# New CEUS Quantification Analysis Demo Guide

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## 【 Version Description 】

The New CEUS (contrast-enhanced ultrasound) quantitative analysis function is applicable to Resona R9 Platinum Edition and above version.

## 【 Technical principle 】

The function of CEUS quantitative analysis is to obtain specific perfusion information of suspicious tissue, through comparing suspicious tissue with normal tissue by CEUS. Quantitative analysis includes two parts: Time Intensity Curve Analysis and Parametric Imaging.

1. Time Intensity Curve Analysis: it is an analytical method to present quantitative perfusion information， which is presented in the form of curve and numerical value. By fitting the time intensity curve of the angiographic image, the quantitative parameters of perfusion of the whole and local tissues or suspicious tissues were obtained, and the slight difference of these tissues can be distinguished.
2. Parametric Imaging: it is a functional imaging method. The original image sequence was obtained by contrast-enhanced ultrasound imaging, and a series of perfusion parameters were extracted through the quantitative evaluation of blood perfusion. The intensity distribution and time distribution of tissue perfusion on the ultrasound scanning plane were visually presented by color-coded map.

## 【 Advantages and highlights 】

1. New CEUS QA provides 14 perfusion quantitative analysis parameters to give quantitative data for distinguishing the differences between normal and suspicious tissues. It helps to improve the efficiency of diagnosis and differential diagnosis (For details, please refer to the description of the table of quantitative parameter analysis results of angiography in demonstration points)
    1) Time parameters (AT, RT, TTP, FT, mTT) display the time information of contrast agent arrival, enhancement, peak, clearance and mean transit in the area of interest, providing diagnostic information from the time dimension.
    2) The amplitude parameter (PKI) shows the peak intensity of CEUS in the area of interest, and indicates the characteristics of high/low perfusion level by comparing the peak amplitude of angiography in different areas.
    3) Amplitude time combination parameters (AUC, WiAUC, WoAUC, AS, DS, SR) depict the area under the curve of time intensity of wash-in and wash-out process and the slope of rise/fall, etc. For example, WiAUC (the integral area under TIC within the time section of RT) and WoAUC (the integral area under TIC within the time section of FT) of different areas can be compared to indicate the characteristics of fast in and fast out, fast in and slow out, etc.
2. Multi-parametric imaging with color coded map manage to give intuitive tissue perfusion information controlled by different parameters. Color-coded maps depict

the characteristics of perfusion distribution, such as centrifugal/centripetal distribution, uniform/uneven distribution, fast in and fast out/fast in and slow out, to improve the clinical diagnostic efficiency.

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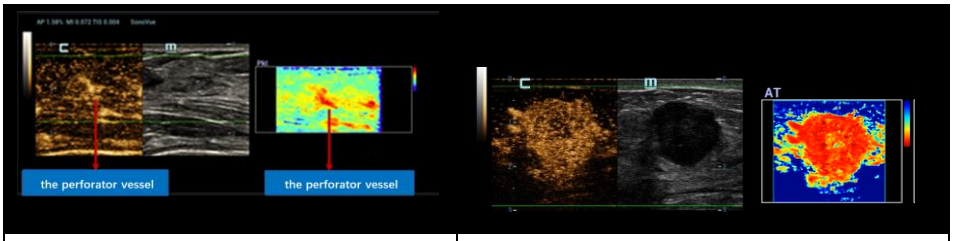
|  | |
| Peak intensity imaging (PKI) imaging directly showed that the contrast agent intensity in the perforator vessel of the breast lesion was significantly higher than that in other lesion tissues and normal breast tissue, suggesting that the perforator vessel was the main blood supply source of the lesion. | Contrast arrival time (AT) imaging can visually show that, the lesion is hyper-enhanced entirely (except for central necrosis), when the contrast agent has just arrived, suggesting that the blood supply in the lesion is abundant and presents a "fast in" feature. |

## 【Demonstration points 】

1. Select the file: open the saved CEUS video clips (It is recommended to store at least 90s-120s of CEUS, which can be adjusted appropriately according to actual needs)
2. Activate the function: click【Contrast QA】on the touch screen, after the quantitative analysis function is started, the 2D grayscale image-contrast image playback window and the global strength trend curve are displayed on the screen.

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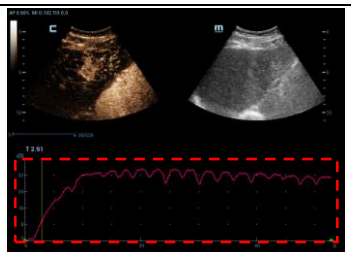
|  |  |
| Click【Contrast QA】to start the function | The global strength trend curve |

3. Generate parametric imaging: place the cursor on the 2D grayscale image- contrast image playback window, delineate a global area of interest (Global ROI, it is recommended to include suspicious organizations and moderately normal organizations), and generate the results of parametric imaging.
    1) The【Para. Image Page】(parametric imaging page) on the touch screen has 1-3 pages in total, and can display up to 12 parameters. The【Smooth】on the touch screen is divided into 1-5 levels to adjust the noise and smoothness of the parameter image. Four window display can be switched to single window display.

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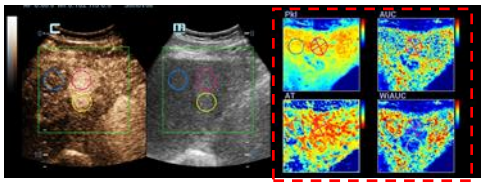
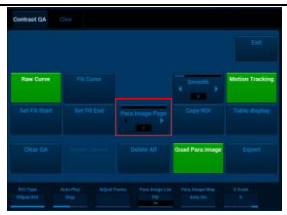
|  Delineate the Global ROI and generate the results of parameter imaging |  【Para. Image Page】has 1-3 pages in total, and can display up to 12 parameters. |

2) If the parametric imaging presets did not work well, it can be manually adjusted with【Para. image map】:including auto (on/off), Min and Max.

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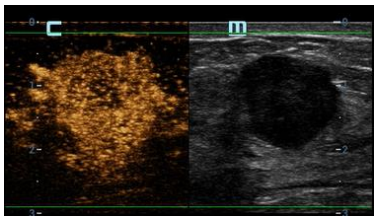
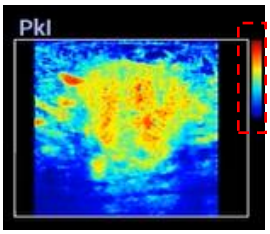
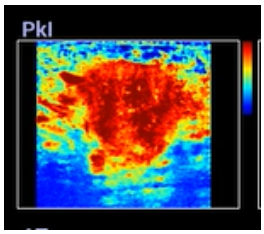
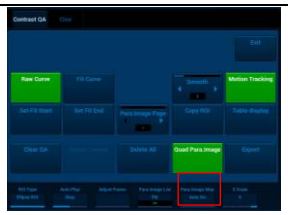
|  The breast lesions shown in the above figure is taken as an example to demonstrate the adjustment of parameter imaging |     PKI imaging (left figure), the difference in color-scale did not clearly highlight the distribution of contrast agents in the lesions or between the lesions and normal liver parenchyma. First click the scale at the top right of the map with the cursor, Then press 【Para. image map】, auto on indicates automatic adjustment, The minimum and maximum values can also be adjusted so that the color gradient can better display the distribution of contrast agents inside and outside the lesion(right figure)。 |
|  【Para. image map】: including auto (on/off), Min and Max. | |

4. Generate time intensity curve and parameter analysis results: put Local ROI (up to 8 ROIs) on suspicious tissue and normal tissue in the global region of interest, and calculate the time intensity curve and parameter analysis results table of the corresponding region.
   1) Press the【Fit Curve】on the touch screen to display the fitting result of the time intensity curve.
   2) Press the【Table Display】to display the table of parameter analysis results.

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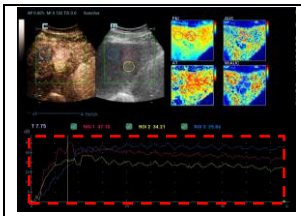
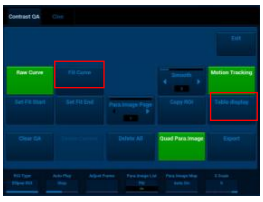
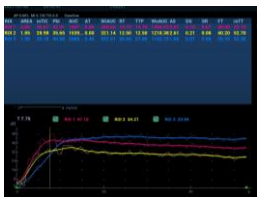
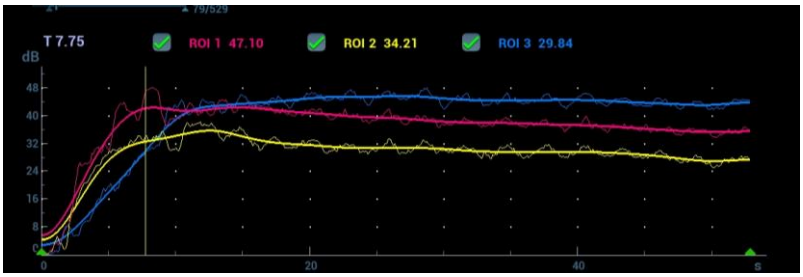
|  Delineate the Local ROI, the time intensity curve in Local ROI was calculated |   The fitting results of time intensity curve and the results of parameter analysis table |

A. Time intensity curve description:



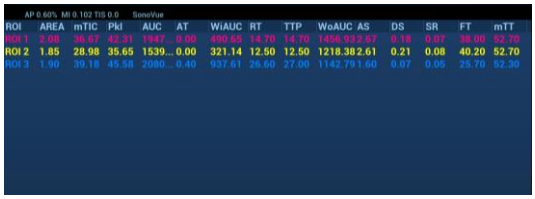

a) Y-axis represents the contrast agent intensity (unit: dB); X-axis represents time (unit: s).

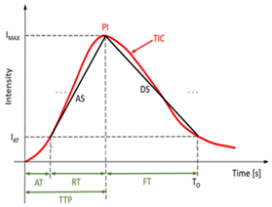
b) Frame mark: a yellow line perpendicular to the X-axis, which can be moved horizontally through the trackball.

c) Click the check box in front of ROI to set display or hide the analysis curve.

d) When the cursor is moved to the curve, the horizontal and vertical values of the current point can be read; If you press "Set" at this point, the contrast image moves to the corresponding frame at the current click moment.

B. Parameter description of contrast quantitative analysis results in the table

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| AT | Time instant at which the TIC reaches a specific level |
| RT | This time is also referred to as Wash-in-Time (WiT). RT = TTP - AT |
| TTP | The time instant at which the TIC reaches PI at each point within the global ROI |
| FT | Fall time is also known as wash out time (FT = To - TTP, If the contrast agent strength does not drop to IAT, and the last moment of film is taken as To. (The FT is usually underestimated.) |
| mTT | Mean transit time, time from contrast enhancement to clearance (mTT=RT + FT) |
| PKI | The maximal value of the TIC at each point within the Global ROI |
| AUC | AUC is the integral area under TIC within the time section of mTT. |
| WiAUC | The integral area under TIC within the time section of RT |
| WoAUC | The integral area under TIC within the time section of FT |
| AS | The ascending slope of contrast enhancement, the slope between the beginning and the peak point: (Imax – $I_{AT}$)/RT |
| DS | The descending slope of contrast clearance, the slope between the peak and the end of clearance (Imax - IAT)/FT |
| SR | Slope Ratio, SR = DS / AS |
| AREA | Local ROI area |

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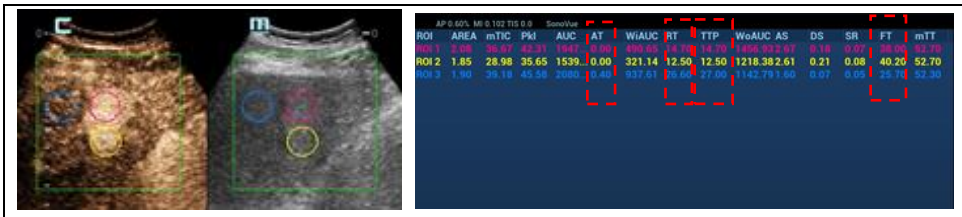
| mTIC | The average intensity of the time intensity curve |

Note: To: the moment corresponding to the time when the contrast agent intensity drops to the arrival time intensity $I_{AT}$. If it does not drop to $I_{AT}$, the rightmost moment will be taken as to. AT: the actual time 3dB higher than the baseline.




For example: The right figure shows the results of quantitative parameter analysis of contrast imaging of liver space occupying lesions (ROI1/ROI2/ROI3 correspond to ROI regions of the same color on gray scale images respectively). From the analysis of parameter results, the arrival time (AT), enhancement time (RT) and peak contrast intensity time (TTP) of contrast agent in the lesion were earlier than those in the normal liver parenchyma, which was in line with the "fast in" feature. The clearance time (FT) of contrast agent in the lesion was longer than that in the normal liver parenchyma, which was in line with the "slow out" feature. Combined with the gray scale image, it was shown as a moderately high echo nodule, which could indicate that the lesion was more likely to be a hemangioma in clinical practice.

5. Store and export data: store curve images, export curve data and analyze parameter data.
   1) Click the【Export】option on the touch screen.
   2) In the "Export" dialog box, select the storage path and enter the file name. (The default disk is drive E and its default format is. CSV.)
   3) Click【OK】to complete the export. Exported data includes: current screen image (format:. BMP); Curve data (format :. CSV); Parameter result data (format:. CSV).
6. Exit function: click【Exit】on the upper right of the screen to exit quantitative analysis, and then press "B" to return to B mode.

## 【Tips】

1. Try to avoid the influence of image instability:
   1) During image scanning, do not move the probe. It is recommended that the patient hold his breath until the end of the storage protocol. During image storage, do not adjust the depth or zoom in, otherwise, the data obtained from quantitative analysis will be inaccurate.
   2) For motion artifacts caused by in-plane motion: for example, for slight breathing movement, you can turn on【Motion Tracking】to dynamically track the sampling area, reduce the impact of in-plane movement, and improve the accuracy of calculation.
   3) For motion artifacts caused by out-of-plane motion: for significant motion induced during the CEUS acquisition, the unwanted section can be removed by selecting 【Mark Frames】, and delete it. The system could re-do the smooth transition for the modified TIC, so as not to affect the accuracy of the

calculation results.

2. Editing ROI:
   a) Trace ROI: press the "Set" key to determine the starting point of drawing. Use the trackball and the "Set" key to locate the next point (up to 12 trace points). When the required figure is drawn, double click the "Set" key to complete the addition of ROI. Press the "Clear" key to cancel the drawing of the last point.
   b) Clear ROI: click【Delete All】on the touch screen to clear all ROIs. Press the "Clear" key to cancel the ROI added last time.
   c) Copy ROI: click【Copy ROI】on the touch screen to copy and add an ROI that is "exactly the same as the last added or currently activated ROI shape".

## FAQ

1. Optimization of parametric imaging:

   When some parameters of parametric imaging need to be changed, it can be adjusted by the【para.image map】on the touchscreen. You can choose【auto on】for automatic adjustment. You can also manually adjust【Min】and【Max】so that the spectrum of the color map can be adjusted to the optimal state, which can show the contrast more clearly. (See the example instructions in Demonstration points)

2. ROI editing:
   1) Global ROI: in the setting process, if the Global ROI setting is not satisfied, it needs to be redrawn, the current version cannot return to the previous step. Only after the parameter imaging results are generated, the Global ROI can be deleted and redrawn.
   2) Local ROI: in ellipse ROI, if you want to modify the ROI, clicking【clear】then redrawn the ROI; in Trace ROI, if you want to modify the ROI, clicking【clear】then system will return to the previous tracing point for editing.

3. The parameter analysis results of wash out process are not displayed or inaccurate:
   1) Parameters of wash out process (such as FT, Wo-AUC, DS) fail to produce results, possibly because the stored film does not contain wash out process.
   2) The results of wash out process parameters (such as FT, WoAUC, DS) are not accurate. The possible reason is that wash out process in the stored film is incomplete. For example, the contrast agent intensity does not drop to IAT, and the last moment of film is taken as To, in this case the FT is usually underestimated.
   3) For the above two cases, it is suggested to appropriately extend the length of the stored film (including the complete wash out process.) to improve the accuracy of the analysis results of parameters in wash out pro.

**If you have any comments or suggestions on this demonstration, please contact the author (email:zuoqiao@mindray.com)**