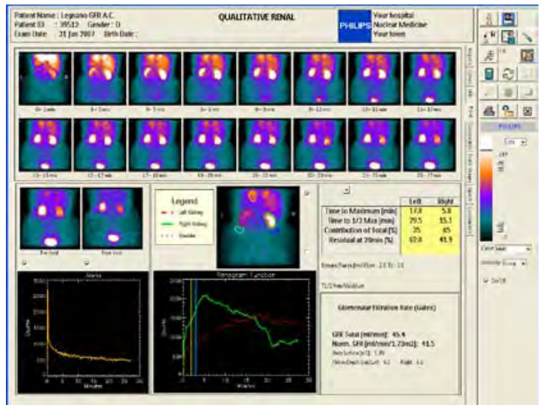
RENAL

10 Qualitative Renal Analysis

10.1 General



The application allows Kidney, Aorta and Bladder Regions, curves and composite images with calculation of T ½ ,Tmax, Percentage contribution left to right, Residual activity at 20 and 30 or 40 min from one, two or three phases, using separate files or a multiphase dynamic renal acquisition. Optional entry of Diuretic time with marker on curve set. Final screens are combined with composite images, first phase and functional curves. Two phase or single phase splash display and optional TER (Bubeck) calculations are included. GFR can be calculated from Full syringe image or Injected activity entry. A Lasix page allows pre- and post-lasix T1/2 and Outflow results calculations. Camera based ERPF (Taylor) can be calculated from additional full and empty syringe images or from user data entry.

10.2 Acquisition

The application can handle five scenarios of acquired dynamic image files, see the table below to find into which data buckets the various files should be loaded.

Nr	Acquired files	Description	Destination data bucket
1	Single	One phase throughout	First phase / multiphase
2	Two files	Flow phase	First phase /multiphase
		Function phase	Second phase

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3	Three files	Flow phase	First phase /multiphase
		Function phase	Second phase
		Lasix phase	Lasix phase
4	Two files	Multi; flow +function phase	First phase / multiphase
		Lasix phase	Lasix phase
5	Single	Multi: Flow+Function+ Lasix	First phase/ multiphase

Example:Matrix 64by or 128 by, Phase 1: 1 second per frame 3 minutes, Phase 2: 20 seconds per frame for 27 minutes , 81 frames. When using two or three phases make sure that the number of frames in the flow phase can fit into one or multiple frames of the function phase. For example: 180 frames of 1 second can be built into three frames of one minute for inclusion in the combined function phase.

Pre and/or Post Void images: if no Pre Void image is available it can be generated from the last frames of the dynamic image automatically. See the Default setting for this.

GFR and ERPF: Full syringe image or Full + Empty images. Without images the injected activity and a dose-multiplication factor can be entered manually.

Bubeck: For the special Bubeck style left to right calculation it is required to have at least 120 frames of 1 sec/frame in the first phase of a two phase study. If less than 120 frames are available or the time per frame is not 1 second the left to right contributions are determined from the full integrals at the user determined time range.

Lasix: The lasix phase is either extracted from the three phase Multiphase file or read from the lasix phase databucket. The matrix size must be the same as used for the flow and function phases. The application does not allow for display of the lasix phase dynamic image in a "Splash" display as it is available for the phase 1 and 2 dynamic images.

10.3 Processing

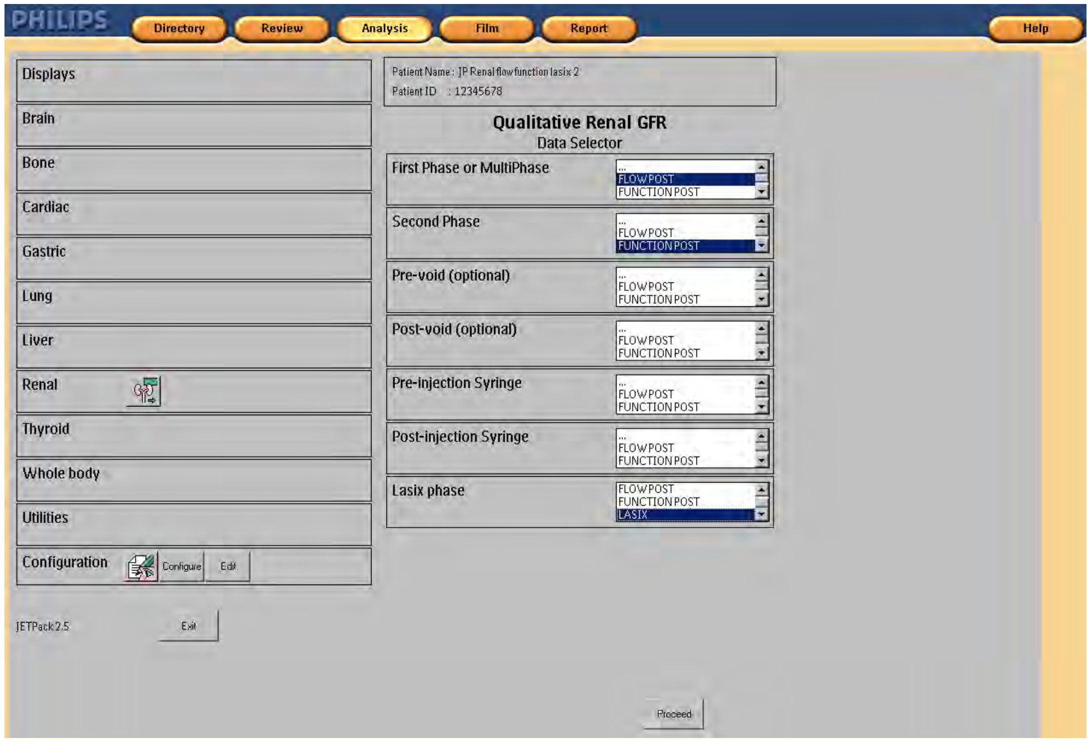


Figure 92 ISP JETPack panel, Qualitative Renal application selected

If required adjust the selected files in the data buckets and click Proceed.

10.4 Regions Page

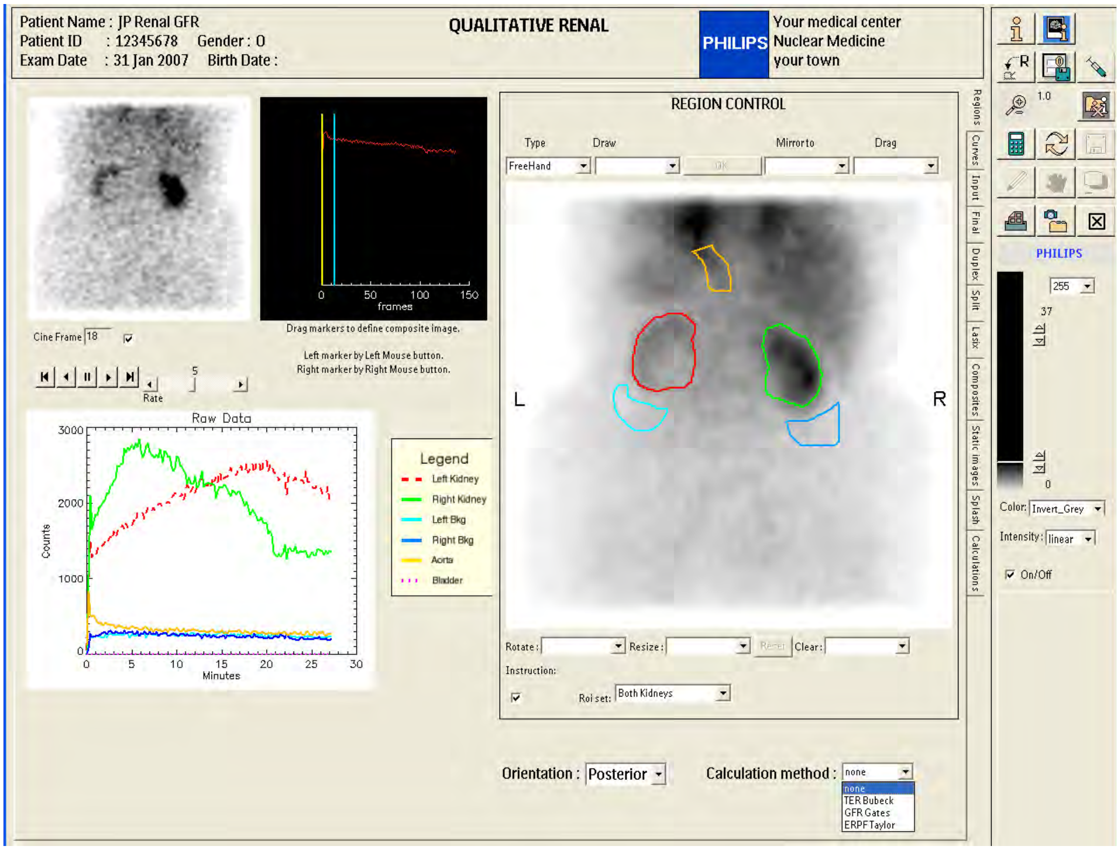


Figure 93 Regions screen, Cine, Composite selection, Regions control, raw Curves

The dynamic image is displayed in the Cine panel and a composite image is generated and displayed in the Region control view port. If a first and second phase set of images is loaded then the two images are also combined to form a functional image from start to end.

By means of the image checkboxes the individual images can be enabled for adjustment of window setting, color map, and Intensity (log, exp) etc.

Use the **cine** controls to display the dynamic image in motion or step through individual frames. Drag the yellow and blue markers on the composite selection curve to build a different **composite image** if so desired. These markers can be preset to certain frames in the Default panel. Select the Orientation to be either Posterior or Anterior to enable the Region selection controls.

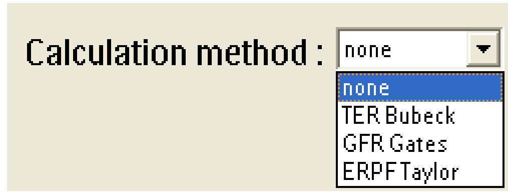


Figure 94 Calculation method: None, TER Bubeck, GFR Gates or ERPF Taylor

The calculation method is preset by the the default selection; however, you can choose a different calculation method from the menu.

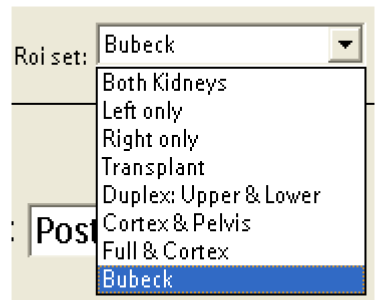


Figure 95 Select the **ROI set** Both, Left, Right , Transplant ,Duplex upper&lower, Duplex cortex& pelvis or Bubeck from the selection menu below the composite image in the Region Control section.

Regions:Draw the Left and Right kidney regions either by Polygon, Freehand or IsoFree method, then select either Auto-Bkg-Left and Auto-Bkg-Right from the Type menu or draw freehand regions for the kidney background regions. The Bladder region and curve is optional, just draw the region to generate the curve. The Aorta region and curve generation can be enabled via the default panel. Once all required regions are drawn the Calculate & Display button is enabled. Click that button to generate the curves. The Raw Curve set will be shown at the bottom left curve display. Continue to the Curves page.

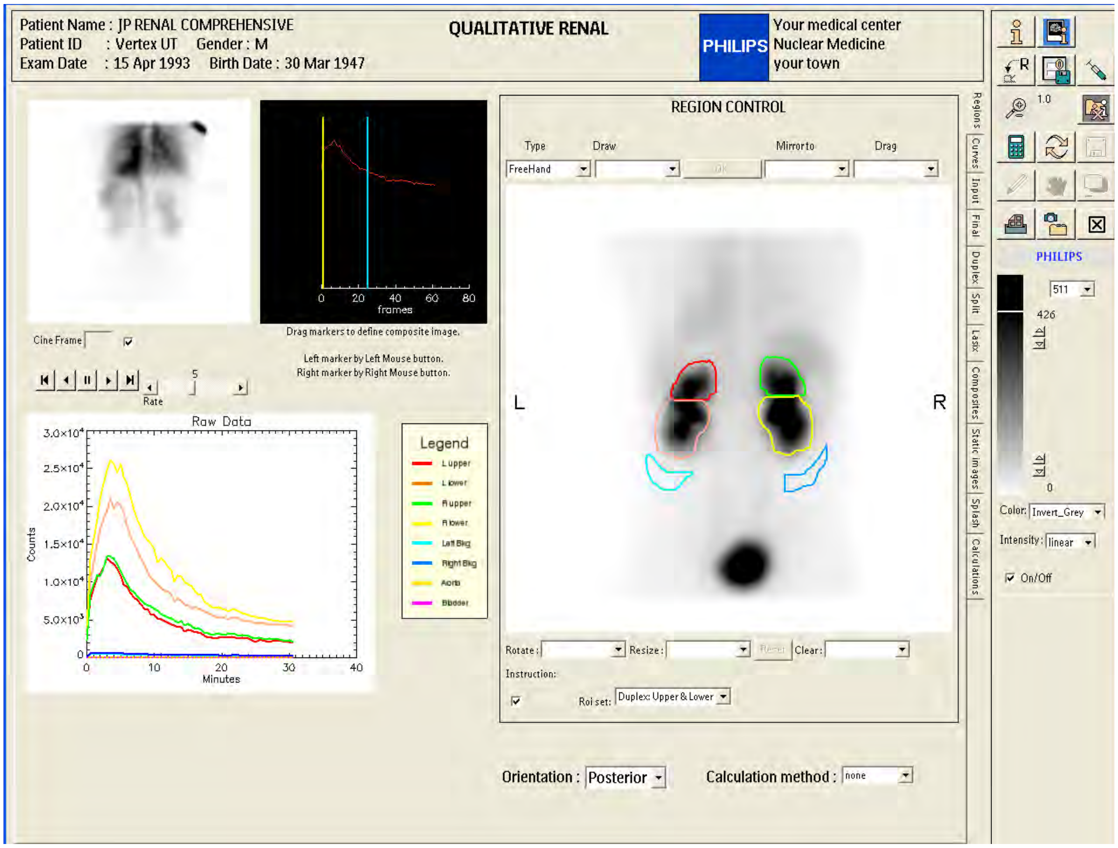


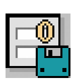
Figure 96 Region page, Duplex upper and lower ROIs

Notice the four raw kidney curves as generated from the Upper & lower ROIs. If you select the Duplex Cortex & pelvis method and the curve legend will be changed to reflect the new situation.

Figure 97 Bubeck ROI set

This is a typical region set as used for the Bubeck method to calculate the left and right contributions. The rectangular 'Body retention' ROI is used to generate the body activity curve. This curve is only used during the first phase of the study to calculate and subtract the individual left and right body activity from the left and right kidney curves. See the Bubeck page description for more details.

10.5 Button Panel



See the General description for an explanation of the various buttons.

Set Defaults: Click this button to bring up the Default entry panel.

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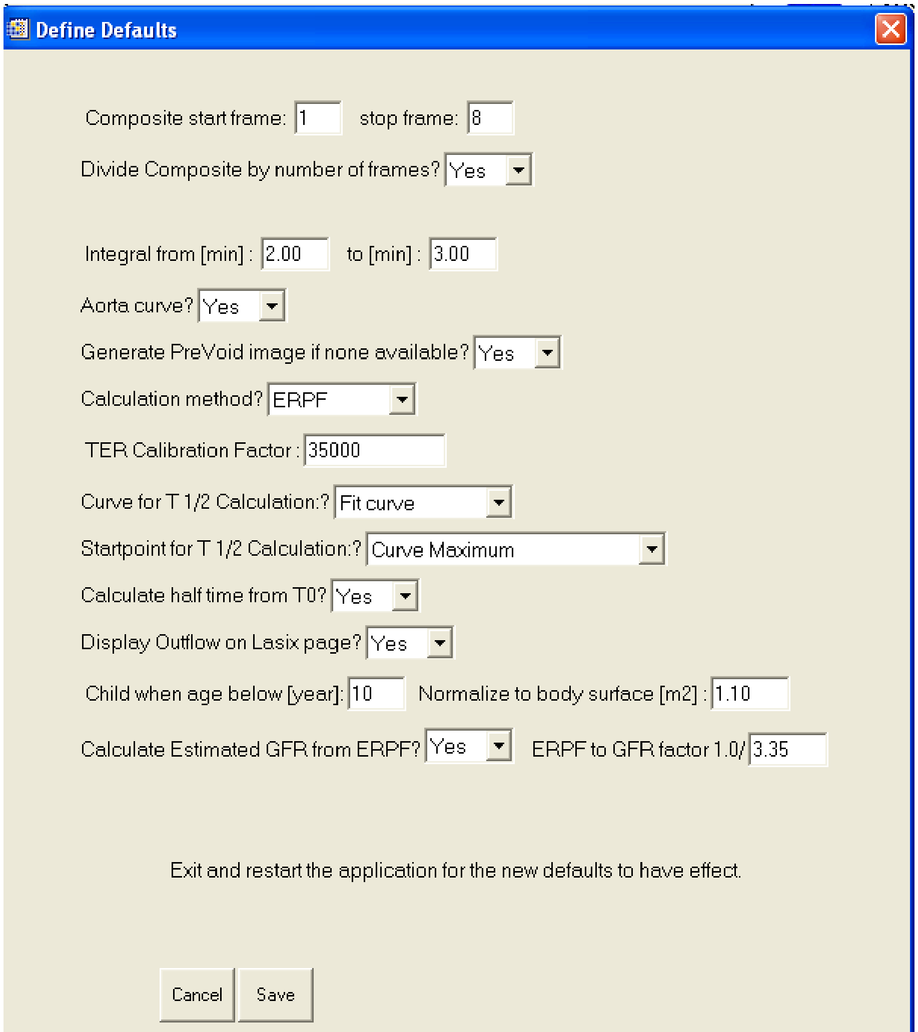

Figure 98 Default entry panel

Composite Start and Stop frame preset the range of frames used for the region composite image.

Divide Composite by number of frames brings the maximum of the new composite in the same range as the frames in the dynamic cine image.

Integral from to defines the time range of the curve sections that are used to calculate the contribution percentages of left and right kidneys.

Aorta curve yes, allows you to draw and generate the aorta curve on the final page.

In the no position the region can be drawn and the curve will be displayed only on the Regions page. If set to yes the Aorta region must be drawn to allow the generation of curves and various calculations.

Generate Pre-void image If a post-void image was loaded but no pre-void the application can generate the pre-void from the last frames of the dynamic image. The pre and post void images are normalized for acquisition duration and matrix sizes. E.g when the post-void was acquired in 128x128 and the dynamic in 64x64 the post void data is multiplied by $2^2 = 4$.

Calculation method for processing:

- **None:** Standard T max, T ½, Left Right contribution and Residual percentages.
- **Bubeck**: Allows calculation of the Tubular Extraction ratio based on the method by Bubeck (see Reference) and the special Bubeck style left and right contributions calculation. Use the Bubeck region set to draw all required regions including a Body region. See the description of the Bubeck page further on.
- **GFR:** To allow calculation of the GFR based on the Gates method.
- **ERPF**: Allows calculation of camera-based ERPF results based on the Taylor method.

This selection presets the Calculation method selection on the Regions page, however during normal execution of the application you can change the preset method.

Curve for T ½ calculation: Calculation is performed on the Fit or Original curve.

Startpoint for T ½ calculation can be either the Maximum of the curve or the time that you enter for Diuretic application. See also the description and examples further on.

Calculate half time from T0? The time displayed as T1/2 is calculated from t0 (yes) or (no) from Time to maximum or Time of injection of the diuretic.

Display Outflow on Lasix page: To preset the display of the Outflow calculations on the Lasix page. Select “yes” to display the results, select “no” to hide the results.

Child when age below[year]: Enter the desired age limit for children in the GFR and ERPF calculations.

Normalize to body surface[m2]: Enter the body size value to normalize the results of GFR and ERPF to in case of children. If you do not want a different value for children and adults enter the value 1.73. That value is used for Adults.

Calulate Corrected GFR from ERPF values: Select yes to estimate the GFR from the calculated ERPF results.

ERPF to GFR factor 1.0/xxx: Enter your factor (xxx) to estimate GFR from ERPF.

Enter Injected Dose : click this button to bring up the panel below

Figure 99 Entry panel for Injected Activity and Urine volume

Enter the amount of activity of the Full and Empty syringes here if the Dose is not already shown on the Study Info panel as it may have been read from the Image header.

To display the Urine voiding per minute on the Final screen enter the Volume and voiding time here.

10.6 Curves Page

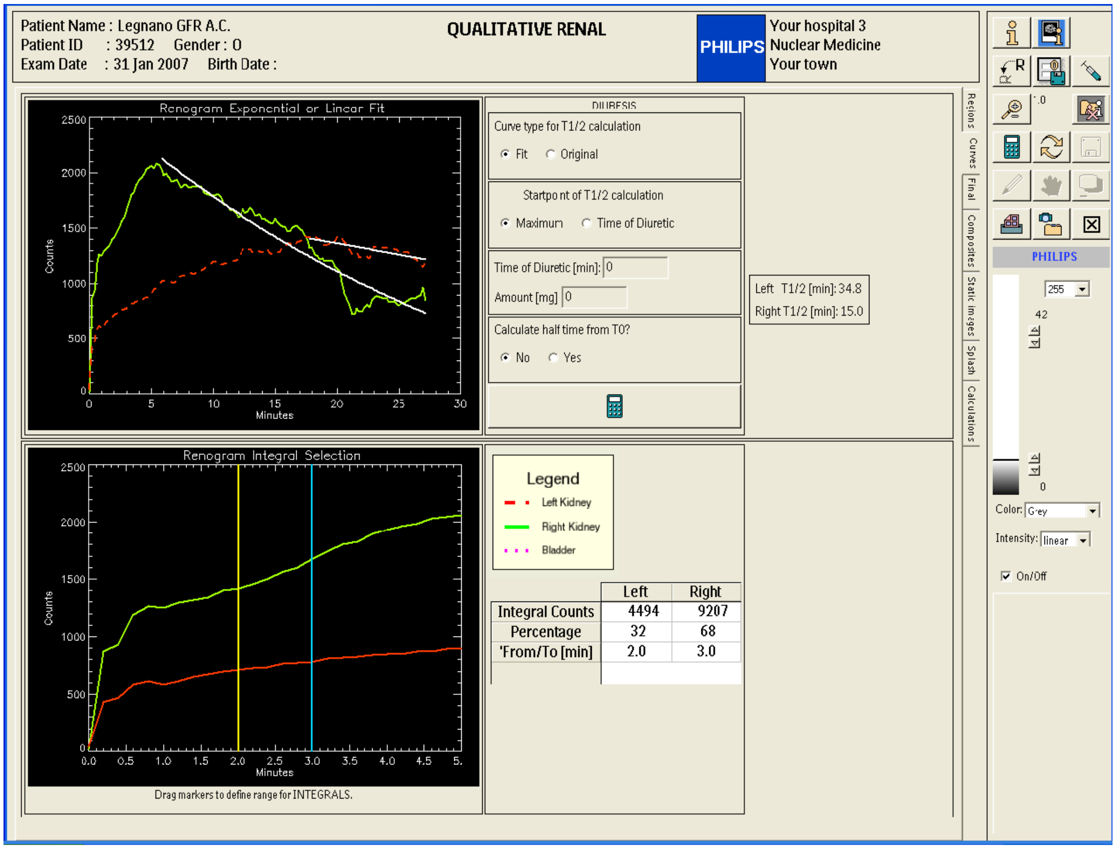

Figure 100 Curves page , Diuresis and Integral selection.

When all regions have been drawn the Calculate&Display button is enabled. Upon selection of that button the various curve sets are generated. The Raw curves on the Regions page, the Area normalized background subtracted curves of Left and Right kidney and Fit curves.

10.6.1 T ½ calculation

The Curves page shows at the Top the Left and Right curve with Fit curves from curve maximum to the end. The fit curve is used to calculate the T ½ time from time of maximum.

An exponential curve is attempted, if not successful a linear fit is tried. If neither is successful the T ½ can not be determined. See the next page for more explanation on the features for T1/2 calculation.

10.6.2 Integrals and ratio percentages Left to Right.

The graph near the bottom shows the Left and Right curve (background corrected) with the two markers to define the range for Integral calculation. The markers are interactive, the Integral counts and percentages of total for Left and Right are recalculated each time a marker is moved.

Hold down the Left mouse button to drag the left marker (yellow), the right mouse button for the right hand marker (blue)

The selected range and calculated percentages are displayed also on the final page.

10.7 T½ Calculation

See the next three examples for the various features.

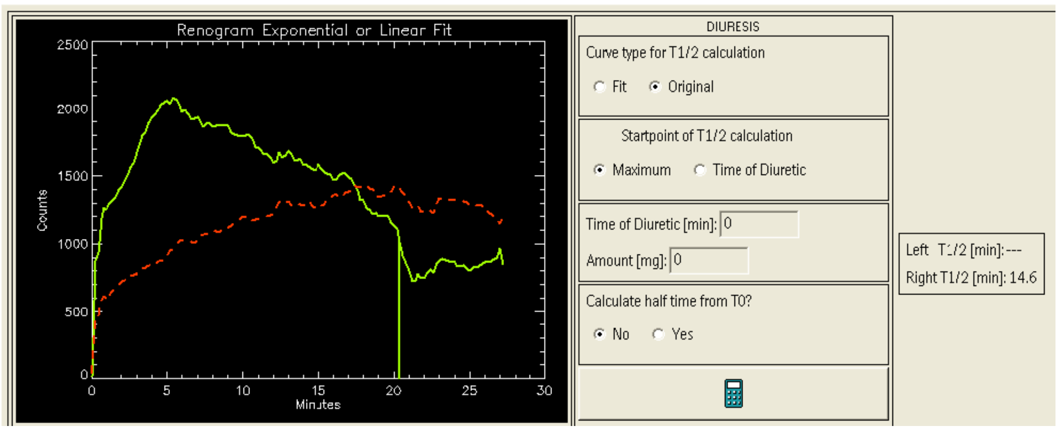

Figure 101 T ½ on original curvees

Figure 101: T ½ calculation on the Original curves starting from maximum values. Notice that time to the half value for the left curve can not be determined as it does not fall with in the range of the curve. Right kidney T1/2 is from Tmax to T ½ activity.

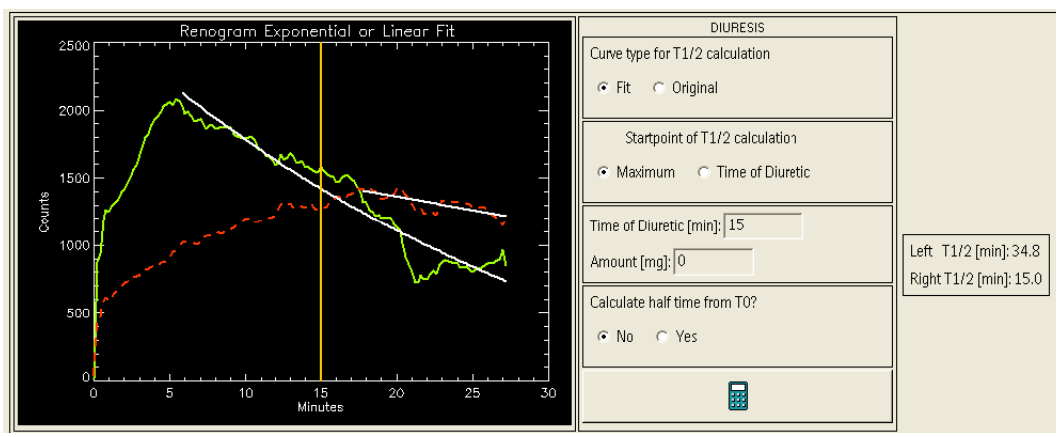

Figure 102 T ½ calculations on Fit curves

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Same curve set, T ½ is calculated on the Fit curves starting from Maximum curve values. A diuretic time marker is inserted but does not affect T ½ calculation (Startpoint = Maximum)

If a Diuretic like Lasix has been applied the amount and time post injection can be entered here. A time-marker will be displayed also on the renal function curve on the final page while both the numeric values of the time and the amount given will be shown there as well. If a third phase or separate Lasix dynamic is available you can use the Lasix page for T1/2 calculations pre and post lasix.

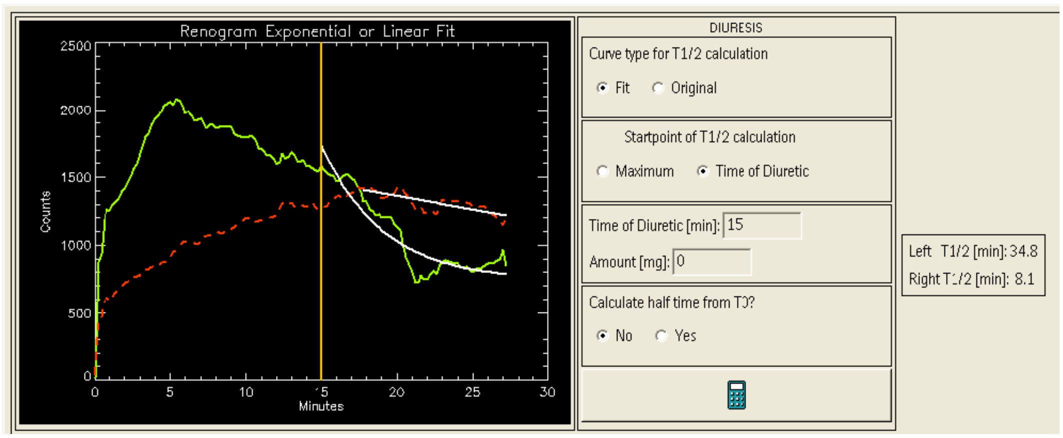

Figure 103 Same curves, Time of Diuretic application is the start point for T ½ calculation

For the Right curve (green) the curve value at the Diuretic time is the maximum value for the remaining curve therefore the curve fit runs from there to the end of the study. For the Left curve (red dotted) the maximum of the curve section from 15 minutes onwards is not at the 15 minute marker, therefore the curve fits starts later at the maximum value.

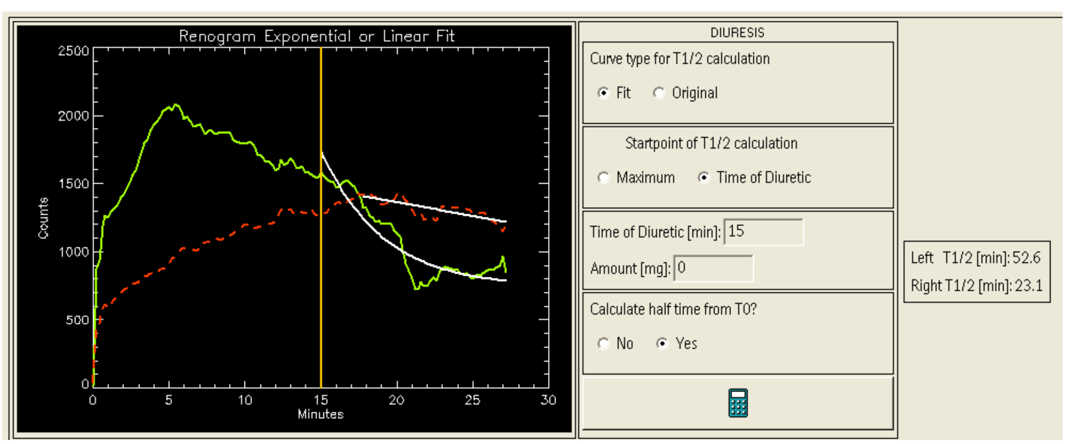

Figure 104 Same situation as above except that “Calculate half time from T0 was switched on.

The Left T1/2 is now 52.6 min from 34.8 min on the linear slope with 17.8 min as the maximum value on the red curve. The Right T1/2 is here 15 + 8.1 = 23.1 minute.

10.7.1 Duplex ROIs

In the case of duplex ROIs the upper and lower ROI per kidney are added to build the full left and right kidney curves for the above T1/2 methods. A separate page “Duplex” will display the curves and calculated results for the four individual kidney sections.

10.7.2 ERPF and GFR

In the case of ERPF and GFR calculations the kidney curves are corrected for attenuation caused by the kidney depths. This may influence the left to right contribution, especially for children. A label "Curves and values are corrected for Kidney depths" is displayed on the Curves page.

10.8 Final Page

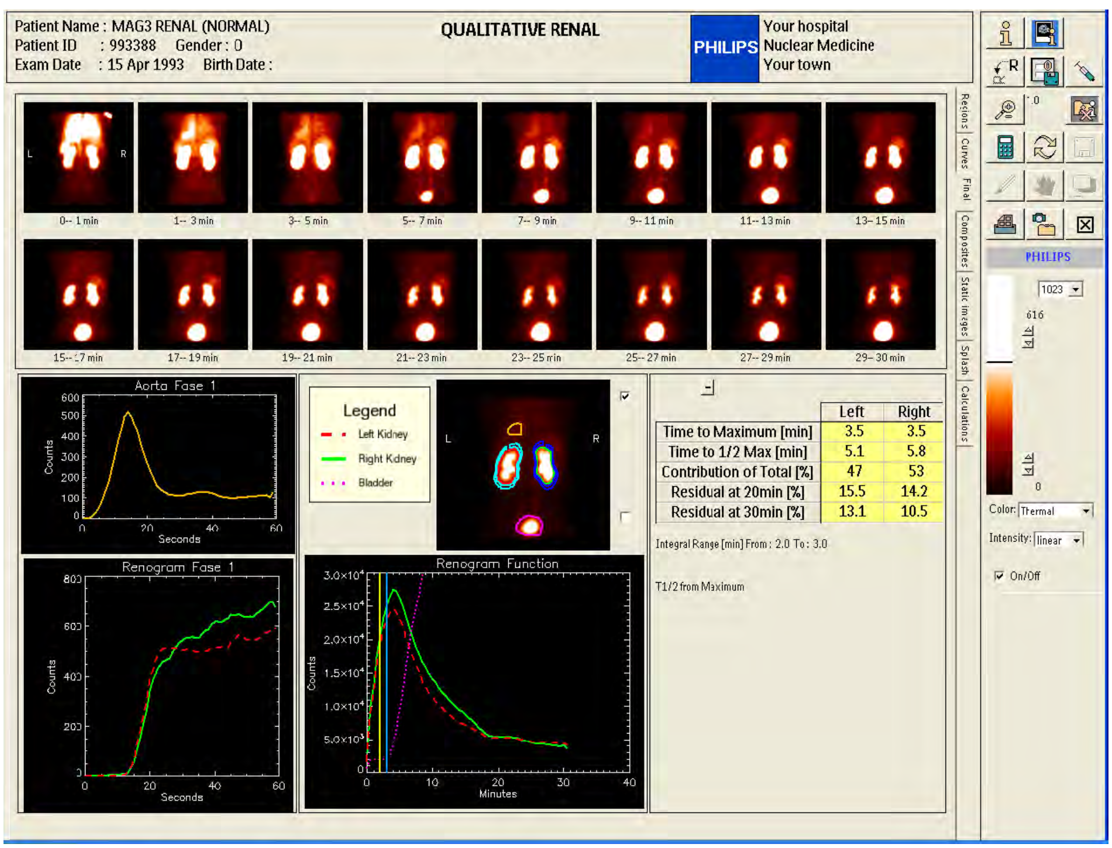

Figure 105 Final screen, two phase dynamic study, Aorta Curve enabled

The final screen shows the following:

Sixteen composite images with time ranges, derived from the input image (Phase 1+2 combined). Each composite image is built by adding frames from the combined phase1+2 dynamic image. For example if the combined dynamic image contains 73 images each composite image is built from 73 / 16 = 4 frames with 73 - (16 x 4) = 9 unused frames. Zoom and Image control can be used to adjust the images as a Series.

Curves: Aorta curve, first phase if available otherwise full length.

- Phase 1 Left and Right curve with X axis in seconds, if a first phase is available otherwise blank.
- Function Curve with selected Integral range and here marker for Diuretic application at 10 minutes as entered by the user. The optional Bladder curve is included in the graph.
- All curves were smoothed with a standard 5 point smooth.

Legends: Curve legend. **Composite image** with all regions superimposed.

Result table with: Time to Max, T ½ from maximum, Left and Right Contribution of Total

Residual at 20 min in percent of maximum counts of each curve. If the curve stretches out to 30 minutes also the Residual percentages at 30 minutes is displayed. In the case that the curve contains 40 minutes of acquisition data the residual percentages at 30 minutes are replaced by the results at 40 minutes.

Diuretic: Time of application in minute p.i. and the amount in mg. A marker is placed on the function curve to indicate the time of application.

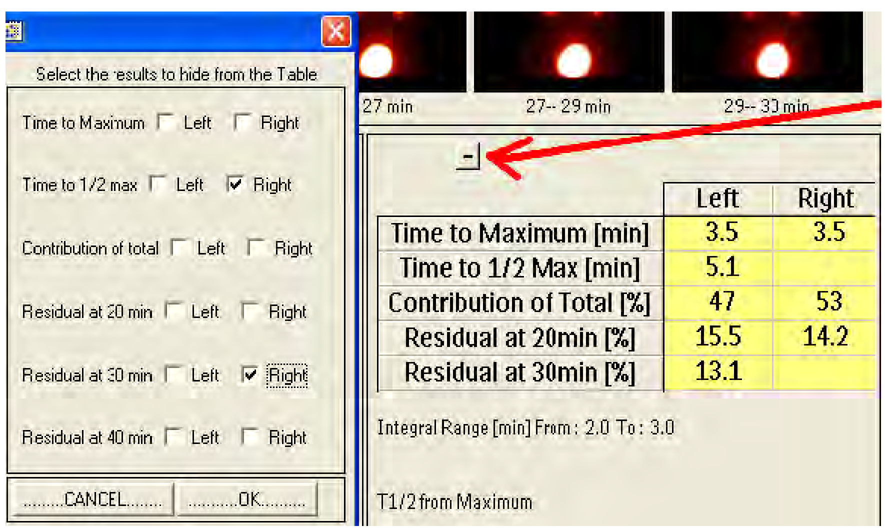

Figure 106 Hide results from the table.

If you click on the small button marked [-] just above the table a panel will appear where you can select items that you want clear from the result table.

To restore the results click on the Calculate & Display button again.

The bottom left corner of the final screen can contain the following items:

- Phase 1 curve only; no Aorta curve, no Void images
- Aorta curve only; Single phase dynamic, no void images
- Aorta + Phase 1 curve; no Void images, see below
- Pre and Post void images with either Phase 1 or Aorta Curve, see below
- Pre and Post void images only; Single phase dynamic, no Aorta curve
- Nothing. single phase dynamic, no Aorta curve, no Void images.

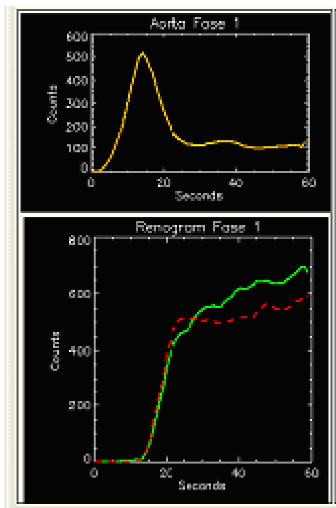

Figure 107 Two phase dynamic study, Aorta curve enabled. Aorta curve on top, first phase kidneys below

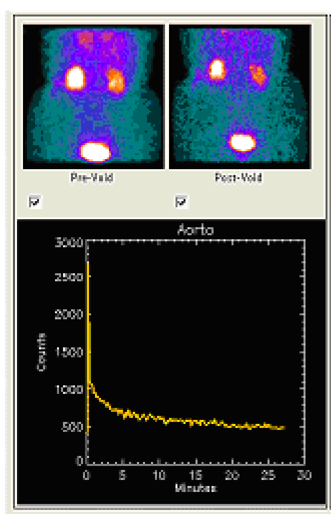

Figure 108 Single phase dynamic study, Aorta enabled, post void image loaded, pre-void image generated by the application.

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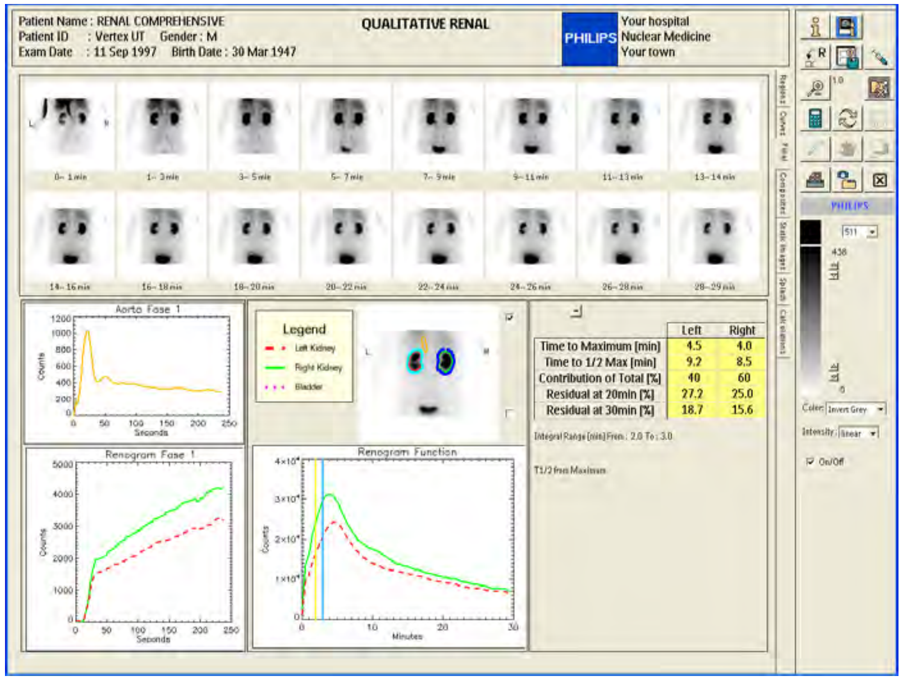

Figure 109 Final screen with Graph background set to white and images displayed in Invert_Grey

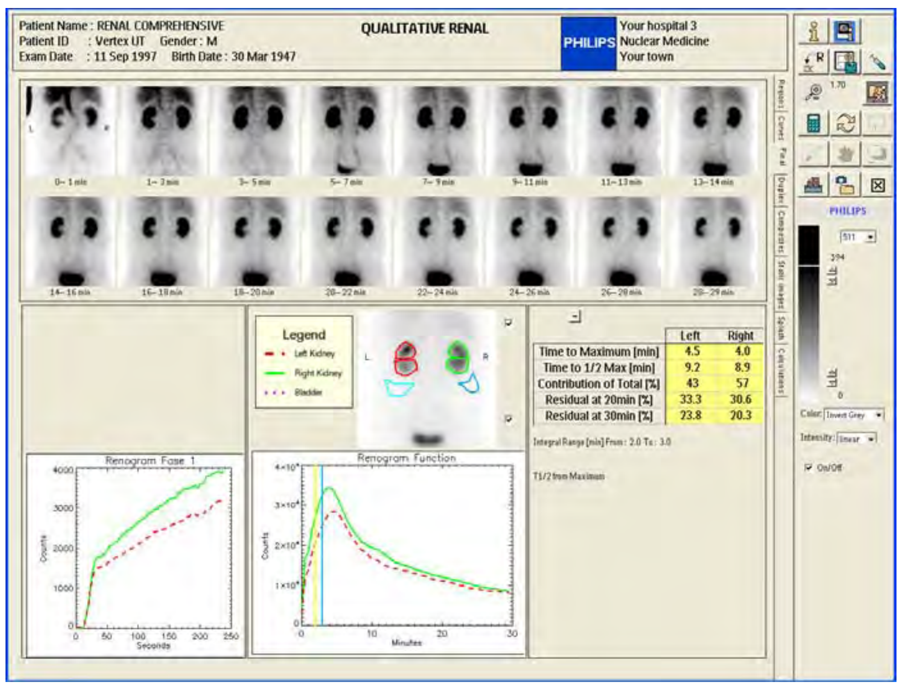

Figure 110 Duplex ROIs on the final screen

In the case of duplex ROIs, upper & lower or cortex & pelvis the final page shows the result of the total left and total right kidneys, in other words the kidney curves are the sum of the upper and lower or cortex and pelvis ROI per kidney. Notice that the upper and lower ROIs have the same color on the left and on the right kidney to indicate that they are added.

The composite image with the ROIs can be zoomed in /out.

10.9 Duplex Page

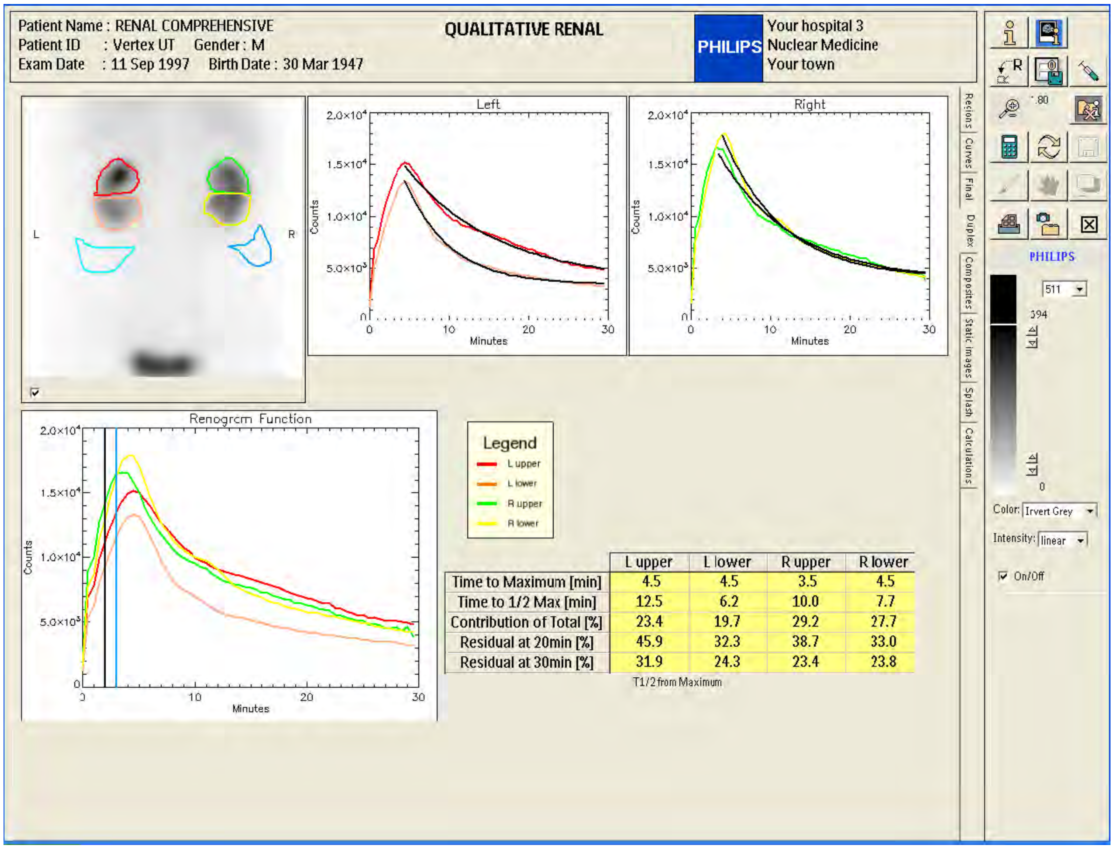

Figure 111 Duplex screen.

The Duplex page shows the composite image with ROIs, the Left and Right graphs with the two area normalized background subtracted kidney curves with exponential or linear fit. The renogram function graph shows all four kidney curves and the two markers that indicate the time range of the integral calculations. The table shows the results per curve for Tmax, T1/2, contribution of total, residual at 20 min and at 30 min, if available. Below the table you find the indication that the T1/2 was calculated as T1/2 from Maximum or T1/2 for t0. This selection is controlled in the Default panel.

The composite with ROIs can be zoomed in or out by clicking the left or right mouse button, respectively, on the zoom button picture in the top right section of the screen.

10.10 Split Renal Page

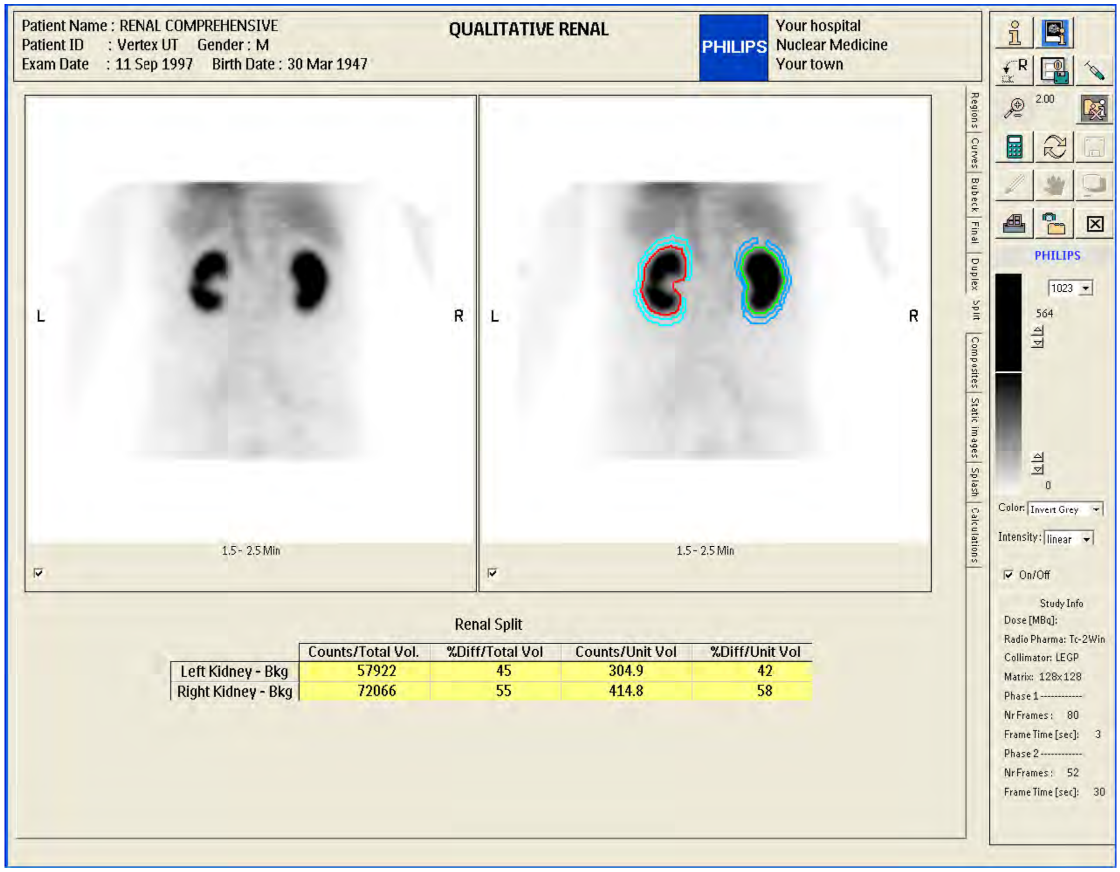

Figure 112 Split Renal page.

In the Both full kidneys situation the application calculates not only the left and right total percentages but also the Average counts of the left and right kidney and the % Difference / Average counts, here indicated as Counts/Unit Volume and % Diff/Unit Volume.

The average counts per kidney are determined by dividing the kidney counts – area normalized background counts by the number of pixels of the kidney ROI.

The average counts of both kidneys are then used to determine the % difference by:

Left Average % = (Left average / Left average + Right Average) x 100 and Right Average % as 100 – Left Average %.

The time range for the composite image is determined by the default setting of the “Integral from” and “Integral To” entries. The Integral range selection on the “Curves” page can be adjusted to determine a different time range.

10.11 LASIX Page

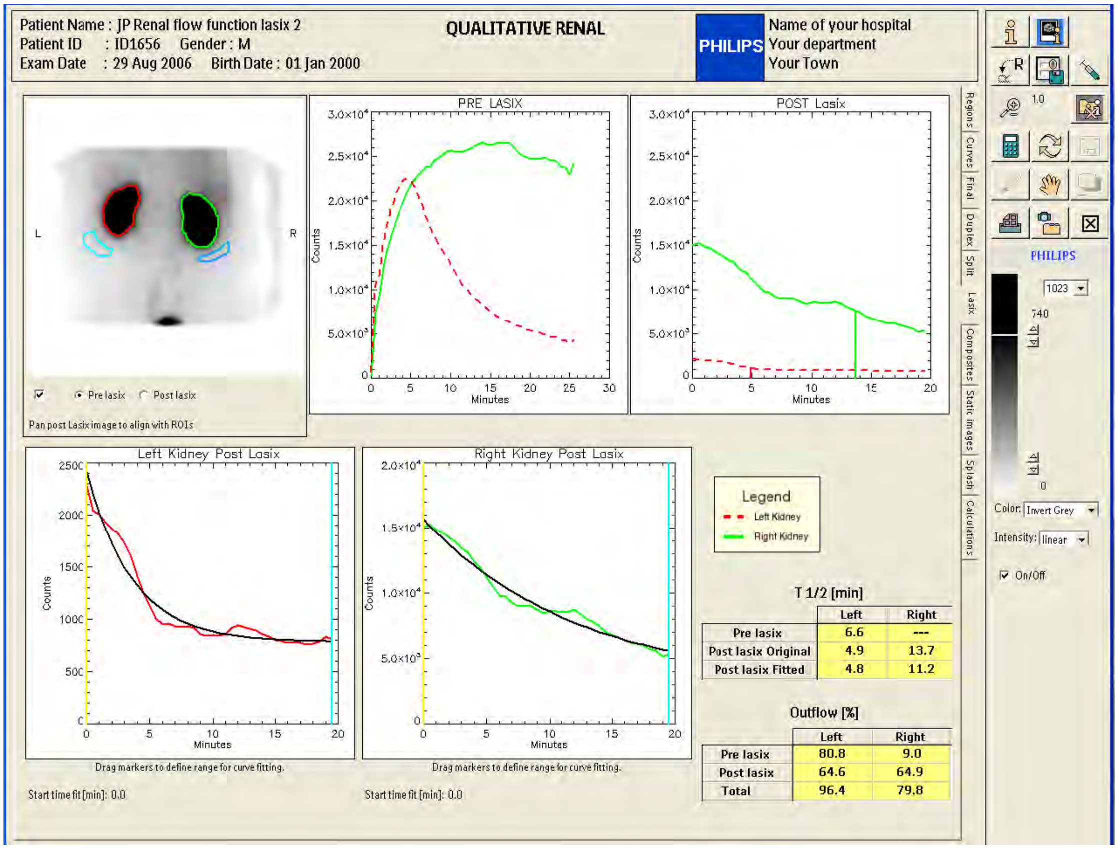

Figure 113 Lasix page, without Post lasix image adjustment

This page displays the Function curve set as shown on the final page here as the PRE-LASIX curve set, see the top center of the page. The T1/2 values for these curves are determined on the Curves page and displayed here as the “Pre lasix” T1/2 values for left and right kidney.

The post lasix curves are generated from the ROIs used on the pre lasix data, the post lasix curves are displayed at the top right of the page. The vertical green and red lines indicate the T1/2 values that were found on the original curves, these values are displayed in the T ½ table as “Post lasix original” values. Notice the jump in counts going from Pre to Post lasix curves in the above figure. This jump can be corrected by shifting the Post lasix image to have the kidneys align properly with the ROIs. See further down.

The left and right kidney curves are displayed separately at the bottom of the screen. Left and right markers on these curves allow you to select the range of original data that is used to calculate the best fit curve. This fit curve can be exponential, if that fails a linear fit is attempted.

This allows you to estimate the T ½ in case the original curve does not contain that value within the acquired time range.

The Pre, Post and Total Outflow values are automatically calculated from the Pre and post lasix curves. You can hide the display of these results through a setting on the Default panel.

The pre-lasix and post-lasix outflow values are defined as:

$$100 \times (\text{Curve maximum} - \text{last frame value}) / \text{Curve maximum}$$

for each curve.

The total outflow is calculated from:

$$100 \times (\text{Curve maximum Pre curve} - \text{last frame value Post curve}) / \text{Curve maximum Pre}$$

10.11.1 Adjusting the Post lasix image position.

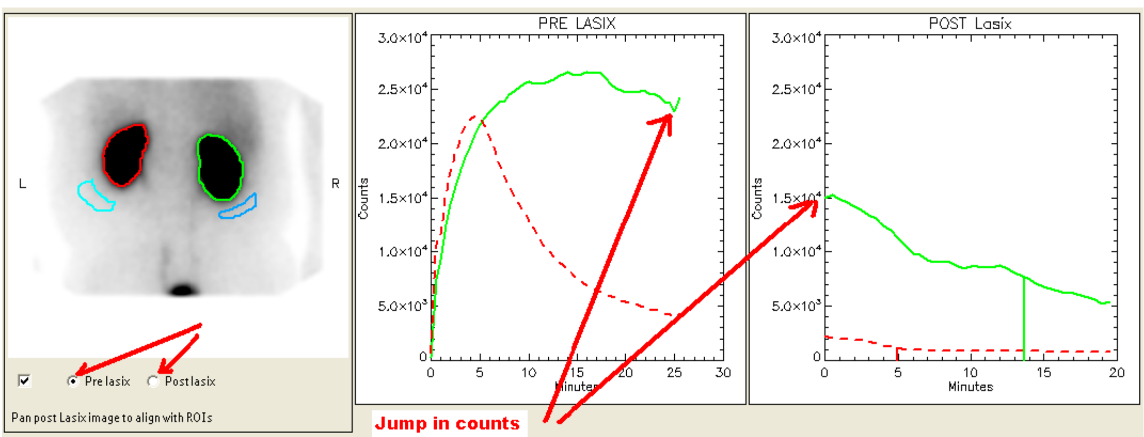

Figure 114 Curves before adjustment

Notice the jump in counts from Pre to Post lasix curves. The Pre-lasix composite image shows the correct ROI positions for generation of the Pre lasix curves. Use the switches below the composite image to switch to the Post lasix composite image view.

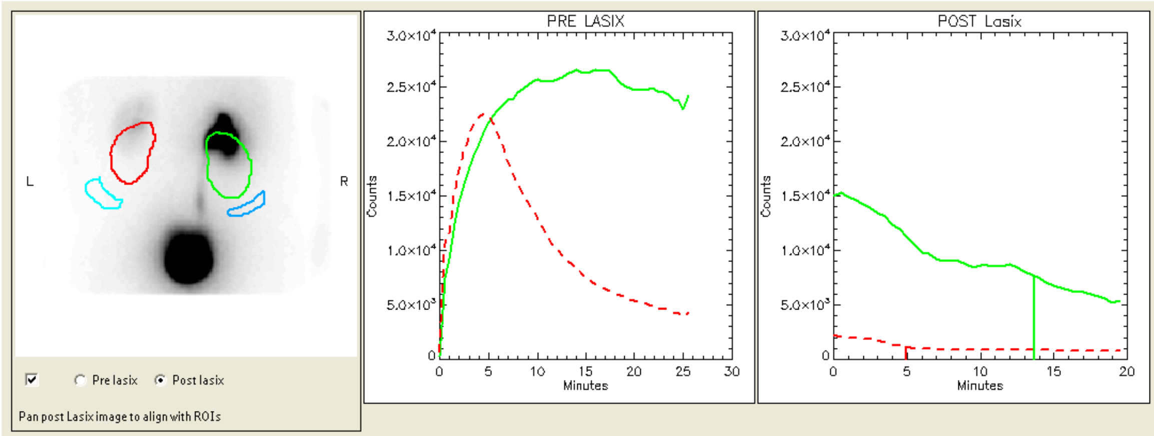

Figure 115 Post lasix image displayed.

The kidneys in the post-lasix composite view are not aligned with the ROIs in this example, therefore the curves as generated from these ROIs are not correct.

Click on the Post lasix composite image then drag the image such that the kidneys align with the ROIs. The Post lasix curves and calculations will be updated upon release of the mouse button.

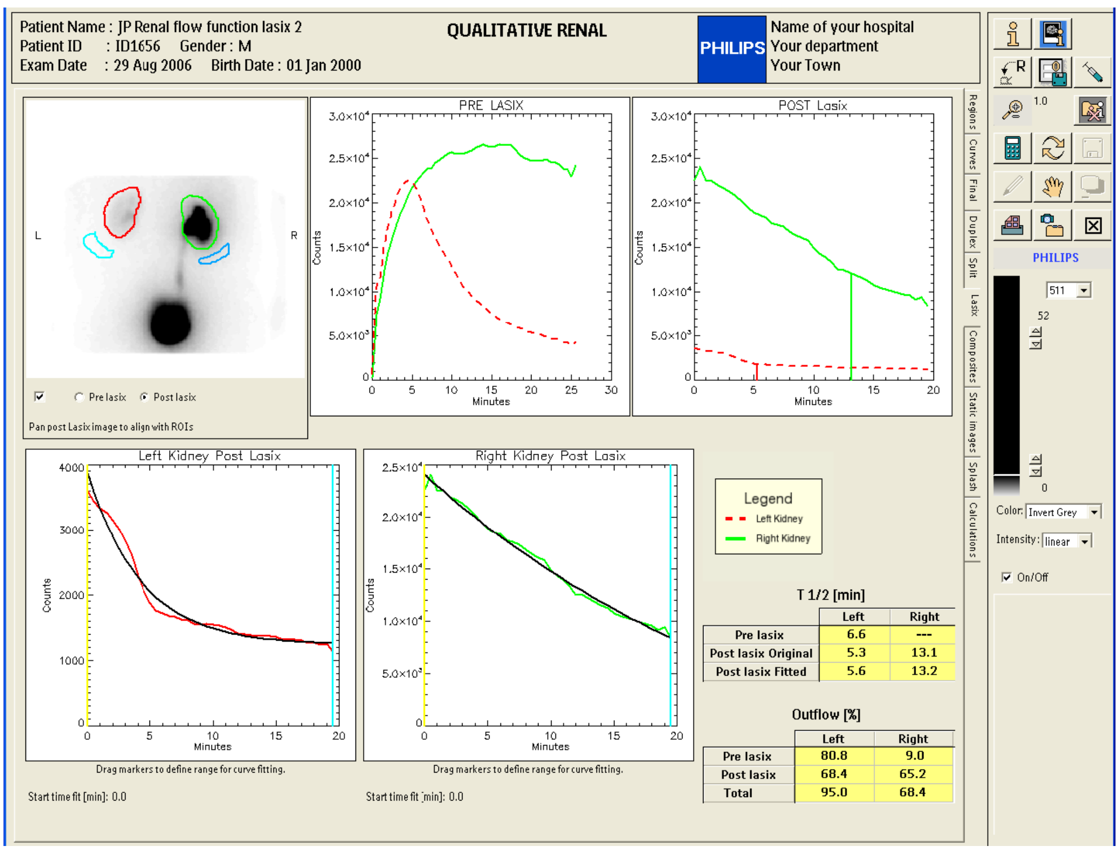

Figure 116 Post lasix composite image aligned with Pre lasix ROIs.

The new position of the composite is used to shift the original dynamic lasix image and to recalculate curves, curve fits, T ½ for post lasix etc.

10.12 Composites Page

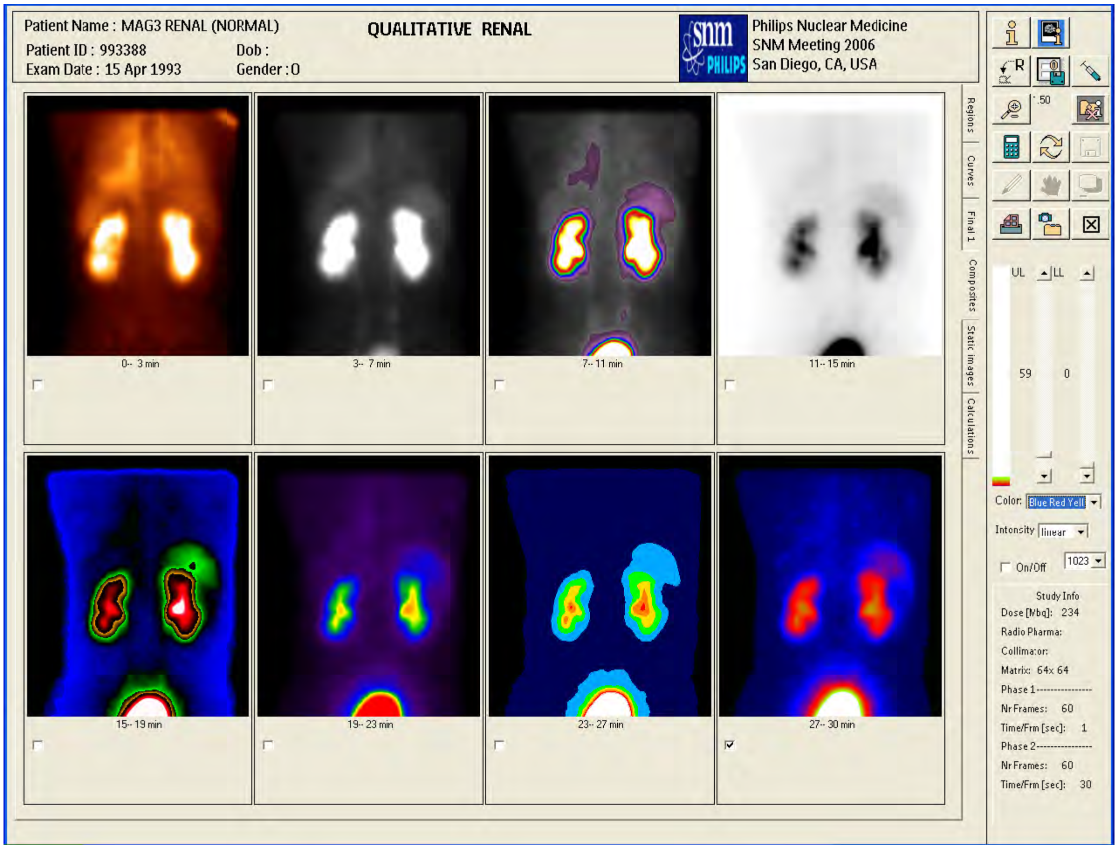

Figure 117 Composites page

The Composites page displays eight composite images that were made from the input images by splitting the total acquisition time of flow and function into 8 segments. The calculated time range per composite is shown below each image. A checkbox near each image allows individual or combined image adjustment. With the On/Off checkbox flagged in the Button Panel all image checkboxes are set or cleared thus causing the Image and Zoom controls on the button panel to work on all composites simultaneously, this behavior is the same as found on Pegasys. In the extreme case shown here, eight color maps were used.

10.13 Static Images Page

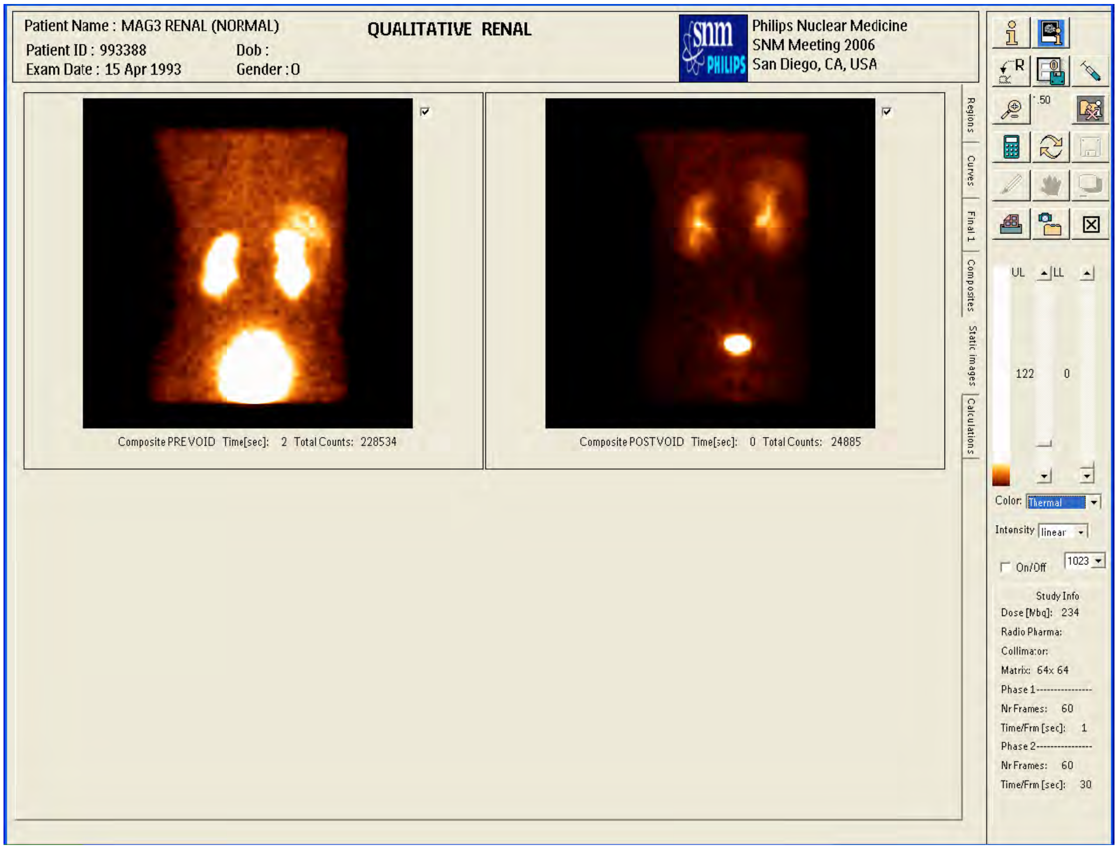

Figure 118 The Pre and Post void images when selected and loaded are displayed on the Static images page with their total counts and acquisition during shown below each image.

Use the checkboxes and normal image controls to adjust the images for display and/or documentation.

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10.14 Splash Page

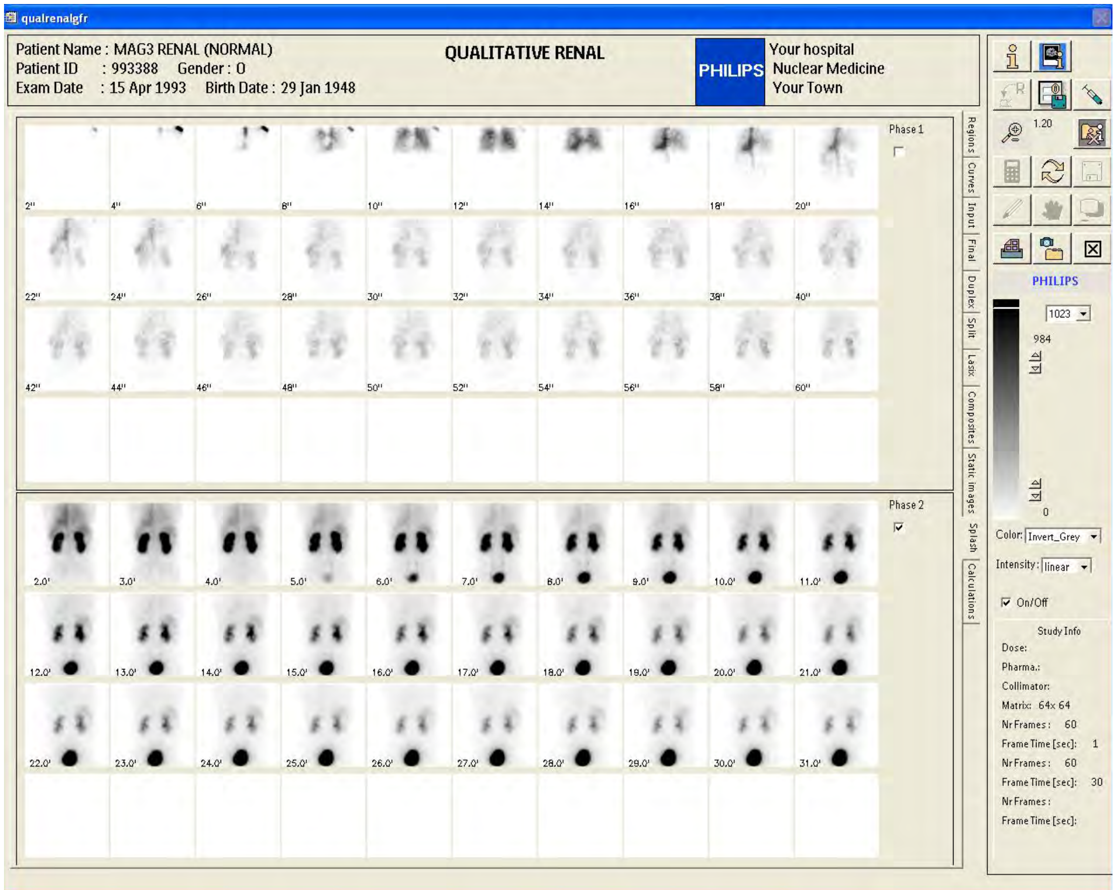

Figure 119 Splash page

The Splash page will show either a single phase study in a maximum of 80 frames or the first two phases of a dual or triple phase study in 40 frames each. If a study phase contains more than 80 frames in single phase mode or 40 frames in multi phase mode the frames will automatically be compressed into composite images to display the "full" length of each phase. Some example compression results into 40 viewports are; phase contains 50 frames, compressed by 2, result is 50/2 = 25 composites; phase contains 65 frames, compressed by 2, result = 64/2 = 32 composites, 1 frame unused.

In the case above, see the study info panel, the first and second phase both contain 60 frames of 1 second and 30 seconds respectively, both phases are compressed into 30 composite images each.

10.15 Tubular Extraction Ratio Calculation (Bubeck)

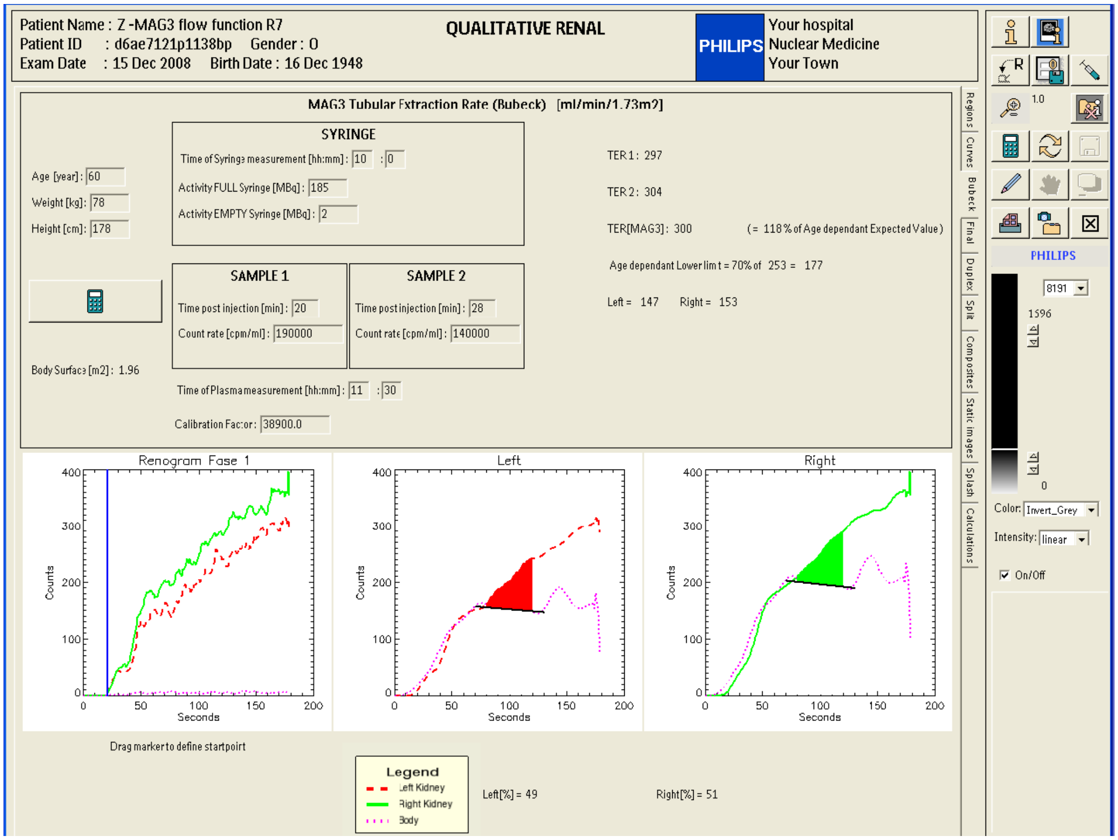

Figure 120 TER (Bubeck) parameters page.

On the page enter or adjust the values for age, weight and height of the patient, the values were read from the image header of the dynamic study. Enter all other values as shown on the page then click on the left hand side Calculate button to perform the calculation of the Tubular extraction rate for sample 1 and 2, the average, the expected value (in this example 253), the lower limit defined as 70% of the expected value (177) and the percentage of Age dependant Expected value. (118 % here). If only one sample is available the calculation can still be performed however the average value will be the same as the value of the single sample TER value. For determination of the Calibration factor see the section Calculations further on.

Adjust the marker, blue in this picture, in the left curve set to coincide with the start of the kidney curves. Notice that a range of 60 -100 seconds after the start point is used to determine the surface under the kidney curve and above the body retention fit curve, indicated by red and green areas for left and right kidney respectively. Each body curve is generated from the original body curve by making the 60 seconds point coincide with each kidney curve. The time range 50 to 110 seconds on these body curves is used to attempt an exponential curve fit and if that is not possible a linear curve fit. The activity of each kidney curve section (60-100 sec) minus the activity of each fit curve will yield a value for left and right. These values are then used to calculate the left and right contribution by L [%] = 100 x L/(L +R) and R [%] = 100 – L[%].

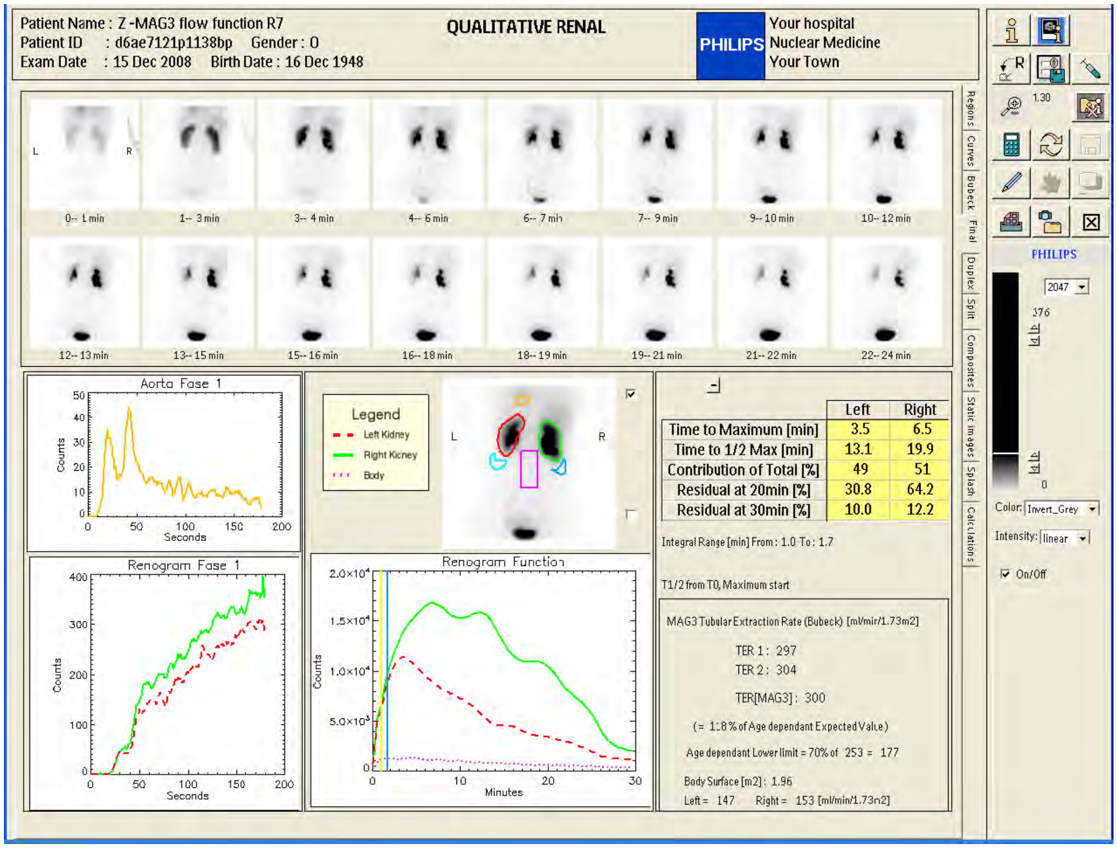

Figure 121 Final page with TER results displayed.

Notice that the time range on the Renogram function and Integral range indicate 1.0 to 1.7 minute or 60 to 100 seconds for the Bubeck integral calculation.

WARNING: Be aware that you can override the Bubeck style integral calculation by adjusting the integral range markers on the Curves page. If you change the position of those markers the Contribution left and right as well as the left and right ml/min values are recalculated.

The reverse is also possible, if you changed the markers on Curves page to recalculate, then any adjustment of the start of activity marker on the Bubeck page will recalculate left and right contributions and TER values, overriding the earlier adjustments.

This is done on purpose to allow you to override the Bubeck integral method that uses the triangular areas in stead of the full integrals.

In the case where there are less than 120 frames or the time per frame is not 1 second in the first phase of the study the left and right contribution can still be determined with the standard full integral method.

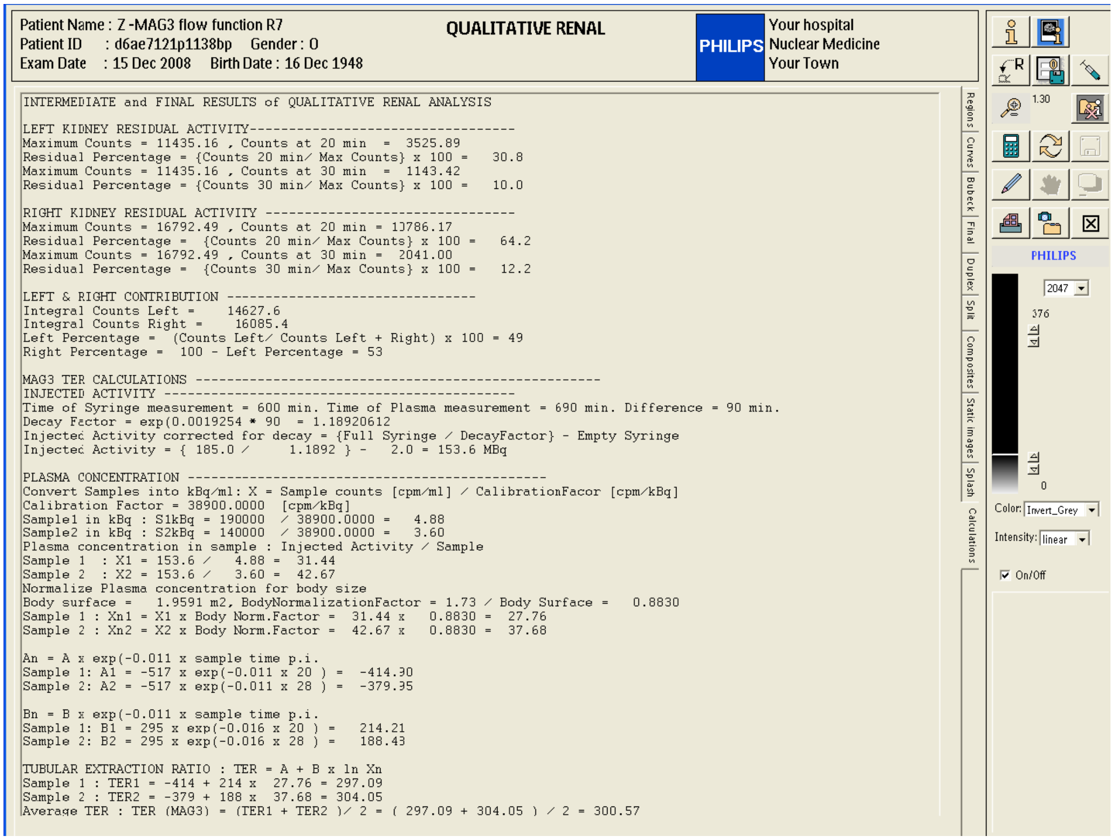

Figure 122 Bubeck Calculations screen.

This screen can be used to verify the results on the Final page. Notice that the MAG3 TER calculations are included here, if this option was not selected this section will not be displayed.

10.16 Calculations

10.16.1 Left & Right contribution:

Integral counts of the curve sections determined by the markers on the Curves page, e.g 2 to 3 minutes, are determined. The Left contribution is defined as:

Left = Left integral / (Left integral + Right integral)   x 100%

Right = 100 % - Left

10.16.2 Residual percentages:

Counts at t = 20 and t = 30 min (if available) as a percentage of the counts at maximum .

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Left Residual = 100 x (Counts Left at 20 min / Counts Left at maximum) [%]

10.17 Tubular Extraction Ratio TER, Bubeck method

For proper calculation of the Tubular extraction ratio a calibration factor must be determined prior to using this option.

10.17.1 Determination Of The Calibration Factor

1 Fill a 2ml syringe with 1ml tc-99m (5 Mbq).

2 Measure the syringe activity three times in a dose calibrator. Correct the results for the zero value and calculate their mean value (A).

3 Transfer the syringe contents into a volumetric flask, and dilute it in several steps with water up to 1000 ml (or 500 ml) and shake the solution well. Rinse the syringe several times.

4 Fill the empty syringe with 1 ml water and measure it 3 times in a dose calibrator. Calculate the mean of the results (value B).

5 Take 3 various 1 ml samples of the diluted solution, measure them in a well type counter for 1 minute and calculate the mean (value C).

6 The calibration factor is calculated according to the formula:

$$CF = \frac{C \times 1000}{(A - B) \times 1000} \qquad [cpm/kBq]$$

,where C x 1000 is the counts per minute in the full 1000 ml amount of dissolved activity and the factor 1000 in the denominator (A-B) x1000 converts from MBq to Kbq

10.17.2 Calculations: see also screen

1 Calculation of the decay factor, time between measurement time of the Syringe and of the Sample in minutes.

Decayfactor for technetium: $e^{0.0019254*time}$

2 Calculation of the Injected activity, correct for decay between the time of measurement of the syringe and the time of sample-measurement.
DecayCorrected FullSyring = FullSyr / DecayFactor
Injected activity: InjAct = DecayCorrFullSyringe - EmptySyr

3 Convert Plasma samples: cpm/ml to kBq/ml
cpm/ml / cpm/Kbq → Kbq/m1
Sample1 in Kbq:S1Kbq = S1Count / CalibrationFactor
Sample2 in Kbq:S2Kbq = S2Count / CalibrationFactor

4 Calculate X = Injected Activity [MBq]/Plasma concentration [kBq/ml]

Sample 1:X1 = InjAct / S1Kbq
Sample 2:X2 = InjAct / S2Kbq

5 Calculate $A = -517 * e^{-0.011 * t}$
A old formula = -517 , A new formula = -372
for Sample 1:A1 t = Time of sample 1
for Sample 2:A2 t = Time of sample 2

6 Calculate $B = 295 * e^{-0.016 * t}$
B old formula = 295 , B new formula = 183
for Sample 1:B1 t = Time of sample 1
for Sample 2:B2 t = Time of sample 2

7 Calculate TER = A + B * In X
for Sample 1:TER1 = A1 + B1 * ln X1
for Sample 2:TER2 = A2 + B2 * ln X2

8 Mean TER = TERmean = (TER1 + TER2) / 2

If only one sample was used Mean TER will be the same as the TER for that sample.

9 Calculate body surface:
$x = weight^{0.425} * height^{0.725} * 0.007184$
BodyNormFactor = 1.73 / BodySurface

10 Normalize TER for body size
Normalized TER for Sample 1:
NormTER1 = BodyNormFactor * TER1
Normalized TER for Sample 2:
NormTER2 = BodyNormFactor * TER2
Normalized mean TER:
NormTERmean = BodyNormFactor * TERmean

11 Calculate Lower Limit from age, as 70 % of mean expectation value.

0-4 years:Lower Limit =(304 + 64.5 * ln(0.015+age)) * 0.70

4-18 years:Lower Limit =(405 - 0.36 * (10-age)**2) * 0.70

from 18 years:Lower Limit =435 - 3.03 * age

12 Left and Right TER in ml/min/1.73

The left and right contribution percentages as calculated from either the full integral or Bubeck method are used to calculate the left and right TER values.

Left TER [ml/min/1.73] = (Left Percentage / 100) x Normalized Mean TER
Right TER [ml/min/1.73] = Normalized Mean TER – Left TER

10.18 Glomerular Filtration Rate (Gates)

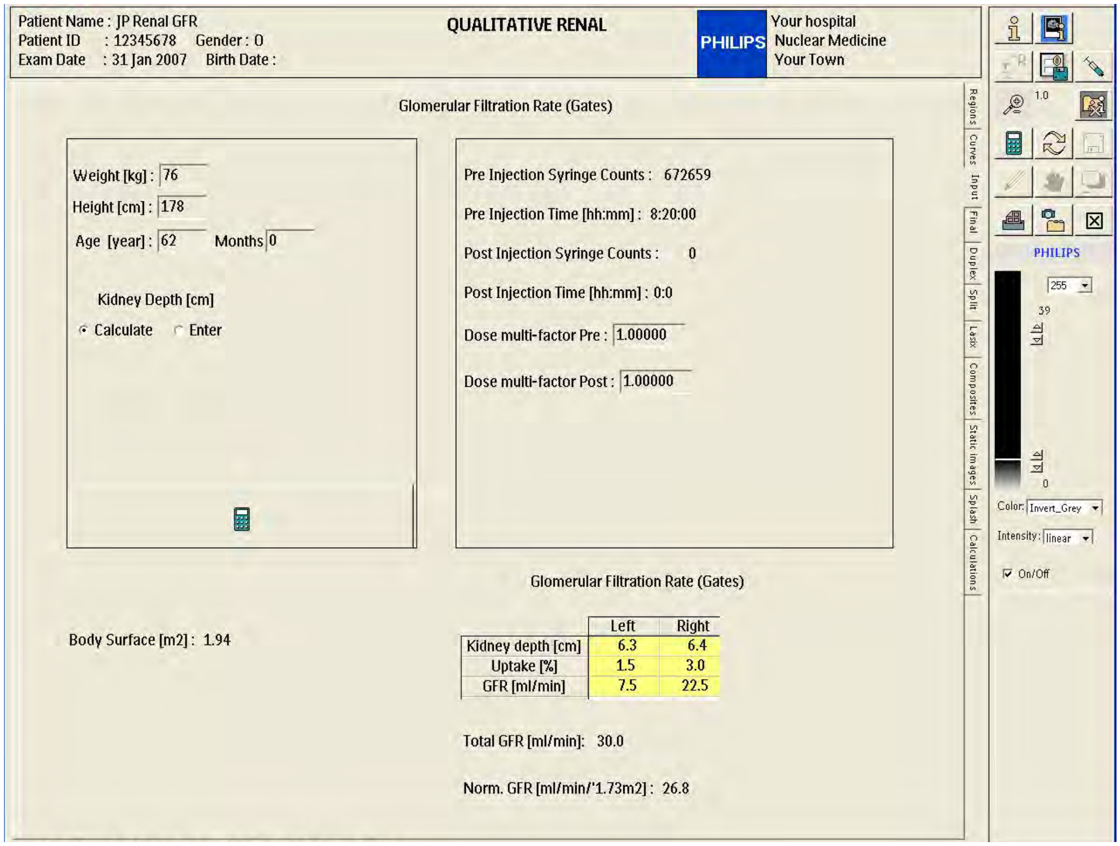

Figure 123 GFR page

In this example the counts of the Pre-injection syringe and the time of acquisition are read from the image header and displayed. No Post-injection image was selected therefore counts and time are both zero. You can enter a multi-factor for both the Pre and Post syringe images if desired.

Note The dose multiplication factors in all situations have a maximum of 9,999,999.

Kidney depth can be calculated from Height ,Weight and Age using the Tonneson formula for ages above 13 years and Gordon for ages below. Kidney depths can also be entered directly if available from another measurement.

Once you have entered all the required data click on the left hand side calculator button to have the application calculate the kidney depths, Uptake percentages, GFR per kidney and the total and body size normalized GFR in ml/min. For adults the total GFR is normalized to a body size of 1.73 m^2; for children the age limit and body size to normalize to is determined by the default values as entered by the user, for instance below 12 years normalize to 1.20 m^2. The results of these calculations are also displayed on the Final page. See next page.

10.19 Final page with GFR and Post Void image

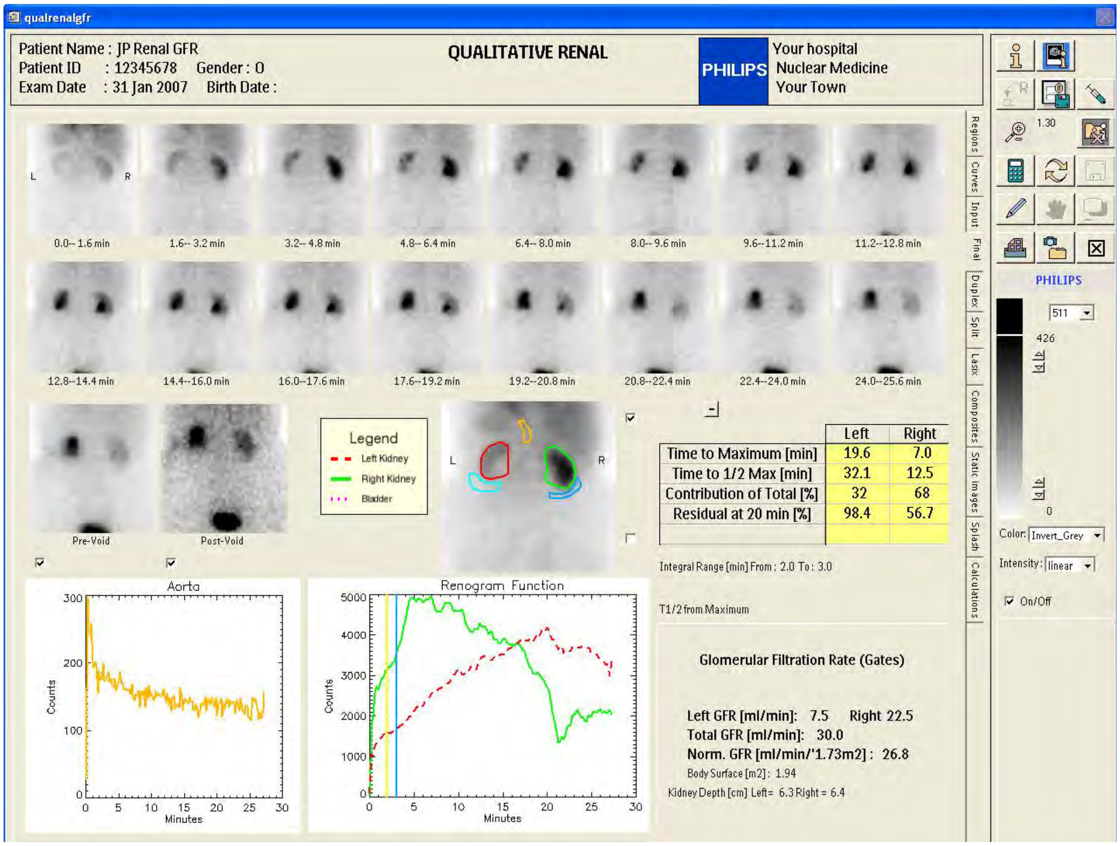

Figure 124 Final Page with GFR results, single phase dynamic, post void image.

In this example a single phase dynamic study was selected together with a full syringe and a post-void image. The GFR results came from the calculation as performed on the GFR page as described earlier. Notice the display of a Pre-void and a Post-void image at the center left side of the screen. The Pre-void image, for lack of a pre-void image from the database, is automatically copied from the last image of the composite images in the top two rows. The Post Void image is normalized to the same time duration and matrix size of the Pre-void image.

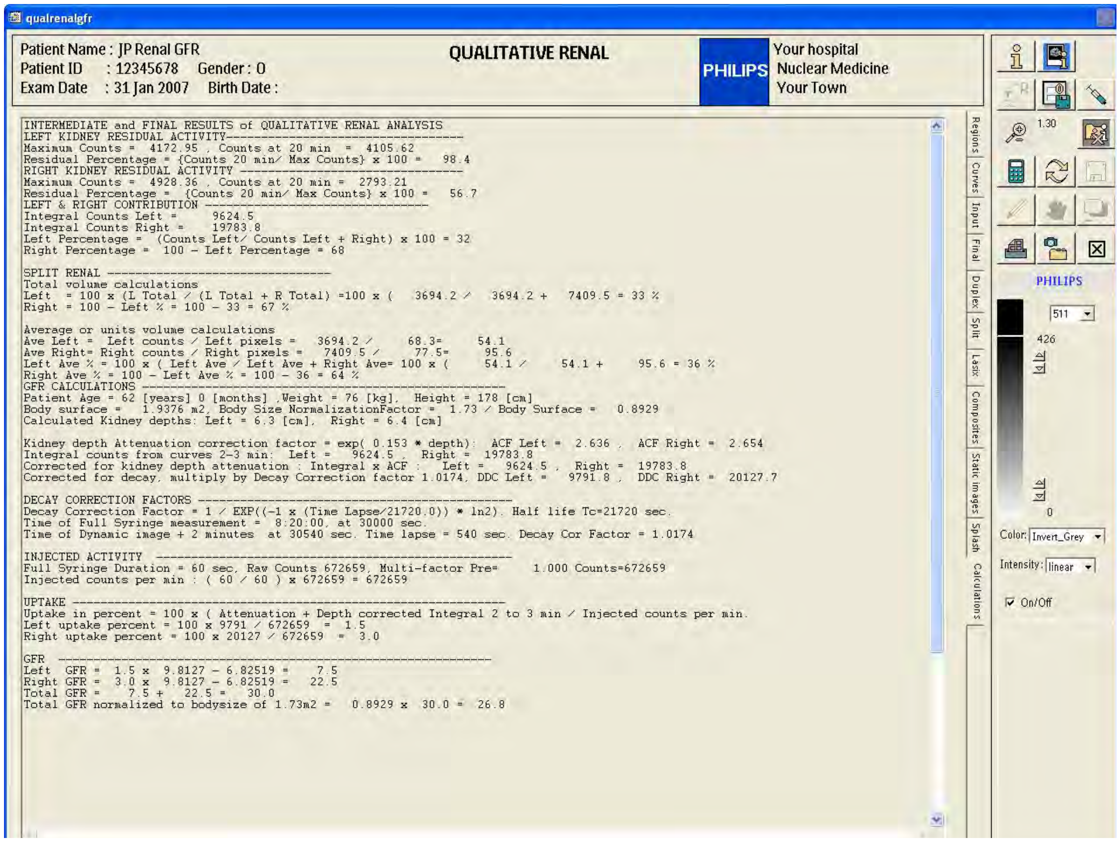

Figure 125 Calculations page with GFR intermediate and f inal results.

10.20 GFR Method

The method is based on procedures established by Gary F.Gates M.D., as described in the " American Journal of Roentgenology: Vol. 138, pp 565-570, March 1982 and modified by Gates in 1983.(1). The renal uptake of the Tc99m-DTPA 2 to 3 minutes after tracer arrival in the kidney is proportional to GFR(1). Within this method, the total GFR is calculated using a formula derived from regression analysis comparing 24 hour creatine clearance to percent renal uptake. This formula is:

GFR (ml/min0 = (% renal uptake) x 9.8127 -6.82519,

Where 9.8127 is the regression coefficient and -6.82519 is the y-intercept. The percent renal uptake in the GFR equation is calculated according to the following formula:

$$\%\ \text{renal uptake} = \frac{((\text{Rt kidney cts} - \text{bkg})/e^{-uDr}) + ((\text{Lt kidney cts} - \text{bkg})/e^{-uDl})}{(\text{pre-injection counts} - \text{post injection counts})} \times 100$$

The percent uptake of the left kidney plus the percent uptake of the right kidney, at 2 to 3 minutes post-injection is calculated by dividing the background and depth-corrected kidney counts by the total net counts injected and multiplying the result by 100. In this equation, u equals 0.153, the attenuation coefficient of Tc99m in soft tissues, and Dr and Dl equals the kidney depths in centimeters for Right and Left kidney respectively. These values (the normalized and depths corrected kidney counts) are obtained from the renogram study.

The total net counts injected is determined by the pre-injection syringe and post injection syringe images, or from values entered by the user for Injection activity and Multiplication factor. The post injection counts are then corrected for decay to compensate for “excess time” between the pre-injection image and the post injection image. Finally the decay-corrected, post-injection syringe counts are subtracted from the pre-injection syringe counts to yield the total net counts injected.

The normalized and corrected kidney counts are determined form 60 seconds of data collected 2 to 3 minutes following tracer arrival in the kidney.

A composite image is created from the dynamic study. Regions of interest are created for each kidney and for the corresponding background areas. The background areas are then normalized to their respective renal areas and the counts in the normalized background areas are subtracted from the counts in the renal areas to give the normalized net kidney counts. These normalized net kidney counts are corrected for kidney depths and activity decay. Kidney depth correction is performed to compensate for attenuation of gamma rays. The kidney depths are either estimated from the patient’s height and weight, according to a formula by Tonneson(2) (for ages > 13 years) or by a formula by Gordon, or entered by the operator. The decay correction is performed to compensate for “excess time” between the acquisition of the pre-injection syringe image and the acquisition of the dynamic study. Finally, the individually normalized and corrected kidney counts are added together to yield the total normalized and corrected kidney counts.

Having determined the total GFR, the program then calculates individual kidney GFR by multiplying the total GFR by the percentage of total counts in each kidney. The patient’s body surface area is calculated from height and weight, and the total GFR is then normalized to $1.73m^2$ for adults or to the user entered value for children. For instance below 12 years normalize to $1.20\ m^2$.

10.21 EFFECTIVE RENAL PLASMA FLOW (camera based Taylor method)

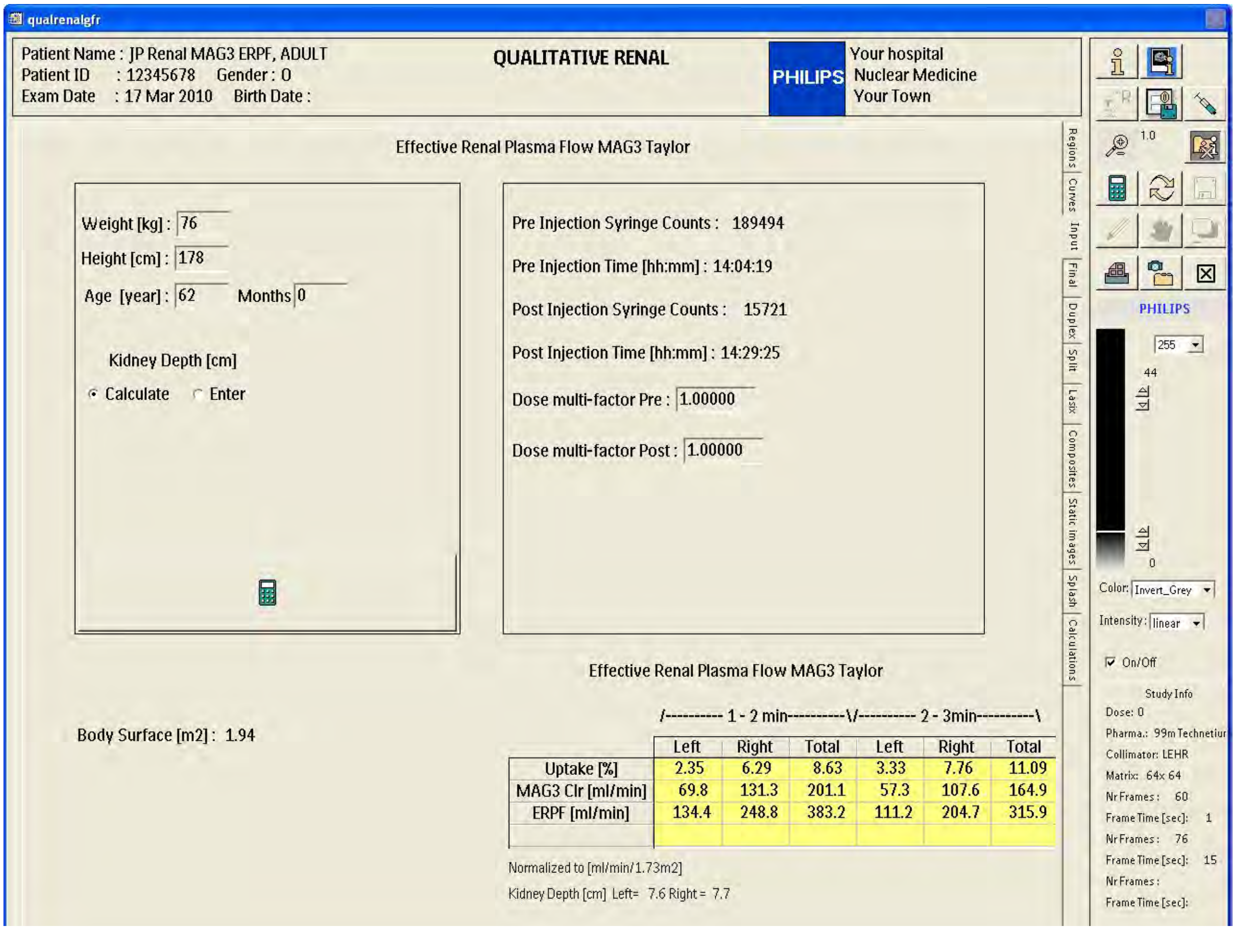

Figure 126 ERPF page

In this example the counts of the Pre-injection and Post injection syringe images and the time of acquisition of each image are read from the image headers and displayed. You can enter a multi-plication factor for both the Pre and Post syringe images if desired.

Note The dose multiplication factors in all situations have a maximum of 9,999,999, 10M"

Kidney depth can be calculated from height, weight and age using the Taylor formula. Kidney depths can also be entered directly if available from another measurement.

Once you have entered all the required data click on the left hand side calculator button to have the application calculate the kidney depths, uptake percentages, MAG3 clearance, ERPF and Corrected (estimated) GFR per kidney and the total of these.

For adults the results have been normalized to a body size of 1.73 m2 , for children the age limit and body size to normalize to is determined by the default values as entered by the user.

The results of these calculations are also displayed on the Final page. See next page.

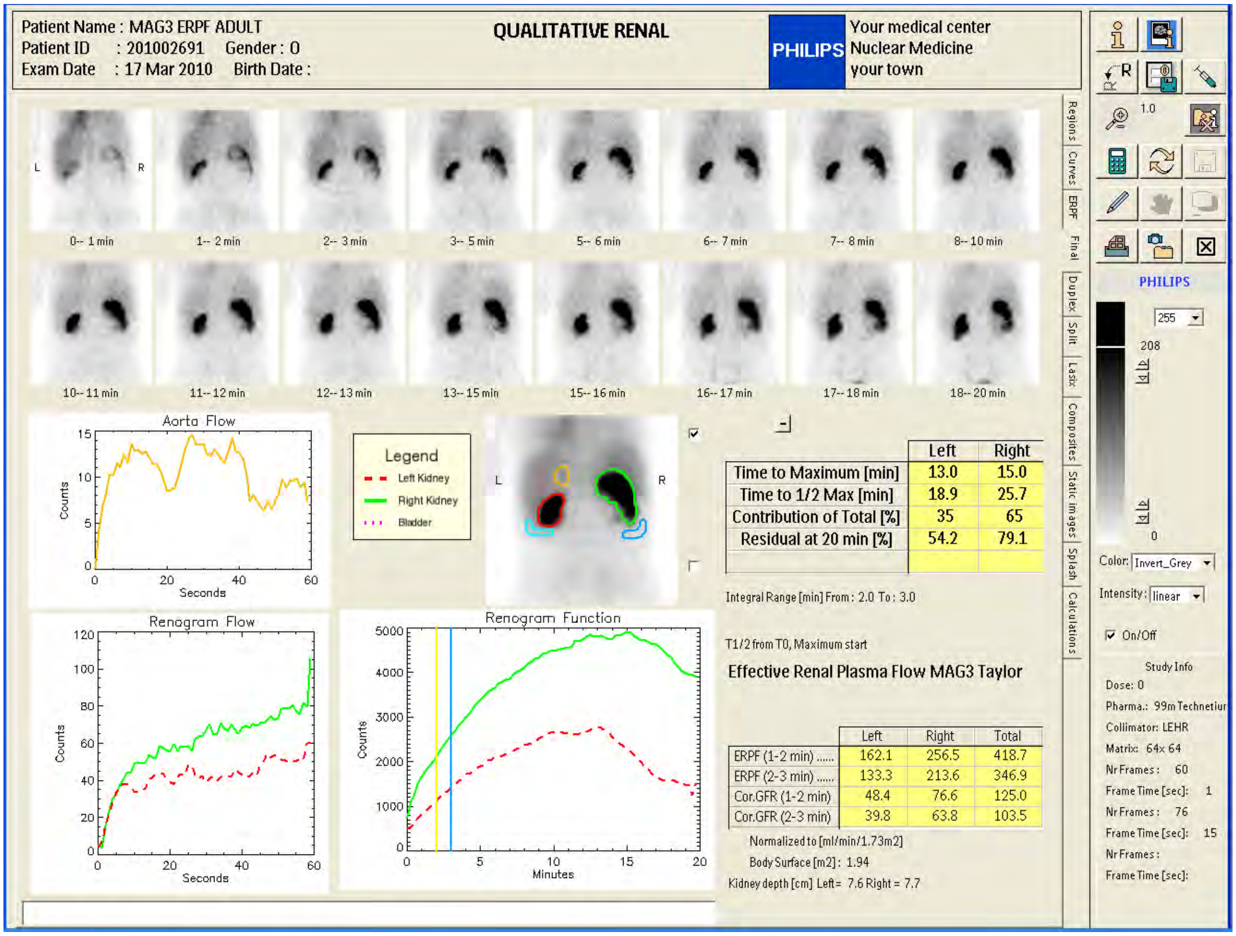

Figure 127 Final page with ERPF results

A dual phase dynamic study was selected together with a full and empty syringe images. The ERPF results come from the calculations done on the ERPF page as described earlier. Notice that the Aorta curve at the left side and the "Corrected GFR" results as displayed in the bottom right hand table can be disabled by means of the defaults setting.

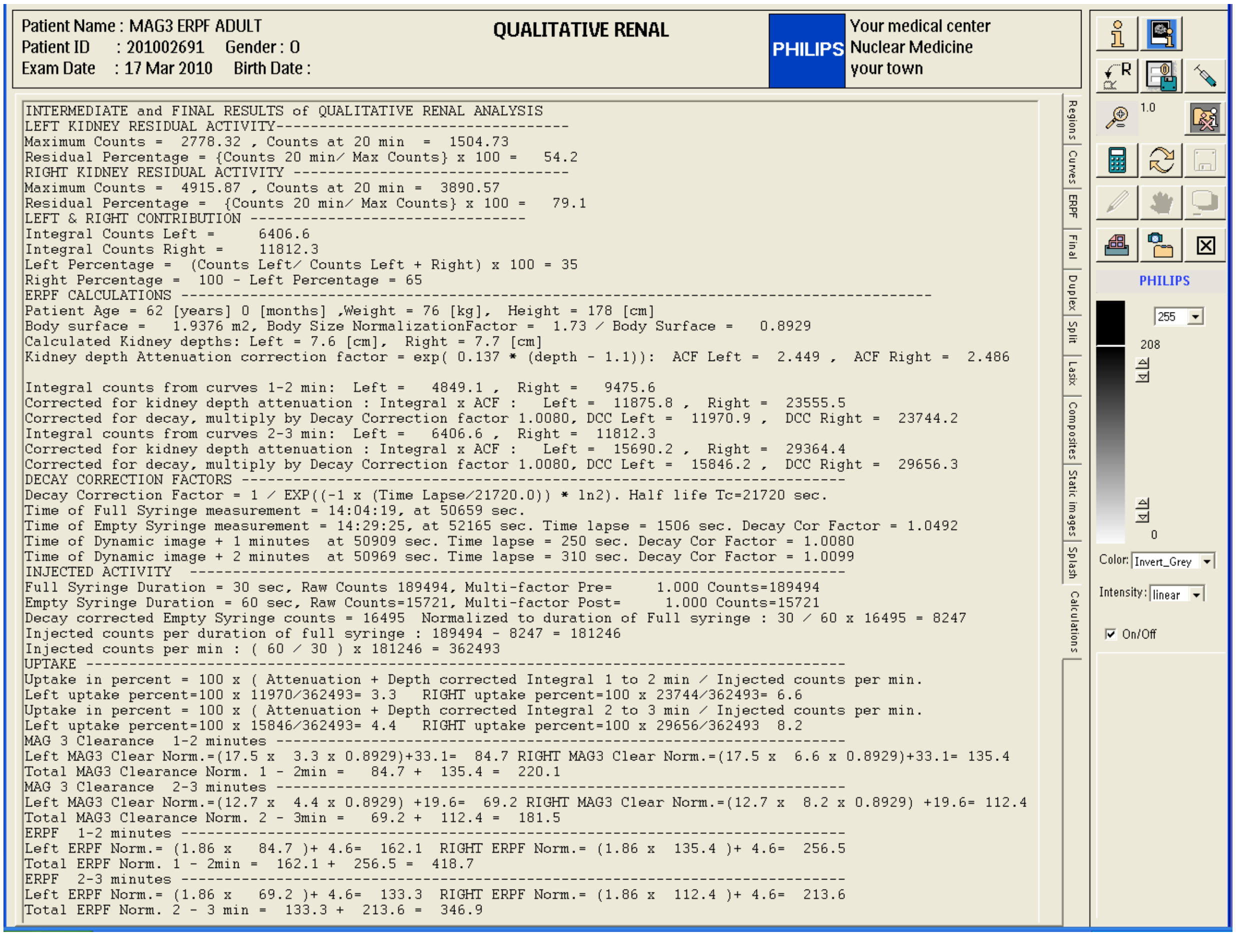

Figure 128 Calculations page with ERPF results

Use this page to verify the calculated results.

10.21.1 ERPF Calculations

Renal depth estimate Taylor method:
Left renal depth (mm) = 161.7 x weight/height + 0.27 x age - 9.4
Right renal depth (mm) = 151.3 x weight/height + 0.22 x age - 0.77
where patient weight is in kilograms and height is in cm. [5].

Attenuation factor
Attn = exp(- µ * (depth/10 - 1.1)) where µ is the effective attenuation coefficient (0.137), and the factor 1.1 (cm) is the depth correction factor that attributes for the volumetric distribution of renal activity[5].

Dose injected
Counts injected= pre-injection syringe counts - post-injection syringe counts
where the counts are normalized to counts/minute.

Percent injected dose in the kidneys

The counts in each kidney are calculated for frames from 1-2 minutes and 2-3 minutes: the sum of counts from each frame under the kidney ROI minus the counts in the background ROI.

Countsleft = TAF * Σ(left kidney counts - background)/Attnleft
Countsright = TAF * Σ(right kidney counts - background)/Attnright

where background is area normalized by:
(Counts in background ROI) x (pixels in kidney ROI)/(pixels in background ROI)

and the Table attenuation factor (TAF) = 1.0

Finally, the Uptake (percent injected dose) is calculated as:
%UL %uptake left = 100 x ((Countsleft) / (counts injected))
%UR %uptake right = 100 x ((Countsright) / (counts injected))
%UT % uptake total = %uptake left + %uptake right

MAG3 Clearance
The normalized clearances are calculated as, see ref 6:

Clearance left (1-2min)   = 17.5 x (%UL at 1-2 min) x (BSA/BSNorm) + 33.1
Clearance right (1-2min) = 17.5 x (%UR at 1-2 min) x (BSA/ BSNorm) + 33.1
Clearance Total (1-2min) = Clearance left (1-2min) + Clearance right (1-2min)

Clearance left (2-3min)   = 12.7 x (%UL at 2-3 min) x (BSA/ BSNorm) + 19.6
Clearance right (2-3min) = 12.7 x (%UR at 2-3 min) x (BSA/ BSNorm) + 19.6
Clearance Total (2-3min) = Clearance left (2-3min) + Clearance right (2-3min)

where Body surface area (BSA) is calculated by:
Calculate body surface: x = $\text{weight}^{0.425} * \text{height}^{0.725} * 0.007184$
BSNorm is the normal surface size defined as 1.73 for adults and user definable for children, for instance 1.20.

ERPF
ERPF left (1-2min) = 1.86 x ClearanceLeft(1-2min) + 4.6
ERPF right(1-2min) = 1.86 x ClearanceRight(1-2min) + 4.6
ERPF Total(1-2) = ERPF left (1-2min) + ERPF right(1-2min)

ERPF left(2-3min) = 1.86 x ClearanceLeft(2-3min) + 4.6
ERPF left(2-3min) = 1.86 x ClearanceLeft(2-3min) + 4.6
ERPF Total(2-3) = ERPF left (2-3min) + ERPF right(2-3min)

Estimated GFR from ERPF
The Estimated GFR from ERPF is calculated by division of the ERPF result with a user definable factor, for instance 1.0 / 3.35. The estimated GFR is calculated for left and right kidney and total.

10.21.2 References MAG3

1 Renography with MAG3, Mag3 Measurement of Renal Function, by B. Bubeck, MD, University of Heidelberg, publication by Mallinckrodt. Medical B.V. Petten Holland.

2 Technetium-99-m-MAG3 für die nuklearmedizinische Nierenfunktionsdiagnostik. By Bubeck, Bernd. Verlag Hans Huber, Bern, Stuttgart, Toronto 1993 (second edition) ISBN 3-456-82348-7

10.21.3 References GFR

3 Gates G.F: Split Renal Function Testing using Tc-99m DTPA, a rapid technique for determining differential glomerular filtration. Clinical Nuc Med., 8:400, 1983.

4 Tonneson KJ, Munck O, Hald T, et al: Influence on the renogram of variation in skin to kidney distance and the clinical importance thereof. Presented at the International symposium on Radionuclides in Nephrology, Berlin, April 1974. J UROL, 116:282, 1976.

10.21.4 References ERPF

5 A. Taylor, Jr., P. L. Corrigan, et al, "Measuring Technetium-99m-MAG3 Clearance with an improved camera-based method", J. Nucl. Med. 1995; 36:1689-1695

6 A. Taylor, Jr., R. Folks, et al, "Camera-based MAG3 clearance with optimized features: comparison with multisample clearances with 53 patients", Nuclides in Nephrourology 1997, Andrew Taylor, MD, Joseph V. Nally, MD, Henrik Thomsen, MD, edits, SNM, pages 145-148

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11 Renal: DMSA Absolute Uptake

11.1 General

-

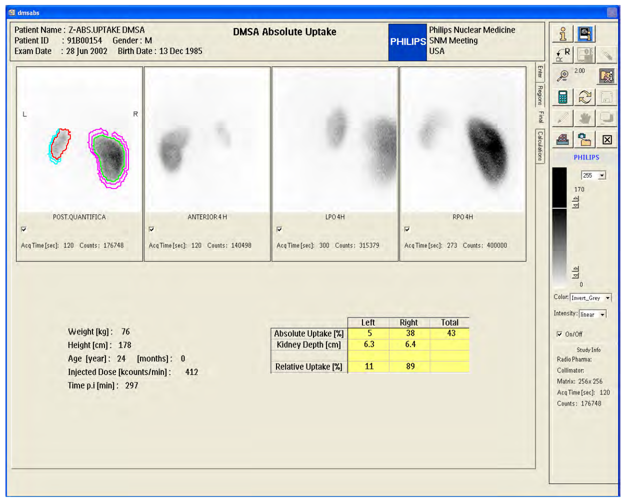

Figure 129 DMSA Absolute Uptake application

The Renal DMSA Absolute Uptake application permits the calculation of the absolute tubular uptake of the left and right kidney with respect to the injected dose, and also the relative left-to-right ratio of both kidneys.

11.2 Acquisition

- Tc-DMSA, 111Mbq / 3mCi (according to the schedule of the Pediatric Committee of the EANM)
- Collimator: Low energy, high resolution (LEHR), parallel hole
- Energy window: 140keV, window 10%
- Views:
  - Posterior quantification
  - Posterior
  - Right posterior oblique
  - Left posterior oblique

Note Instead of a posterior quantification image, you can acquire an anterior view for display only. In case of a transplant kidney, you can use an anterior view of the abdomen for the uptake calculation instead of the posterior quantification image.

- **Time of acquisition:** 2 - 4 hours post injection
- **Type of acquisition:** Static
- **Full syringe image:** Syringe at 30 cm distance from the collimator, matrix 256x256, time duration: 10 seconds
- **Empty syringe image:** Syringe at 30 cm distance from the collimator, matrix 256x256, time duration: 10 seconds
- **Optional injection site image**: No zoom, matrix 256 x 256, time duration: 120 seconds
- **Posterior quantification image**: No zoom, matrix 256 x 256, time duration: 120 seconds
- **Other views**: Posterior LPO and RPO: Zoom 1.5 - 2, matrix 256 x 256, 400 kcount per image or 300 seconds

The following views are for display use only:

11.3 Processing

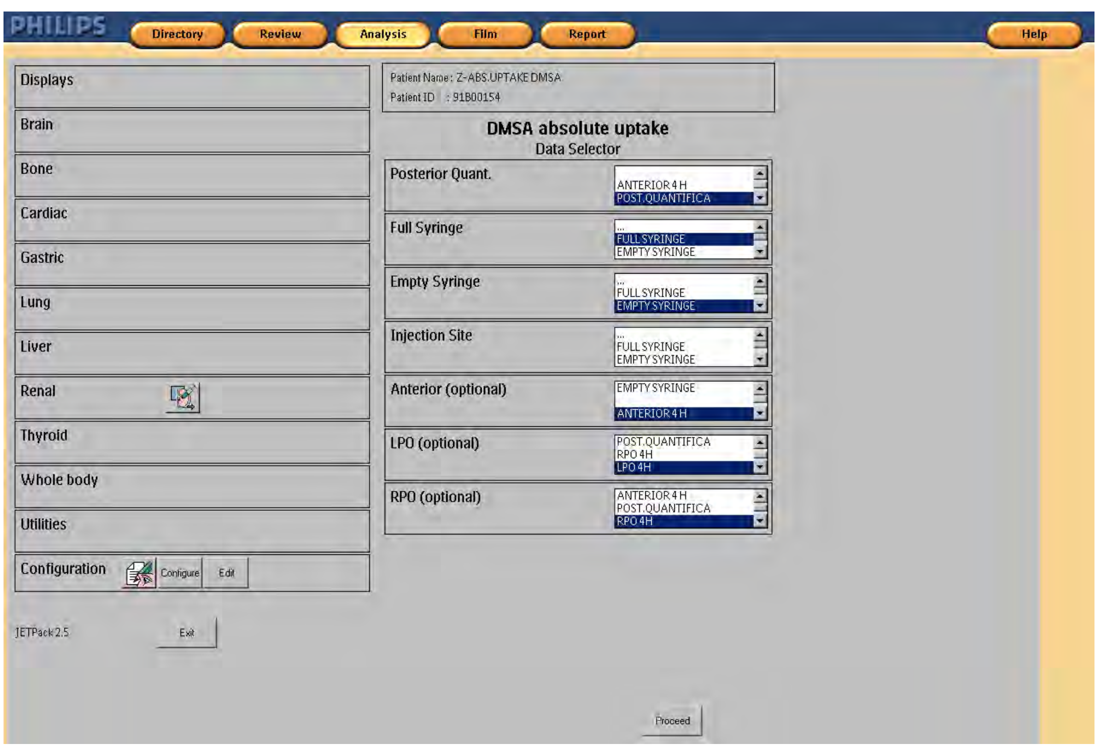

Figure 130 ISP JETPack panel, DMSA Absolute application selected

Select the full syringe, empty syringe, optional injection site image, the posterior quantification image, and up to three additional optional images in the data buckets and click Proceed.

Figure 131 Kidney Depth Input screen

The posterior quantification image and any optionally selected images appear.

The patient's **Weight**, **Height**, and **Age** are extracted from the image and displayed; however, you can edit the fields.

For kidney depth determination, set the switch to either **Calculate** (default) or **Enter**. In **Calculate** mode, the kidney depth is calculated from patient weight, height, and age using the Gordon or Tonneson formulas. In **Enter** mode, enter the depths in cm for the left and right kidneys in the corresponding fields.

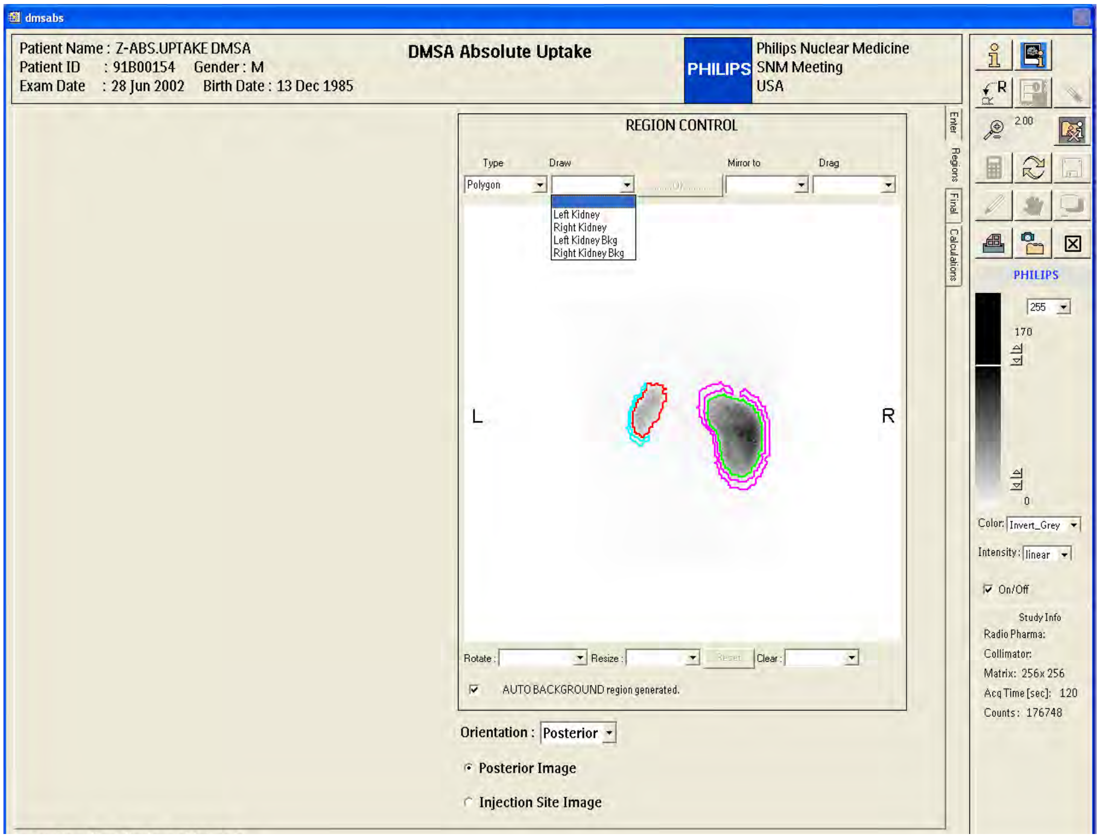

Figure 132 Region Page: Posterior Quantification image.

Select either **Anterior** or **Posterior** orientation from the menu. This allows selection of the regions in the Regions screen and puts labels to indicate left and right on the image in the Regions control viewport.

Note Use the radio buttons to select the **Posterior Image** or **Injection Site Image**.

If you select the injection site image, the radio buttons for selection of **Posterior Image** or **Injection Site Image** become available. The selection is preset to **Posterior Image,** and that image appears in the regions control viewport.

If there is no separate injection site image available, it is possible to draw an injection site ROI on the posterior quantification image. In that case, you must draw the left and right kidney ROI and a background ROI for each.

Note The injection site ROI is available in the menu but optional.

The ROI **Types** available are **Polygon**, **Freehand**, **IsoFree** and **AutoBkg** for left and right.

When you have drawn or generated all four regions, switch the selection from **Posterior Image** to **Injection Site Image** to change the image in the viewport and the menu selection.

Figure 133 Injection Site image

Note This is not a real injection site image.

Draw the injection site ROI, using the standard region controls, around the active area of the injection. Only the **Freehand** drawing mode is available here. The ROI menus only have one single ROI selection: injection site.

Once you have drawn the compulsory kidney and background ROIs, and in the case of the presence of an injection site image, also the injection site ROI, the Calculate & Display button is enabled to allow further processing.

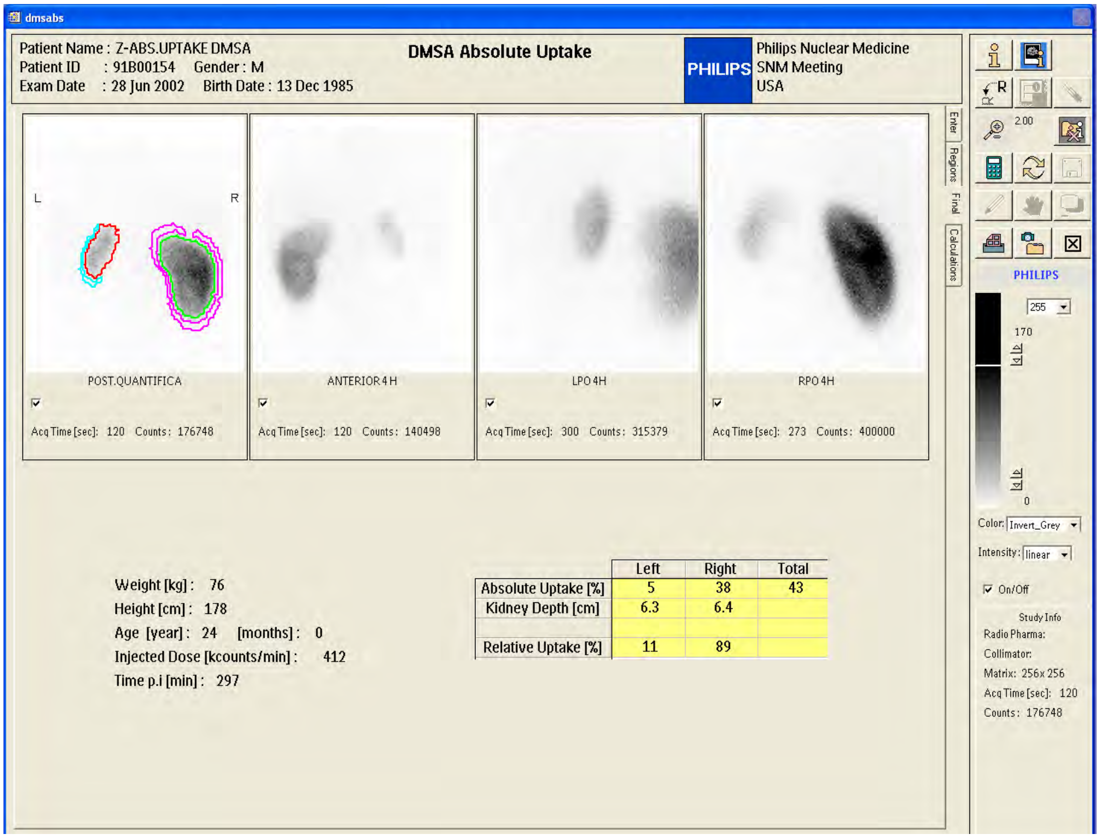

Figure 134 Final page

The final page shows the posterior quantification image with the selected ROIs superimposed. Any optionally selected images appear with their proper view labels, acquisition duration, and total counts. The patient's weight, height, and age as entered or obtained from the input image also appear. The calculated injected dose, time post injection of the posterior quantification image appear at the left side of the screen

The absolute uptake percentages, kidney depths as calculated or entered, and the relative uptake percentages appear in the table.

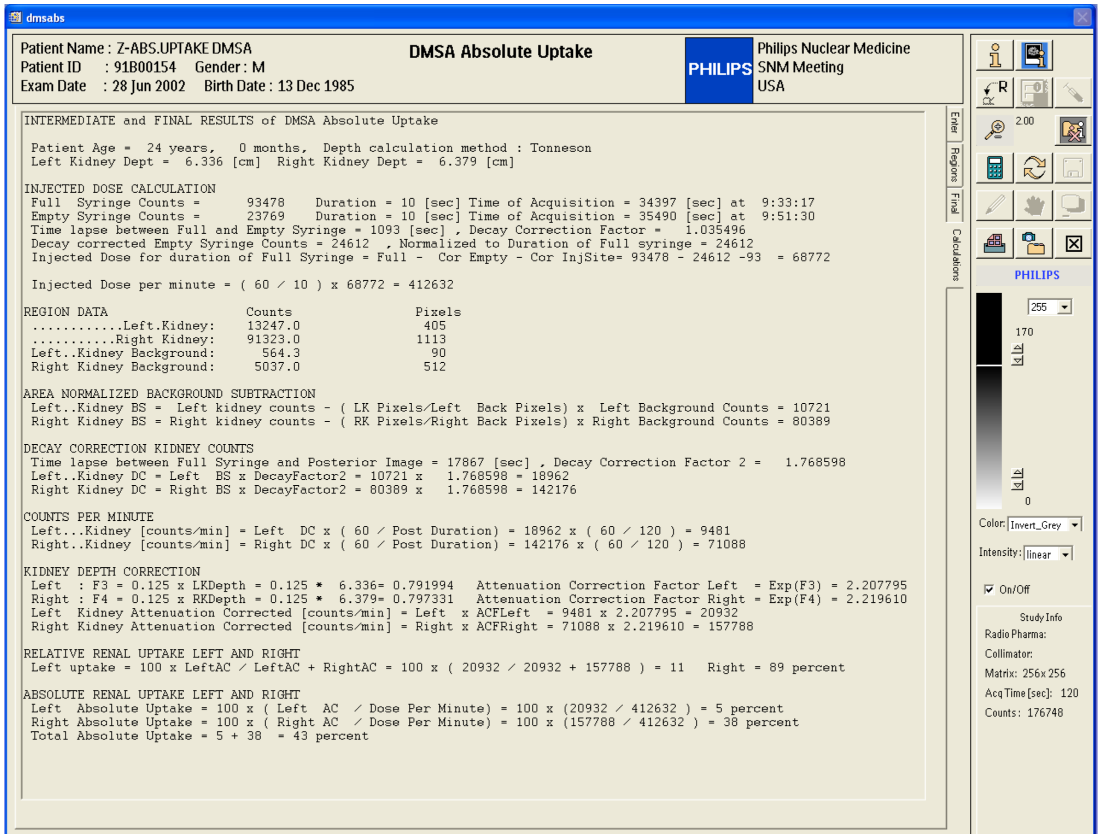

Figure 135 Calculations page

The calculations page allows verification of the calculated results by giving all the details of intermediate and final results.

11.4 Calculations

11.4.1 Dose Calculation

- Obtain the total counts and the acquisition frame time from the image headers of the full and empty syringe images:
  - FullSyringeCounts
  - FullSyringeFrameTime
  - FullSyringe Time of Acquisition
  - EmptySyringeCounts
  - EmptySyringeFrameTime
  - EmptySyringe Time of Acquisition
- Decay correct the Empty syringe counts:
  - Determine the Timelapse1 between the Time of acquisition of the full and empty syringe.

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- TimeLapse1 = EmptySyringe Time of Acquisition - FullSyringe Time of Acquisition

$$e^{In(2) \cdot \frac{TimeLapse}{halftime}}$$

- Decay correction factor = e
- For Tc-99m the halftime is 6.01 hour = 21636 seconds.
- Multiply the Empty Syringe Counts by the DecayCorrectionFactor.

• Normalise the empty syringe counts to the frame time of the full syringe:

$$ESN = EmptySyringeCounts \times \frac{FullSyringeFrameTime}{EmptySyringeFrameTime}$$

• Injection Site counts

If a separate injection site image has been acquired and selected during processing, or when the injection site region has been placed on the posterior quantification image, then those counts are calculated the same as the empty syringe counts. The counts are decay-corrected for the time after full syringe measurement and also the counts are normalized to the acquisition time of the full syringe image. (SCN)

• I**njected dose** is the difference of full and empty syringe:

- InjectedDose = FullSyringeCounts – ESN

In the case of Injection Site counts subtraction:

- InjectedDose = FullSyringeCounts – ESN - SCN

• **Injected dose per minute** calculation:

$$DosePerMinute = InjectedDose \times \frac{60\ [sec]}{FullSyringeFrameTime\ [sec]}$$

11.5 Regions of Interest

• Get counts and pixels of all four ROIs:

- Left Kidney counts: LKcounts
- Left Kidney pixels: LKpix
- Left Kidney Background counts: LKBcounts
- Left Kidney Background pixels: LKBpix
- Right Kidney counts: RKcounts
- Right Kidney pixels: RKpix
- Right Kidney Background counts: RKBcounts
- Right Kidney Background pixels: RKBpix

- Decay correction

Determine the time-of-acquisition for full syringe and posterior quantification images and calculate the TimeLapse2 between the two images in seconds.

$$e^{In(2) \cdot \frac{TimeLapse}{halftime}}$$

Decay correction factor = e

For Tc-99m, the halftime is 6.01 hours = 21636 seconds

Multiply the LKcounts, LKBcounts, RKcounts and the RKBcounts by the decay correction factor.

- Correct kidney counts for area normalized background counts:
  - LK = LKcounts - (LKpix / LKBpix) x LKBcounts
  - RK = RKcounts – (RKpix / RKBpix) x RKBcounts
- Normalise counts to counts per minute:

Get the acquisition frame time of the Posterior (Anterior) Quantification image => PQFrameTime [sec]

  - Left kidney counts per minute: LKmin = LK x (60 / PQFrameTime)
  - Right kidney counts per minute: RKmin = RK x (60 / PQFrameTime)
- Kidney depth correction
  - You can enter the kidney depth for each kidney directly into Figure 131 or have the application calculate it from age, weight and height.

For babies and children under 13 years of age, the Gordon formula is used to calculate the kidney depths in mm:

  - Depth = (0.0742 * PatientWeight) +20.8

Left and right kidney depths are considered the same, in cm and the depth is divided by 10.

  - LKdepth = Depth/10 [cm]
  - RKdepth = Depth/10 [cm]

If the age is 13 or higher, then the kidney depths are calculated using the Tonneson formulas:

  - RKdepth [cm] = 13.3 * Weight/Height + 0.7
  - LKdepth [cm] = 13.2 * Weight/Height + 0.7

The attenuation caused by the kidney depth is corrected for by the formula:

  - ACF = exp $^{AC \times d}$ where

    AC = attenuation coefficient, 0.125 /cm

d = kidney depth in cm.

- ACFLeft = exp (0.125 x LKdepth)
- ACFRight = exp(0.125 x RKdepth)

The left and right kidney counts per minute are then corrected for depth using multiplication by the individual correction factors.

LKminAC = LKmin x ACFLeft

RKminAC = RKmin x ACRight

- Relative uptake Left and Right calculation

  Left Relative uptake:

  $$LRU = \frac{LKminAC}{(LKminAC + RKminAC)} \times 100\ [\%]$$

  Right Relative uptake: RRU = 100 – LRU [%]

- Absolute uptake left, right and total calculation

  Left Absolute uptake:

  $$LAU = \frac{LKminAC}{DosePerMinute} \times 100\ [\%]$$

  Right Absolute uptake:

  $$RAU = \frac{RKminAC}{DosePerMinute} \times 100\ [\%]$$

  Total Absolute uptake: TotalAU = LAU + RAU [%]

11.6 Reference

Taylor A, Lewis C, C. Giacometti, A Hall, E.C and K.P. Barefield. Improved formulas for the Estimation of Renal Depth in Adults, J. Nucl. Med. 1993, 34:1766-1769

12 DMSA Duplex Uptake

12.1 General

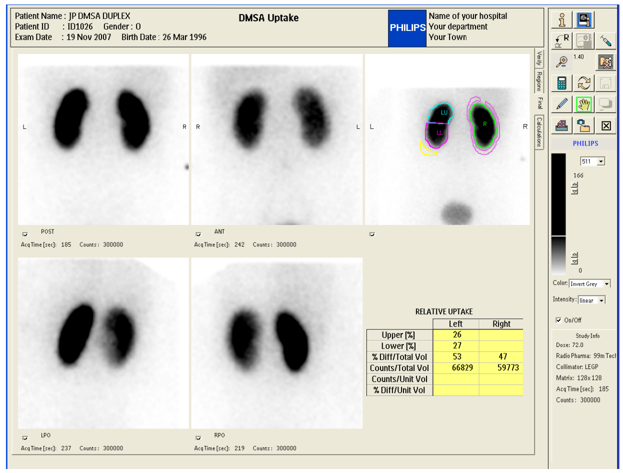

Figure 136 DMSA duplex application

The application allows generation of a geometric image from anterior and posterior views with manual image alignment. The differential percentages can be calculated for full left and right kidney ROIs, for duplex ROIs on both or one kidney. The differential percentages per Unit volume (pixel average) is calculated in the case of full kidney ROIs.

12.2 Acquisition

- Static image of Posterior view in 256x256 matrix, 5 minutes duration
- Anterior, LPO and /or RPO view images are optional.

12.3 Processing

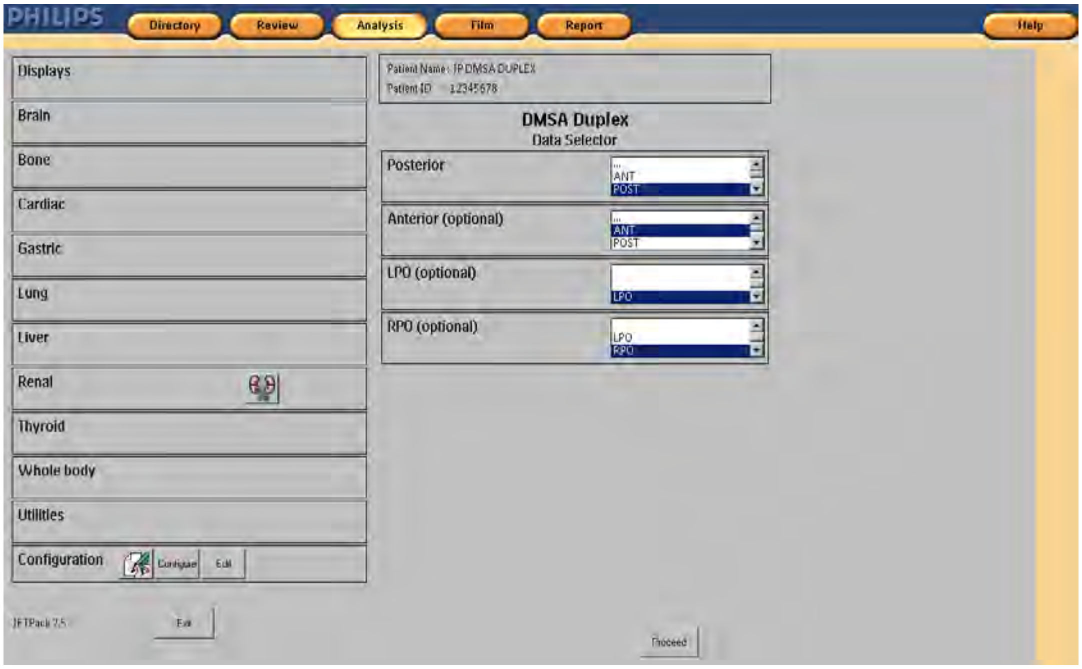

Figure 137 ISP JETPack panel, DMSA Duplex application selected

Select at least the Posterior view image. If the Anterior view is selected in addition to the Posterior view the application automatically generates the Geometric mean image from the posterior and flipped-anterior view. The Geometric image is then used in stead of the posterior image for uptake calculations. You can select one or two additional images for display together with the calculated results.

If required adjust the selected files in the data buckets and click Proceed.

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12.4 Verify Page

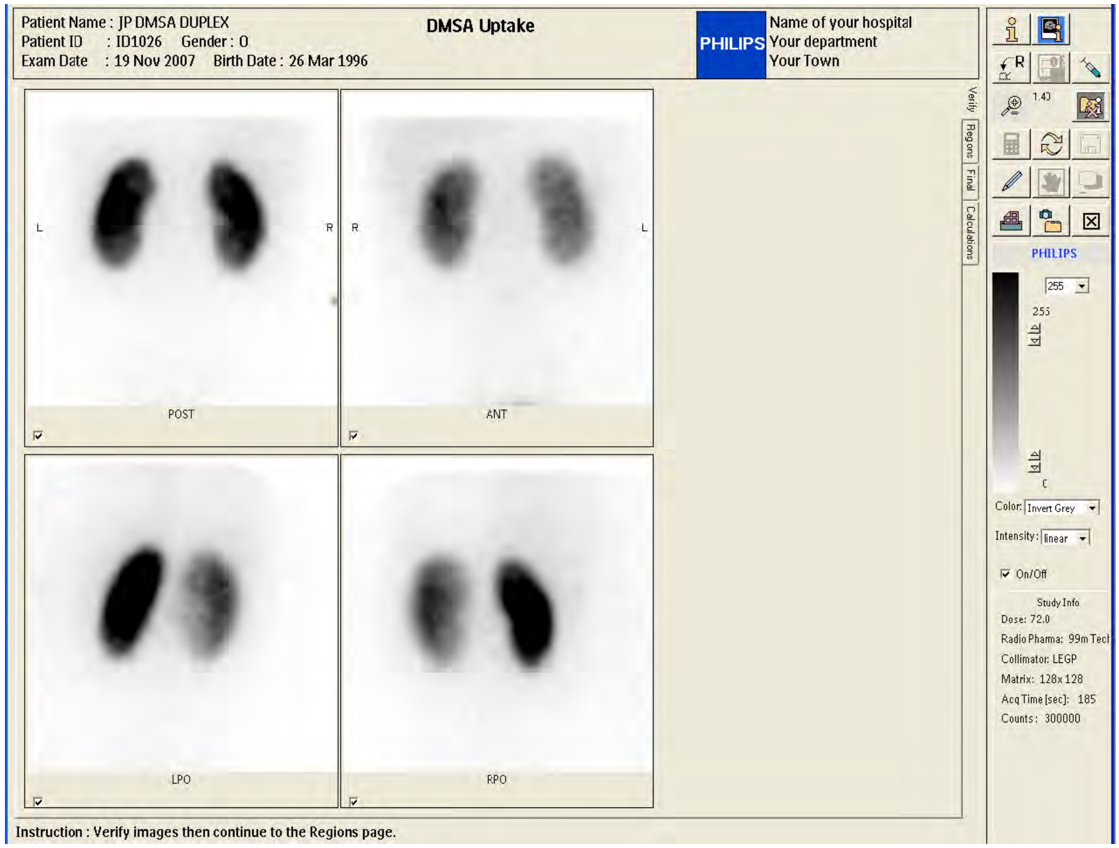

Figure 138 Verify screen

Use this page to view the loaded images. Notice that images can be Rotated, Zoomed and Annotated on this page and on the Final page.

12.5 Regions Page

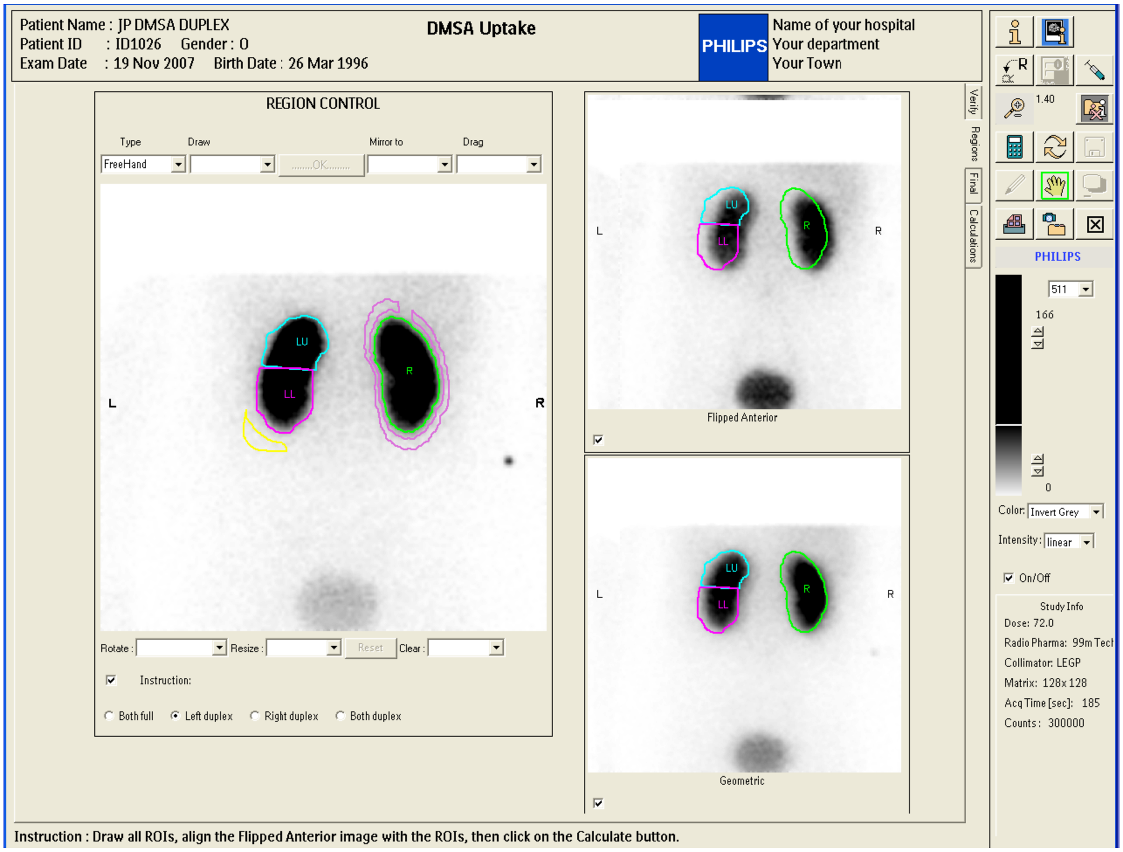

Figure 139 Regions page, regions drawing

Draw the regions on the Posterior image. When the Anterior image is loaded it will be displayed in reversed (flipped) mode at the top right corner. In that case the geometric image is generated automatically and displayed at the right bottom corner of the screen.

Notice that the anterior image is not aligned with the regions yet, this causes an inaccurate geometric mean image.

The controls to draw regions are the same as found in other applications. The following region sets can be selected by the “radio” switches below the image:

- **Both full**: left and right full kidney, background left and right.
- **Left duplex**: left upper and lower pole, right full kidney, background left and right.
- **Right duplex**: left full kidney, right upper and lower pole, background left and right. This is shown in the above figure of the regions page.
- **Both duplex**: left upper and lower pole, right upper and lower pole, background left and right.

Automatic background regions can be applied to left-full or right-full kidneys only.

After all regions have been defined the Calculate & Display button will highlight. Click on that button to perform the calculations and display the final page.

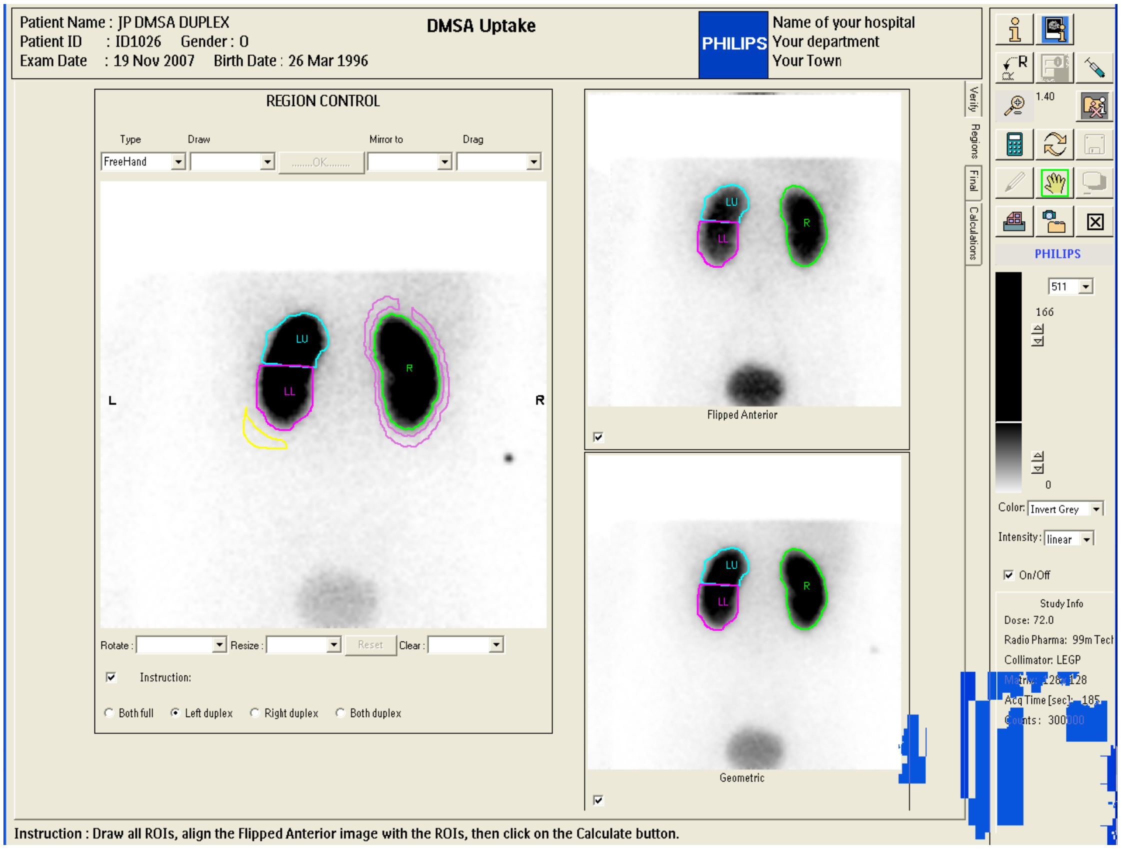

Figure 140 Regions page, Anterior image aligned.

To align the Anterior flipped image with the regions click and drag the image at the top right corner such that the regions do fit the activity. Notice that the activity in the flipped anterior view will be somewhat different from the posterior view. Upon release of the mouse button the geometric image will be updated. Repeat the drag process until you are satisfied with the alignment and the geometric image.

When you are done aligning click on the Calculate & Display button to calculate the results and display the final page.

12.6 Final Page

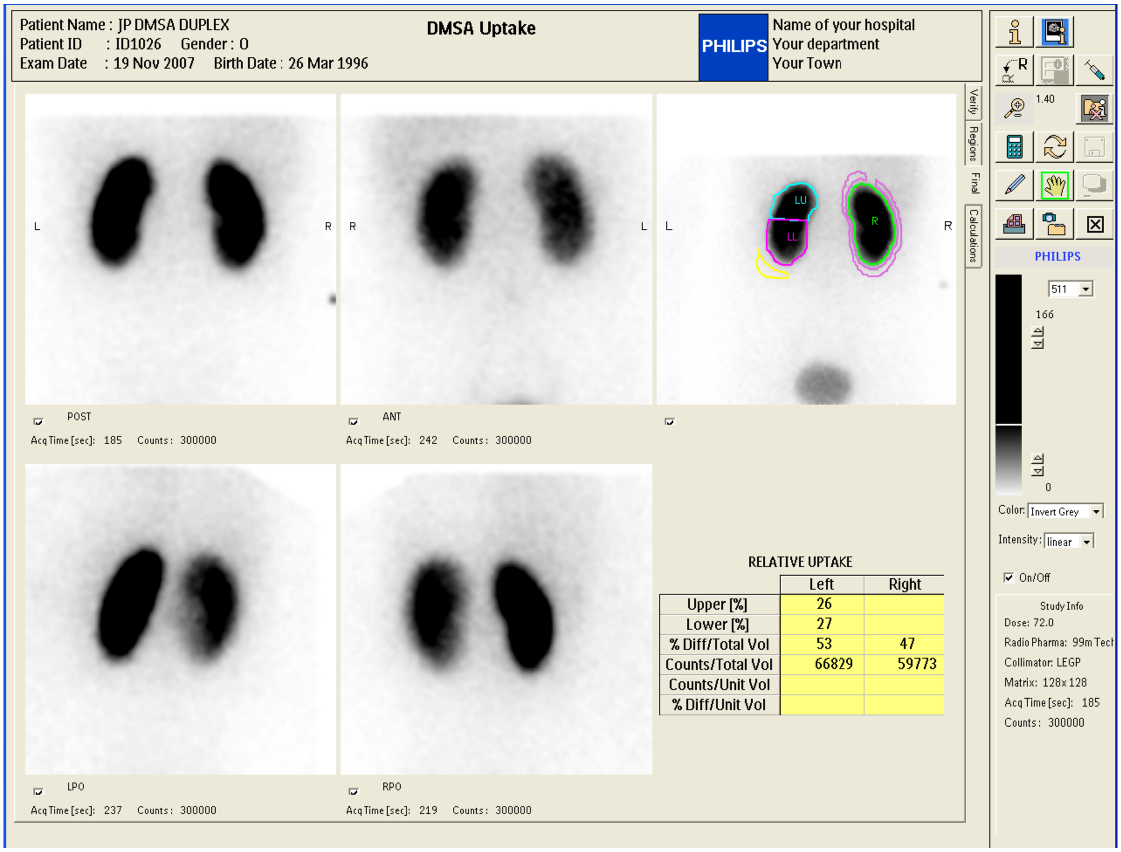

Figure 141 Final page, left kidney duplex ROIs

Up to four images, posterior, anterior, lpo, and rpo, can be zoomed, panned, and annotated. Be aware that if you rotate the images after drawing the regions and calculation of the results, all regions and results will be cleared. Click on the checkbox near an image to ‘freeze” its display. Adjustment of the contrast, pan and zoom operations will only affect images where the checkbox has been marked. Notice that annotation and pan operation selection are indicated by the green border around the active button. At the end of annotation the pan operation is enabled, these two buttons work like “radio” buttons.

Note

In Upper and Lower mode the mirror function will mirror as usual from the left to the right or v.v. on the screen. It will not mirror from upper to lower or v.v. part of the screen.

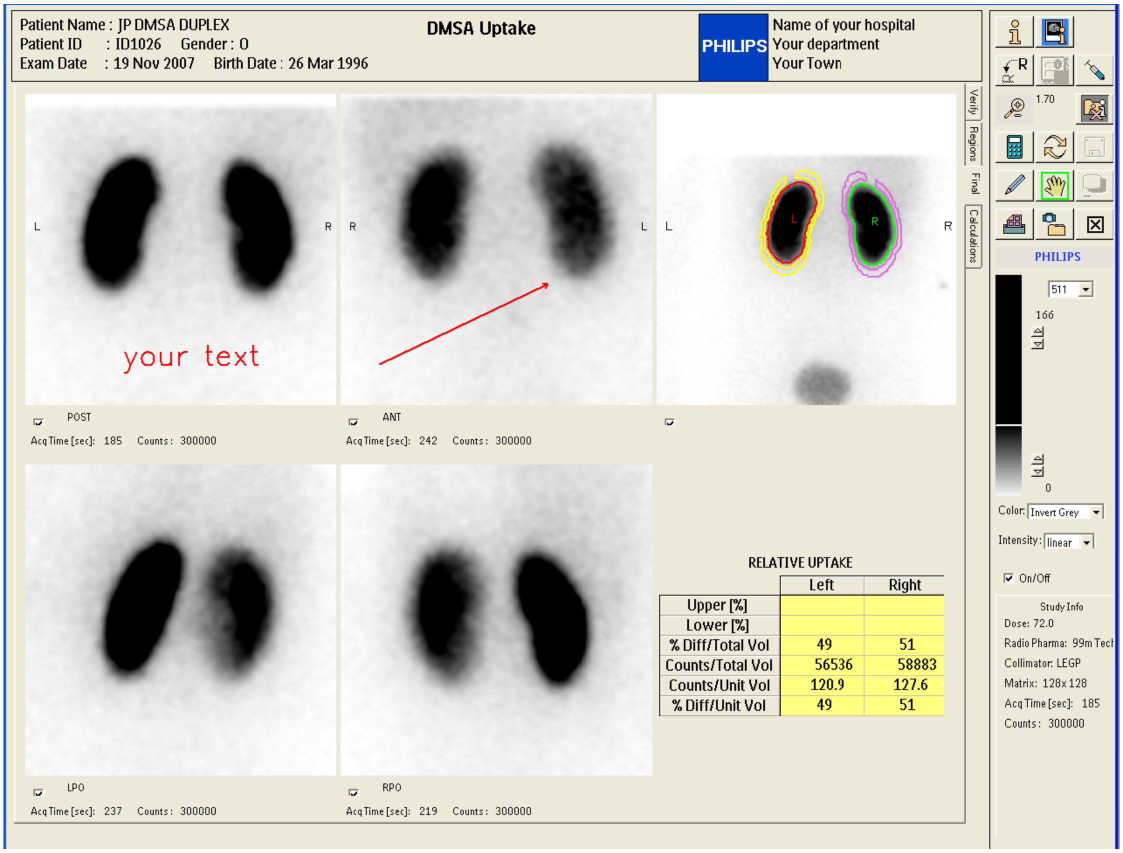

Figure 142 Final page , Both full kidney ROIs

In the Both full kidneys situation the application calculates not only the left and right total percentages but also the Unit volume counts of the left and right kidney and the % Difference Unit volume counts.

The Unit volume counts can be considered as the average counts per “Unit volume” or here per pixel of the geometric or posterior image.

The Unit volume counts per kidney are determined by dividing the kidney counts – area normalized background counts by the number of pixels of the kidney ROI.

The Unit volume counts of both kidneys are then used to determine the % difference by calculation of : Left % Unit volume =

(Left Unit volume counts / Left Unit volume counts + Right Unit volume counts) x 100 and Right %Unit volume as 100 – Left % Unit volume.

12.7 Calculations Page

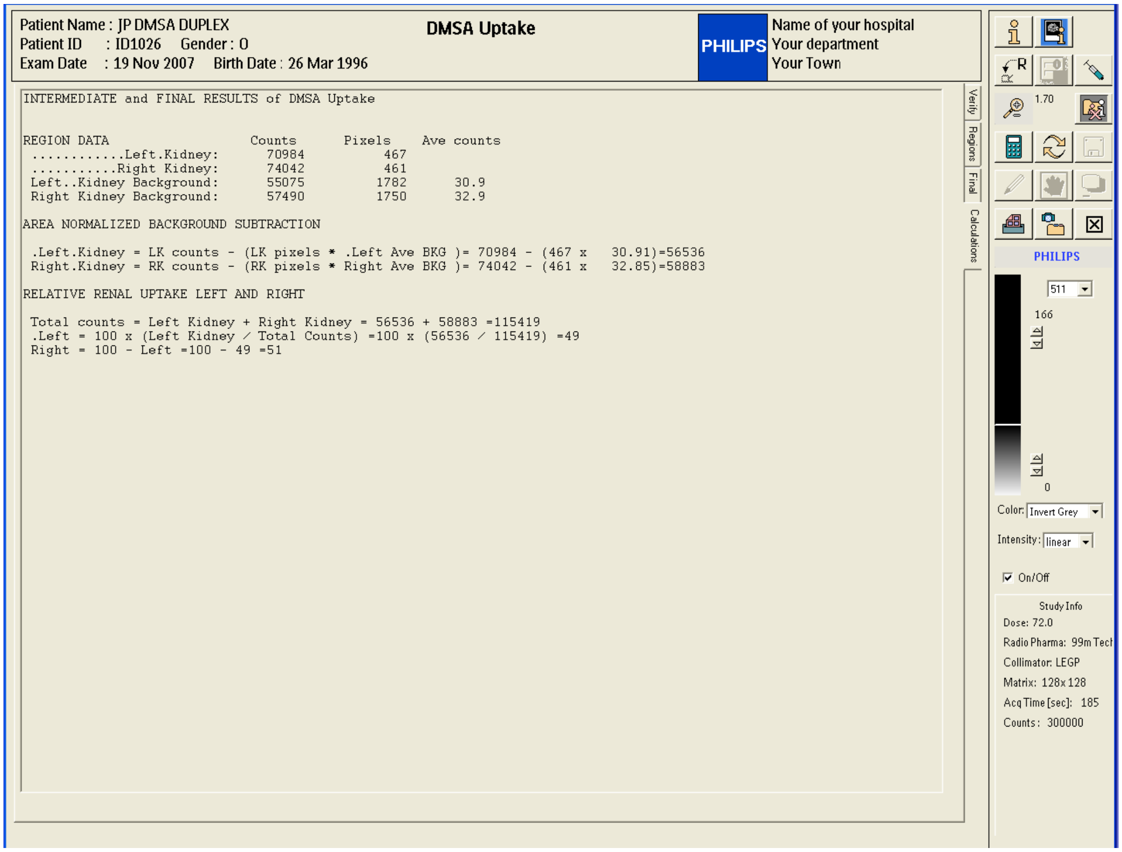

Figure 143 Calculations page

Use this page to verify the calculated results of the Final page.

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13 Renal: Micturition

13.1 General

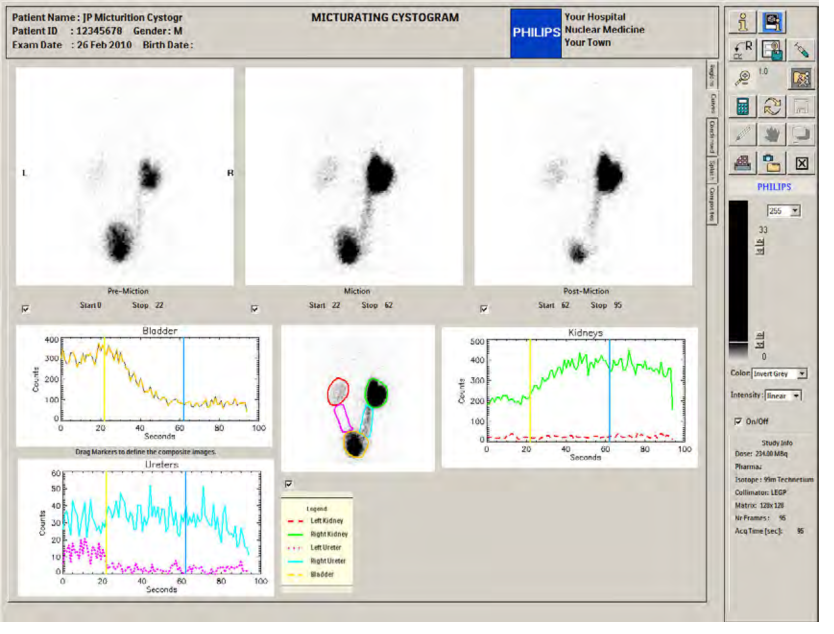

Figure 144 Renal Micturition application

This application allows generation of kidneys, bladder, ureter curves, and condensed images left and right from a micturition study. You can generate three composite images: pre-micturition, micturition and post-micturition. Condensed images calculated from Left and Right Ureter ROIs can be added to the final display.

13.2 Acquisition

Matrix: 64 x 64 or 128 x 128. Usually 120 frames at 2 seconds/frame stopping early if indicated, 10-15 seconds after micturition completed to acquire enough frames to create the post micturition image.

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13.3 Processing

;

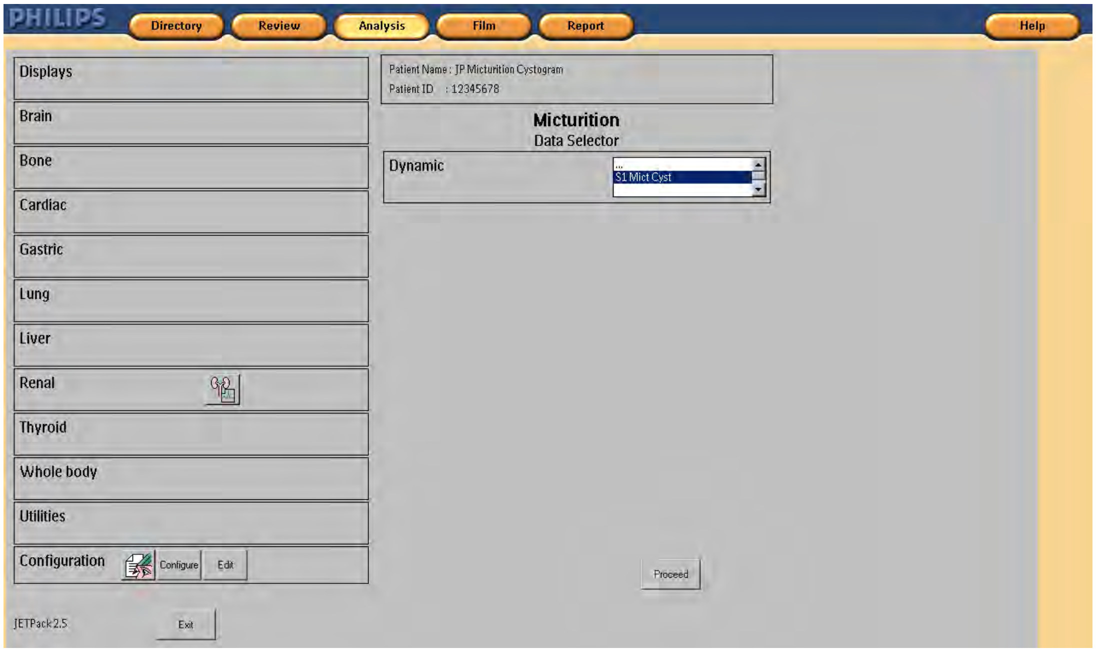

Figure 145 ISP JETPack panel, Renal Micturition application selected

If required adjust the selected file in the data bucket and click Proceed.

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13.4 Regions Page

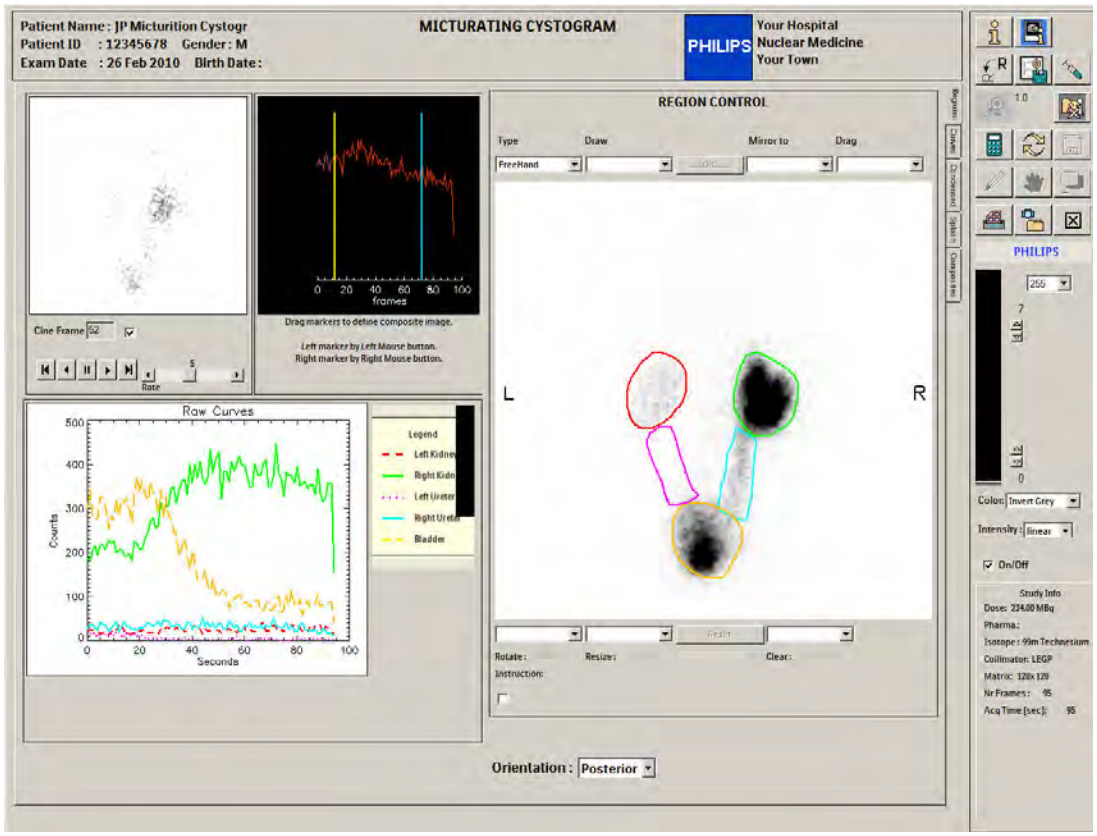


Figure 146 Regions page, cine, composite selection, regions control, raw curves

The dynamic image appears in the cine panel and a composite image is generated and appears in the region control viewport. By means of the image checkboxes, you can enable the individual images for adjustment of window setting, color map, and intensity (log, exp), etc.

Use the cine controls to display the dynamic image in motion or step through individual frames.

The composite image**,** as displayed in the region control viewport, is controlled by dragging the two markers on the curve display. The curve shows the activity of the full matrix without any regions; it is displayed to show the available frame range. Drag the markers interactively to change the range of frames used to build the composite image.

Regions: Draw the left and right kidneys, left and right ureters, and the bladder regions in **Polygon**, **Freehand**, **Box**, or **Ellipse** mode. See Chapter 1, “Getting Started.” for details. Once you have drawn all five regions, the Calculate & Display button is enabled. Click that button to generate the curves. The raw curve set appears at the bottom left curve display. Continue to the curves page by clicking the **Curves** tab.

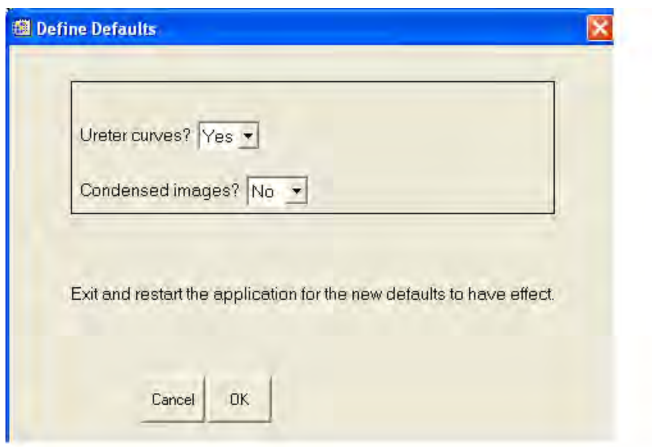
13.5 Button Panel and ROI Controls

See Chapter 1, “Getting Started.”

13.5.1 Default setting

In all situations the Bladder and Kidney curves are displayed on the final page. You can make the following default selections;

- **Ureter Curves No/Yes**: Displays the curves as generated from the Ureter ROIs on the final page.
- **Condensed Images No/Yes**: Displays the condensed images of the left and right Ureter ROIS if selected. In this case you should draw the Ureter ROIs as large box ROIs that encompass the kidney, ureter and half of the bladder as shown in Figure 148 on page 178.



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13.6 Curves Page

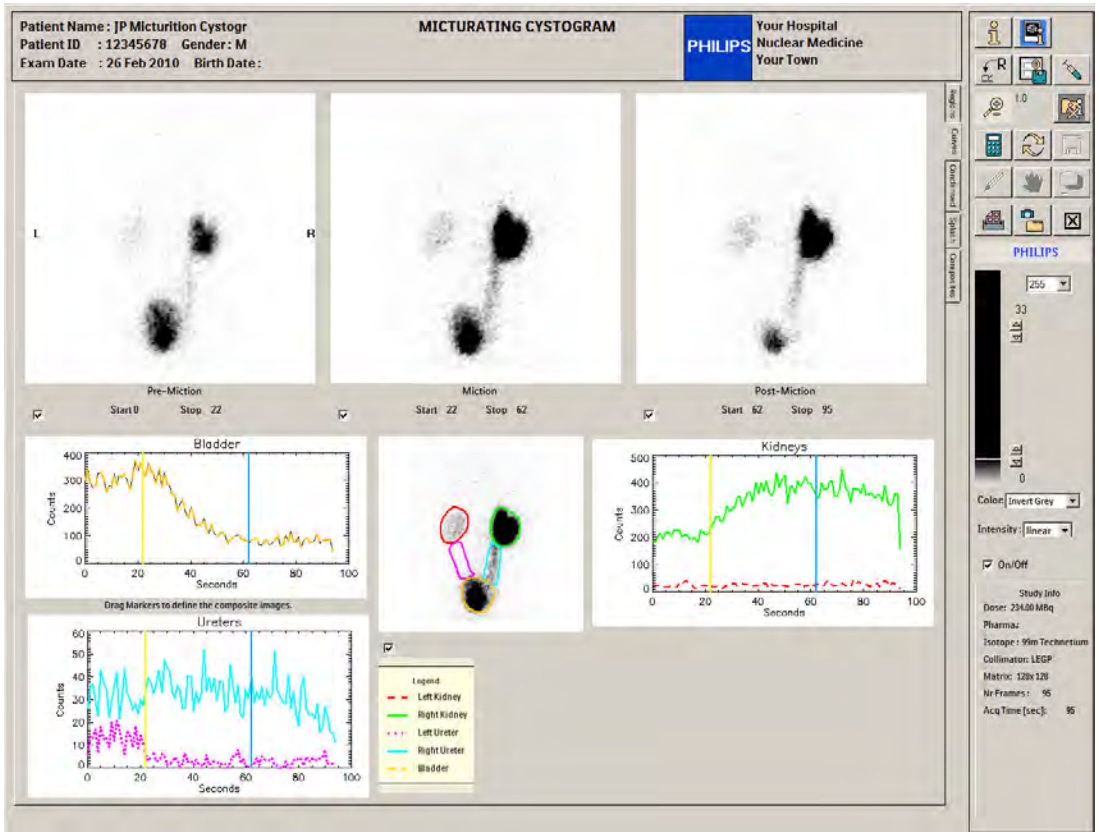


Figure 147 Curves page and Study Info panel

Default mode: Ureter curves, no condensed images.

In the upper half of the screen, the premicturition, micturition, and postmicturition images appear. The lower half of the screen shows, from left to right, the curves of the left and right kidneys with the bladder, the composite image with regions superimposed, and the left and right ureter curves.

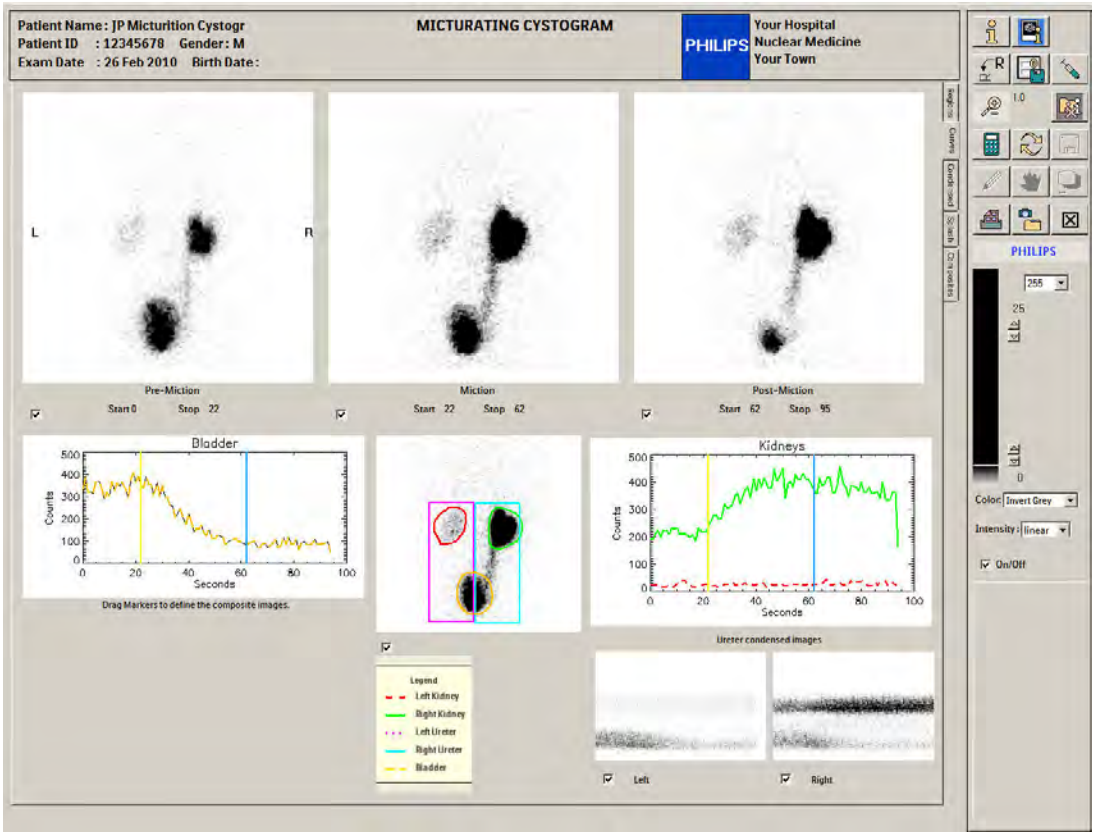


Figure 148 Curves page with Condensed images

Defaults mode is Ureter curves is No, Condensed images is yes. Notice the Condensed images of the left and right ureter ROI areas at the bottom of the screen. Be aware that you can select to have ureter curves only, condensed images only, both ureter curves and condensed images or none of either.

The recommended ROIs for the Condensed images are a rectangular ROI that includes the left kidney, left Ureter, and part of the bladder for Left Ureter ROI, and a similar ROI for the Right Ureter ROI. See Figure 148.

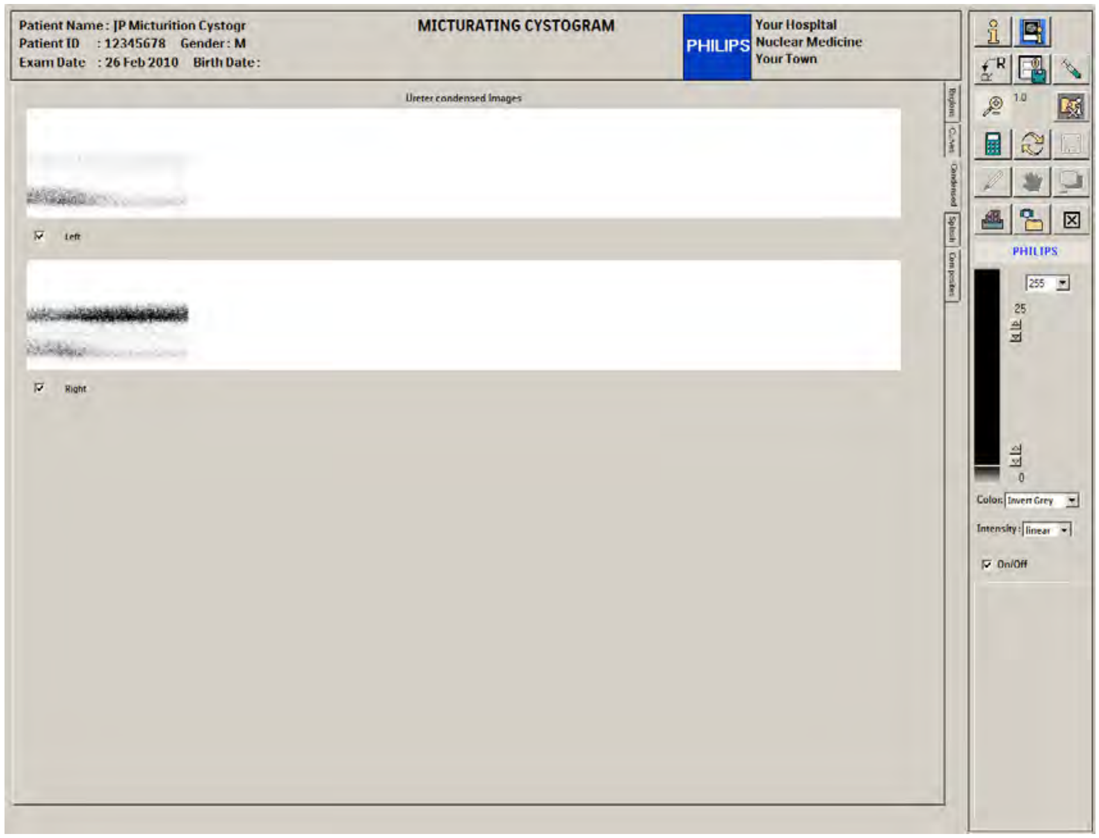


Figure 149 Condensed images page

The Condensed page displays the condensed images of the left and right ureter ROIs with a maximum of 1024 frames in the original dynamic image.

The condensed images on the Curves page only displays the result of the first 200 frames at maximum.

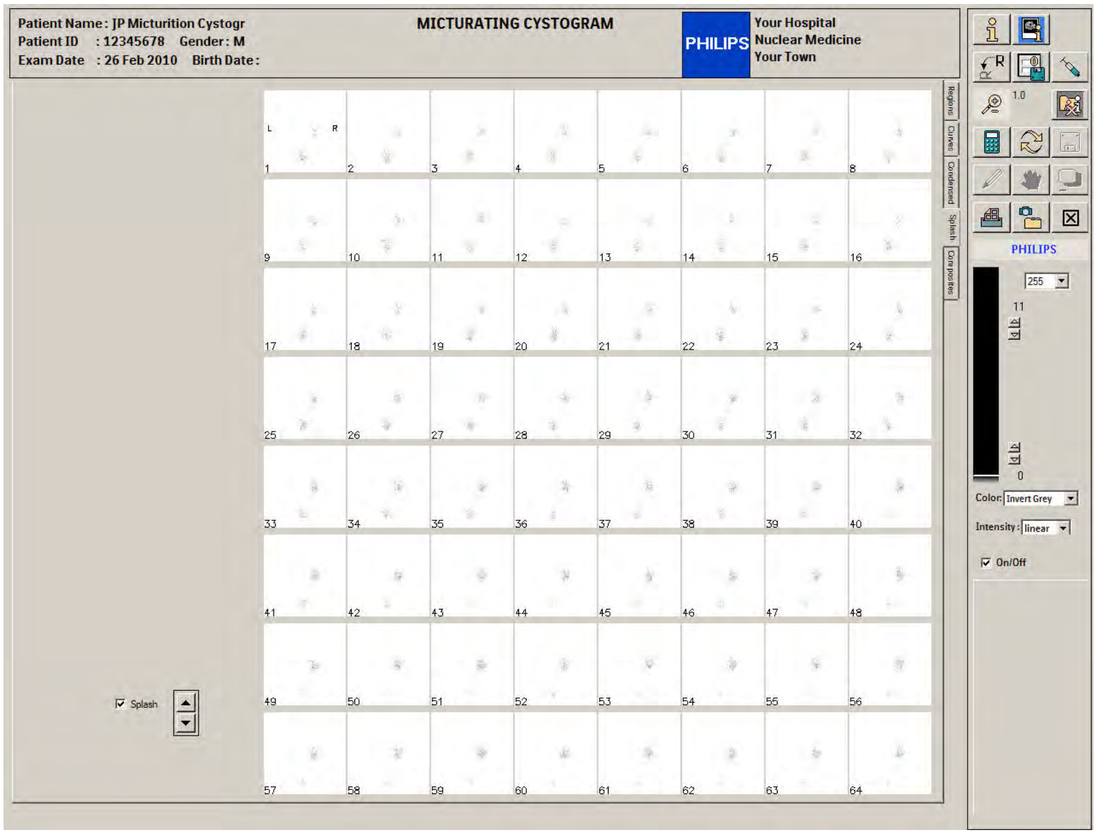


Figure 150 Splash page

The splash page show a maximum of 64 frames of the dynamic image. Use the up and down controls in the lower left hand corner to change the range of displayed images by one row (8 frames) at a time.

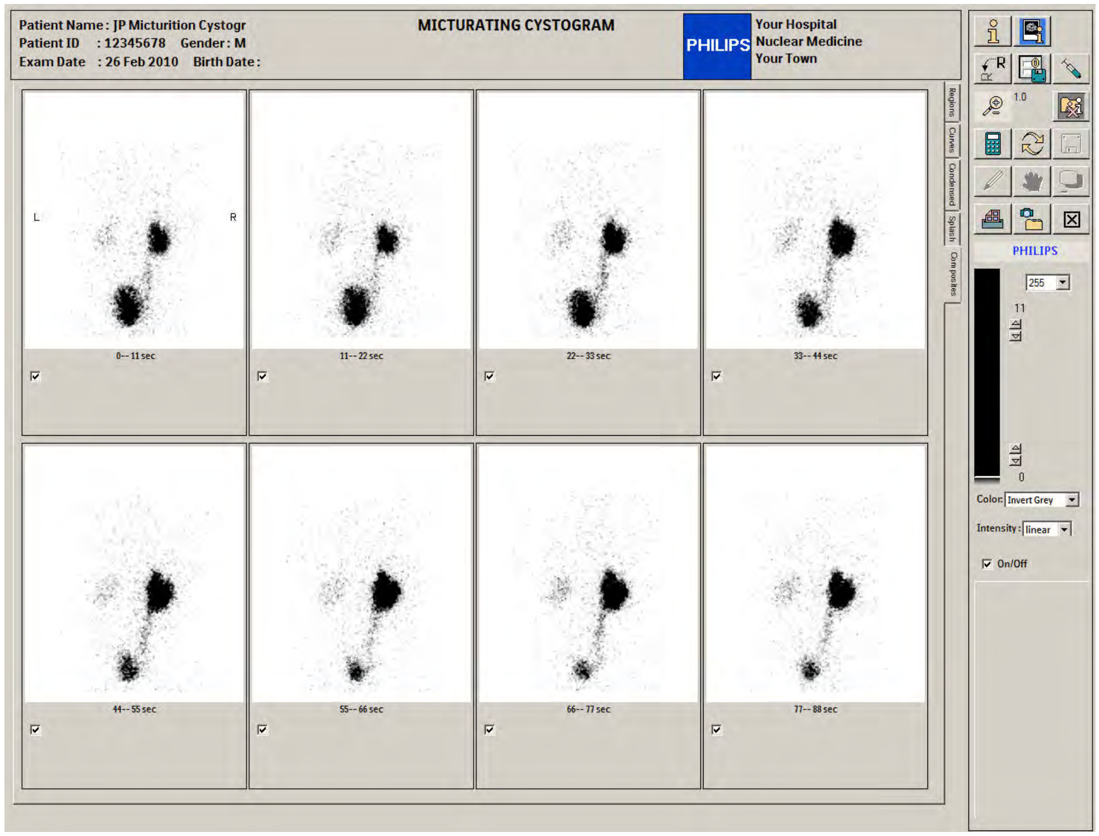
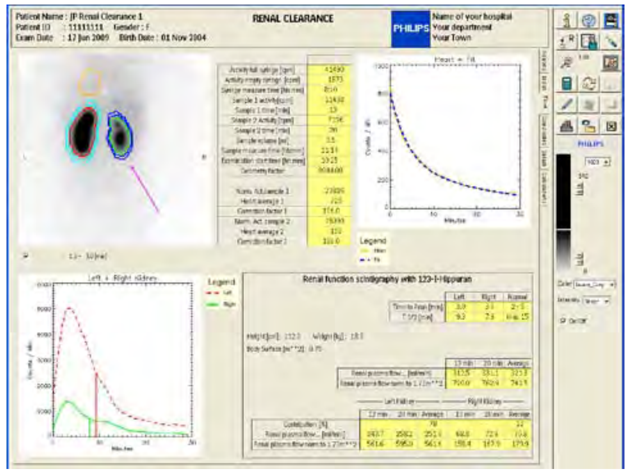


Figure 151 Composite images page

The eight composite images are automatically produced by dividing the full time range of the dynamic image into eight equally sized time ranges. You can adjust images individually or as a group by clicking the on/off checkbox on the button panel. You can select a different colormap, intensity, and contrast with the sliders for each image.

14 Renal Clearance

14.1 General



The application allows for calculation of renal clearance in children and adults, using I-123 Hippuran.

The method requires one or two blood samples. For children it uses the curve from the heart region and a bi-exponential or mono-exponential curve fit thereof for determination of the clearance. For adults a body retention curve is generated from a large region above the kidneys. Left and right kidney curves with area normalized background subtraction are generated. Left to right contribution, total clearance per blood sample and clearance per sample per kidney are the results of this application. The applications allows for selection of Upper and Lower kidney in stead of Left and Right. The application is based on the methods by the Medizinische Hochshule in Hannover (MHH) in Germany.

14.2 Acquisition

The input for this application must have a minimum total acquisition time of 25 min minutes, where phase one has a duration of at least 150 seconds. For example:

Single phase dynamic.

e.g. 180 frames of 10 sec/frame; 30 min total

Dual phase, single file, dynamic;

e.g. phase 1 : 30 frames of 12 sec/frame, 6 min

phase 2 : 24 frames of 1 min/frame, 24 min

Dual phase, two files, dynamic

e.g. file 1, phase 1 : 30 frames of 12 sec/frame, 6 min and
file 2, phase 2 : 24 frames of 1 min/frame, 24 min

Matrix 64x64 or 128x128

In case of dual phase acquisition it is recommended to acquire 5 or 6 minutes in phase 1 for proper determination of the acquisition start point and range for left to right contribution.

The application cannot handle a three phase acquisition.

14.3 Processing

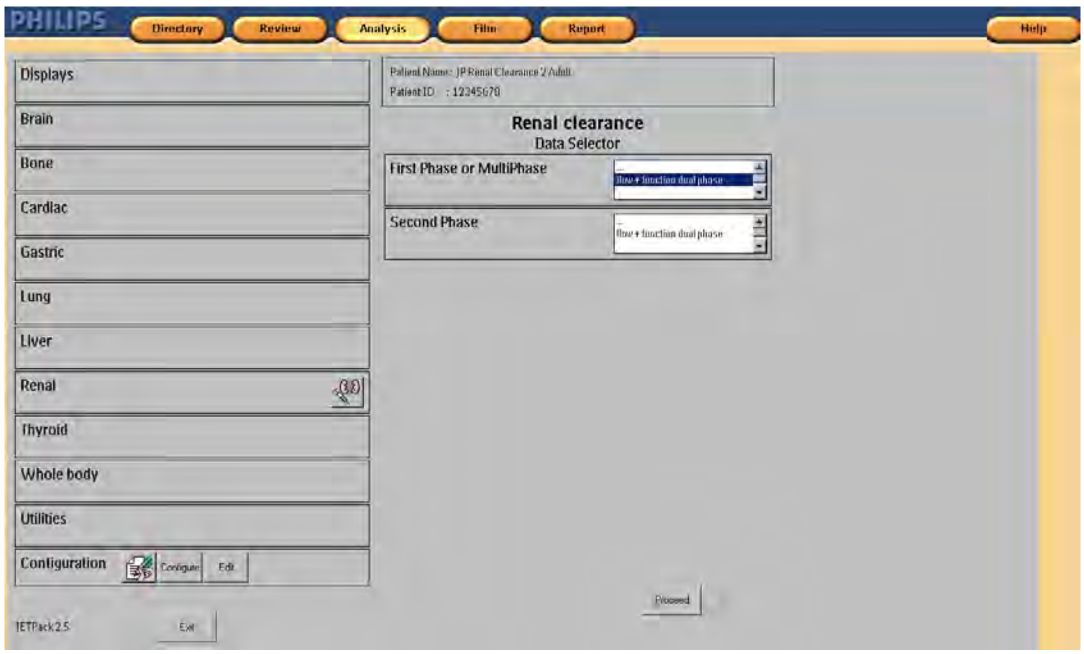


Figure 152 ISP JETPack panel, Renal Clearance application selected

If required adjust the selected files in the data buckets and click Proceed.

14.4 Regions Page

On the Regions page select the Orientation to be anterior or posterior and the Processing Mode Child or Adult then adjust the markers on the curve at the top of the screen to build the desired composite image. Select the kidney mode Both, Left only, Right only or Upper + Lower to set up the ROI selection menus. Draw the proper ROIs and click the

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Calculate button on the right side panel. Notice that the Child method requires drawing a small ROI on the heart while the Adult method requires a large Body ROI.

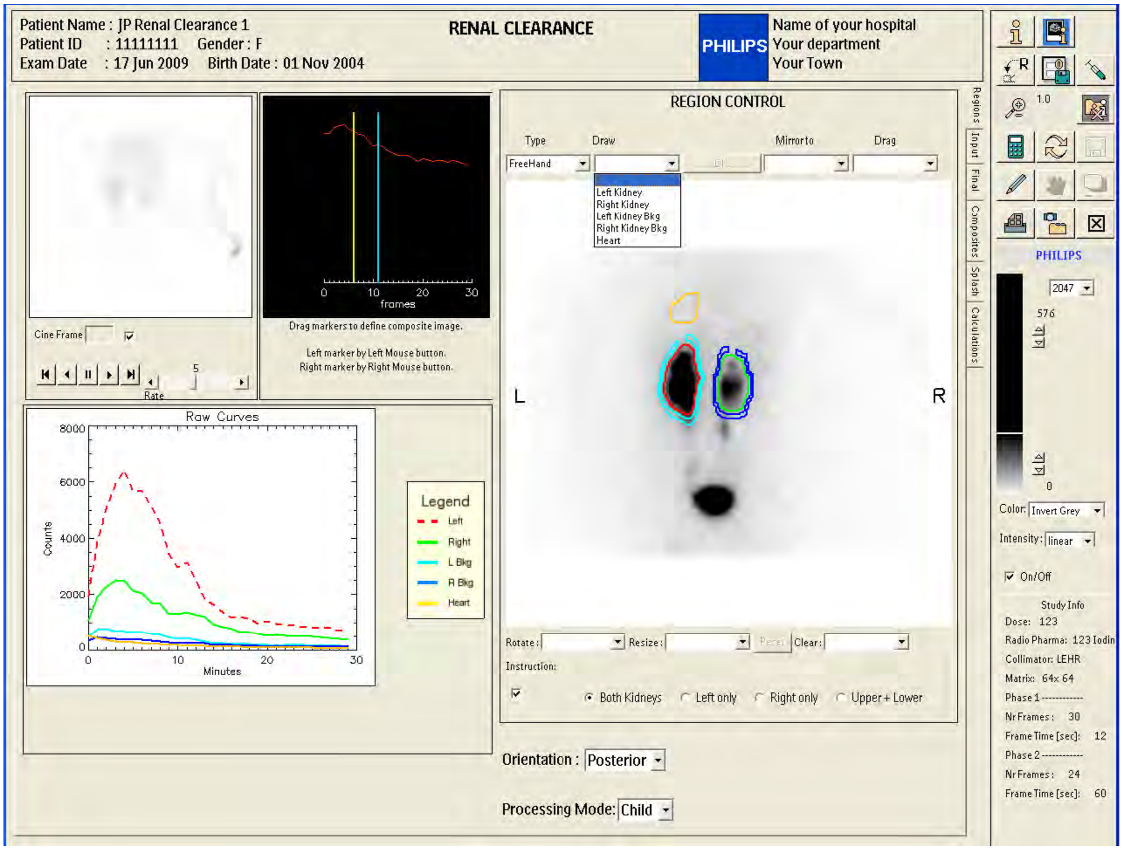

Figure 153 Regions page, all ROIs selected and Calculate button clicked.

After clicking the Calculate button the raw curves are generated and displayed as shown in the figure above. The dynamic image maybe displayed in cine mode using the controls and view port at the top left side of the screen.

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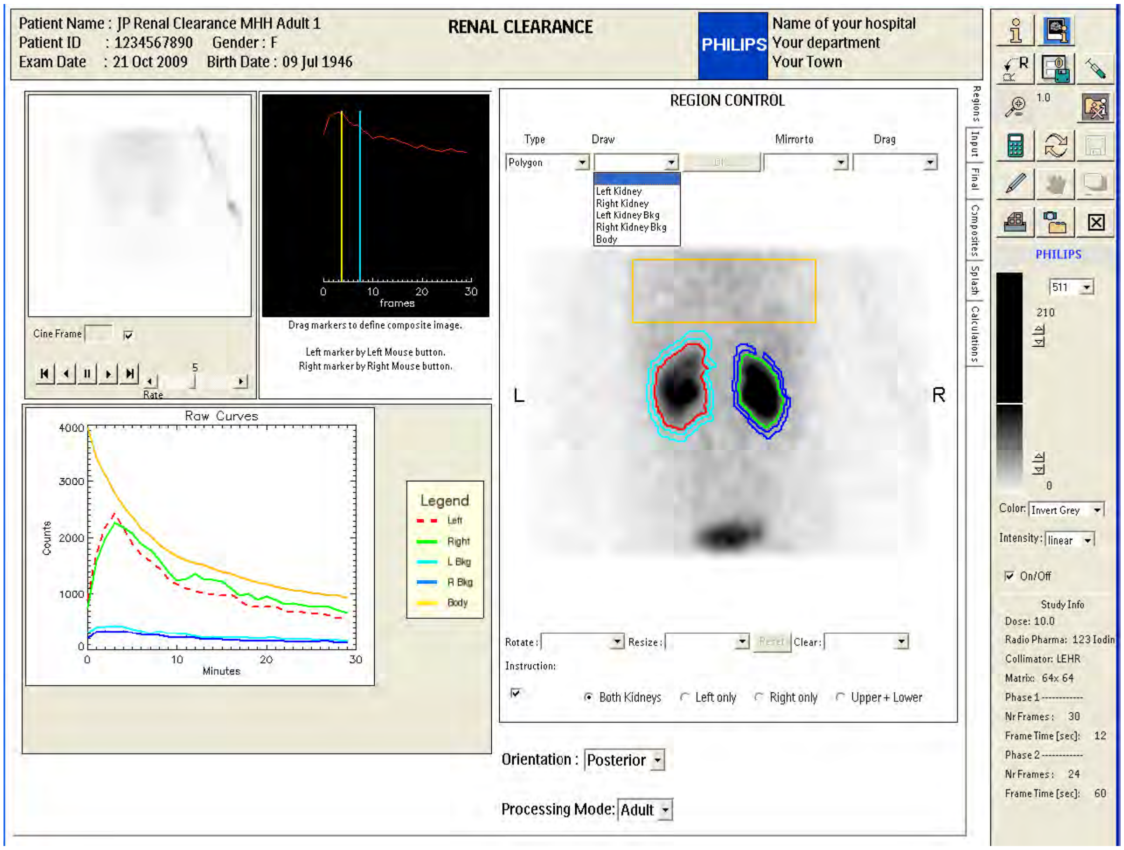
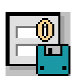


Figure 154 Regions page, processing mode Adult, notice the large Body ROI

14.4.1 Button Panel and Region Control



See the General description for an explanation of the various buttons.

Set Defaults: Click this button to bring up the panel below:

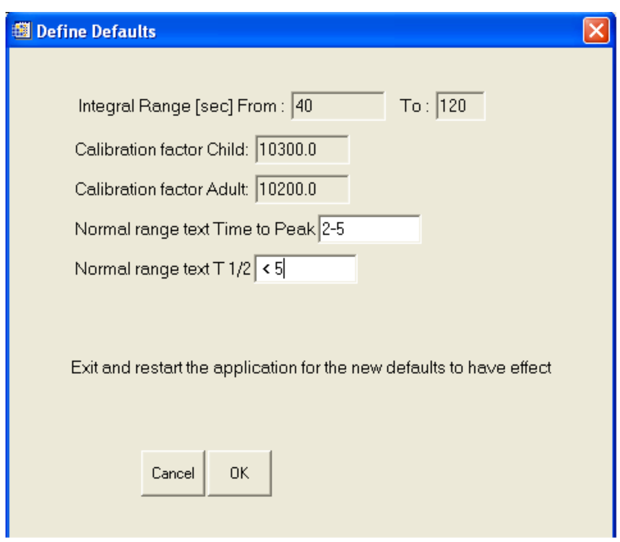


Figure 155 Default panel

The defaults that can be set are shown in the figure. When this panel is launched it shows the current defaults. For new defaults to be effective after clicking OK you must exit and restart the application. Notice that two items can be set as default values;

- **Start and stop time** in seconds for curve sections that will be used to determine left and right contribution in percent.
- The **calibration factors Child and Adult** for determination of injected activity from full and empty syringes. The blood sample sizes for children and adults may vary e.g 0.5 ml and 1 ml, the geometry factor may vary accordingly.
- **Normal range text Time to Peak**: Text for the normal time range of time to peak, the text appears in the table on the final screen.
- **Normal range text T1/2**: Text for the normal time range of T 1/2 , the text appears in the table on the final screen.

14.5 Input Page

On the Input page enter the data for the syringe and samples in either Child or Adult processing mode. Figure 156 shows the input panel in child mode. Adjust the start point of the curves in the lower left view port by dragging the blue marker. Dragging the marker to the right will move the curves for integral selection to the left thus adjusting the selected range for integral and contribution determination. Adjustment of the start point will also adjust the function curves of the left and right kidney and the heart curve. The markers for the integral range are placed according to the values of the default selection, however the markers may be adjusted here to select a different range. The values in the table at the right side of the screen will be updated accordingly.

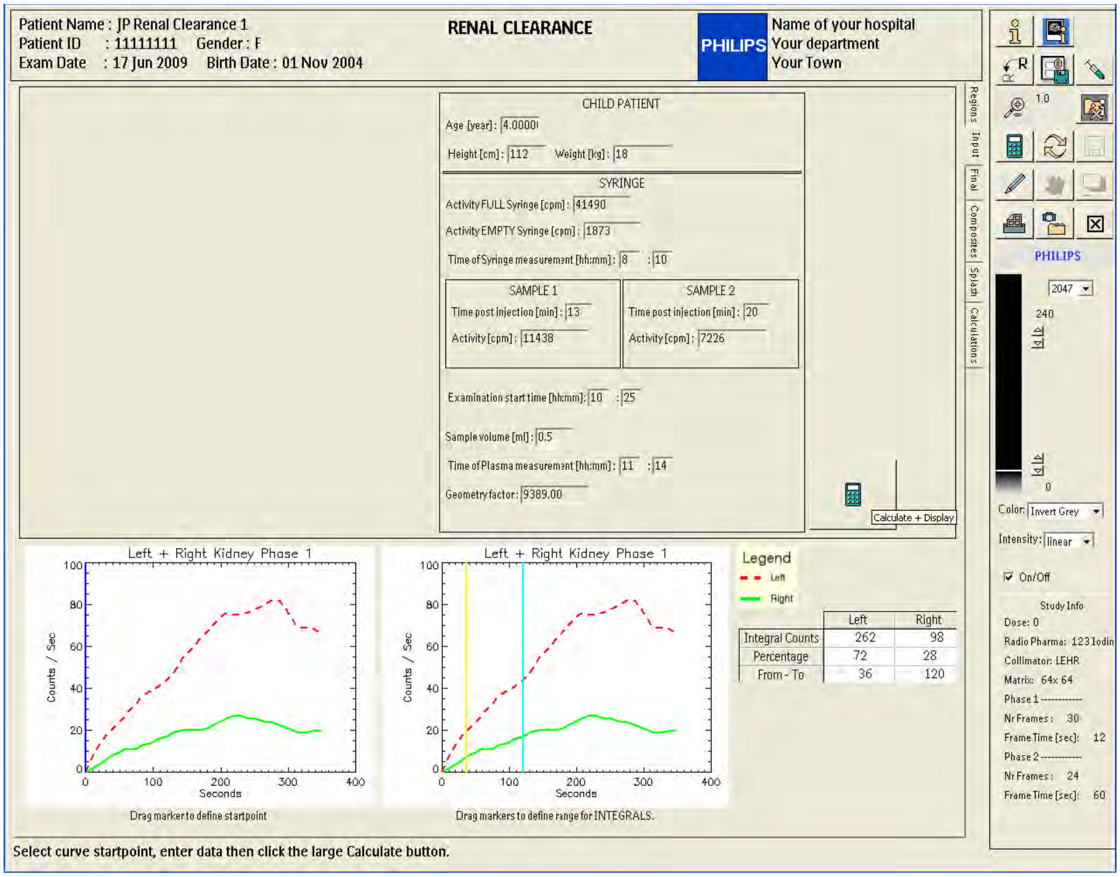


Figure 156 Input page Child mode, with data entered and mouse over the calculate button at the right middle of the screen.

In Child mode enter or adjust the data for;

- Age, height and weight
- Activity full syringe
- Activity empty syringe
- Time of Syringe measurement
- Sample 1: Time and activity
- Optional Sample 2: Time and activity
- Adjust if needed the Examination start time
- Sample volume, Time of plasma measurement and Calibration factor

In the above example there is no need to adjust the start point, however in the example below an adjustment would be required.

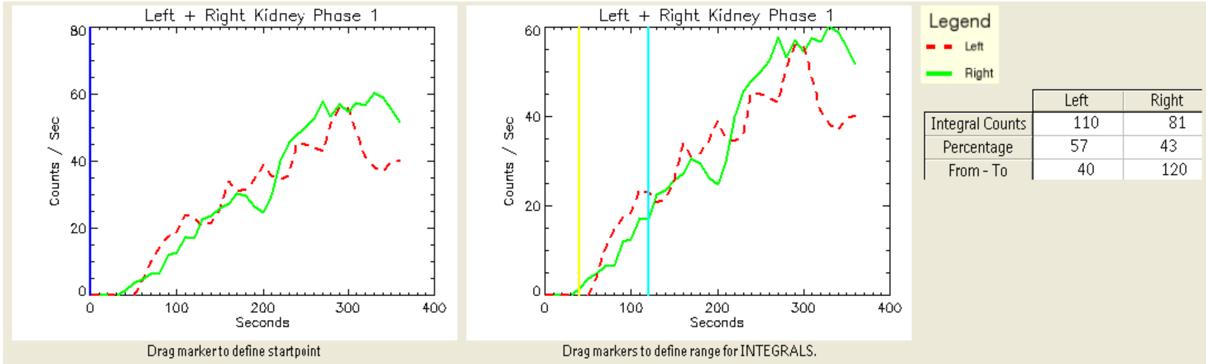


Figure 157 example study where the Start point of the curves needs correction : before

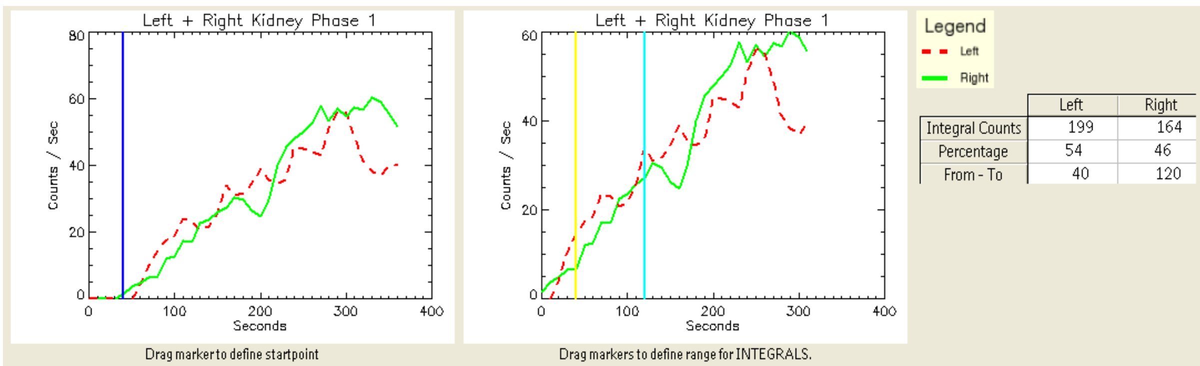


Figure 158 after adjustment of the start point

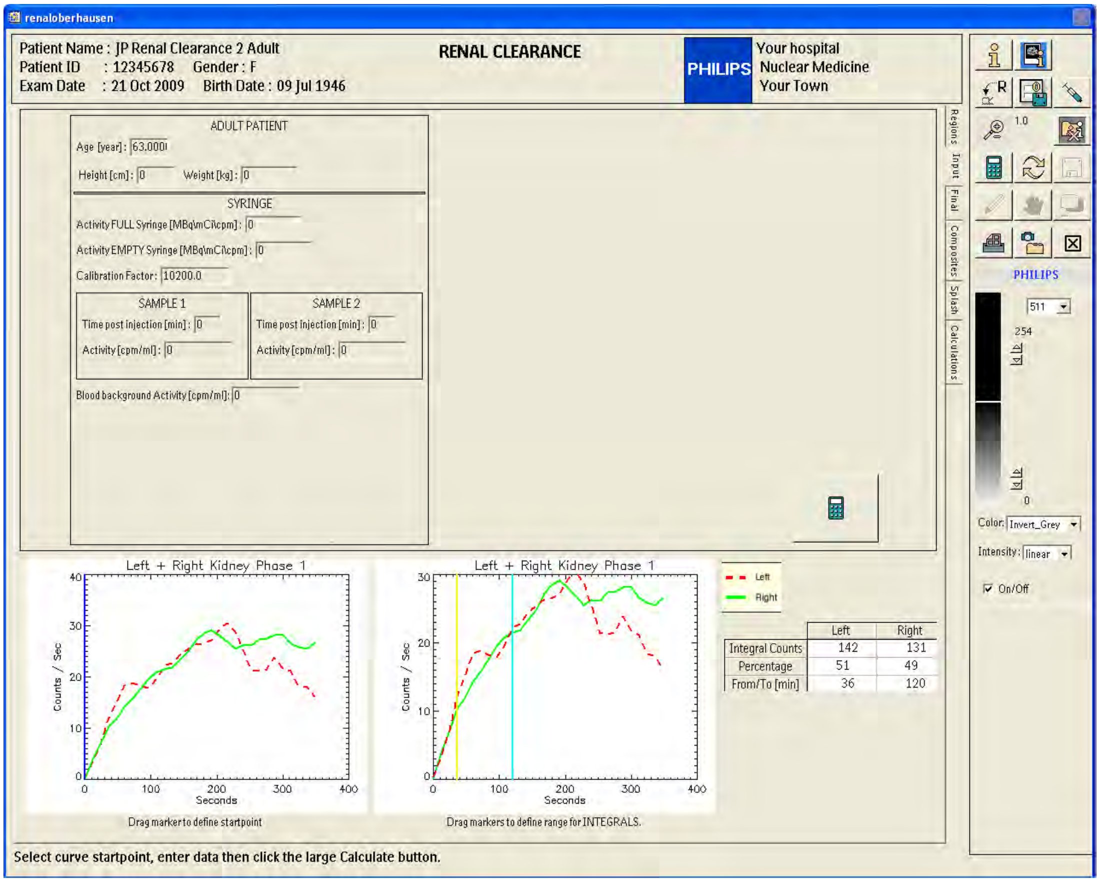


Figure 159 Input page, Adult processing mode

In Adult mode enter or adjust the data for;

- Age, height and weight
- Activity full syringe
- Activity empty syringe
- Calibration factor (geometry factor)
- Sample 1: Time and activity
- Optional Sample 2: Time and activity
- Blood background activity, if measured otherwise leave as 0
- Isotope I -123 or I-131

14.6 Final Page

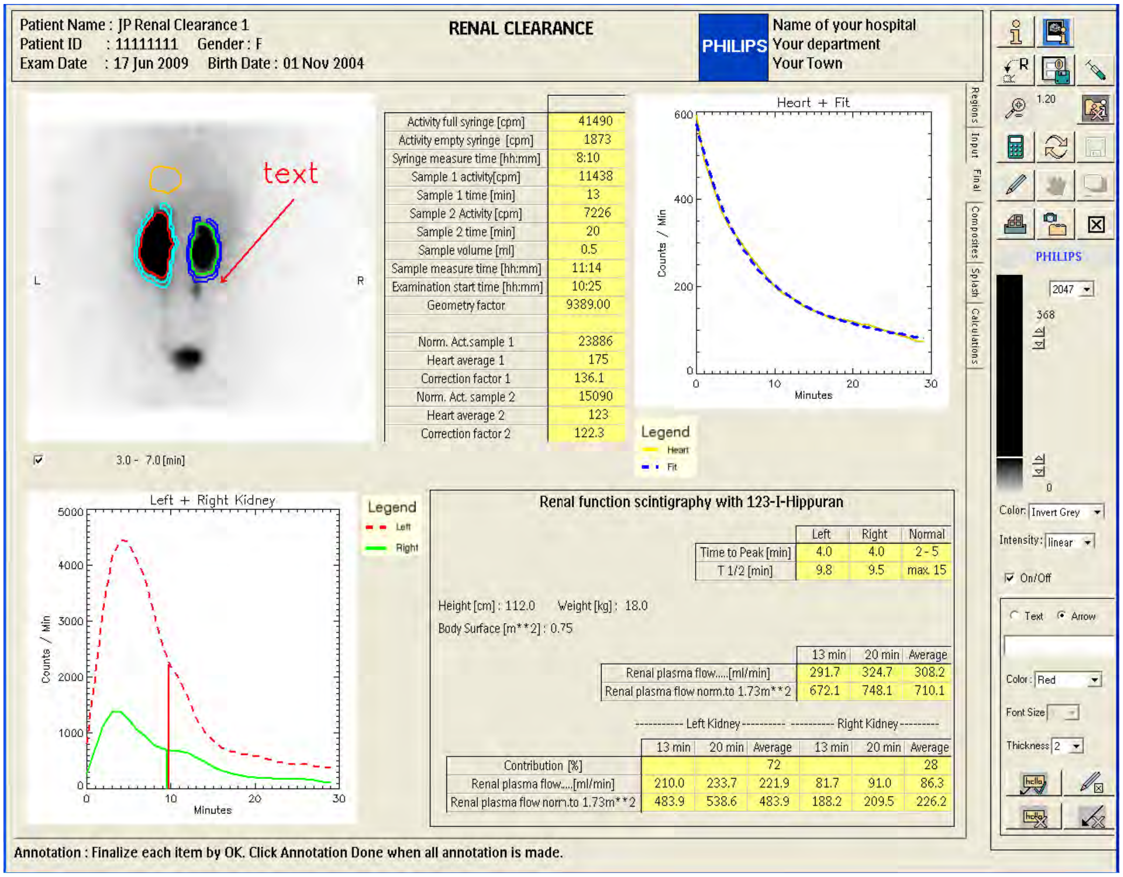


Figure 160 Final screen in Child mode, with annotation panel active.

The final page shows the input values and intermediate results in the table at the top. The composite image displays the selected ROIs. The image can be enlarged and annotated using the standard tools.

The top right graph shows the original Heart curve in yellow and the automatically generated bi-exponential curve in blue. At the lower left corner of the screen the curves of the left and right kidney display the activity from start to end of the study combining both phases of the study. The vertical markers indicate the time, (T ½) where half of the activity in each kidney is reached.

A shift of the start point on the Input page also shifts these left and right curves, as well as the heart curve. A proper start point will affect the fitting of the heart curve for best results.

The calculated results on the page are;

- Time to peak and T half for left and right kidney curves in min.
- Total renal plasma flow at sample time 1 and 2 and the average in ml/min

- Normalized total renal plasma flow at sample time 1 and 2 and the average in ml/min/1.73m^2
- Patient Body surface from patient height and weight in m^2
- Contribution left and right in %
- Renal plasma per kidney at sample time 1 and 2 and averages in ml/min
- Normalized renal plasma per kidney at sample time 1 and 2 and averages in ml/min/1.73m^2

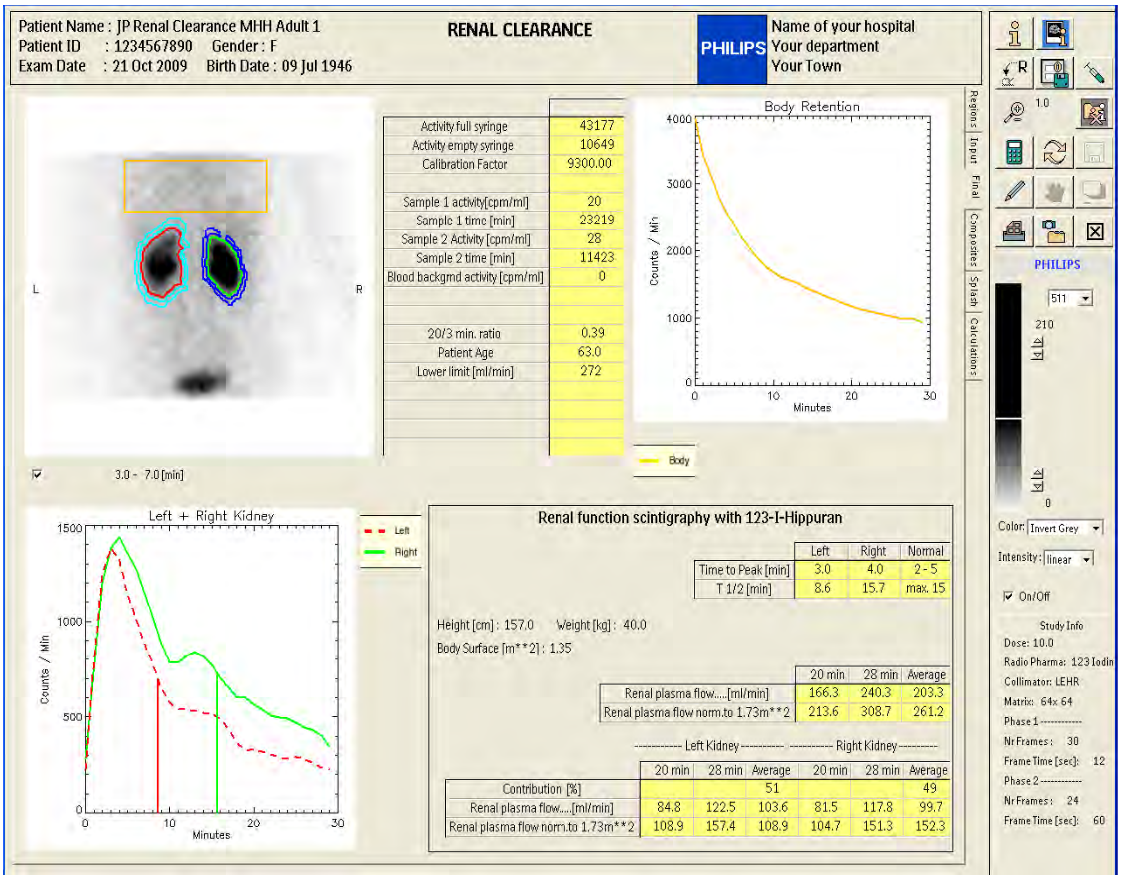


Figure 161 Final page in Adult processing mode

The top right graph shows the Body retention curve in yellow. At the lower left corner of the screen the curves of the left and right kidney display the activity from start to end of the study combining both phases of the study. The vertical markers indicate the time, (T ½) where half of the activity in each kidney is reached.

A shift of the start point on the Input page also shifts these left and right curves, as well as the body curve. A proper start point will affect the calculated results.

The calculated results on the page are;

- Time to peak and T half for left and right kidney curves in min.

- Total renal plasma flow at sample time 1 and 2 and the average in ml/min
- Normalized total renal plasma flow at sample time 1 and 2 and the average in ml/min/1.73m^2
- Patient Body surface from patient height and weight in m^2
- Contribution left and right in %
- Renal plasma per kidney at sample time 1 and 2 and averages in ml/min
- Normalized renal plasma per kidney at sample time 1 and 2 and averages in ml/min/1.73m^2
- The 20 / 3 minute ratio of the Body retention curve (top center table)
- Patient age and calculated lower limit for that age (top center table)

14.7 Composites Page

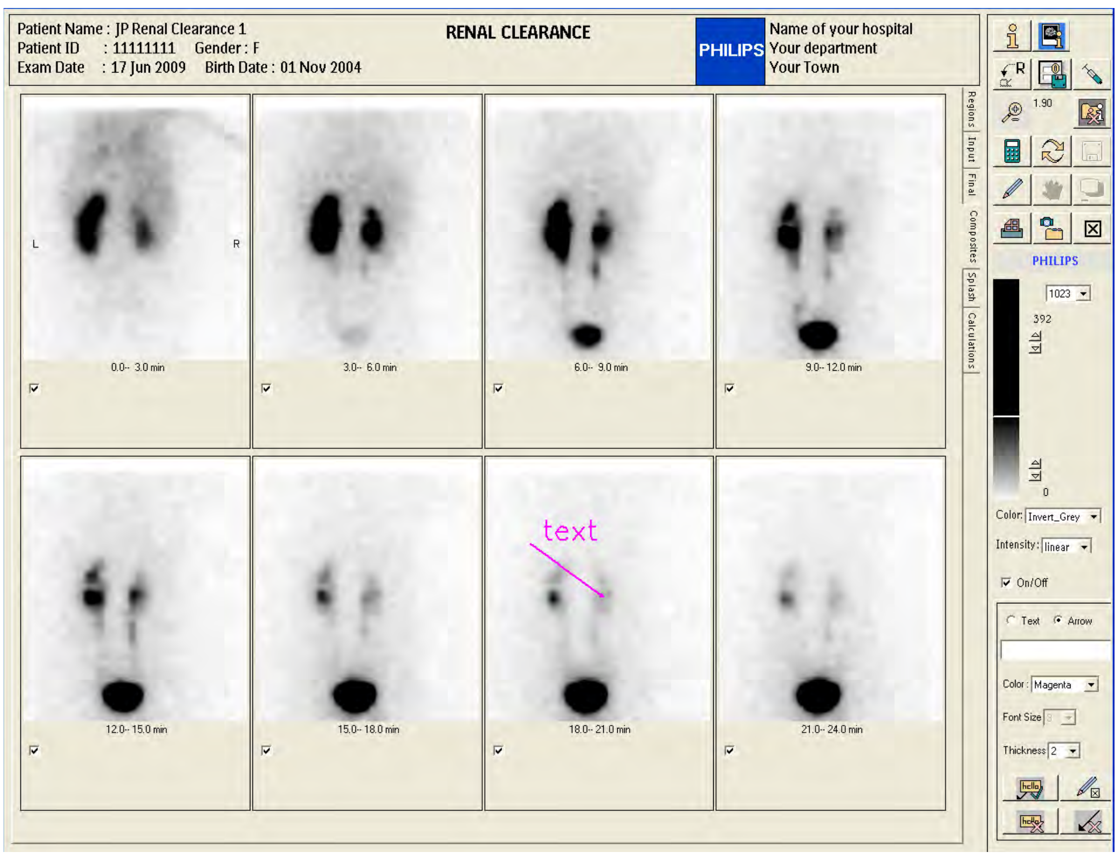


Figure 162 Composites page with some annotation entered

The composites pages automatically displays eight composite images as derived from the total set of images in phase 1 and phase two of the dynamic images or from the total single phase acquisition.

14.8 Splash Page

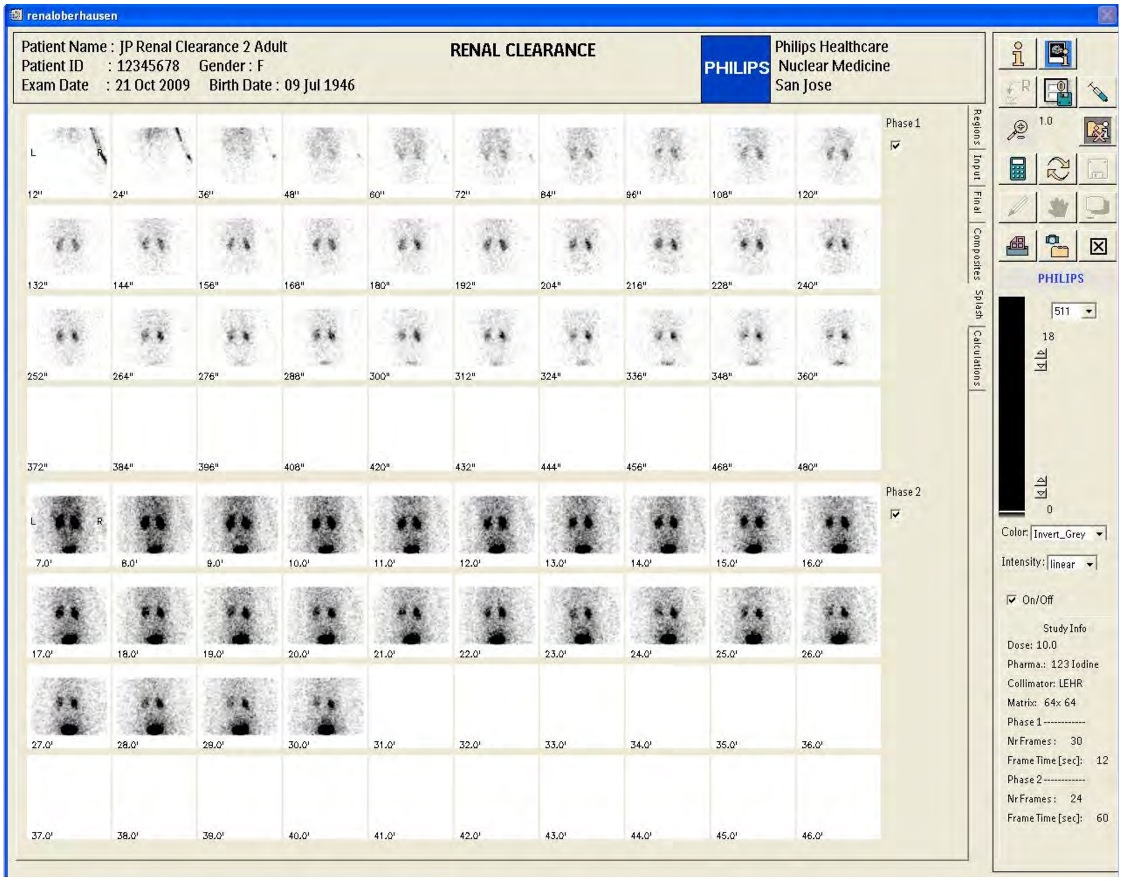


Figure 163 Splash page shows two phase

The splash page displays phase 1 and 2, if available, in separate containers that may be adjusted individually for image contrast, zoom and color scale.

The images are compressed into 40 composites, shown here for phase 2 or displayed as individual frames if the number of frames in the phase is less than 40, see phase 1 at the top of the screen.

14.9 Calculations Page

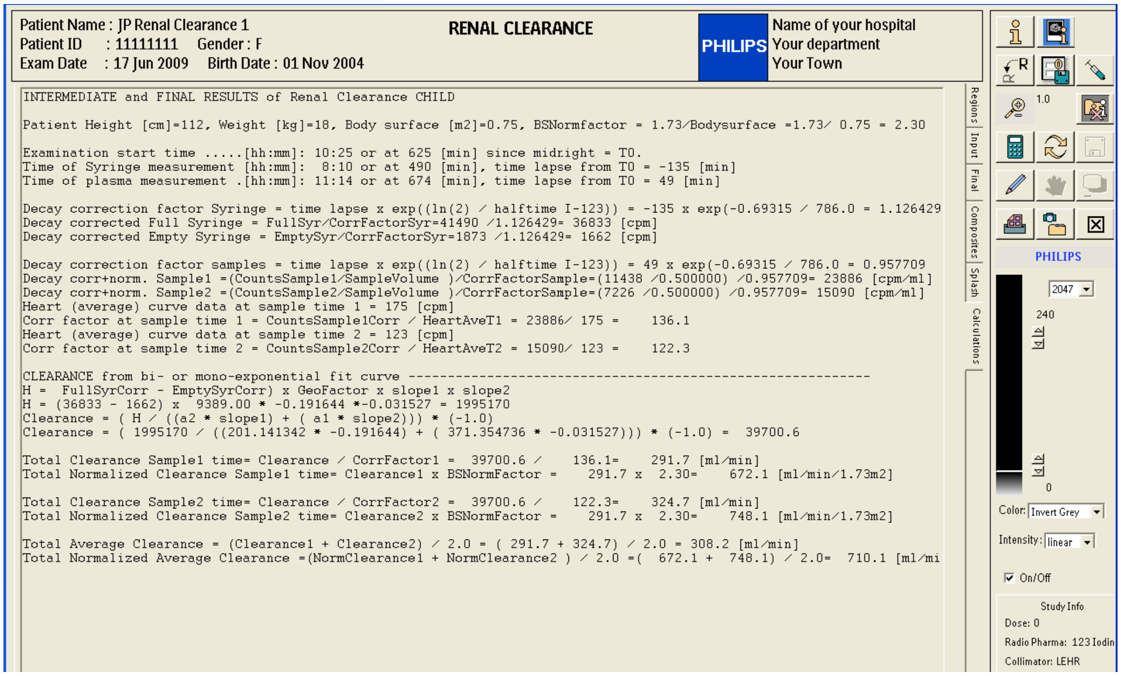


Figure 164 Calculations page in Child mode, shows intermediate and final calculated results.

Use the calculations page to verify the results as presented on the Final page.

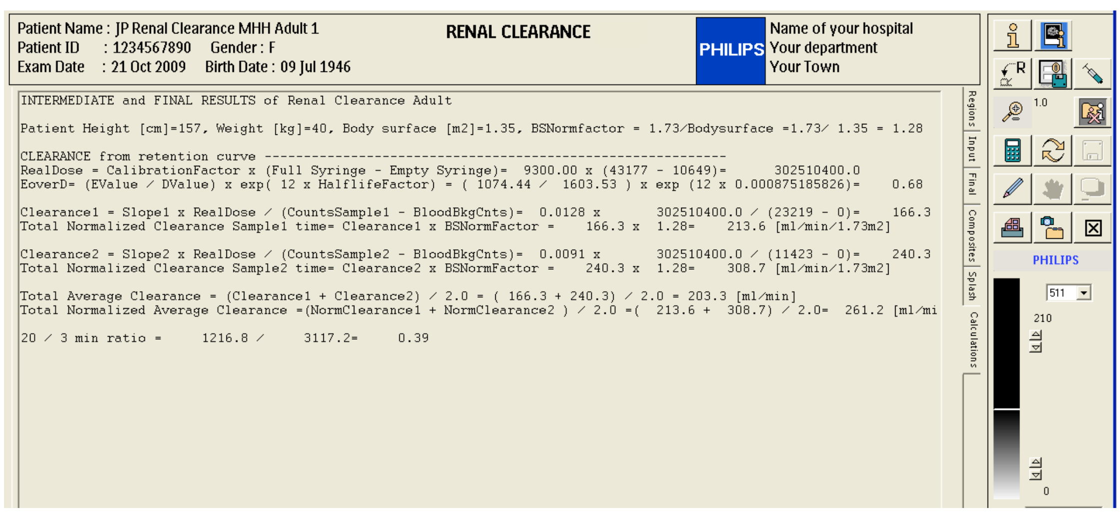


Figure 165 Calculations page in Adult mode.

14.10 References

1 Guidelines for standard and diuretic renogram in children. Isky Gordon e.a. Under the Auspices of the Paediatric Committee of the European Association of Nuclear Medicine.

2 Volumes of Distribution and Clearance of Intravenously Injected Creatine in the Dog. Leo A. Saperstein, e.a. p 330 – 336, vol 181, May 1955

3 Nuklearmedizinische Untersuchungsverfahren in der Urologie. Teil 1, E. Oberhausen. W19-W24, Weiterbildung, 3/91, Schriftleitung Prof. M. Ziegler, Springer Verlag, Urologe[A], 30.3 and Urologe[B]31.3

4 Nuklearmedizinische Nierenclearance-Untersuchungen, E. Oberhausen, Radiologe (1981) 21: 548-552, Springer Verlag 1981

14.11 Determining the calibration factor

Perform this procedure for each of the nuclides that will be used in the application.

1. Fill a 1000 or 500ml volumetric flask to half with water and then add 5 to 10 MBq 99mTc Pertechnetate. Record the activity of the full syringe in MBq or mCi.
2. Measure and record the activity of the empty syringe using the same units as the full syringe.
3. Fill the vial to its mark and mix well.
4. From this solution extract 5 samples of 0.1 ml and measure them in a well counter for 1 minute each. Be aware that the count rate should not be too high because of the dead time of the counter. Consult the well counter operator's guide to determine the count rate limitation of your well counter.
5. Calculate the average of the 5 sample counts (cpm) value and convert that to 1 ml. For example for a sample amount of 0.1 ml multiply the obtained average value by 10. The result is the average sample counts in cpm/ml.

   You may eliminate the need to account for the sample volume by using a sample volume of 1 ml. Ensure that the count rate is appropriate for the well counter.
6. Calculate the calibration factor:

```
Calibration factor = V [ml] x Average Sample counts
[cpm/ml] / ( Full - Empty) [MBq or mCi]
```

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14.12 Calculations in Child mode

14.12.1 Left to right fractions and percentages

The integral counts of the curves between the two markers on the phase 1 curve are determined as IntLeft and IntRight.

LeftFraction = IntLeft / IntLeft + IntRight
RightFraction = IntLeft / IntLeft + IntRight
LeftPercent = 100 x LeftFraction
RightPercent = 100 - LeftPercent

14.12.2 Body size normalization factor

Body surface = PWeight$^{0.425}$ x PHeight$^{0.725}$ x 0.007184
BSNormFactor = 1.73 /BodySurface

14.12.3 Time lapses

AcqStartTimeMin = time of acquisition in minutes since midnight = T0

SyrTimeInMin = time of syringe measurement in minutes since midnight

SampleTimeInMin = time of plasma sample measurement in minutes since midnight

Time lapse in minutes between Acquisition and Syringe measurement, negative number.

SyrToAcqTimeDiff = SyrTimeInMin - AcqStartTimeMin

Time lapse in minutes between Acquisition and Samples measurement:

AcqToSampleMeasureTimeDiff = SampleTimeInMin - AcqStartTimeMin

14.12.4 Correct full and empty syringe counts for decay until time of acquisition

Correction factor for the syringes:

Corr = (-0.69315 / 786.0) ;; 786 = 13.1 hr ,halftime for I-123 in minutes

CorrFactorSyr = exp(SyrToAcqTimeDiff * Corr) ;; decreases syringe values ,

;; Negative time

Decay corrected full and empty syringe counts

FullSyrCorr = FullSyr / CorrFactorSyr
EmptySyrCorr = EmptySyr / CorrFactorSyr

14.12.5 Correct sample 1 and 2 counts for decay (reverse) to time of acquisition

CorrFactorSample = exp(AcqToSampleMeasureTimeDiff * Corr)

Normalized to 1 ml and decay corrected sample counts:

CountsSample1Corr = (CountsSample1 / **SampleVolume**) / CorrFactorSample

CountsSample2Corr = (CountsSample2 / SampleVolume) / CorrFactorSample

14.12.6 Counts of 1 minute time range of the Heart curve at sample 1 and at sample 2 time

HeartAveT1 for sample 1
HeartAveT2 for sample 2

14.12.7 Correction factors for sample 1 and 2

normalized sample counts / body counts at T1

CorrFactor1 = CountsSample1Corr / HeartAveT1
CorrFactor2 = CountsSample2Corr / HeartAveT2

14.12.8 Bi-exponential curve fit

A bi-exponential curve fit of the Heart curve or if the fit fails a mono-exponential curve fit delivers the parameters; a1, a2, slope1 and slope2

14.12.9 Clearance calculation

H = (FullSyrCorr - EmptySyrCorr) x Geometry Factor x slope2 x slope1

Clearance = (**H** / ((a2 * slope1) + (a1 * slope2))) * (-1.0)

14.12.10 Total Clearance at sample 1 and 2 time

Clearance1 = Clearance / CorrFactor1
Clearance2 = Clearance / CorrFactor2
Average clearance = (Clearance1 + Clearance2) / 2

14.12.11 Normalized total clearance at sample 1 and 2 time

NormClearance1 = Clearance1 * BSNormFactor
NormClearance2 = Clearance2 * BSNormFactor
Average Normalized clearance = (NormClearance1 + NormClearance2) / 2

14.12.12 Left and Right clearances for sample 1, 2 and average

LeftClearSample1 = LeftFraction * Clearance1
RightClearSample1 = Clearance1 - LeftClearSample1
LeftClearSample2 = LeftFraction * Clearance2
RightClearSample2 = Clearance2 – LeftClearSample2
LeftClearSampleAve = LeftFraction x ClearanceAve
RightClearSampleAve = ClearanceAve - LeftClearSampleAve

14.12.13 Normalized Left and Right clearances for sample 1, 2 and average

NormLeftClearSample1 = LeftFraction * NormClearance1
NormRightClearSample1 = NormClearance1 – NormLeftClearSample1
NormLeftClearSample2 = LeftFraction * NormClearance2
NormRightClearSample2 = NormClearance2 - NormLeftClearSample2

NormLeftClearSampleAve = LeftFraction * NormClearance1
NormRightClearSampleAve = NormClearanceAve - NormLeftClearSampleAve

14.13 Calculations in Adult mode

14.13.1 Real Dose

Full syringe Empty syringe and calibration factor are obtained from the input panel.

RealDose = CalibrationFactor x (Full Syringe - Empty Syringe)
CalibrationFactor,FullSyr,EmptySyr,RealDose

14.13.2 C,D,E, and F Values

These values are the activity of the Retention curve at 3, 12, 24 and 20 minutes respectively.

CValue

DValue

EValue

FValue

14.13.3 E over D corrected for decay at 12 minutes for the selected isotope

For I-123 the **HalflifeFactor** = 0.000875185834

EoverD= (EValue / DValue) x exp(12 x HalflifeFactor)

14.13.4 Clearance at sample 1 time

The Counts of sample1 and the blood background counts are obtained from the input panel; **CountsSample1 BloodBkgCnts**

The **Slope1** value is delivered by the function CalcRetentionSlope, where the EoverD and the time of sample 1 are input data.

Clearance1 = Slope1 x RealDose / (CountsSample1 - BloodBkgCnts)

Total Normalized Clearance Sample1 time= Clearance1 x BSNormFactor

14.13.5 Clearance at sample 2 time

The calculations for clearance at sample2 time follow the same route using the time and activity of sample 2 from the input panel.

14.13.6 Left and Right clearances for sample 1, 2 and average

These calculations are the same as for Child clearance calculations.

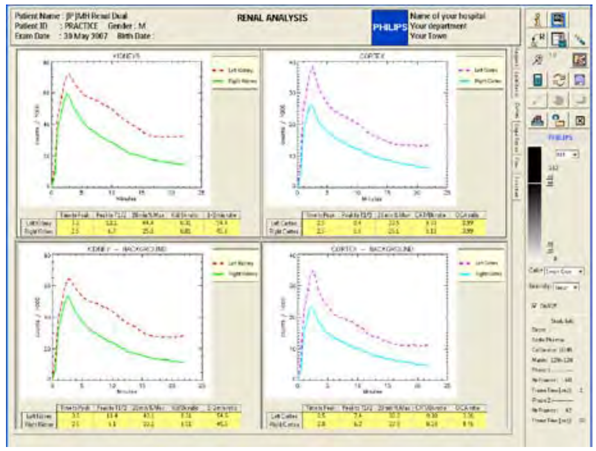
14.13.7 Normalized Left and Right clearances for sample 1, 2 and average

These calculations are the same as for Child clearancecalculations.

20 / 3 minute ratio is determined as FValue / CValue

15 Renal Analysis

15.1 General



The Renal Analysis application allows processing of Dual and Transplant kidney acquisitions**.**

In Dual mode Split kidney percentage uptakes are determined from the composite 1 to 2 minute image. Curves from Kidney, Cortex and background ROIs are generated allowing display of Time to peak, T1/2, Residual at 20 minutes, Kidney to Background ratios and uptakes. Slope index calculations are determined from Aorta and Kidney upward curve slopes. The application contains several result pages; Split Renal, Curves, Slope Ratios, Flow splash and Function splash

15.2 Acquisition

All images are acquired in 128x128 matrix

- Flow: 60 frames at 1 sec/frame
- Function: 42 frames at 30 sec/frame
- PostVoid static: 2 minutes

15.3 Processing

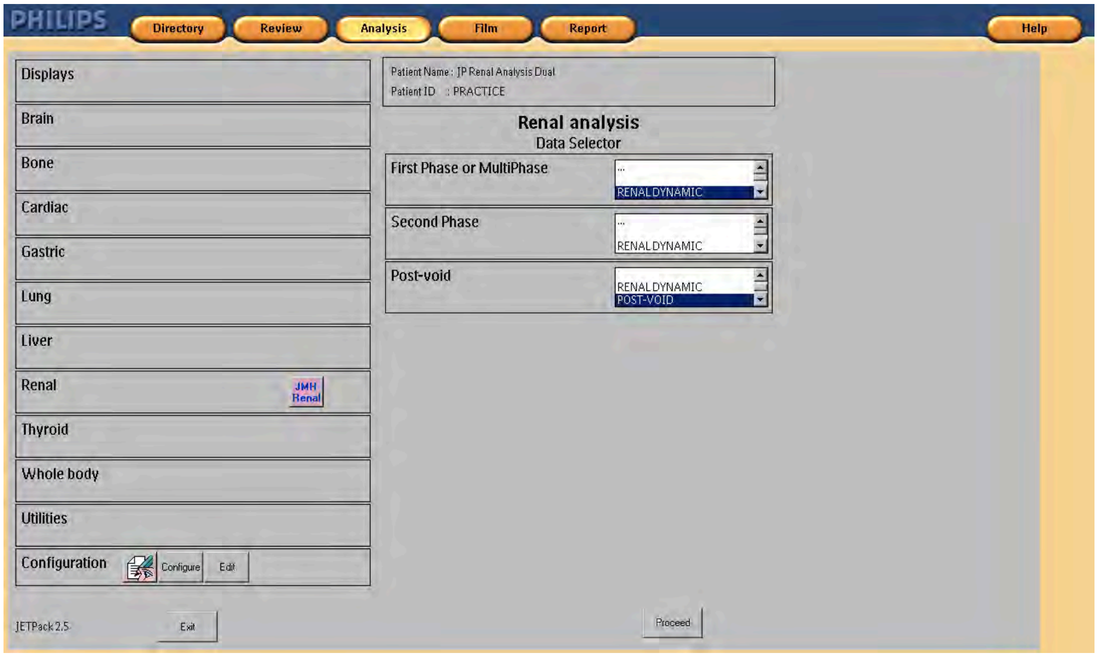


Figure 166 ISP JETPack panel, Renal Analysis application selected

If required adjust the selected files in the data buckets and click Proceed.

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15.4 Regions Page

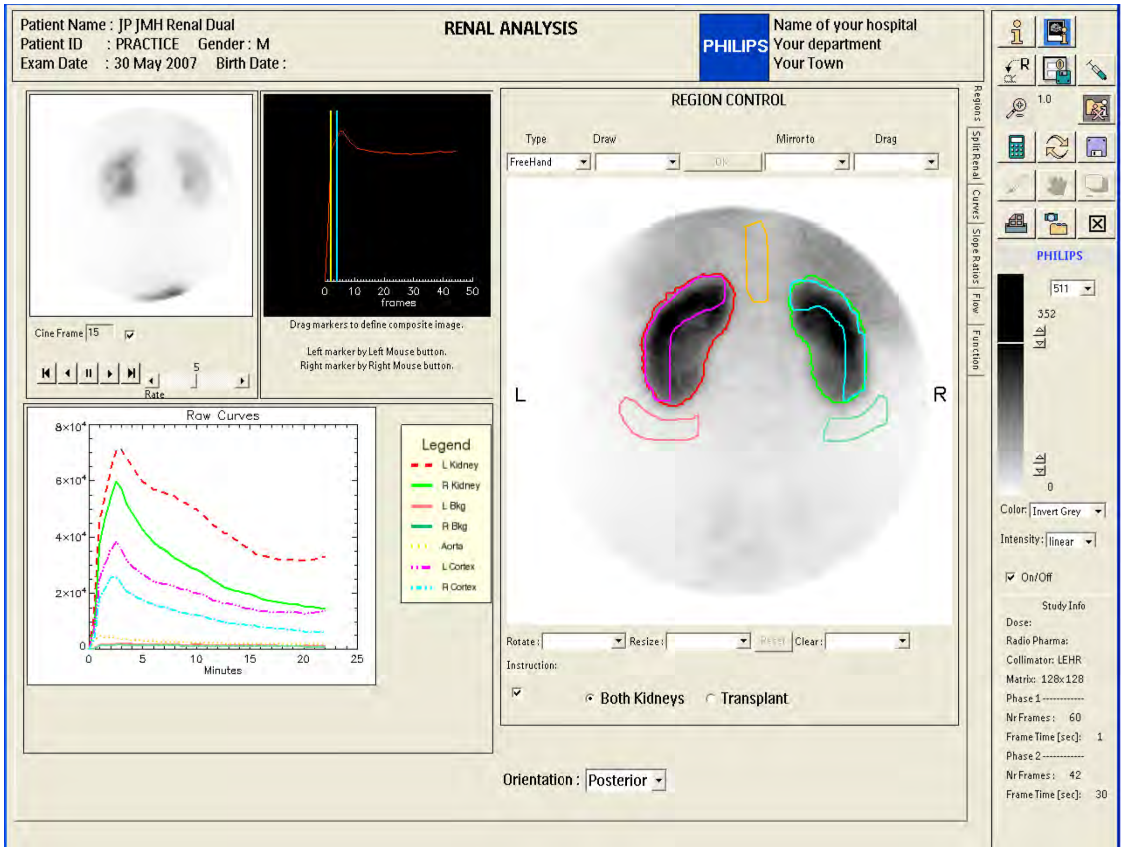


Figure 167 Regions page DUAL mode all ROIs selected

On the Regions page select the patient orientation from the Orientation menu near the bottom for Anterior or Posterior mode. That enables the selection menus in the ROI Control section of the page. Select **the processing mode Both kidneys or Transplant** to set up the desired ROI menus. At the top left of the screen is the Cine display with controls for speed and direction. The composite image in the ROI control is built from 1-2 minutes of frames in the acquired dynamic image. You can change the composite image by dragging the yellow and blue markers at the curve display near the top of the screen. In Dual mode the ROIs for aorta, kidney, cortex, background of left and right are required. After all ROIs have been drawn click on the Calculator button to generate the curves. Raw curves are displayed at the left bottom of the screen.

The study info, as shown near the bottom right, can be displayed by clicking the “More” button on the button panel. The Dose on that panel can be manually entered by clicking the “syringe” button.

15.5 Split Renal page Dual mode

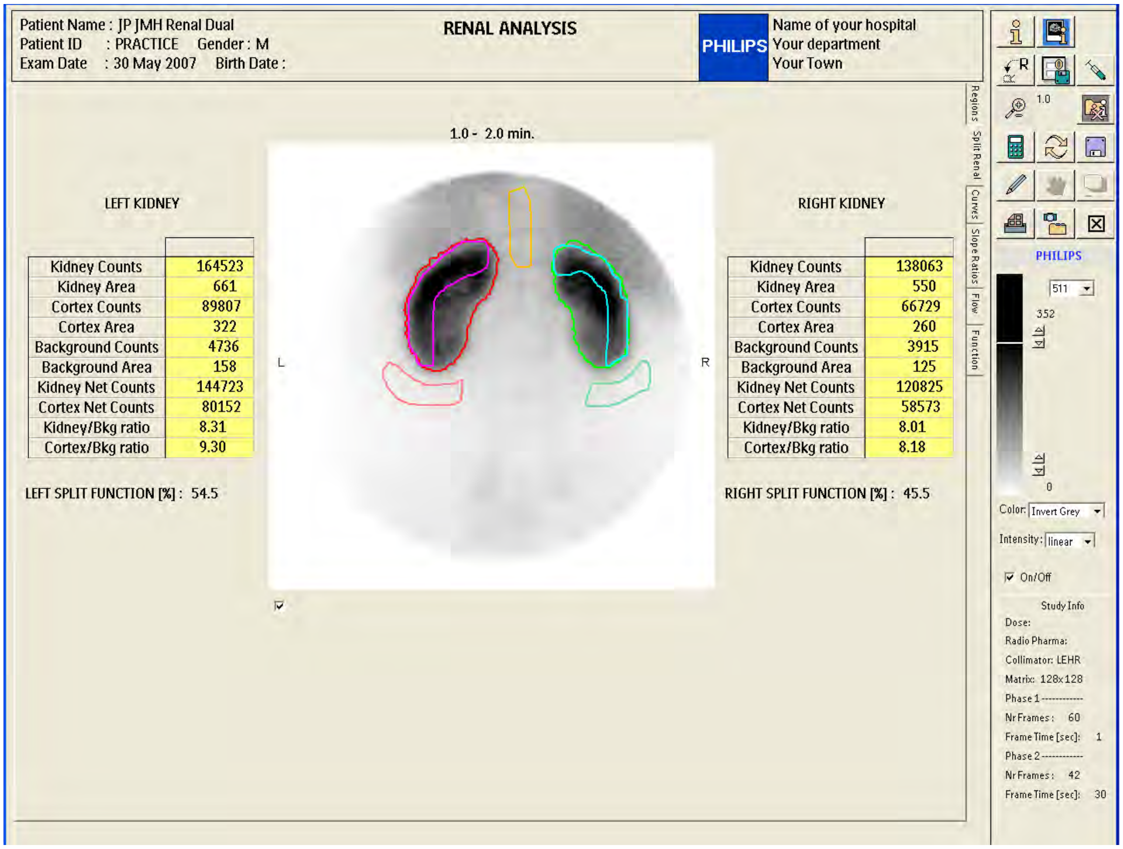


Figure 168 split renal page in Dual mode

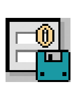
The **Split Renal page** shown here determines the Kidney /Background, Cortex /Background ratios and Left and Right split percentages from Kidney, Cortex and background regions on the 1-2 min composite image of the dynamic renal study. The time range for the composite can be preset to different default values. The Net counts for Kidney and Cortex are obtained by subtraction of area-normalized background counts.

The Left to Right Split calculation is determined as follows:

$$\text{LSplit} = 100 \times \frac{\text{LeftKidneyNet}}{\text{LeftKidneyNet} + \text{RightKidneyNet}}$$

$$\text{RSplit} = 100 - \text{LSplit}$$

15.6 Button Panel and Region Control



See the General description for an explanation of the various buttons.

Set Defaults: Click this button to bring up the panel below:

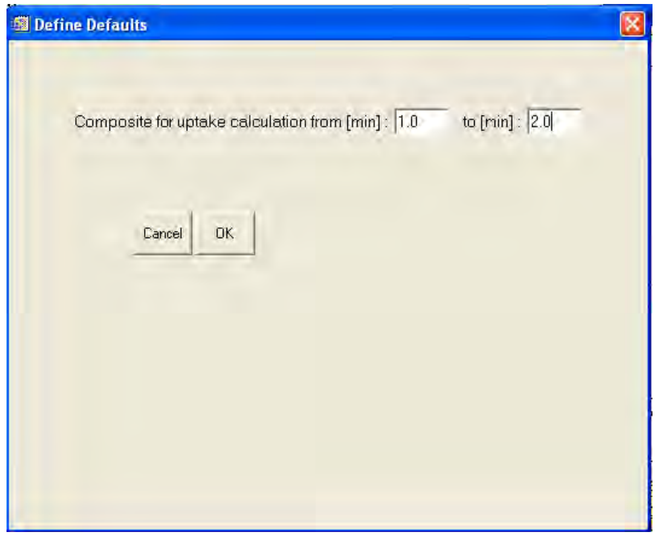
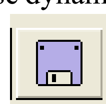


Figure 169 Default entry and Current Defaults display

The defaults that can be set are shown here. When this panel is launched it displays the current defaults. Here you can enter the time range for the composite image that is used for the calculations on the Split Renal page. The next time the application is started the new default values will be used.

Save images: The first phase dynamic image, compressed to 20 frames,



and the second phase dynamic, compressed to 11 frames, can be saved to the database by clicking this button.

15.7 Curves Page Dual mode

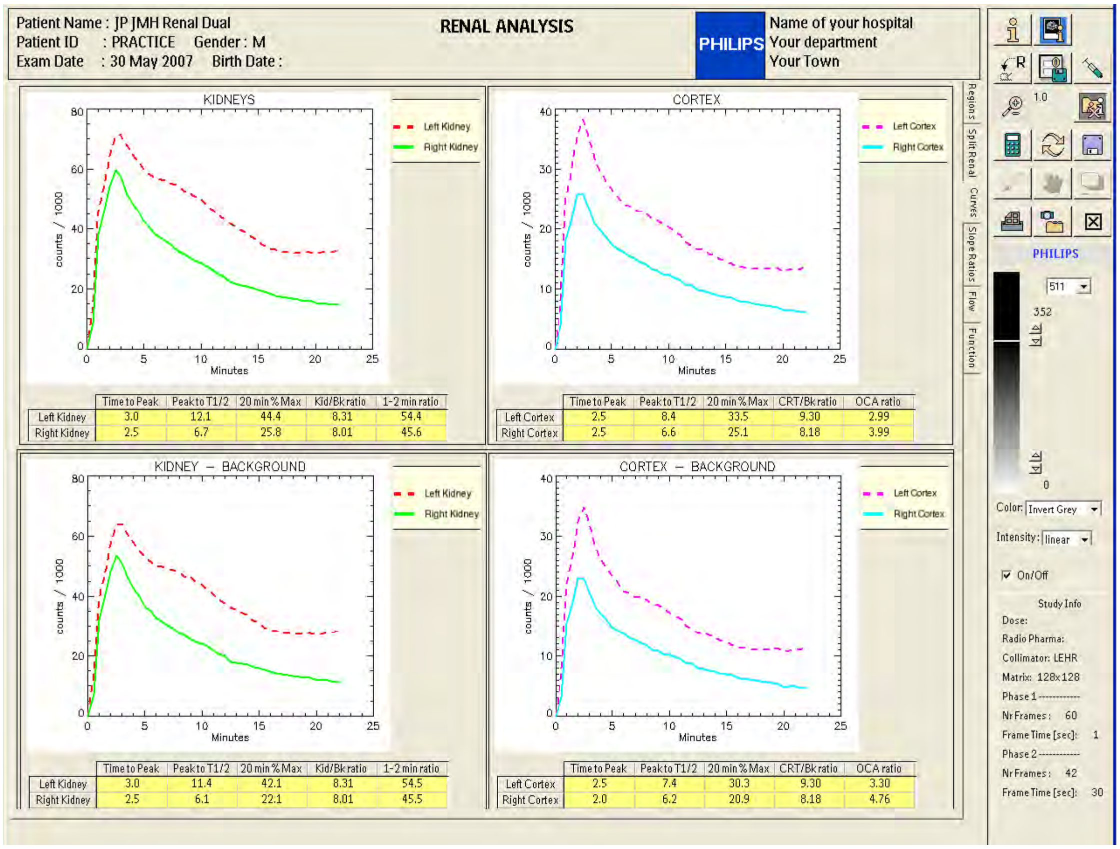


Figure 170 Curves page in Dual mode

The Curves page shows the raw Kidney and Cortex curves at the top and area-normalized background subtracted curves at the bottom of the screen.

Time to Peak, Peak to T ½, Residual at 20 minutes as percentage of Maximum is determined and displayed below each curve set. The Kidney/Background ratio and Cortex /Background ratios as well as the Split renal ratio (1-2 min ratio) from the Split Renal page and the OCA ratio (Original Cortex Activity ratio) can be found in the tables. The oca ratio is defined as follows:

$$\text{OriginalCortexActivityRatio} = \frac{\text{Activity at 2.5 min}}{\text{Activity at 20 min}}$$

15.8 Slope Ratios page Dual mode

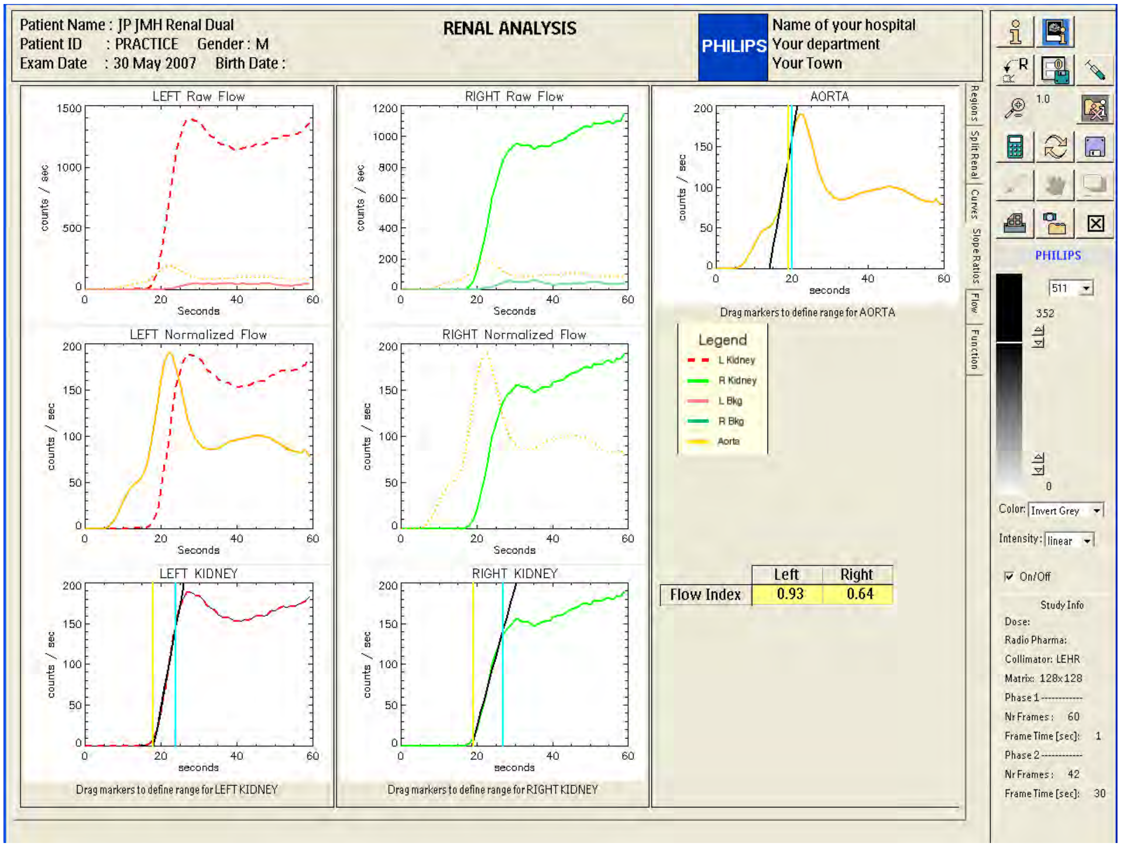


Figure 171 Slope Ratios page in Dual mode

The “Slope Ratios” page shown above displays the Left and Right kidney curve sets as two columns of graphs. At the top of the screen you find two graphs with the Kidney, Background and Aorta activity of the first phase of the acquisition. At the center of the page the graphs show the kidney curves corrected for background, displayed together with the Aorta curve where the maximum of the kidney curves is normalized to the maximum of the Aorta curve. The bottom two graphs and the graph at the top right allow you to set the range of the curve data, - by means of the yellow and blue cursors -, that is used for the linear fit calculation of the Left, Right and Aorta curve respectively. The black linear curves as well as the flow index values are updated each time you adjust any of the cursor lines. The kidney curves are normalized to the maximum of the Aorta curve.

$$\text{Flow index} = \frac{\text{Kidney linear slope}}{\text{Aorta linear slope}}$$

15.9 Regions Page Transplant mode

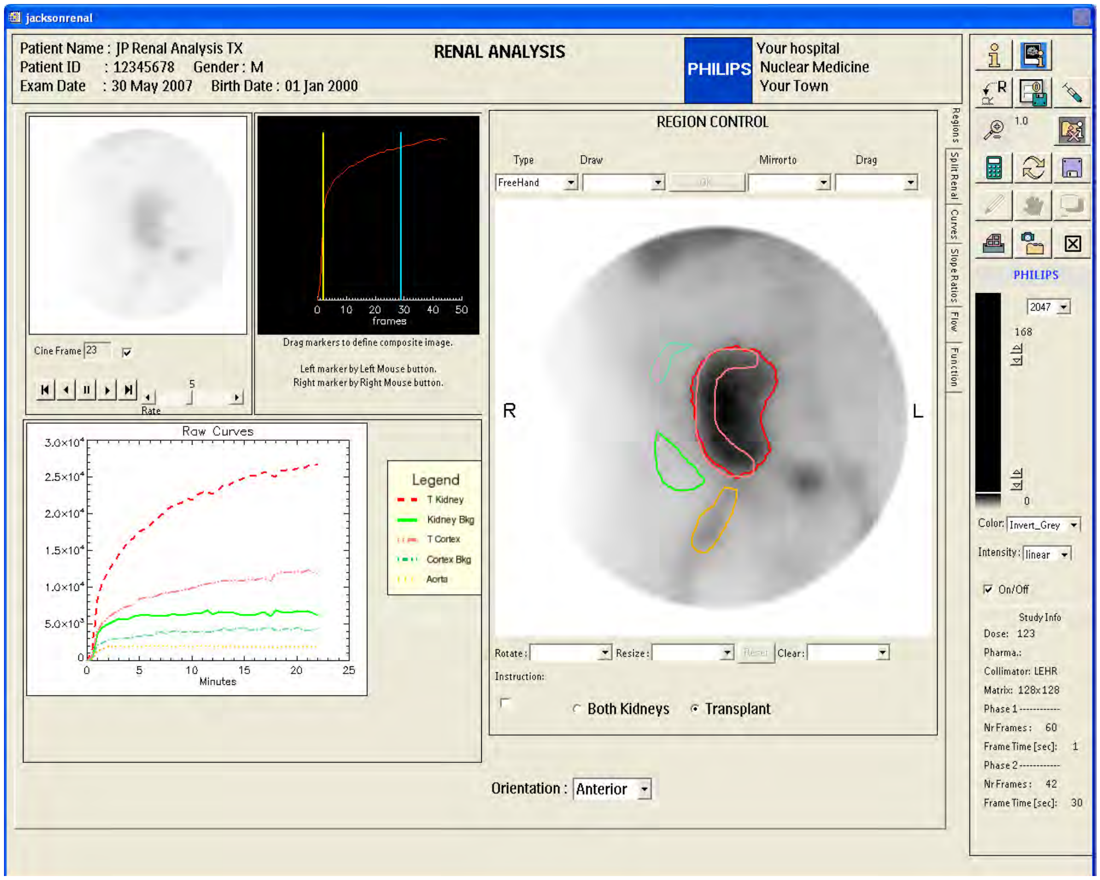


Figure 172 Region selection Transplant mode: Kidney , Cortex kidney background, cortex background and aorta

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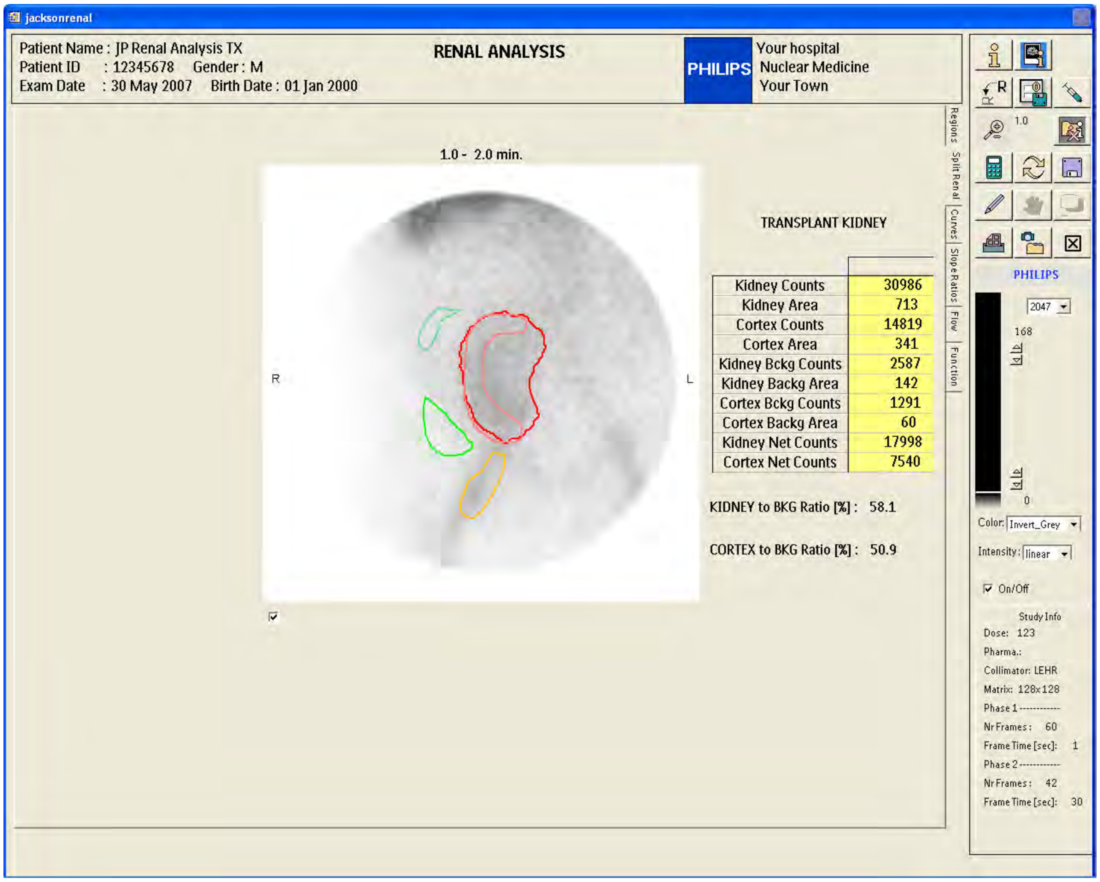

Figure 173 Split renal page calculations Transplant mode

The following is determined and displayed on the page;

Area size in number of pixels and counts for;

- Kidney,
- Cortex,
- Kidney background,
- Cortex Background.

The Net counts for Kidney and Cortex are obtained by subtraction of area-normalized background counts. The Kidney counts contain the kidney + background counts, similarly the Cortex counts contain the cortex + background counts.

The following ratios are determined;

$$\text{Kidney to BKG ratio [100\%]} = 100 \times \frac{\text{Kidney Net Counts}}{\text{Kidney Counts}}$$

$$\text{Cortex to BKG ratio [100\%]} = 100 \times \frac{\text{Cortex Net Counts}}{\text{Cortex Counts}}$$

15.10 Curves page Transplant mode

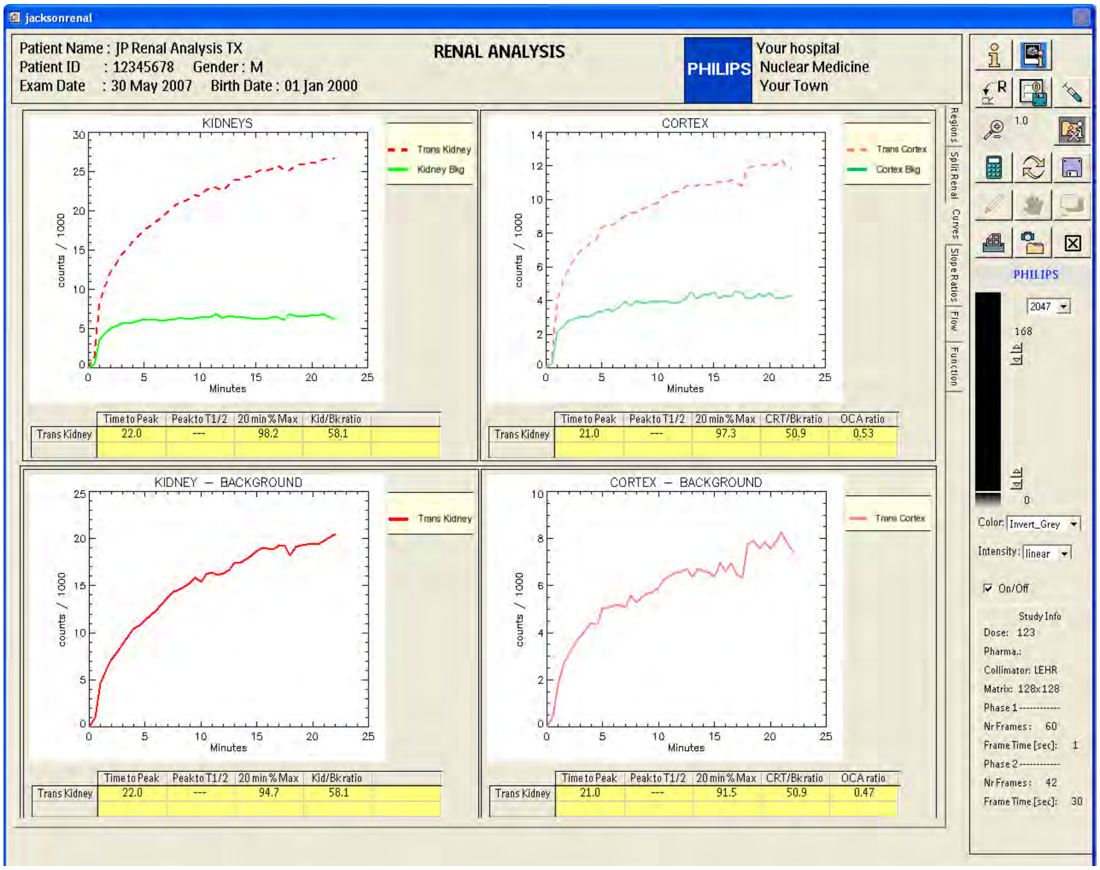

Figure 174 Curves page Transplant mode

The curves of transplant kidney and kidney background are shown at the top left of the screen, the transplant cortex and cortex background are at the top right of the screen. The bottom left curve shows the transplant kidney with the area normalized kidney background subtracted. The bottom right shows the transplant cortex curve minus the area normalized cortex background curve.

The Time to Peak, Peak to Half, residual activity percentage at 20 minutes, Kidney to Background ratio, Cortex to background ratio and OCA ratios are presented in the tables below the curves.

15.11 Slope Ratio page Transplant mode

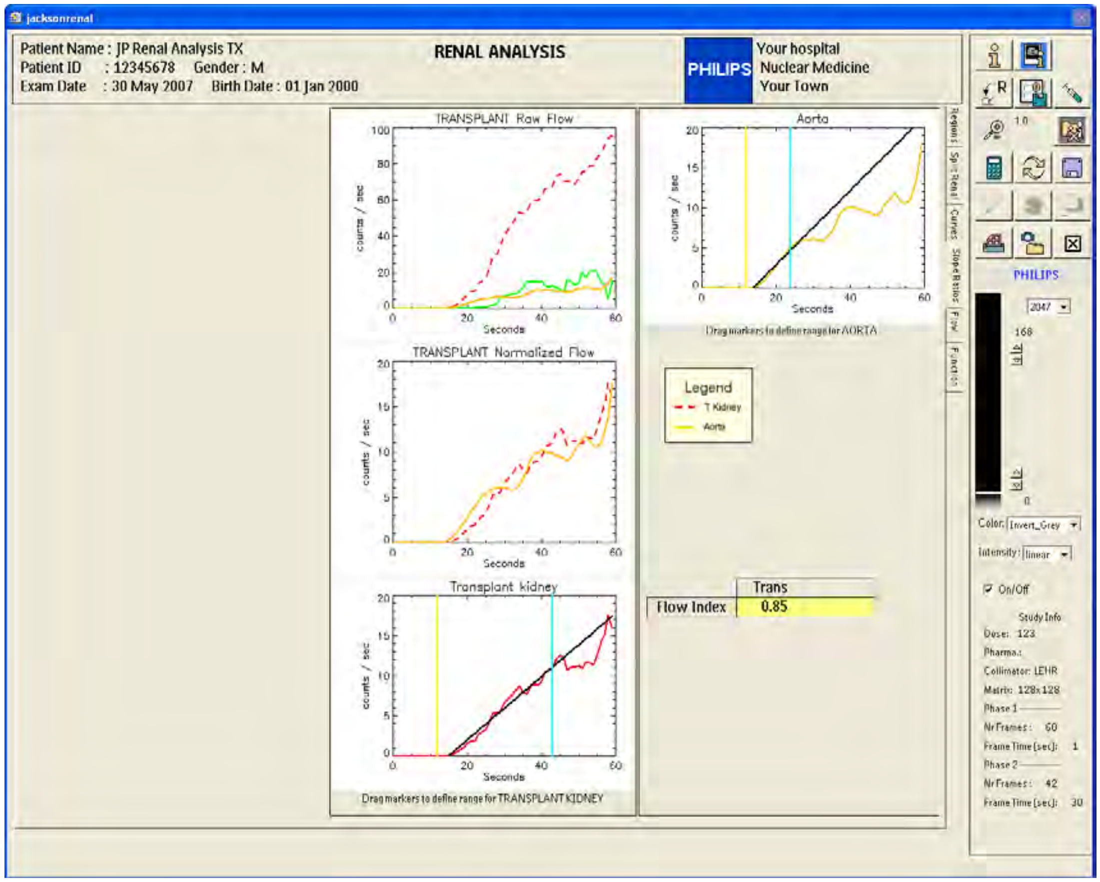

Figure 175 Slope calculation page for Transplant mode

The yellow and blue vertical cursors on the Transplant and Aorta graph allow you to set the range of the data that will be used for the linear curve fit. The slopes of the linear fit curves of aorta and transplant kidney is used to calculate the flow index.

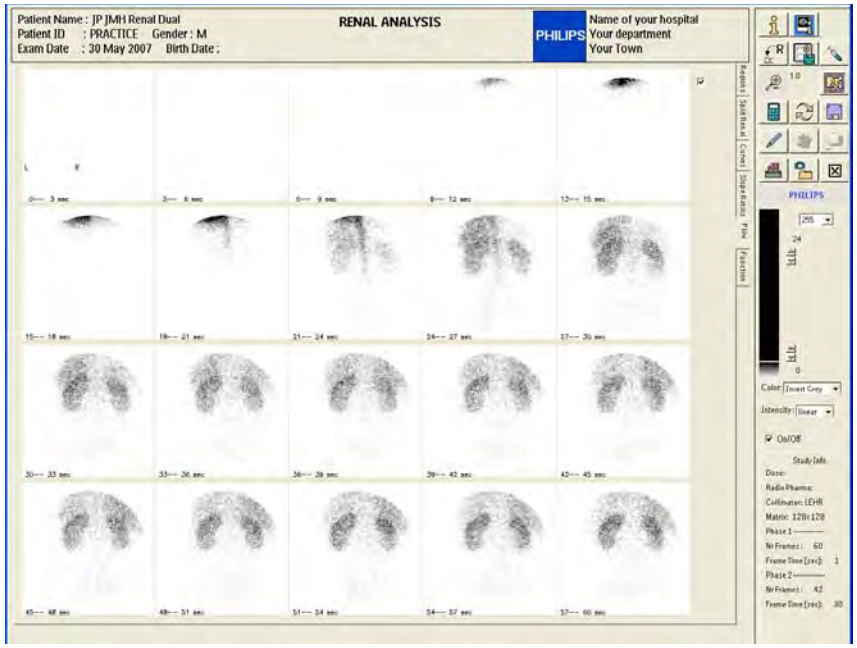

Figure 176 Flow splash page

This page shows the flow phase as a splash of 20 composite images. The Time range per composite is displayed on each image.

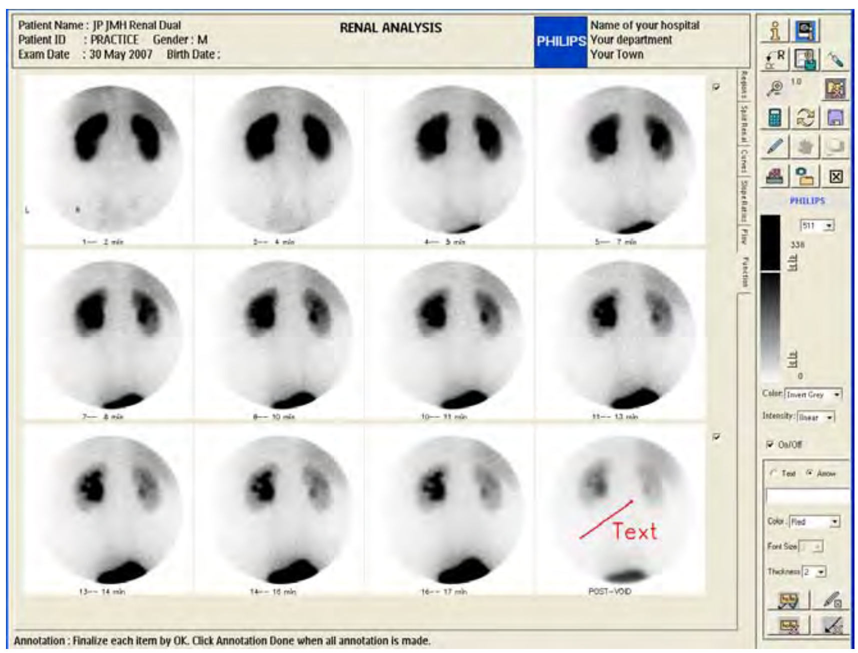

Figure 177 Function splash page

The Function page displays the second phase of the acquisition in 11 composite images. The **Post-void static image** is to be found at the bottom right corner of the page. The composite images and the post void image can be adjusted for contrast independently.