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RENOGRAPHY SYSTEM QUALITY CONTROL TEST PROCEDURE

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ABSTRACT

Renography System Quality Control Test Procedure. *The quality control (QC) test procedure for renography system has been developed. The QC test procedure is included in renography operation software. In addition of applied standard quality control procedures for acceptance and reference tests of instruments, It is developed to attain high reliability of service. The result of QC test is stored in a file with txt extention format. This file can be used to continuously monitor operation from time to time and to evaluate performance of the renography system.*

Keywords: renography system, quality control, equipment performance

ABSTRAK

Prosedur Uji Kendali Mutu Sistem Renograf. *Telah dikembangkan prosedur uji kendali mutu (Quality Control, QC) untuk sistem renograf. Prosedur uji kendali mutu ini merupakan bagian dari perangkat lunak operasi renograf. Sebagai pelengkap prosedur uji kendali mutu standar yang biasa digunakan untuk uji keberterimaan dan acuan peralatan, prosedur ini dikembangkan agar didapat tingkat kepercayaan pelayanan yang tinggi. Hasil uji QC disimpan pada file dengan format ekstensi txt. File ini dapat digunakan untuk secara terus menerus memantau operasi dari waktu ke waktu dan untuk mengevaluasi kinerja dari sistem renograf.*

Kata kunci: sistem renograf, kendali mutu, kinerja peralatan.

1. INTRODUCTION

Renography systems using collimated probes were introduced in the 1950s. Even though the systems do not provide images and lacks of specificity, it was widely accepted as diagnostic modality for evaluating renal functions for a certain period. Nowadays evaluations of renal functions in the majority of nuclear medical centers are using gamma cameras. In Indonesia, renography system using collimated probes are still accepted as a diagnostic modality in some centers. The reasons for keep using the renography technique are they cannot afford to operate gamma cameras or they try to reduce working load for their gamma cameras or they try to optimize the use of isotopes. BATAN engineers keep do continuous effort on refurbishment and modernization of renography system on hardware and software parts. Further modernization on hardware has been done mainly on replacing ISA Bus by USB interfaces. The modernization on software parts has been done in order to accommodate the change of interface type, to provide a more user-friendly environment, and to apply an embedded quality control test procedure and automatic recording test results as the part of the software. The quality control procedures implemented in the software are adopted from IAEA-TECDOC-602.

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2. RENOGRAPHY SYSTEM

When introduce in the 1950s, the renography technique was performed using scintillation detector probes to monitor the arrival, uptake, transit and elimination of radiopharmaceutical by kidneys following its intravenous injection. Each scintillation detector connected to amplifier, single channel analyzer, rate meter, and chart recorder. The chart recorder output representing kidney renogram. The physiological of renogram responses reflects accurately both individual renal function and urine transport (urodynamic). Typically, the result of renogram curve is shown as depicted in Figure 1. Normally the urologist and nuclear medicine doctors are familiar to the renogram and its variation.

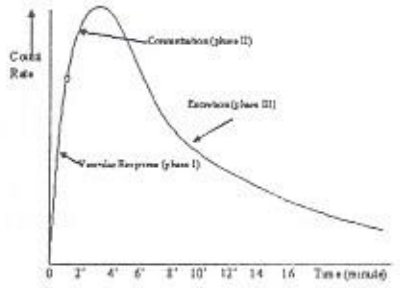

Figure 1. A Typical Renogram Curve.

Hardware

On modernized renography system, the hardware also consists of two pieces scintillation detectors, which connected to Gaussian amplifier, and Single Channel Analyzer (SCA). The rate meter is replaced by a counter-timer. Whereas the chart recorder is replaced by PC system and the necessary interface. The SCA window is set by the operational software via controlled DACs. On previous version of modernized renography, the hardware system was integrated on an Add On Card which installed on ISA-Bus slot. Due to the current development on all new PC which does not provide ISA slot anymore, the Add On Card are replaced by an external SCA-Counter module and connected to PC using USB interfacing technique. Block diagram of the current modernized renography system is shown in Figure 2.

On the external SCA-Counter module, the amplifier gain and High Voltage (HV) supply of detector operation voltage should be set and aligns manually. The HV should be set on a safe operation region according the certificate of the detector. The amplifier gain is adjusted so that the voltage of Cs-137 (with energy 664 keV) peak lies on 4.327 Volt.

The SCA energy windows are controlled from the computer through an 8 bit I2C-DAC (0-255 steps). In this DAC, a value of 255 decimal (&HFF hexadecimal) on input will give 5 volts DC output. With a maximum 255 channels on energy spectra, the value of 4.327 Volt will relate to channel number 221.

Accordingly, this HV and amplifier gain settings will make peak of I-131 (with energy 364 keV) fall in channel 121 and peak of Tc-99 (with energy 140 keV) will fall in channel 46. Gain settings on both PMT based should also be adjusted to get same detectors gain.

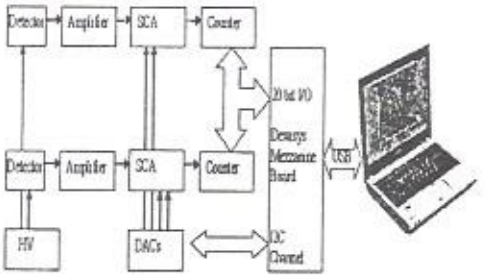

Figure 2. Block Diagram of the Renography System

The external SCA-Counter module is installed in the USB-Renograph module along with HV and LV DC power supplies, USB interface, and other components. The photograph of the USB-renograph module is shown in Figure 3.

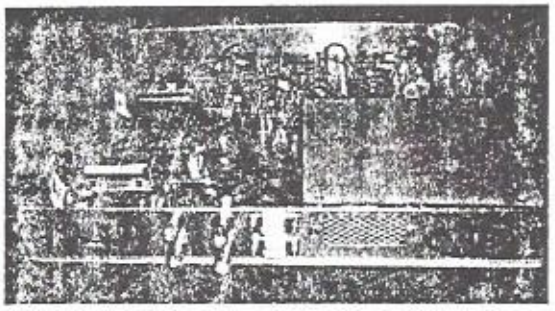

Figure 3. Photograph of renograph electronic module

Software

The software package for renography system consists of acquisition renogram, retrieve of saved renogram file, and QC test to check the readiness of the system. The operator must pass QC test in each day to do an acquisition renogram of new patients.

On the first run of the software, it creates a new sub directory name "My Renogram". Under this sub directory, it also creates "Data", "Log File", and "Sample" sub-sub directories. Sub-sub directory "Data" is intended for saving renogram files., Sub-sub directory "Log File" is intended for recording the QC result. Sub-sub directory "Sample" is intended for saving some real sample renogram files.

Data Acquisition

The sequence of acquisition renogram data is as the following:

- fill up the patient data entry form to entry patient data.
- Patient is injected with radiopharmaceutical using Bolus injection technique, preferred in ante-cubital region.
- And at the same time start the acquisition of renogram data.
- After process of renogram data acquisition completed, data are saved

After pass QC test, to do a renogram measurement, the operator should fill patient data form. On the end of renogram measurement, the patient data saved as part of renogram file. Clicking the continue button, the acquisition form will be displayed. The measurement can be start at the same time with injection of the radiopharmaceuticalto a patient, preferred in ante-cubital region, using Bolus injection technique.

Similar to multi scaling on a Multi Channel Analyzer (MCA), to emulate of X-T chart recorder operation, the software collect a series of 4 seconds counting measurement during measurement process. Counting duration, typically, is 20 minutes and it can be shortened or be extended to maximum 40 minutes. The software does the ***on fly reading*** of the counter data during 4-seconds counting period to monitor the counting process.

After counting process is terminated, counting data can be saved to a file with **.dat** extension format.

The software automatically gives a name of the file with "RYYMMDDNN" format (whereas: R- for Renogram, YY for year, MM for month, DD for date, NN for patient number on the same DD day). The patient data which are collected using Patient Data Entry form are also be saved on the same file on the sub-sub directory Data.

Renogram File Retrieval

A Renogram file can be retrieved any time when the software has been started. A preview of patient data and its renogram curve are displayed during file selection.

When the selested file opened, full renogram curve on superimposed mode will be displayed. In this mode, the left and right kidneys renogram are displayed on the same picture. To change from super imposed to spatial displays, simply just by clicking Spatial Button on Renogram Display Button or through pull down menu. Examples of super imposed and spatial display mode are shown in Figure 4 and 5 respectively.

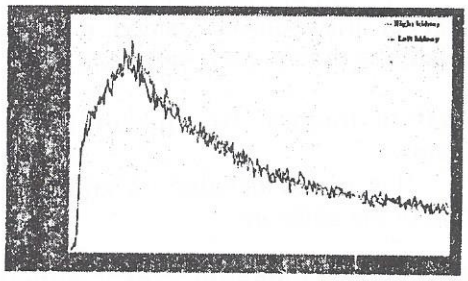

Figure 4. Superimposed Mode Renogram Display

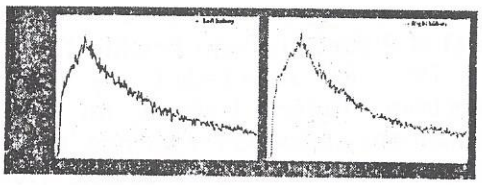

Figure 5. Spatial Mode Renogram Display

Quality Control Test

On QC test, the operator performs the set up by collecting a test spectra using radiopharmaceutical as radiation source, followed by one chi-square test procedure. The test spectra collected by counting along spectra range using the fixed energy window width of SCA. The peak channel and FWHM displayed after a spectrum of one batch of scanning collected.

When the spectra collection stopped by the operator, LLD and ULD related to 1.5 FWHM value around peak channel will also displayed. The operator has a possibility to change the window energy setting. Closing the spectra collection form will automatically open the chi-square test form.

The chi-square test is performed automatically by collecting 20 measurements on 4 seconds counting time. After this, data of Test Date, Test Time, Lower Spectra channel, Higher spectra channel, Peak Left, Peak Right, FWHM Left, FWHM Right, Lower Level Discriminator, E-Window Width, Right Chi-Square Result, Left Chi-Square Result, and operator name are saved on a log file.

The software automatically generates a new QC log file when the renography system is operated in a different month. The format of file name for QC log file is CHLOGYYMM.txt whereas YY stands for year and MM is for month. The QC log file can be open using "Notepad" or Excel program.

Only when the spectra test passed, one can make the Chi-Square test. If Chi-Square test does not passed, the operation for acquisition of new renogram cannot be performed.

4. Discussion

The IAEA-TECDOC-602 especially on chapter 4: Single and Multi-Probe Counting Systems for Gamma Radiation Measurement in Vivo is used as a reference for the renography system QC test procedure on operating software. Relation between test procedures on chapter 4 of IAEA-TECDOC-602 with test procedure on the application software is as the following:

Test of Function of Scaler-Timer / Rate Meter

This is superseded by spectrum test, function of Scaler-Timer demonstrated by on fly reading during spectra collection. In addition, during start up the software would give some alert signal if some communication

problems occured between PC and Renograph module. On the Simulation Mode, one cannot be performing a real renogram measurement.

Test of Energy Calibration

This is not included as embedded part of the software. The Energy Calibration test using Cs-137 is performed during alignment of amplifiers, HV Voltage, and PMT gain by setting CS-137 peak voltage equals to 4.327 Volt. The 4.327 Volt relates to channel number 221 on the spectra. This HV and amplifier gain setting will make peak of I-131 (364 keV) fall in channel 121 and peak of Tc-99 (140 keV) will fall in channel 46.

Test of Energy Resolution (% FWHM)

Test of Energy Resolution is carried out using spectrum test on each operation day. If excessive FHWM happened, the software would generate an alert message.

The FWHM test is very important to predict condition of the NaI(Tl) scintillation crystal inside the detector. Sudden big change of FHWM values indicate the crystal is cracking and if FHWM values were slowly changed from day to day to larger values, it is indication of leaking on hermetic of the detector.

Test of Sensitivity

This is not included as embedded part of the software.

Test of Counting Precision

Chi-Square test is carried out by counting 20 data automaticaly. The software also display the result of on fly reading during counting. At the end of automatic counting, the result will be displayed. If Chi square test not passed, one cannot perform measurement for new patient.

After the chi square test, the test result automatically is saved in a file with "CHLOGYYMM".txt format. This file can be opened using excel program.

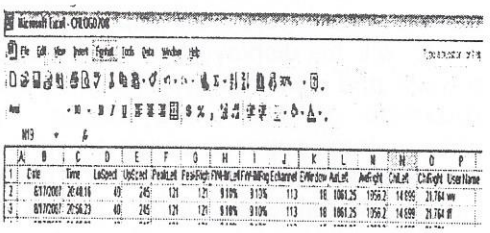

Figure 2. QC test result log file opened using in Excel

Test of Linearity of Energy Response

This is not included as embedded part of the software since it is not related to renography operation.

Test of Integral Background Count Rate

This is not included as embedded part of the software.

Test of Linearity of Activity Response

This is done during validation process. This is not included as embedded part of the software.

Test of Preset Analyzer Facilities

This is superseded by test spectrum. Preset facilities on this system are related to HV voltage, PMT gain, and amplifier gain setting. HV voltage lost will cause lost of counting during test spectrum. HV voltage, pmt gain, and amplifier setting changes caused by electronics component defecti will be indicated by shifting of spectrum peak.

On LLD and ULD setting, although selection or setting of LLD and ULD of the SCA automatically done by the software using 1.5 x FHWM rule, the user can manually adjust the LLD and ULD setting. If the window energy is excessively opened, the software would generate an alert message.

Test of Linearity of Recorder and Test of Chart Drive of Recorder

This is superseded by printer test under Windows operating system

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5. Conclusion

This renography system QC test procedure includes almost all test procedures on chapter 4 of IAEA-TECDOC-602, which related to daily QC test as a part of operating requirements of a renography system. It means that the operational software of the renography system follows the QC test procedure.

The renography system QC test procedure in the renography operationing software assures that each of renogram data acquisition in the renography system follows the QC test procedure. So that the data can be trusted.

In addition, automatic saving of QC test result would make the renography system more users friendly. The QC test result file can be used to monitor and to evaluate the performance of the modernized renography system.

6.Acknowledgemens

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7. References

1. Bairi, B.R et al. (1994). Handbook of Nuclear Medical Instruments. Tata McGraw-Hill Publishing Company Limited, New Delhi
2. P.H. O'REILLY, MD., FRCS, Nuclear Medicine in Urology and Nephrology, Butterworths & Co. Ltd. (1986).
3. SUYITNO Gogot (2001), Detector Probes Renography, Radiology Dept. Dr. Sardjito General Hospital, Yogyakarta - INDONESIA
4. Rony DJOKORAYONO et al. (1987), "Animasi dan akuisisi data alat renograf menggunakan komputer PC-XT"., PPI-PPNY BATAN.
5. INTERNATIONAL ATOMIC ENERGY AGENCY. Quality Control of Nuclear Medicine Instruments. TECDOC 602. IAEA. Viena. 1988.
6. Prayitno (1996), "PETUNJUK PEMAKAIAN PERANGKAT LUNAK RENOGRAF MODEL BI-756" PPNY BATAN
7. PRIBADI et al, (2002)"RENO2002 ACQUISITION SOFTWARE INSTALLATION AND OPERATION MANUAL", P2PN-BATAN.