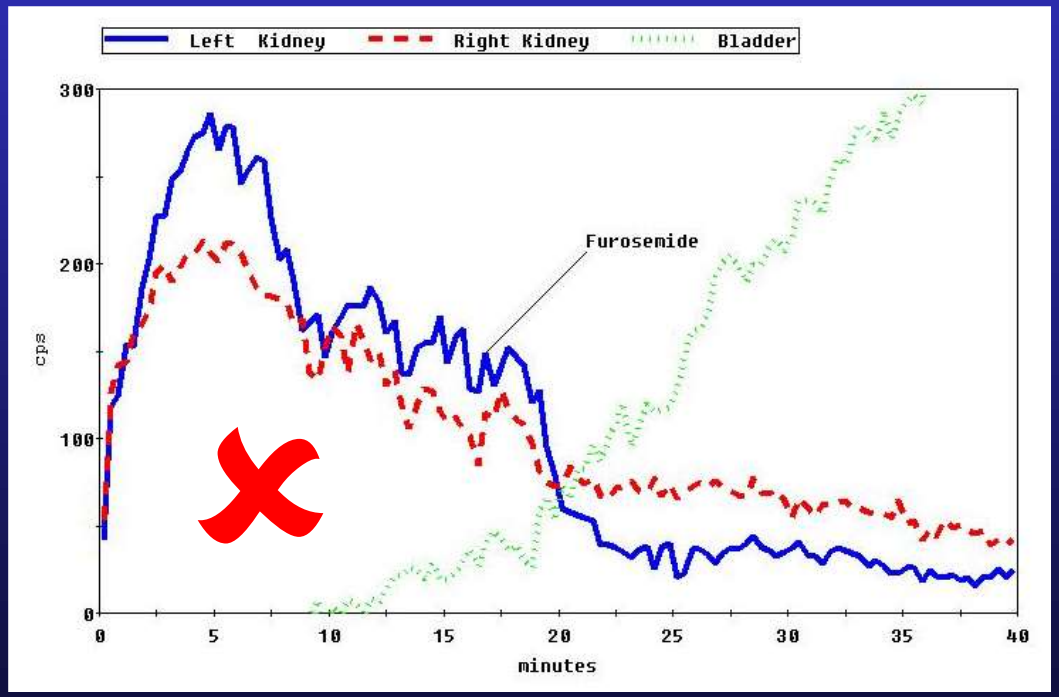


DO

- Check that kidney curves rise smoothly from zero

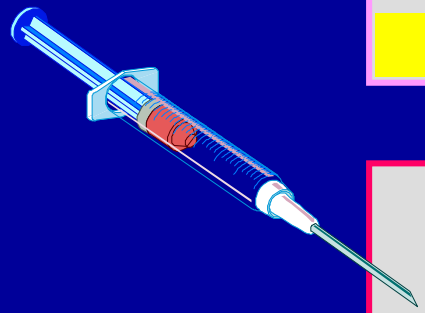
DON'T

- Accept curves that still show a vascular phase

Why not?

Here's a model ……

Renogram Model

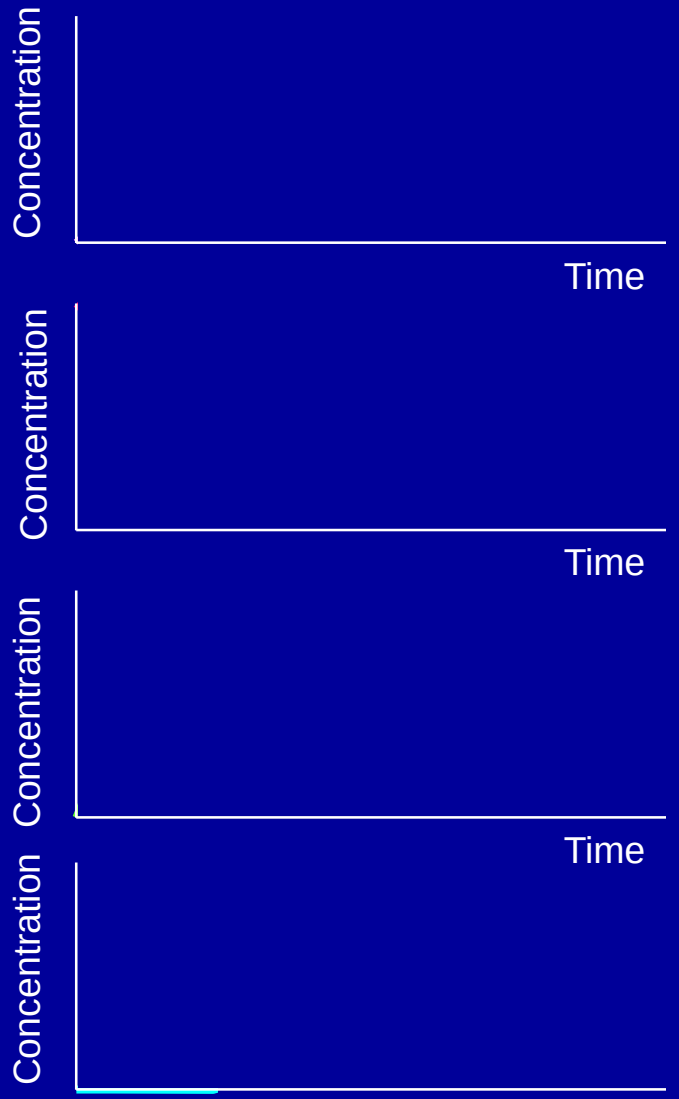


Extravascular
Tissue

Blood

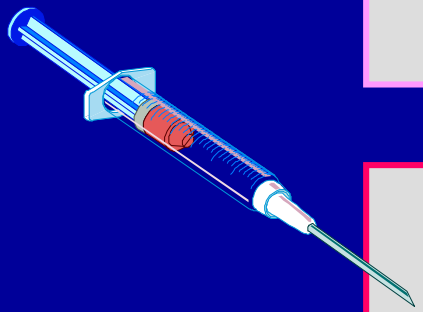
Kidney
Tubules + pelvis

Bladder



Richard Lawson
Richard.Lawson@physics.org

Renogram Model



Extravascular
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Blood

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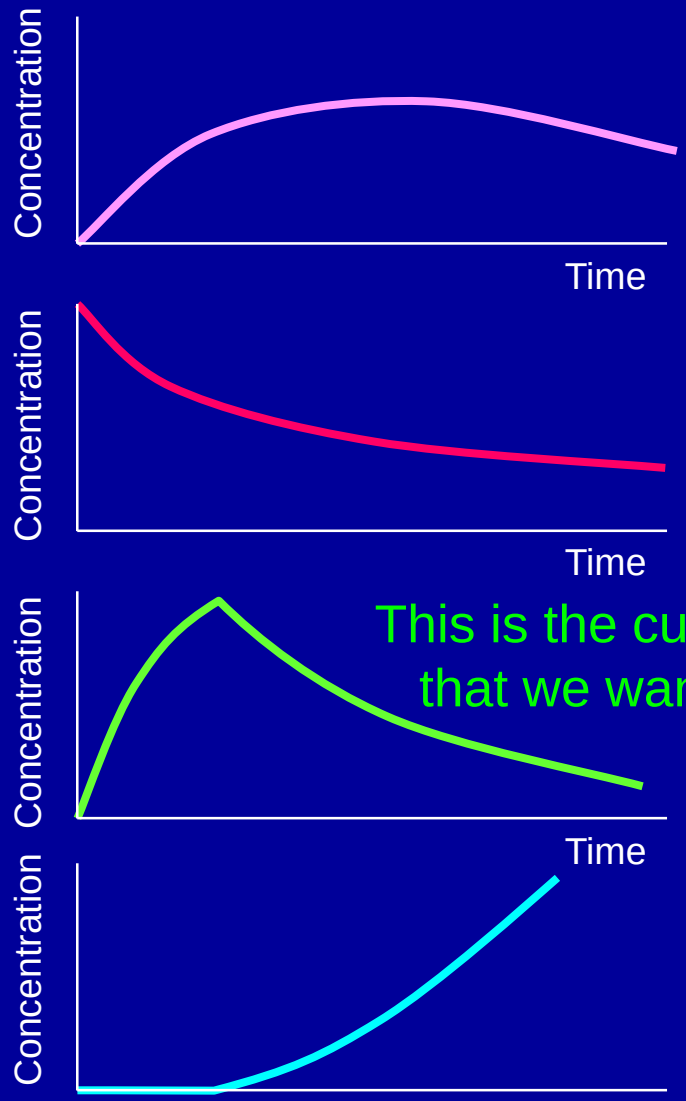
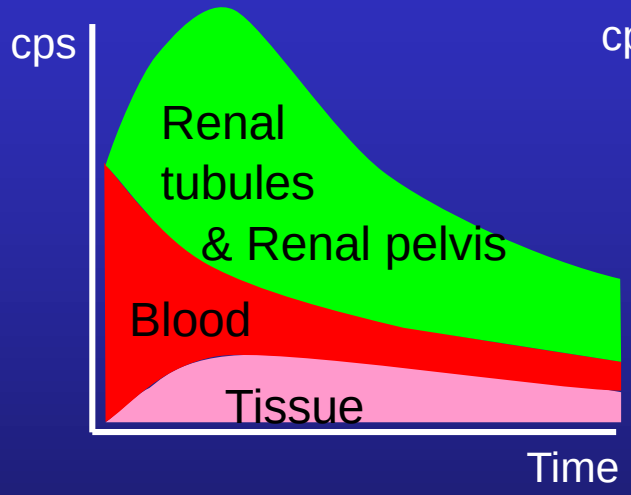
Bladder



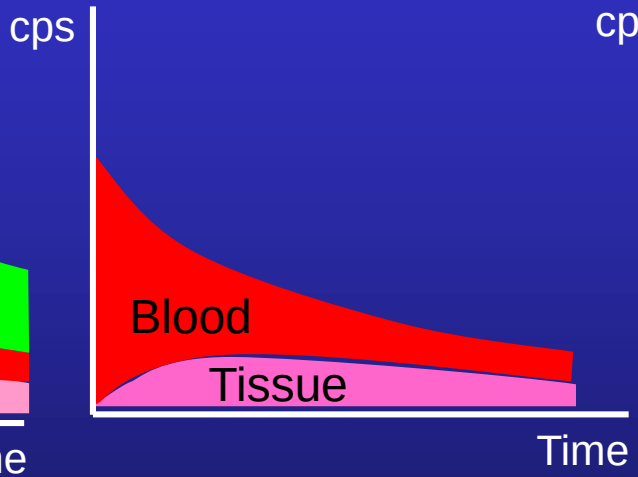
Richard Lawson
Richard.Lawson@physics.org

Background Subtraction

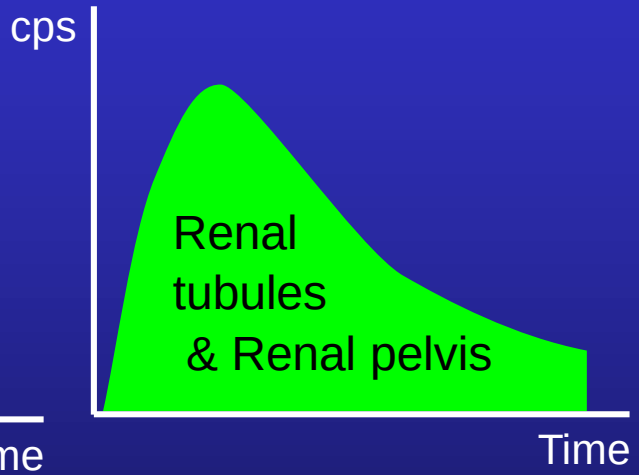
Curve from kidney ROI



Curve from background ROI



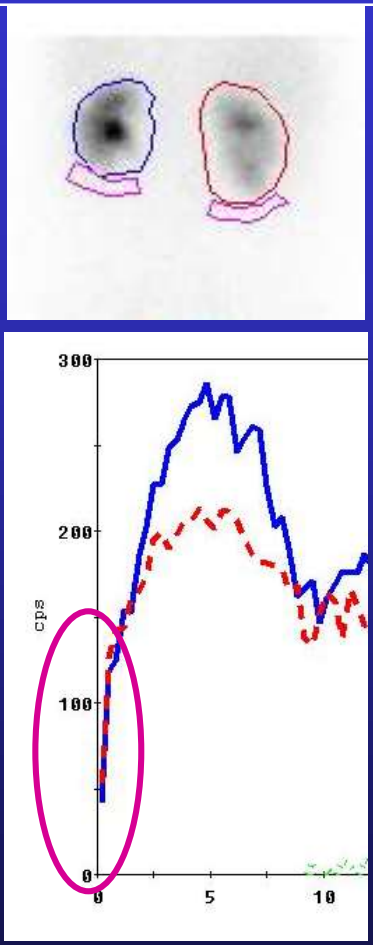
Background subtracted renogram



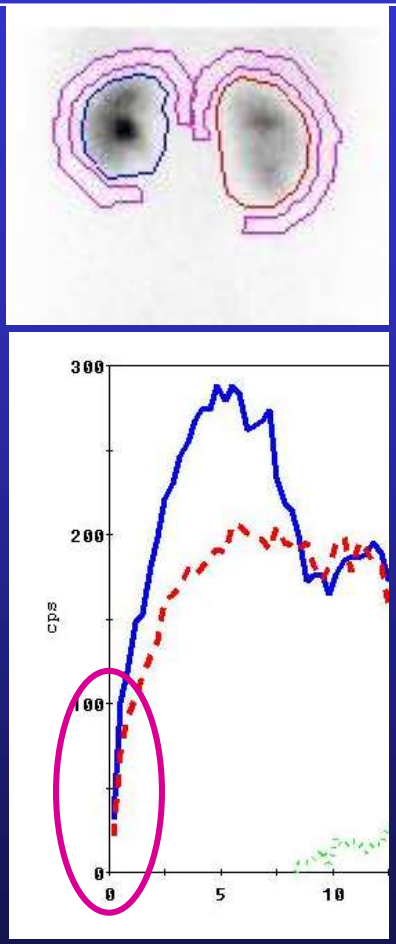
- If background subtraction is correct, the renogram curve should rise smoothly from zero
  - If it doesn't there is still some blood background present

Richard Lawson
Richard.Lawson@physics.org

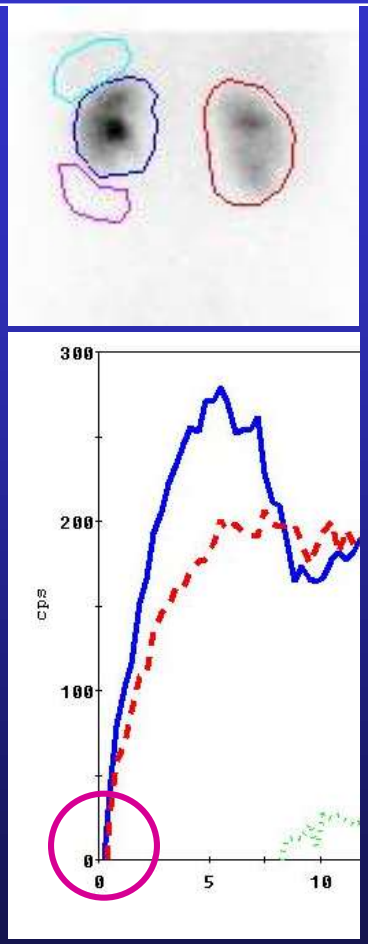
Correct background subtraction



- Bgnd below kidneys
  - Very little blood
  - Under-subtracted



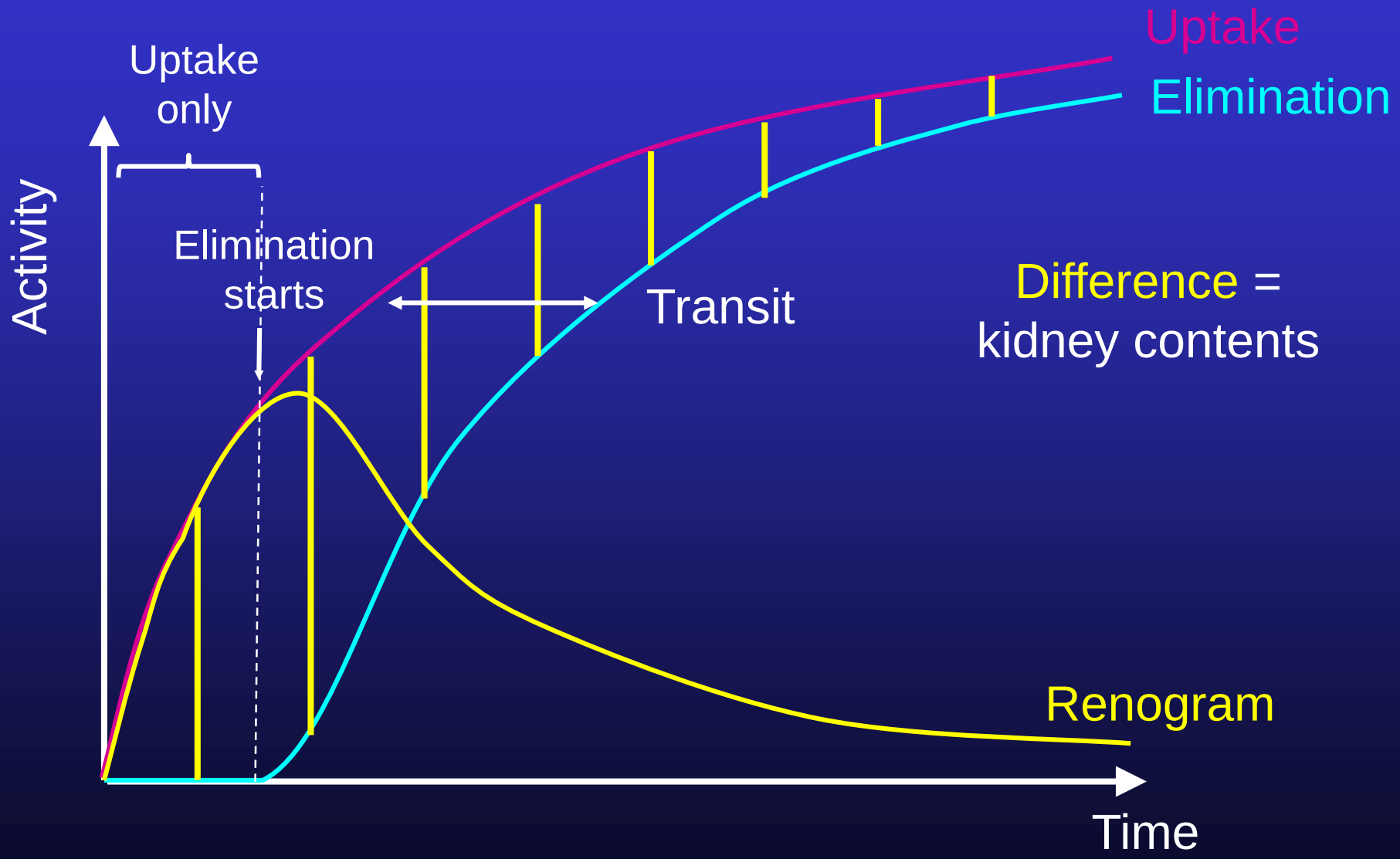
- Perirenal bgnd
- Some blood & tissue
  - Better



- Rutland method
- Optimum mixture
  - Perfect

Richard Lawson
Richard.Lawson@physics.org

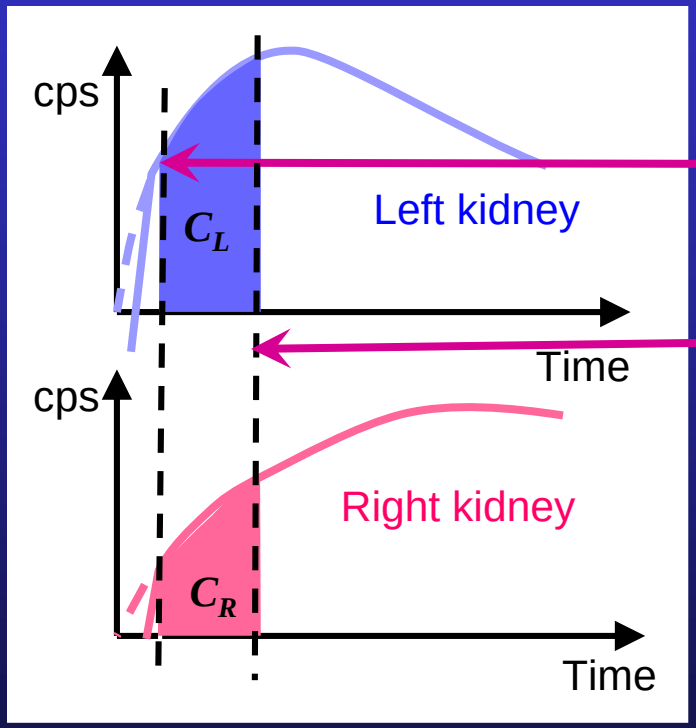
Renogram Components



Richard Lawson
Richard.Lawson@physics.org

Calculate Divided Function

9.5. The divided function should be calculated. This may be most simply obtained from the integral of these curves…….



- **DON'T**
  - Start integration before 60 sec
    Because background subtraction is unreliable due to incomplete mixing
  - Continue integration after peak
    Because kidneys have started to empty just before peak

The program will calculate relative function from the relative areas

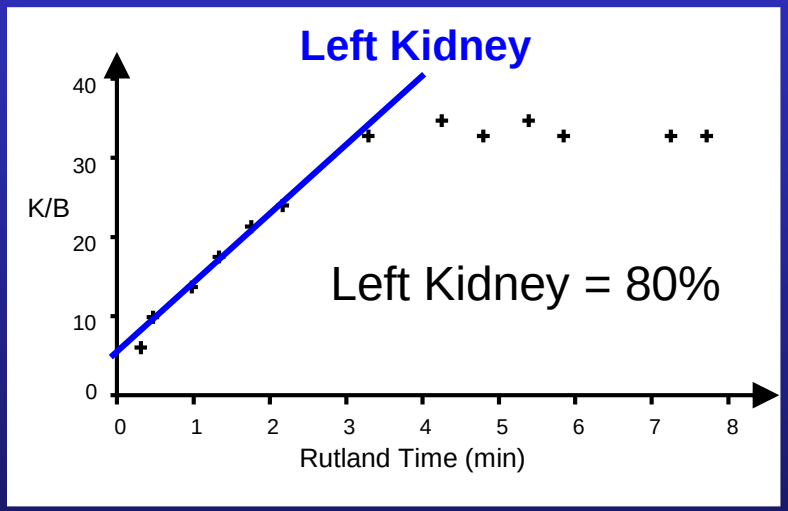
$$\text{Relative function (Left)} = \frac{C_L}{C_L + C_R} \times 100\%$$

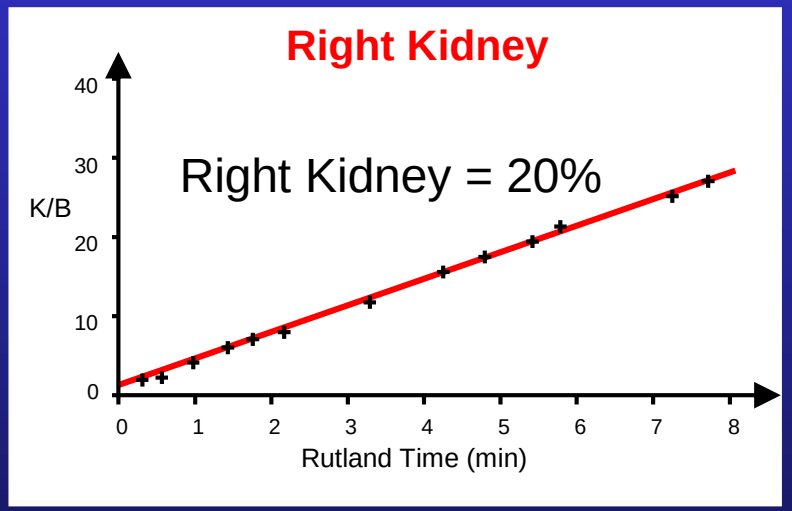
$$\text{Relative function (Right)} = \frac{C_R}{C_L + C_R} \times 100\%$$

Richard Lawson
Richard.Lawson@physics.org

Rutland Plot is More Reliable

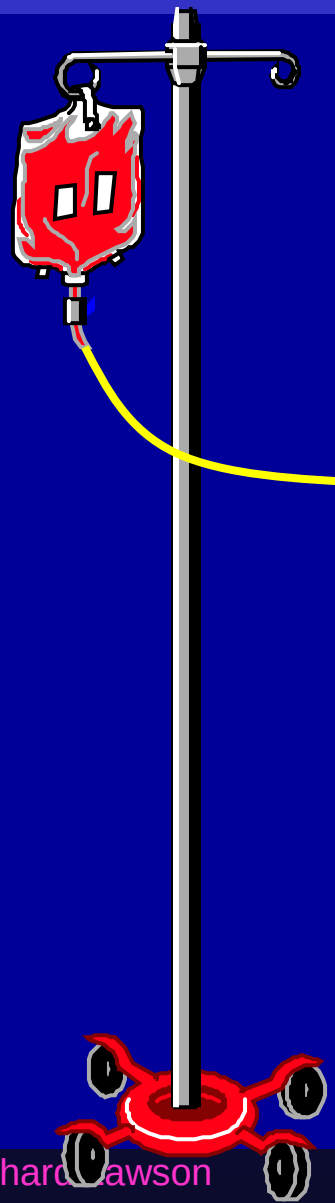
9.6. A more reproducible and robust divided function may be obtained from a Rutland/Patlak plot. This is recommended particularly if ^{99m}Tc DTPA is used or if renal function is poor…..





- The Rutland plot is also known as the Patlak plot
- What is it this?
  - Here's another model ……..

Constant Infusion Model

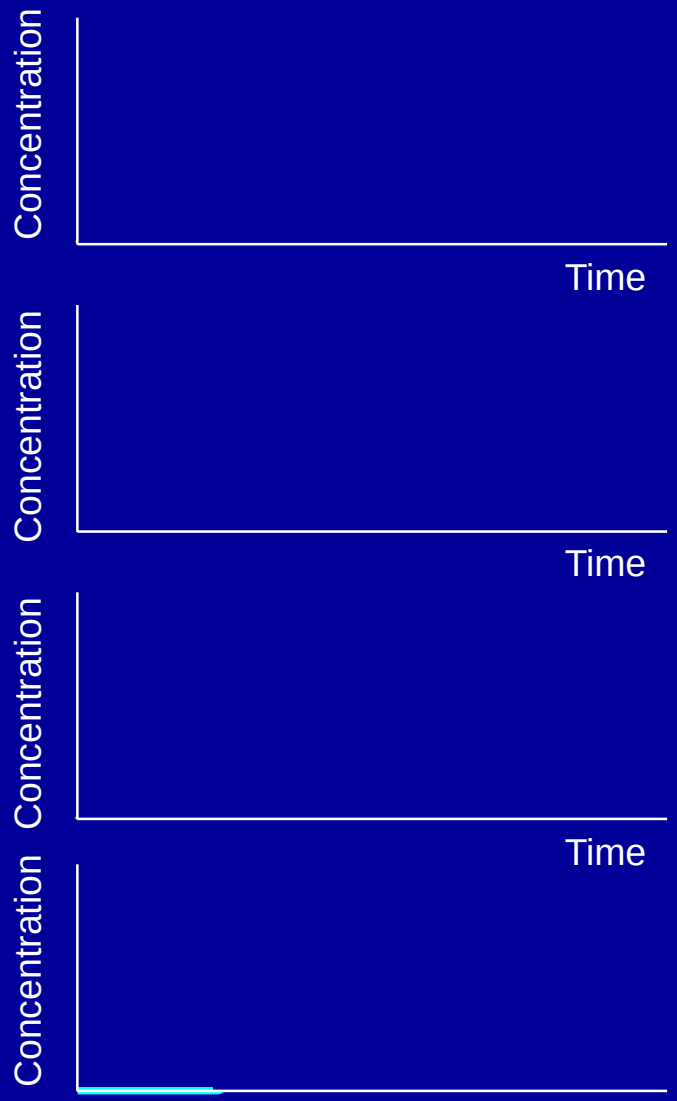


Extravascular Tissue

Blood

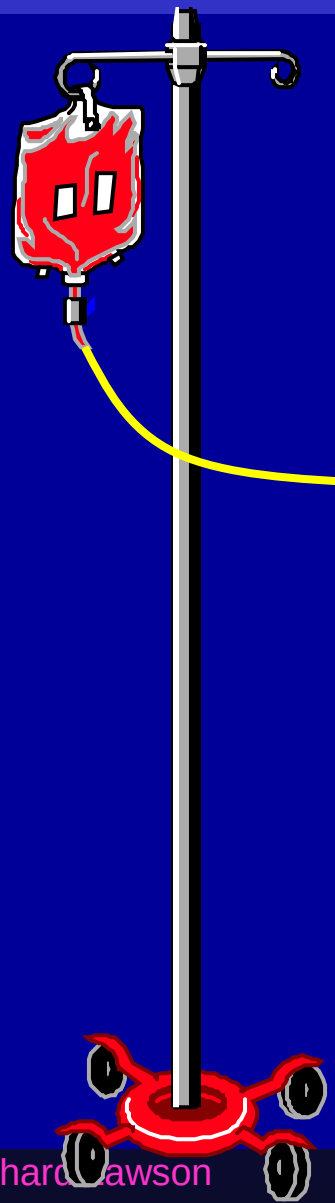
Kidney

Bladder



Richard Lawson
Richard.Lawson@physics.org

Constant Infusion Model



Extravascular Tissue

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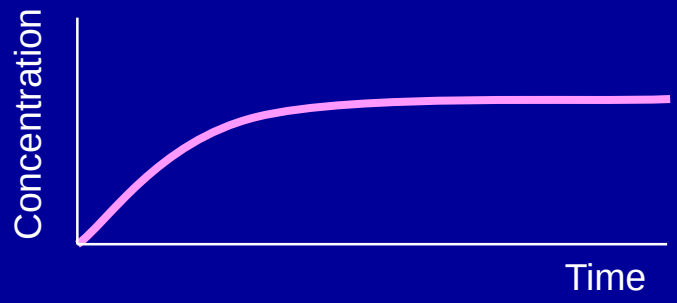
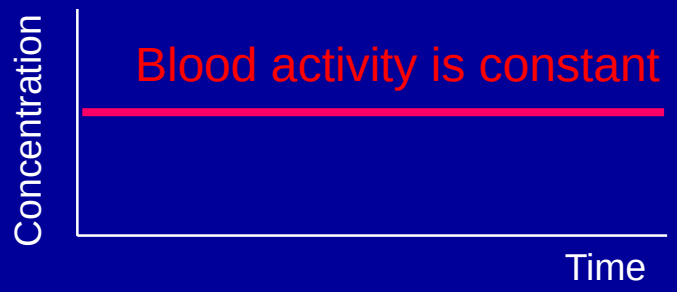
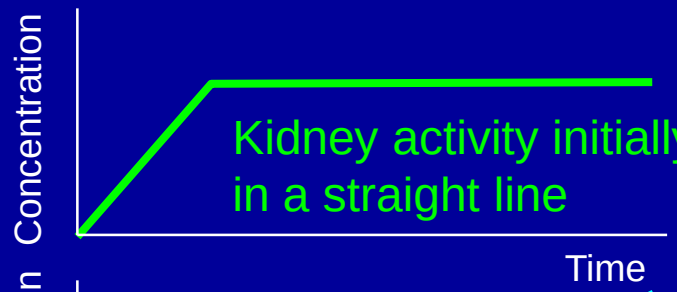
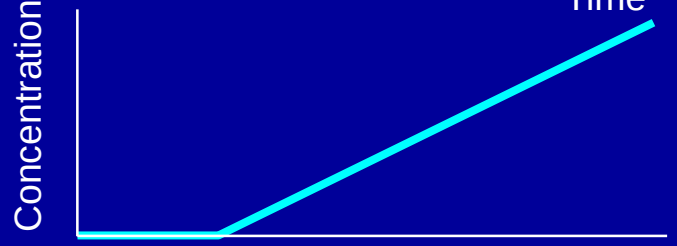




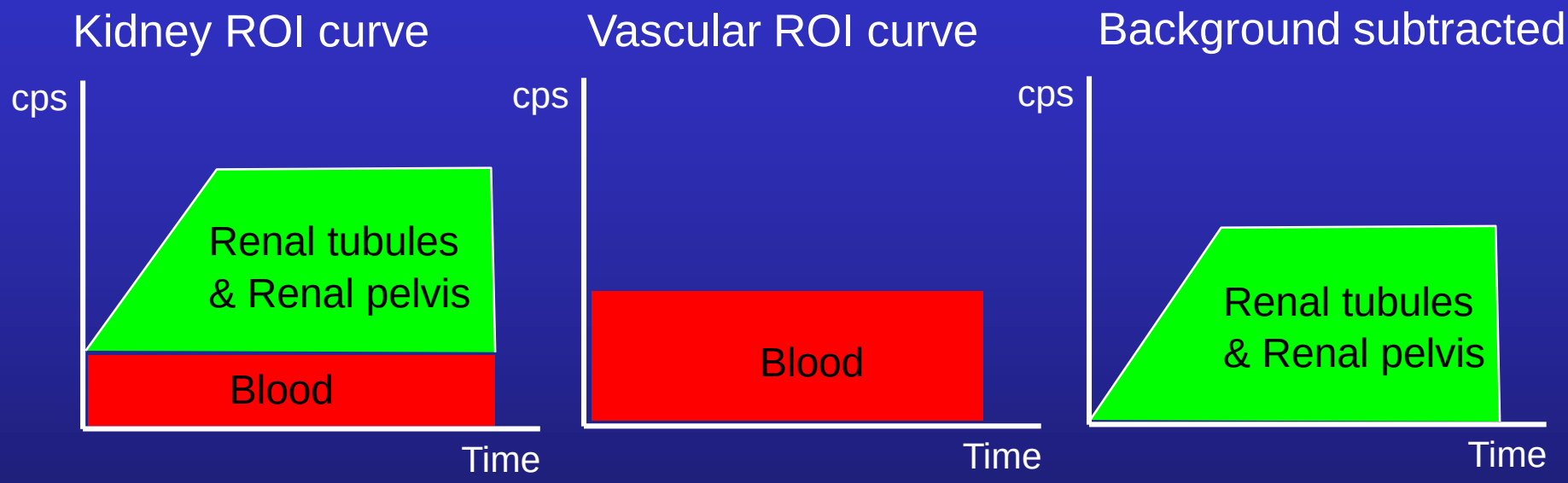




Richard Lawson
Richard.Lawson@physics.org

With Constant Infusion

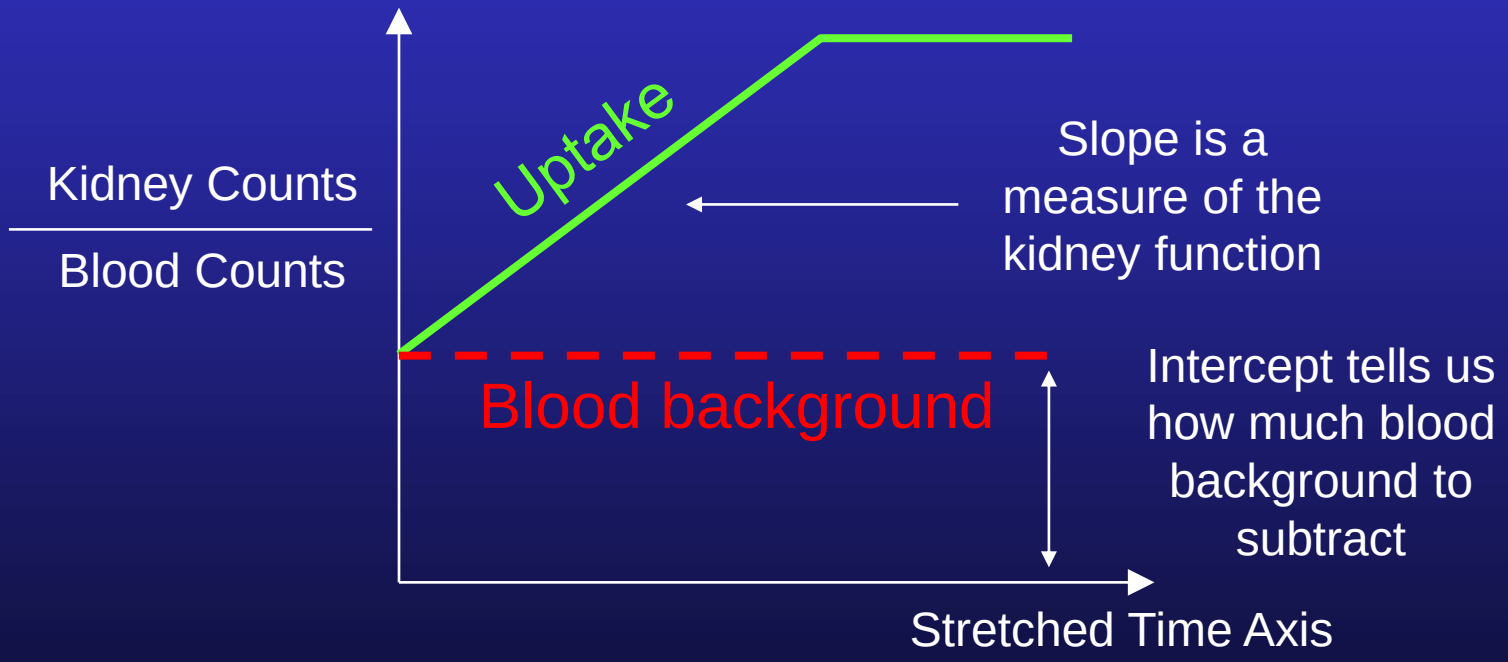
After subtraction of tissue background



- Constant infusion would make background subtraction easy
- The Rutland plot simulates this from real data
  - By normalising kidney activity to blood activity and using a stretched time scale

The Rutland Plot

The Rutland plot is a mathematical manipulation of the renogram that simulates what would happen if blood activity was constant

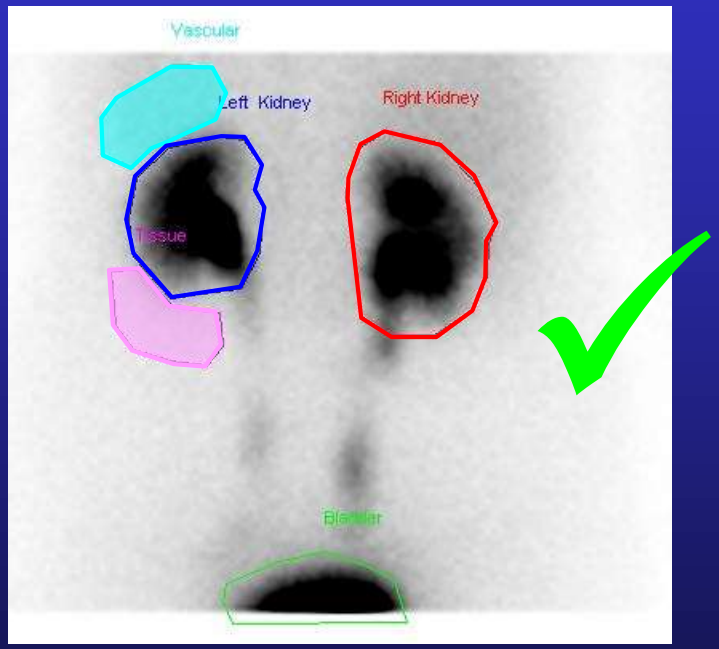


Rutland Plot

Richard Lawson
Richard.Lawson@physics.org

Rutland Plot is More Reliable

9.6. A more reproducible and robust divided function may be obtained from a Rutland/Patlak plot…..



- **DO**
  - Draw a suitable vascular ROI
    Over heart or spleen
  - Make sure that the program subtracts tissue background first
    Using single tissue ROI
    Or perirenal ROIs

Richard Lawson
Richard.Lawson@physics.org

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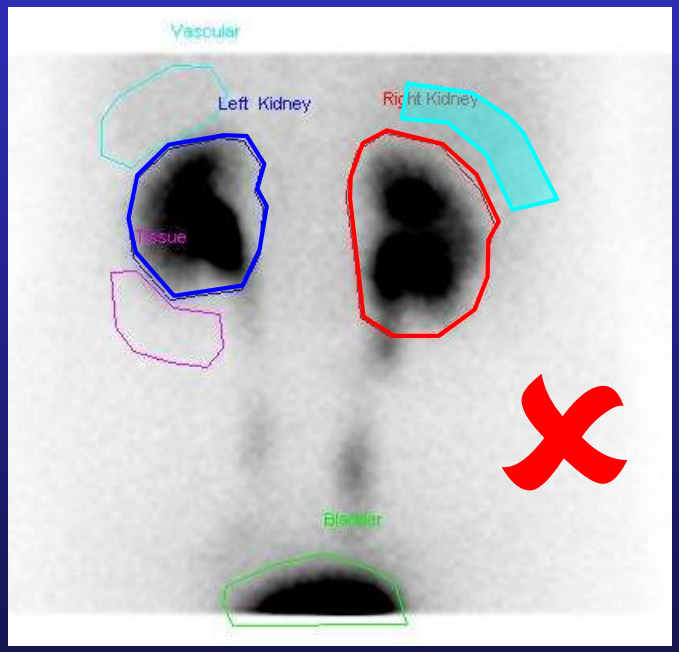
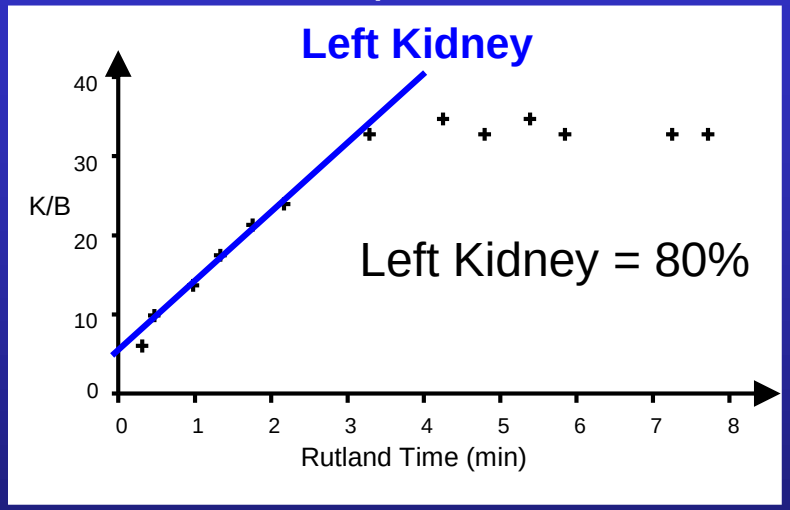


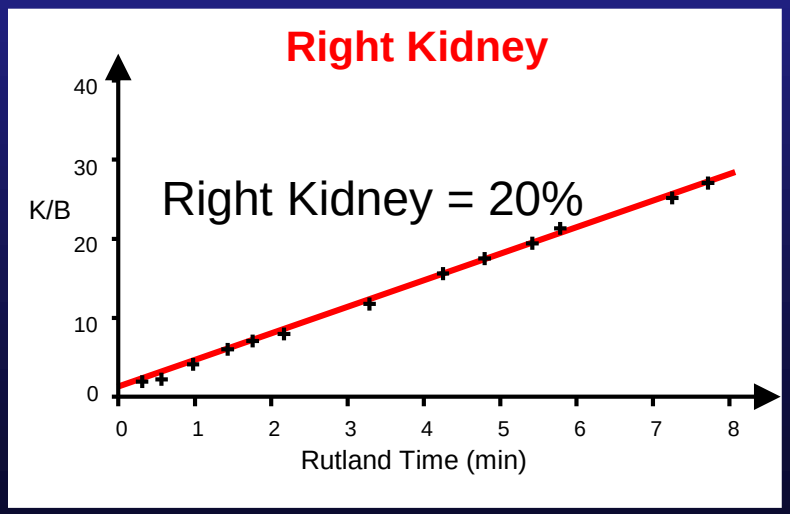
- **DO**
  - Draw a suitable vascular ROI
    Over heart or spleen
  - Make sure that the program subtracts tissue background first
    Using single tissue ROI
    Or perirenal ROIs
- **DON'T**
  - Put vascular ROI over liver
    If using MAG3

Richard Lawson
Richard.Lawson@physics.org

Rutland Plot is More Reliable

9.6. A more reproducible and robust divided function may be obtained from a Rutland/Patlak plot…..





- **DO**
  - Make sure that only the straight line section of the plot is used
    Because this corresponds to uptake

The program will calculate relative function from the relative slopes of the straight line sections

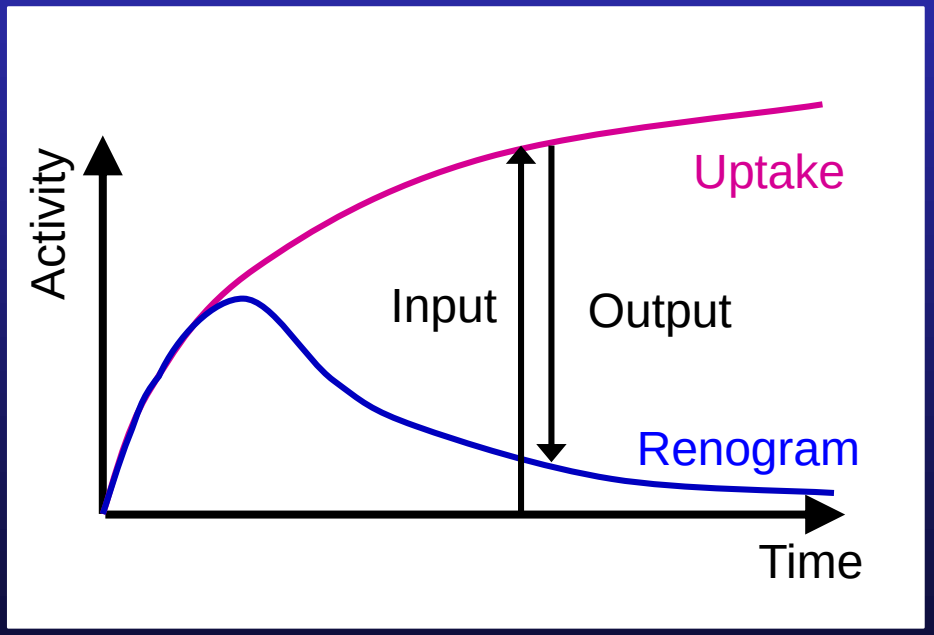
Richard.Lawson@physics.org

Calculate Output Efficiency

9.7. The output efficiency is a useful method of quantifying renal clearance in possible obstruction.

The analysis program will generate uptake curves for each kidney by extrapolating the first few minutes of the renogram

Using the integral of the blood curve



$$\text{Output efficiency} = \frac{\text{Output}}{\text{Input}}$$

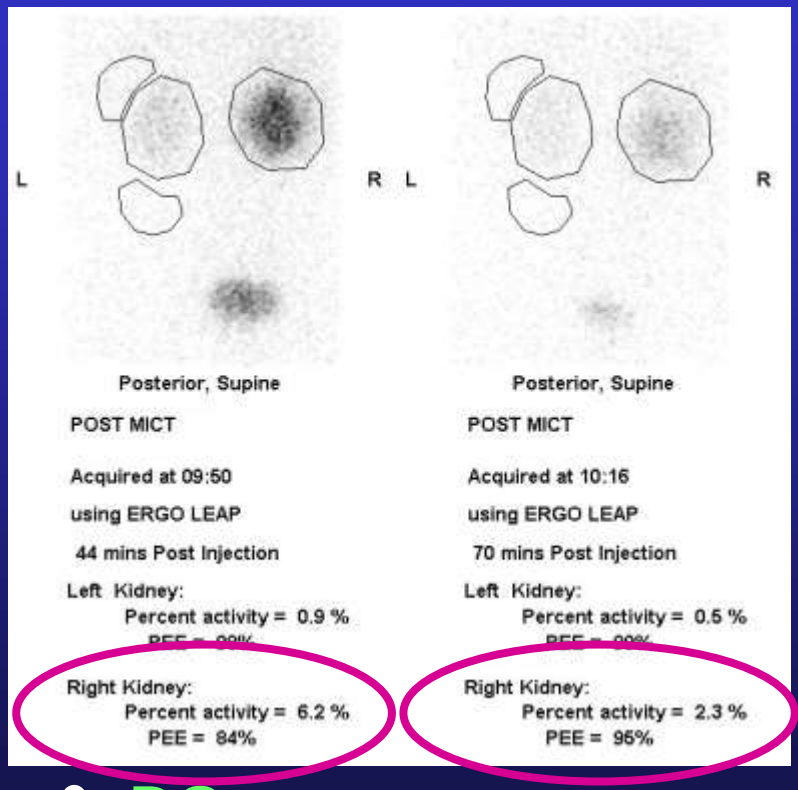
- Renal Output Efficiency (Barts)
- Pelvic Excretion Efficiency (GOSH)

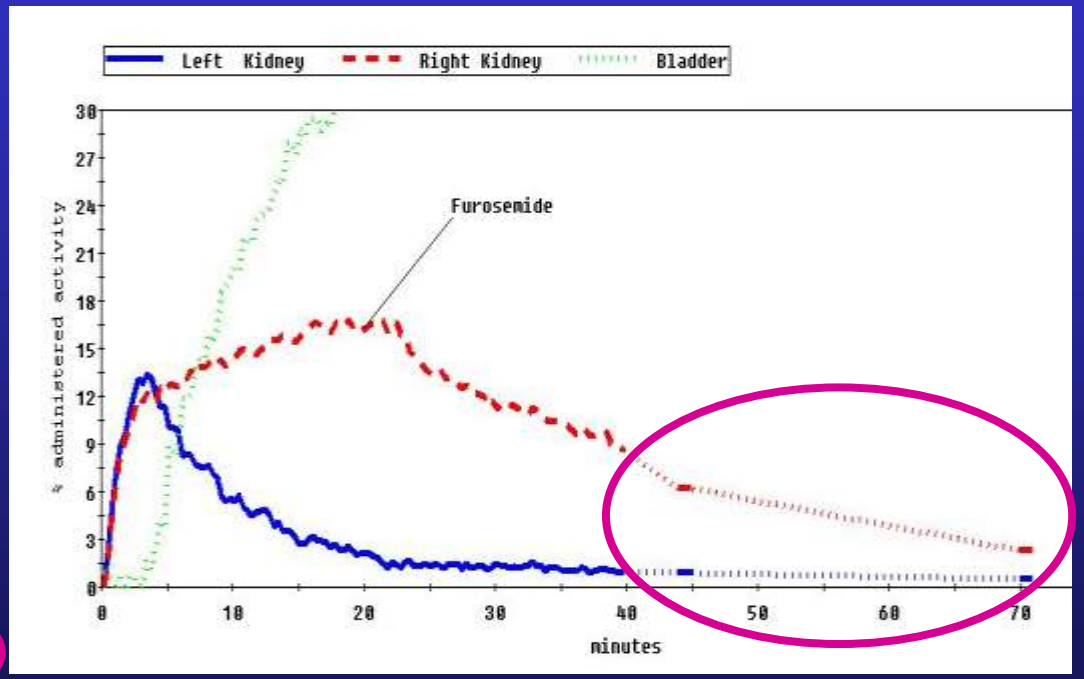
Richard Lawson

Richard.Lawson@physics.org

Draw Regions on Late Images

9.8. Regions should also be drawn on the pre-and post-micturition images and any late images to compare kidney activity with the activity at the end of the renogram.





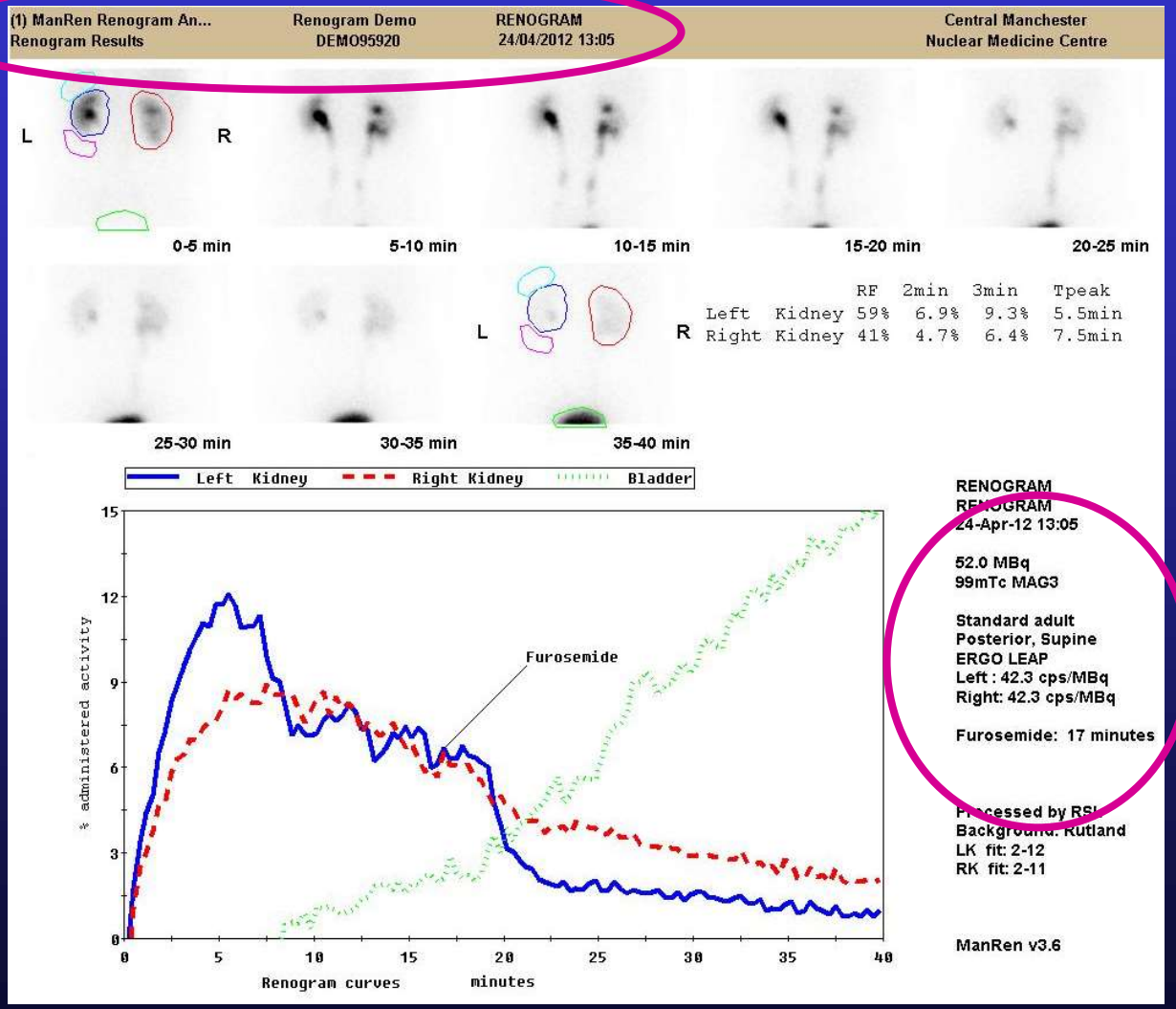
- **DO**
  - Calculate percentage of activity remaining in each kidney
    Allowing for the camera/collimator used and radioactive decay
  - Plot these as extended points on the renogram curves

Output must be labelled

10.1. Output must be labelled . . . .

- **DO include**
  - Patient name
  - Patient ID
  - Date of study
  - Radiopharmaceutical
  - Timing of diuretic
  - Urine flow rate

    If calculated

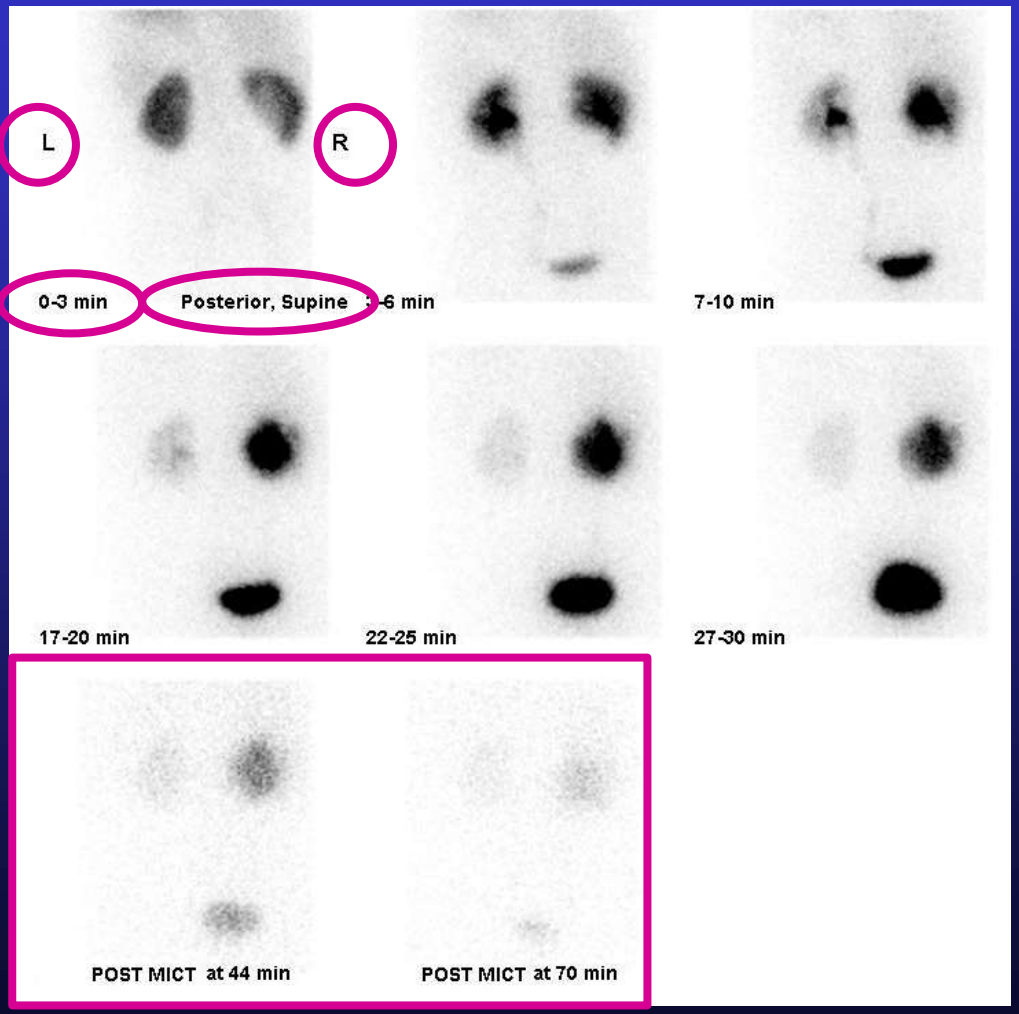


Richard.Lawson@physics.org

Show Summed Images

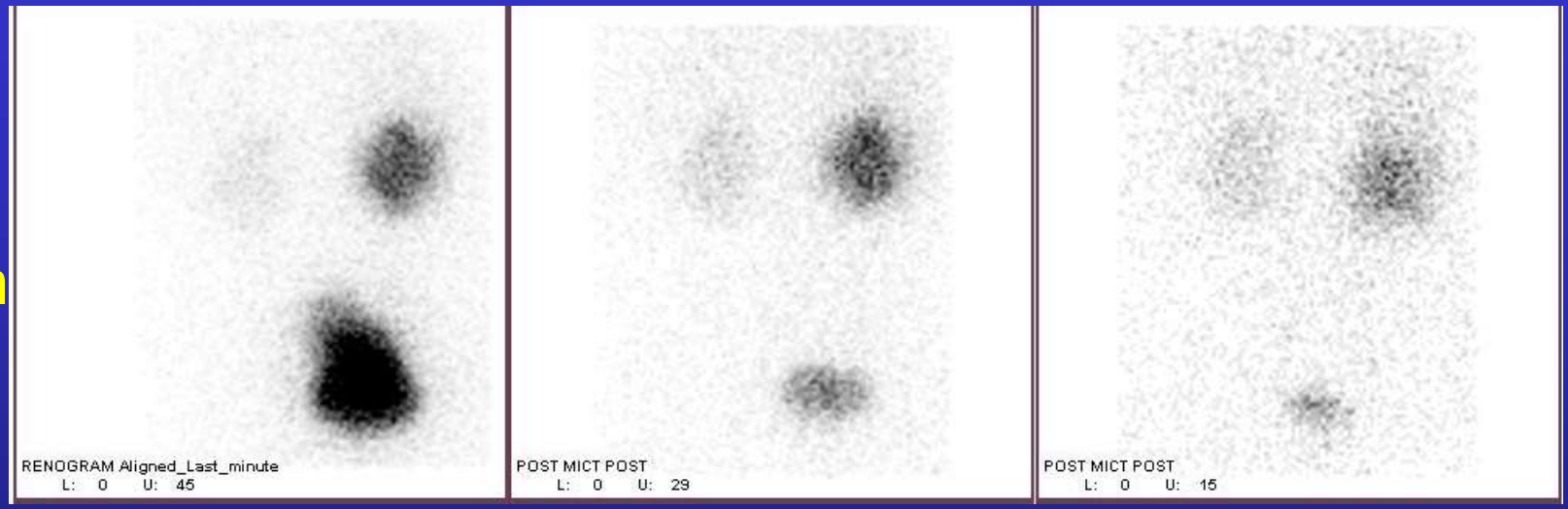
10.2. Images should be generated from 0-30 or 0-40 seconds…., at about 2-3 minutes…. and then at intervals to show the different phases of the study…..

- **DO**
  - Make all summed images the same duration
  - Display all images with the same maximum
  - Include pre and post-micturition images
  - Label each image
  - Include left and right markers



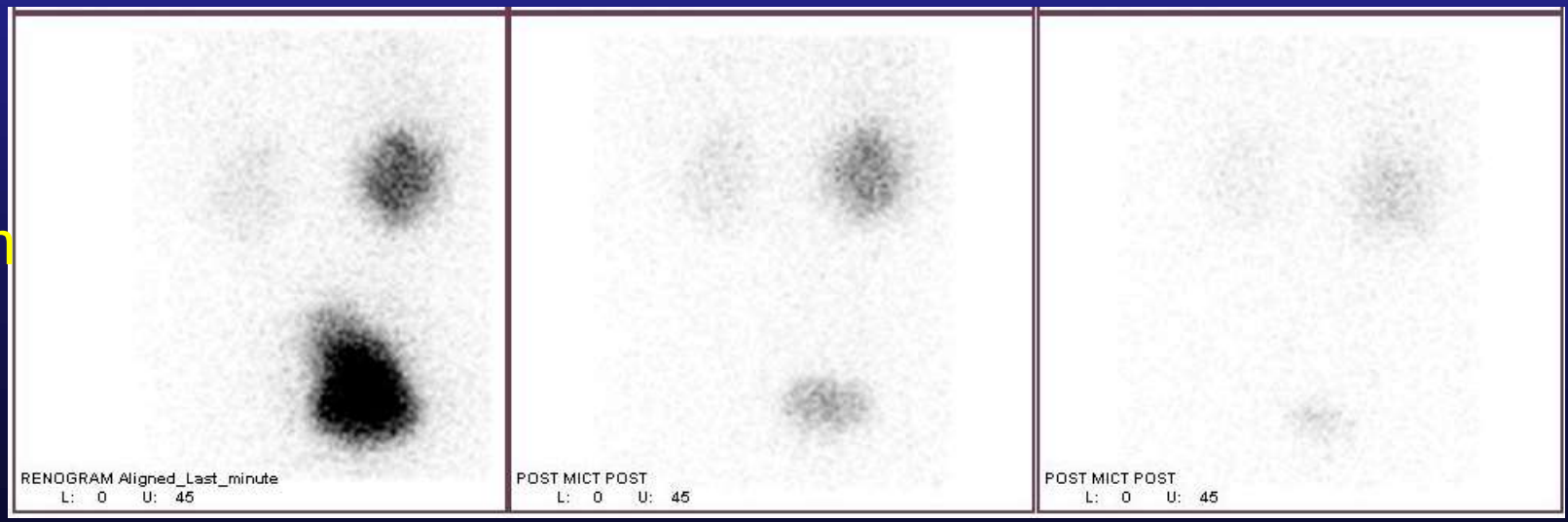
Why image scaling is important

Default maximum



Pre-mict 40 minutes | Post-mict - 44 minutes | 70 minutes

Same maximum

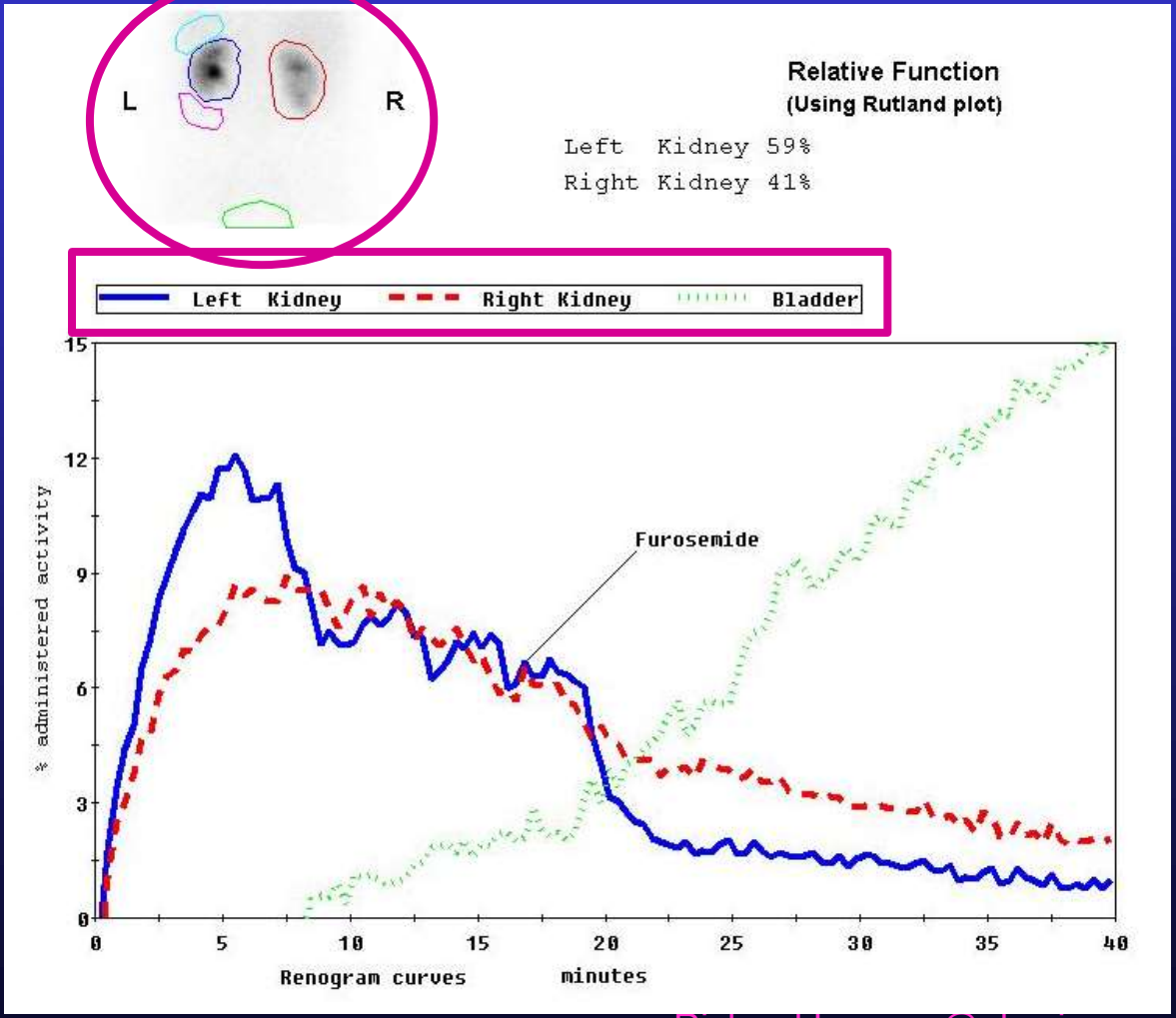


Richard Lawson
Richard.Lawson@physics.org

Show Curves

10.3. Curves should be recorded and labelled so that there is clear indication of which curve corresponds to which kidney…

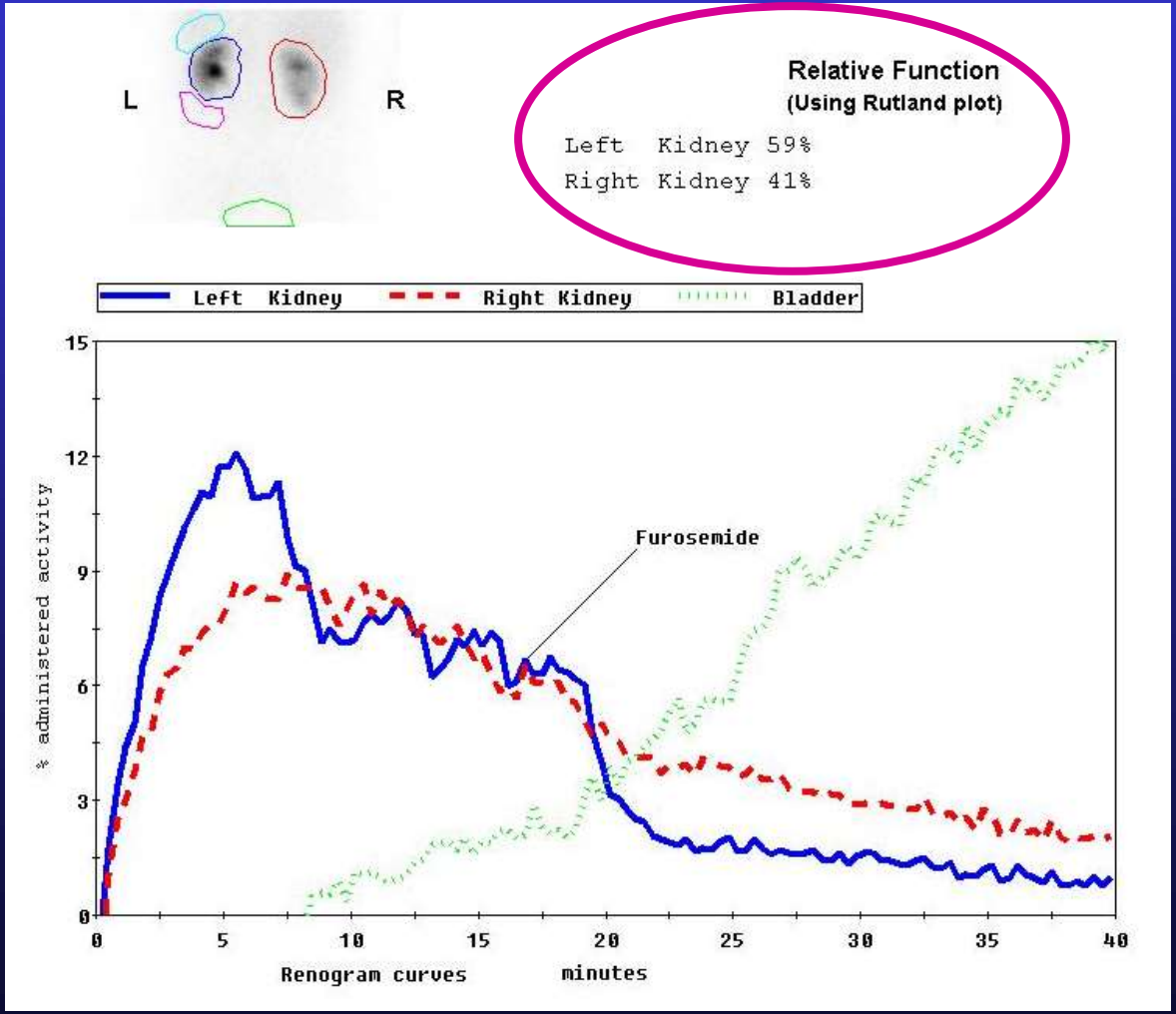
- **DO**
  - Identify curves and ROIs by name
  - Use different colours and different line styles
  - Show ROIs on images



Show Divided Function

10.4. The divided function must be recorded and the method used for its calculation should be indicated.

- **DON'T**
  - Try to quote better than nearest 1%

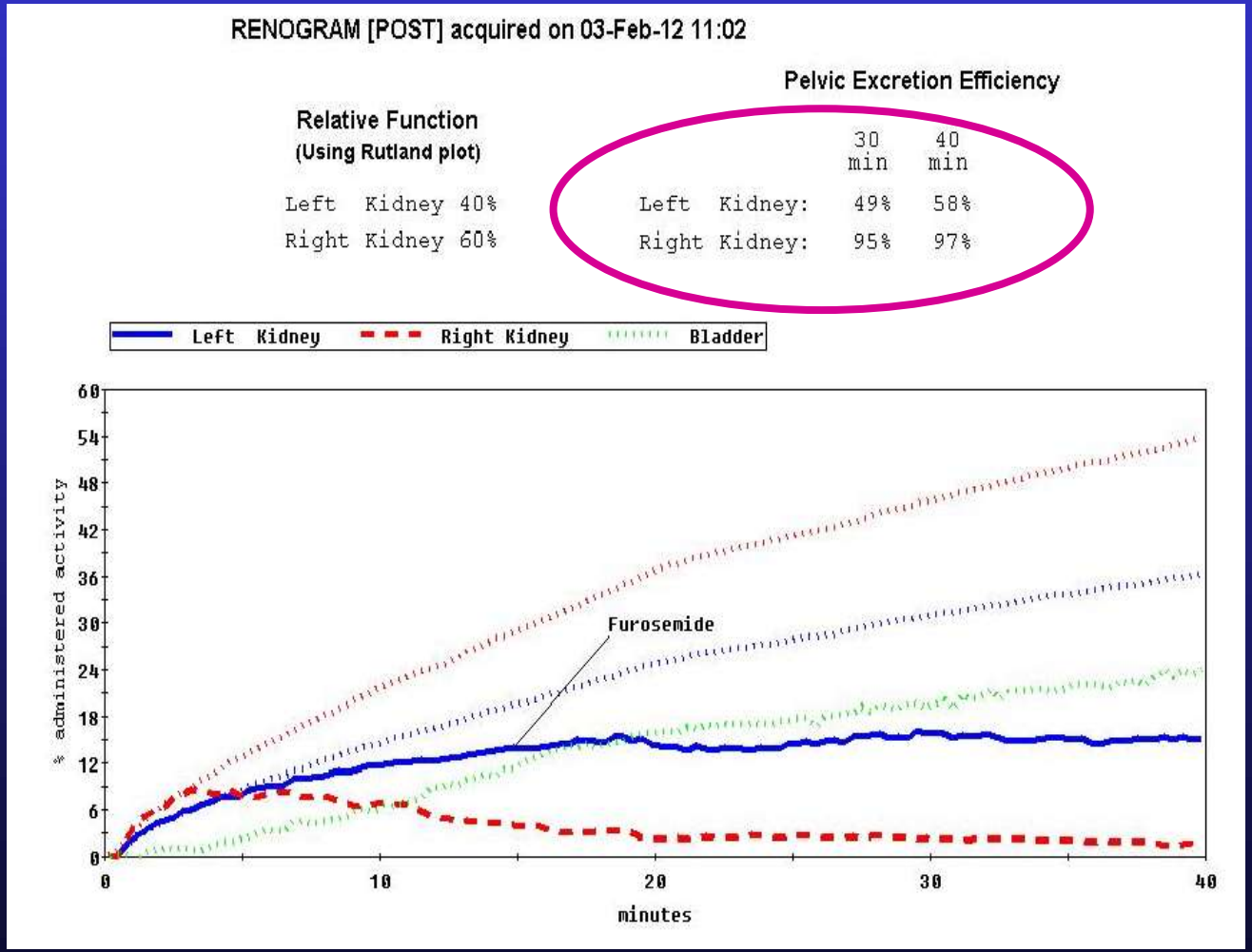


Richard.Lawson@physics.org

Show Output Efficiency

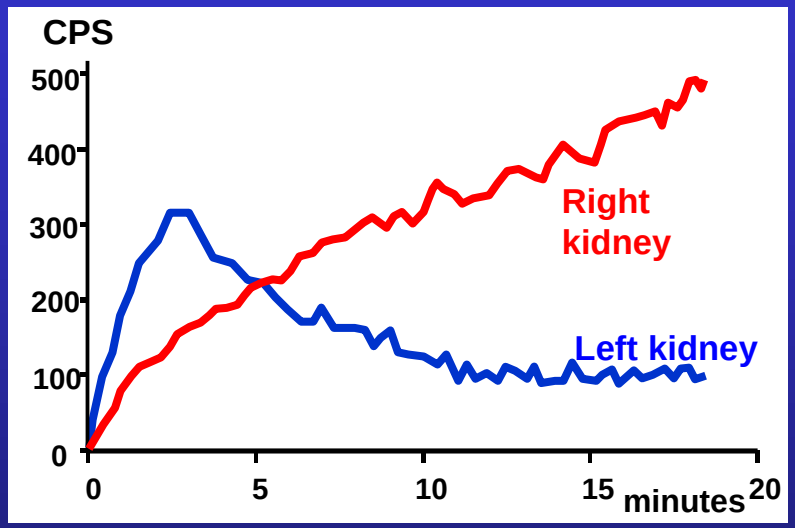
10.5. If the output efficiency has been calculated, the curves and output should be recorded.

- **DO**
  - Show the times that output efficiency was calculated

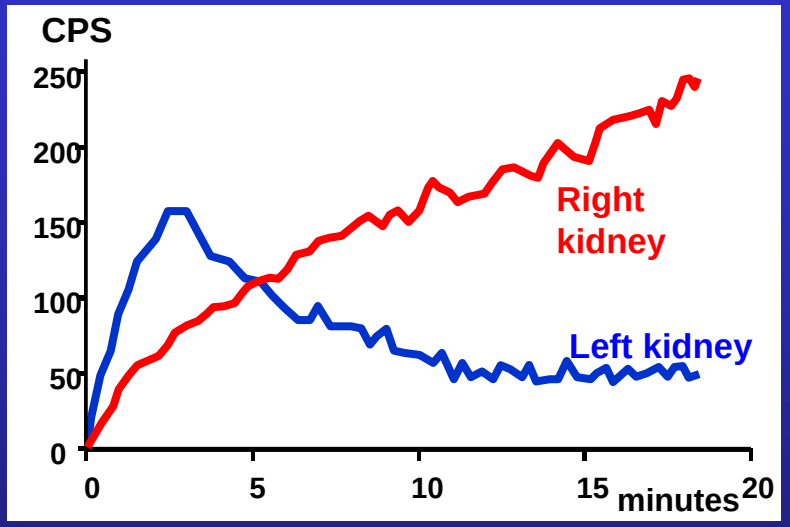


Dealing with Serial Studies

Previous renogram



Current renogram

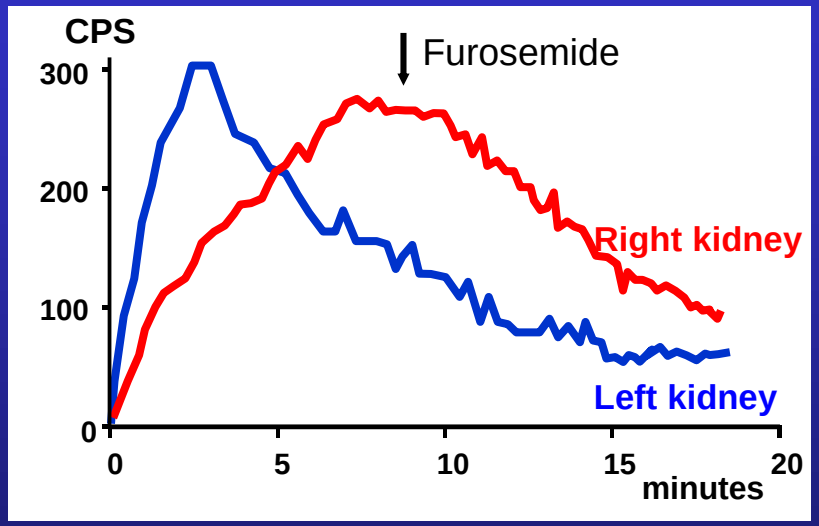


Has the left kidney function changed?

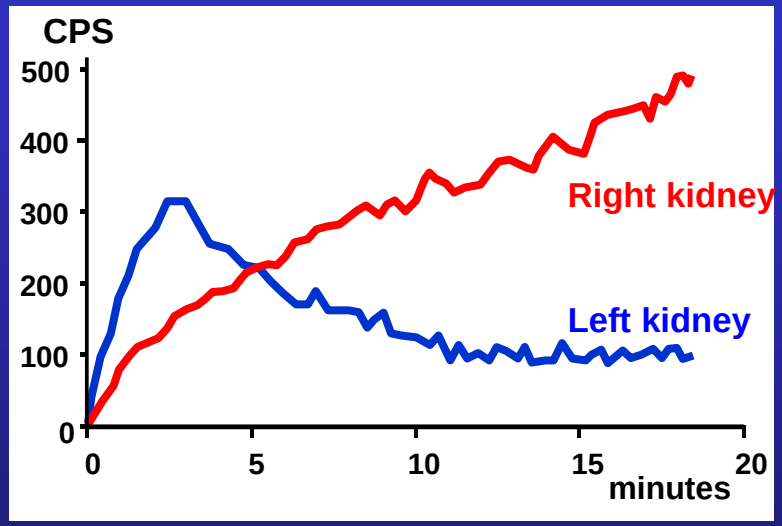
- First impression – no change
- More careful examination – peak activity fallen from 300 to 150 cps
- But – there could be other reasons for this
  - Changed administered activity from 100 MBq to 50 MBq
  - Changed from LEGP to LEHR collimator
- So cps is not a good measure of absolute function

More Serial Studies

Previous renogram with furosemide



Current renogram without furosemide



Assuming that administered activity and collimator are the same, has the function of the left kidney changed?

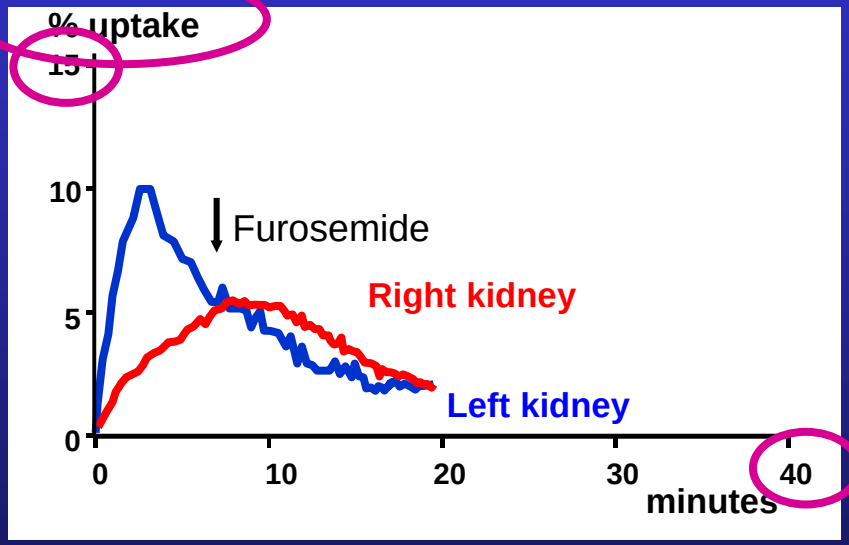
- First impression – Yes, its fallen
- More careful examination – peak activity is still 300cps
- Changing maximum of scale is confusing for serial studies

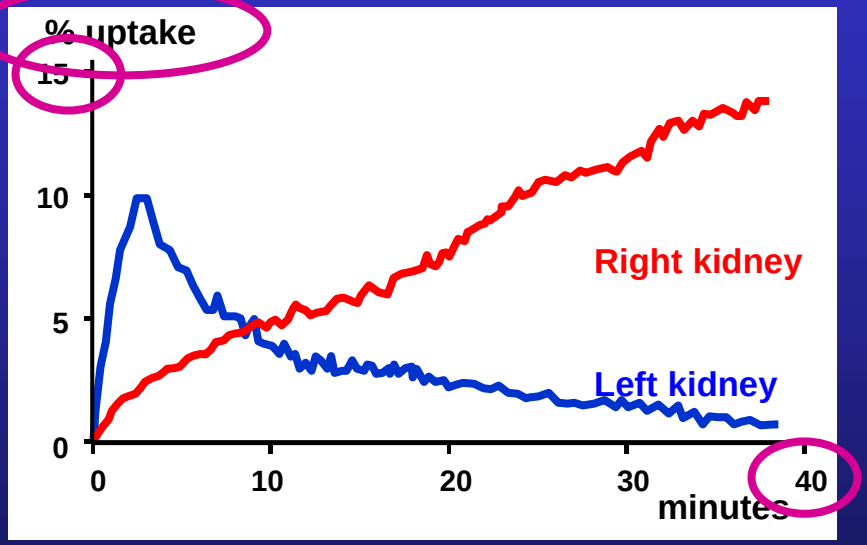
Richard Lawson

Richard.Lawson@physics.org

Display as percentage of injected dose

10.6. To allow comparison between studies, it is helpful to display the curves either as a percentage of the injected dose, or normalised to a standard activity and patient size. The scale used should be consistent from one study to another.





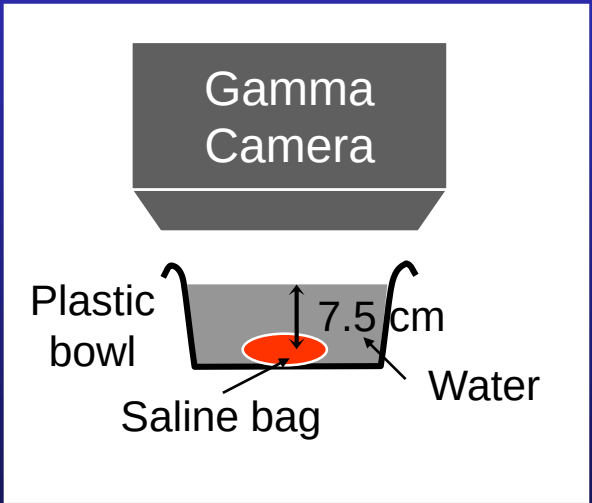
- **DO**
  - Use percentage of injected dose for vertical scale - not cps
    To give a true indication of absolute function
  - Use same maximum for all studies
  - and same horizontal scale for all studies
    To make comparison of serial studies easier

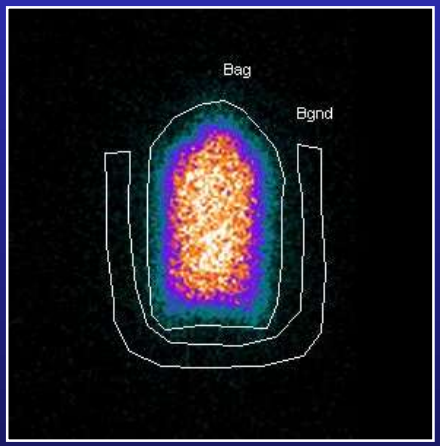
Richard Lawson
Richard.Lawson@physics.org

Calculating Percent Uptake

$$\%\ \text{Uptake} = \frac{\text{Kidney cps}}{\text{Administered activity (MBq)} \times \text{Decay Factor} \times \text{Camera Sensitivity (cps/MBq)}} \times 100\ \%$$

To measure camera sensitivity:





- Acquire image of kidney phantom with known activity at typical kidney depth
- Draw ROIs like kidney
- Determine cps/MBq

Richard Lawson
Richard.Lawson@physics.org

Example of Display

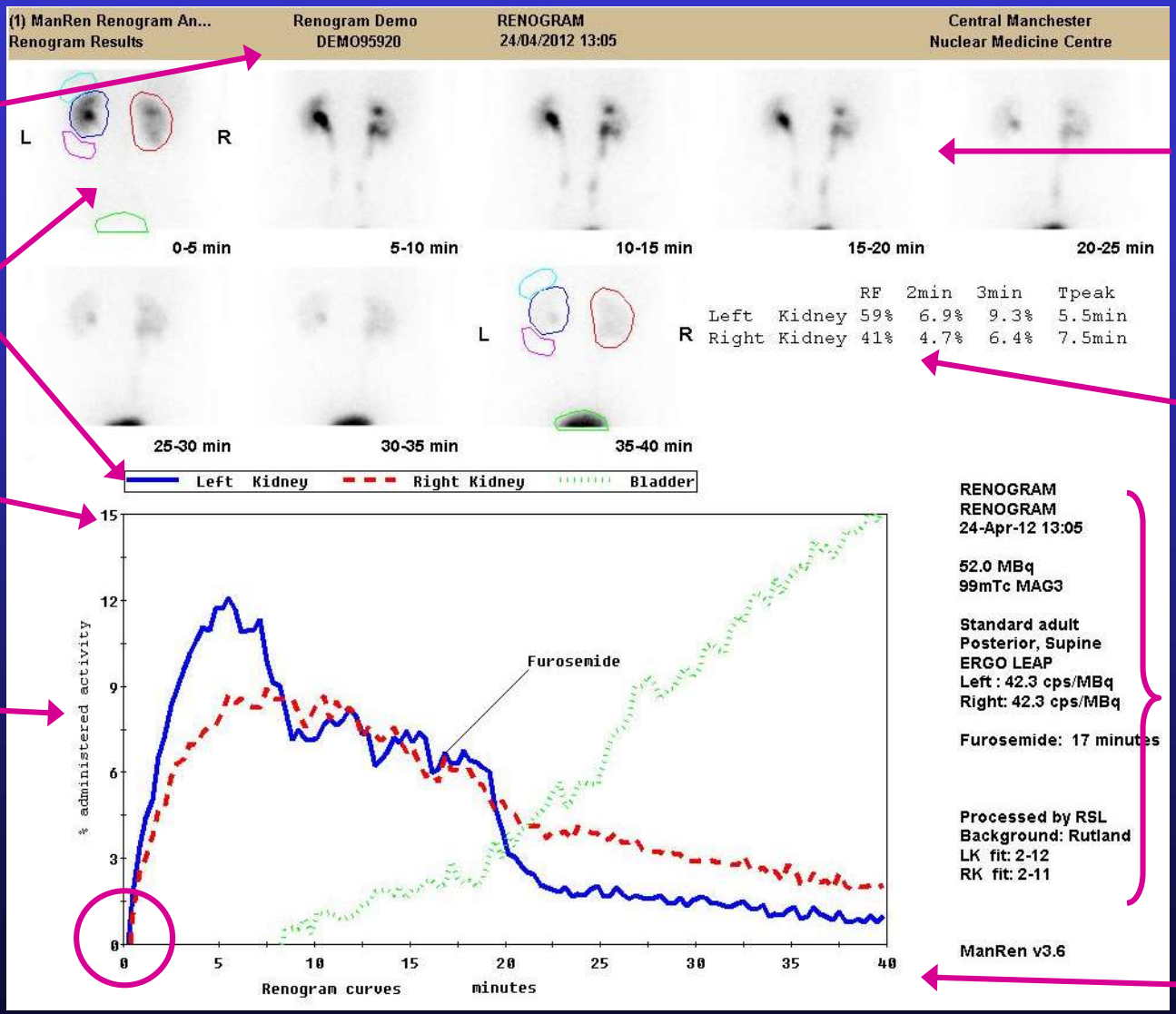
Patient & study details

Regions & curves in same colour

Fixed vertical scale

Percent activity (not cps)

Correct background subtraction



Summed images to same maximum

Functional results

Acquistion and processing parameters

Fixed time scale

Richard Lawson

Richard.Lawson@physics.org

Summary

- **DO**
  - Check for patient movement
  - Make sure regions include all of the kidney
  - Check regions on cine display
  - Make sure that background subtraction is correct
    Curves should rise smoothly from zero
    Rutland method is more reliable
  - Calculate divided function
  - Quantify late images
  - Display images, late images, curves, output efficiency
- **DON'T**
  - Let images scale to their own maximum
    That makes it difficult to judge emptying
  - Display curves as cps
    That makes it difficult to see absolute function
  - Use different scales each time
    That makes it difficult to compare serial studies

Richard Lawson Richard.Lawson@physics.org