INTER-COMPARISON OF ACQUISITION AND PROCESSING SOFTWARE FOR MUGA STUDY AND PIP

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ABSTRACT

Software quality assurance in nuclear medicine can be performed by software phantom if the system has the universal interface. Patient file data from a particular computer system may be converted into the standard interfile format, and subsequently converted from interfile format to the specific file format of another computer system. If the system has no interfile option, hardware phantom must be used to validate the accuracy of the software analysis result. The dynamic cardiac phantom was used to verify both acquisition software and analysis software. This make it more importance to guarantee quality and reliability in multi-gated acquisition (MUGA) study. The data set from GE was used to analyze on Trionix and PIP (Portable Image Processing) software. The result shown that GE and Trionix were not different but PIP will give low ejection fraction (EF) than those two systems.

INTRODUCTION

The quality of nuclear medicine imaging depends on the whole investigation procedure.[1] If any of the different steps is unsatisfactory, the result is not reliable. In 1988, COST B2 (Cooperation in the field of Scientific and Technical research) project with the objective of establishing some software quality assurance programs for nuclear medicine software was being formulated in Europe.[2] More recently, the growing interest in software quality assurance has increased the demand for exchange of image data between systems in order to compare the results yielded by applications programs to measure the same parameters.[3,4] Some computer vendors supply utility program to facilitate image file transfer from another format to their own.

The exchange of nuclear medicine image file between difference computer systems is one of the main immediate issues of the project. Crucial problems lie not with image exchange itself but with exchange of the administrative and total file content, since each manufacturer has a unique file structure. The concept of a standard format intermediate file (interfile) is using ASCII key-value pairs for storage of administrative data parameters(*.hdr), and a purely binary data file(*.img).[5,6] Patient file data from a particular computer system may be converted into the standard interfile format, and subsequently converted from interfile format to the specific file format of another computer systems. In this way, patient data may be transferred to any computer system by using only a single interfile read and write program for each type of computer system. Storage of software phantoms in interfile can then be made on any standard removable storage media, for example MS-DOS formatted floppy disks used for PCs.

A software phantom is a set of real or pseudo data, or a mathematically derived set of data that can be formatted into the equivalent of a patient data file,

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for purposes of validation of analysis software.[7] Such data sets cannot be used to validate the acquisition software. A pseudo patient data set is usually obtained from some simple physical model or phantom. More complex software phantoms may be derived from data collected from phantoms with mechanical motion such as various type of cardiac phantom. The advantage that such phantoms offer is that the condition of data collection may be rigidly controlled and the acquisition software may be tested. On the other hand, The phantom of this nature cannot be expected to simulate all conditions likely to be encountered in clinical practice.

In order to validate software on different systems, it is desirable to use the same software phantom in each case. Unless the same input data are used in each case, it is impossible to determine if variations are due to differences in the data or in the analysis software. Transfer or interchange of software phantoms between systems has a number of associated problem which arise at different level, media interchange, file structures and incomplete data. The objective of this study is to perform an inter-comparison of the three systems processing program for left ventricular ejection fraction (LVEF) using a single operator and image data transfer between systems.

MATERIALS AND METHODS

The Veenstra dynamic cardiac phantom model DCP 101 was used to provide identical data between GE (Camstar) and Trionix (Triad) SPECT system.[8] The phantom consists of two compartments, one of which (Fig.1) is fixed and simulates the background areas (lung, left atrium, aorta, liver and spleen). The other compartment (Fig.2) has a hollow chamber which simulates the left ventricle and right ventricle. Both compartments were filled with a homogeneous mixture of Technetium-99m, 111 Mbq for background compartment and 37 Mbq for ventricle compartment. The movement of metal jaws (Fig.3) will attenuate the peripheral activity of the cardiac chamber and synchronize to the electrical output to the R-wave trigger.

Fig.1 A hollow background chamber simulates atrium, aorta, liver and spleen

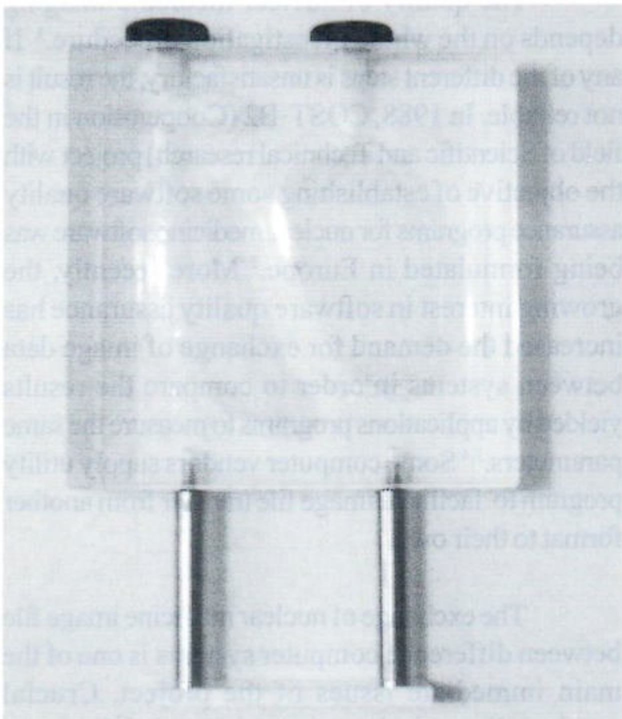

Fig.2 A hollow cardiac chamber that represents the RV and LV

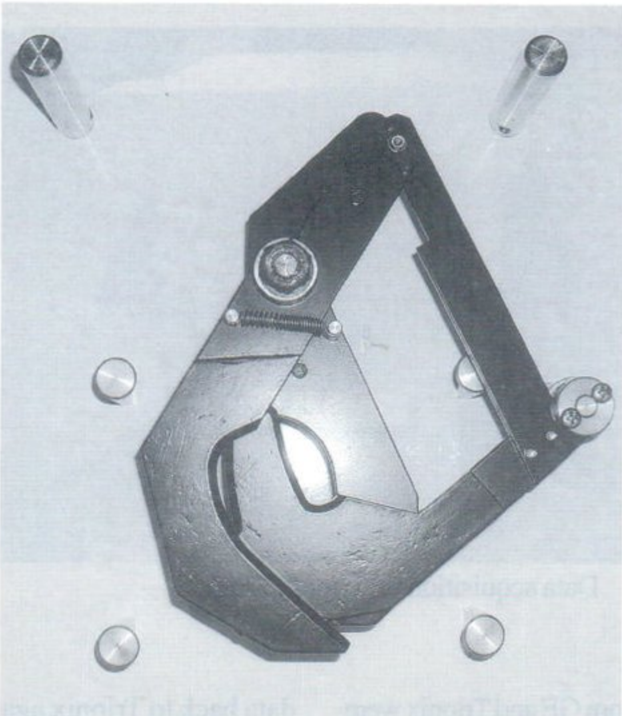

Fig.3 Metal jaws to simulate the beating heart

The three presets EF of 30%, 60% and 80% and heart rate 40, 80 and 160 beet/min were used for MUGA data acquisition. The acquisition matrix 64x64, 24 frames for each cycles, acquisition time 10 min, zoom 2.67 and LEGP collimator was used for GE Camstar (Fig.4) and zoom 1.6, LEUR collimator was used for Trionix Triad (Fig. 5).

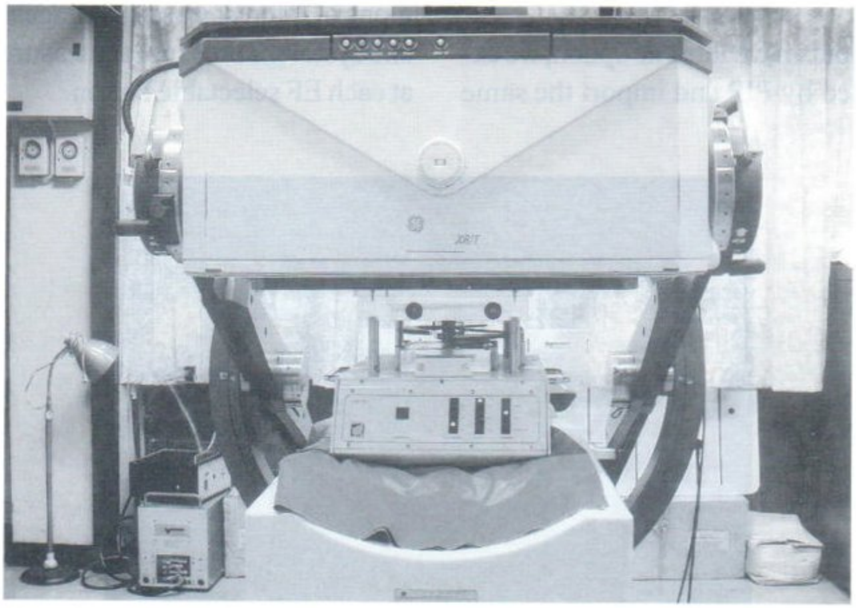

Fig.4 Data acquisition on GE Camstar

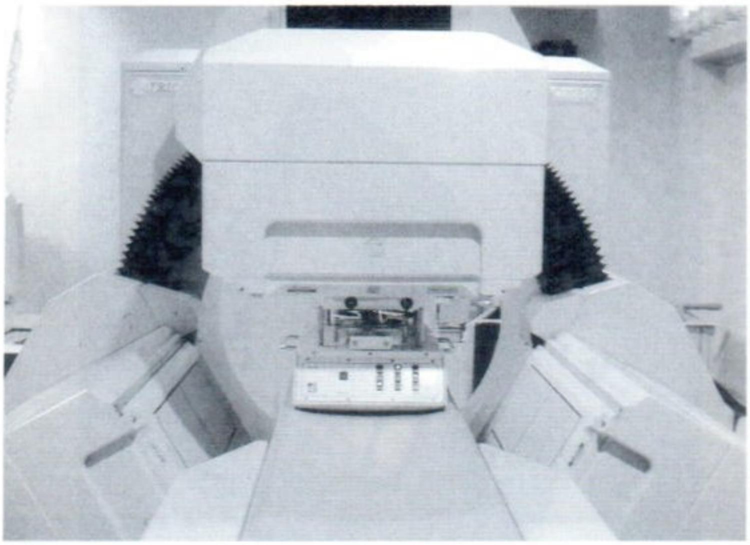

Fig.5 Data acquisition on Trionix Triad

The acquisition data from GE and Trionix were analyzed both manual and semi-automatic methods. With some help of GE Camstar maintenance service officer to read and write GE Camstar data file on personel computer (PC), we can used ImageJ program to open file and save as image file (*.img). We created header file (*.hdr) as interfile version 3.3 format and analyzed these data on PC by PIP (Portable Image Processing) software.

Because Trionix have Interfile option, we export data to analyzed by PIP and import the same data back to Trionix again to analyze by semi-automatic method.

With the background chamber removed, the movable jaws were first set at the widest position (end-diastole) and static image was acquired for 1 minute, then at closed position (end-systole) and acquired static image again. Perform the same at each preset selectable to determined EF by drawing regions of interest on static images (Fig.6) at diastole and systole. Three repeat measurements were made at each EF selectable button.

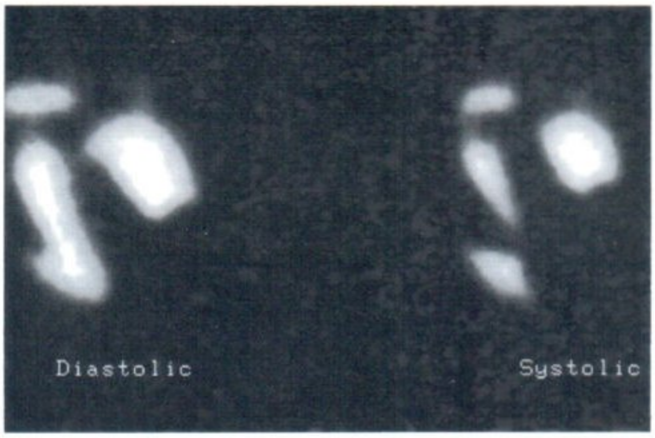

Fig.6 Static images from GE used to draw ROI to calculate EF

STATISTIC ANALYSIS

The paired-sampled t-test was used to compare means of ejection fraction between static and MUGA acquisition. $P < 0.05$ was considered statistical significant.

RESULTS

The results on LVEF in percent was recorded in Table 1 acquired by GE Camstar, using semi-automatic (Fig.7) and manual (Fig.8) modes compared to analyze by PIP (Fig.9).

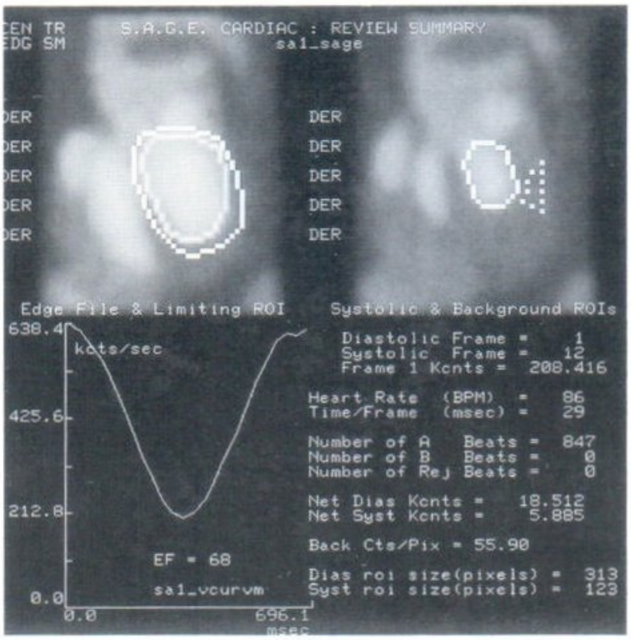

Fig. 7 GE semi-automatic method at HR 80 and EF60

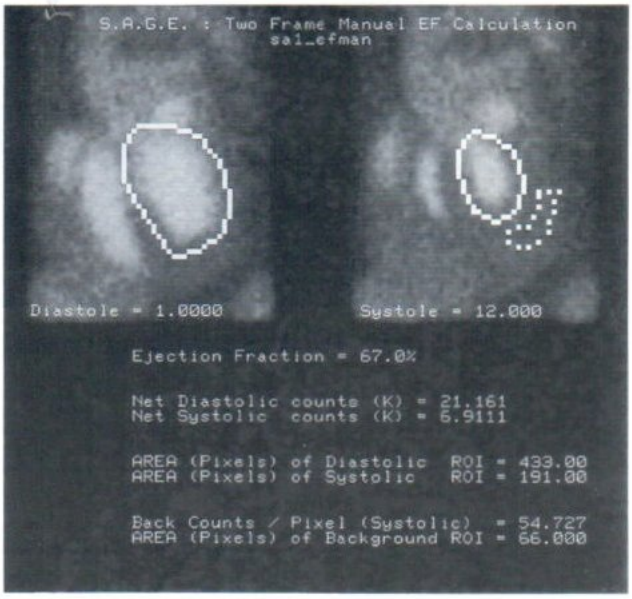

Fig.8 GE manual 2 frame method at HR80 and EF60

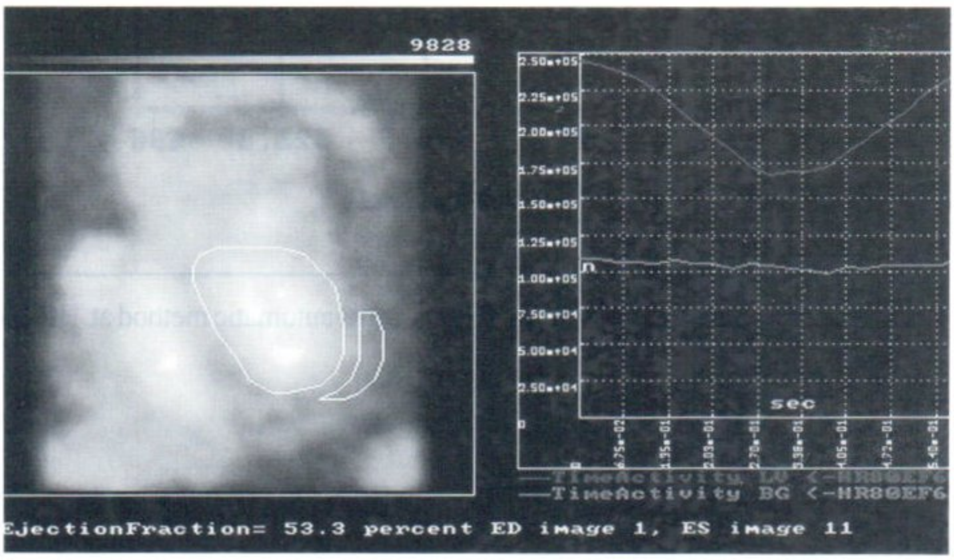

Fig. 9 GE data at HR80 and EF60 analyzed on PC with PIP

Fig.10 Trionix semi-automatic method at HR80 and EF60

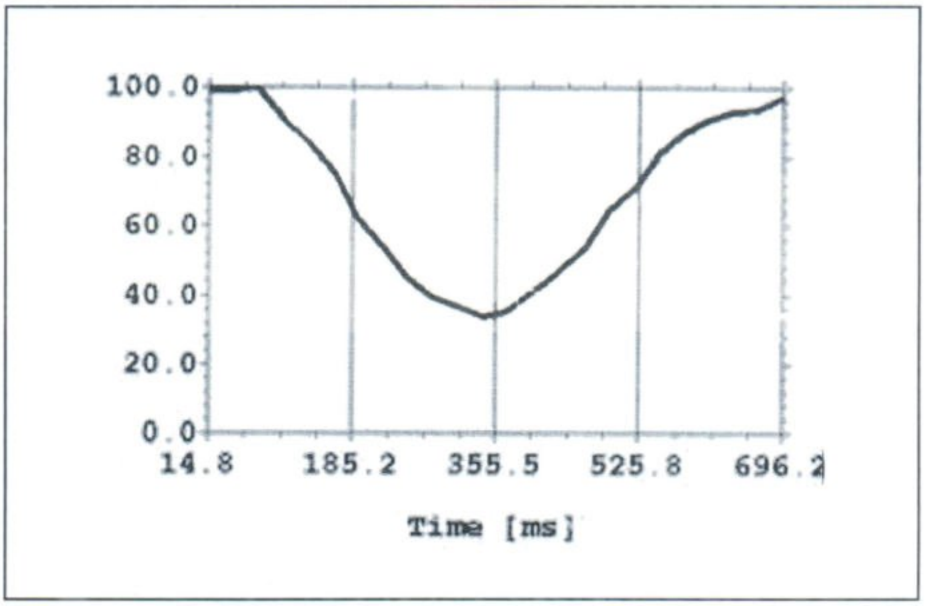

Fig.11 Time activity curve from Trionix semi-automatic method at HR 80

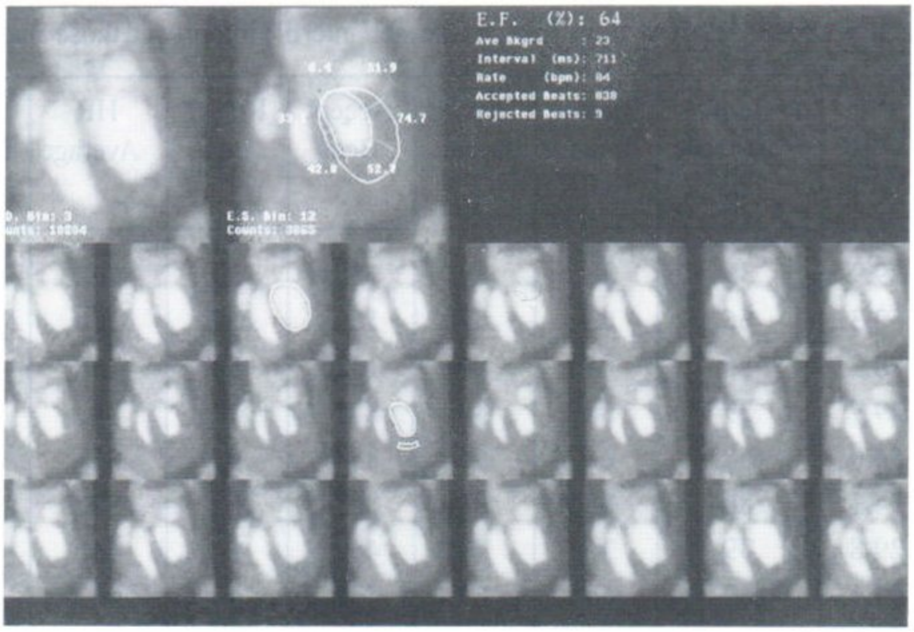

Fig.12 Trionix manual 2 frame method at HR80 and EF60

The results on LVEF in percent was recorded in Table 2 acquired by Trionix Triad, using semi-auto matic (Fig.10-11) and manual (Fig12) modes compared to analyze by PIP.

GE data in form of interfile format was send from PC to analyzed on Trionix via network. The result was given on Table3 compared to GE and PIP.

The mean results from static image at each EF from both system was record on Table 4 compared to the MUGA data at same EF.

Table 1 The result of MUGA analysis from GE data and those analyzed on PIP

Veenstra	PIP %EF	Semi Automatic %EF	Manual 2Frame %EF	Accept Beat	Reject Beat	HR Average	ED Frame No.	ES Frame No.
HR160EF30	30.5	44	43	1541	48	166	1	12
HR160EF60	55.5	69	68	1549	44	166	1	13
HR160EF80	72.8	86	85	1541	35	166	1	11
HR80EF30	30.4	42	42	842	0	86	1	13
HR80EF60	53.3	68	67	847	0	86	1	12
HR80EF80	72.4	85	85	834	0	86	1	12
HR40EF30	30.7	41	41	486	1	49	1	12
HR40EF60	54.8	67	67	481	0	49	1	11
HR40EF80	73.4	84	83	486	0	49	1	11

Table 2 The result of MUGA analysis from Trionix data, self interfile import and those analyzed on PIP

Veenstra	PIP %EF %EF	Semi Automatic %EF	Manual 2Frame %EF	Interfile Import %EF	Accept Beat	Reject Beat	HR Average	ED Frame	ES Frame
HR160EF30	29.9	39	38	39	1591	30	162	2	12
HR160EF60	52.3	66	63	67	1578	12	159	1	12
HR160EF80	78.9	86	84	86	1528	58	158	2	12
HR80EF30	29.7	39	38	39	875	1	86	1	12
HR80EF60	54.0	68	64	66	838	9	84	1	12
HR80EF80	74.1	86	83	85	827	5	82	1	12
HR40EF30	29.8	39	36	40	460	1	45	1	11
HR40EF60	57.1	67	66	67	462	4	46	1	12
HR40EF80	74.0	85	84	87	483	4	48	2	11

Table 3 Inter-comparison of analysis software by using data set from GE and those analyzed on Trionix and PIP (%EF)

Veenstra	GE (Original)	Trionix	PIP
HR160EF30	44	43	30.5
HR160EF60	69	71	55.5
HR160EF80	86	87	72.8
HR80EF30	42	41	30.4
HR80EF60	68	70	53.3
HR80EF80	85	86	72.4
HR40EF30	41	41	30.7
HR40EF60	67	70	54.8
HR40EF80	84	86	73.4

Table 4 The mean %EF from static image and MUGA at each preset button (mean±s.d.)

Veenstra	Mean Static GE	Mean Static Trionix	Mean MUGA GE Trionix (Semi)	Mean MUGA on (Semi)	Mean GE on PIP	Mean Trionix PIP
EF30	39.3±0.2	36.4±1.1	42.3±0.2	39.0±0.0	30.5±0.2	29.8±0.1
EF60	66.8±2.8	65.3±1.3	68.0±1.0	67.0±1.0	54.5±1.1	54.5±2.4
EF80	88.3±0.6	83.3±0.2	85.0±1.0	85.7±0.6	72.9±0.5	75.7±2.8

DISCUSSION

Table 1 and 2 shows that heart rate detection on GE is more stable than Trionix. At high heart rate more rejected beat is observed compare to low heart rate on both system. This may be due to electrical noise of the system. The heart rate have no effect on EF. No differences between Semi-automatic and Manual 2 frames method. End-diastolic frame were major on frame number 1 but end-systolic was different in ±1 frame between two systems.

Table 2 show that Trionix import interfile have no effect on result ($p = 0.782$) compared to original data, but rejected beat will be set to zero. Trionix edge detection algorithm was not correct in some frame. So, operator must adjust it by manual, frame by frame. Trionix can not change diastolic and systolic frame by manual method as compare to GE. These two frames were detected by oval ROI on LV. This may be missing some part of LV due to Oval shape and wrong detection frame may occur.

The acquisition data from dynamic cardiac phantom and analyzed by its own semi-automatic algorithm had shown no significant differences between GE and Trionix ($P = 0.12$). When we analyzed both data on PIP, lower EF was observed with significant ($p < 0.001$) differences compared to original system. This may be due to differences in algorithm because PIP used fix ROI but GE and Trionix used varied ROI according to the edge of LV.

Table 3 shows inter-comparison analysis software by using GE data when analyzed on Trionix having no significant changes ($p = 0.067$) but having significant changes on PIP ($p < 0.001$)

Static image was used to perform calibration of pre-set button value. Table 4 show that no significant differences on MUGA from GE ($p = 0.746$) but significant differences on MUGA from Trionix ($p < 0.001$). This may be due to very small matrix as MUGA is using and error on drawn ROI because image was very small.

When we used Veenstra dynamic cardiac phantom, parallel plane must be strictly checked between phantom and detector. Wrong results may be due to geometrical error. However, pre-set EF value may be adjusted by means of multiturn potentiometers so that a wide range of EF values may be simulated. This phantom was easy to be used, simple to be operated but relatively heavy.

CONCLUSION

The acquisition MUGA on both GE and Trionix give the same result. PIP software will give lower EF with significant change due to calculation algorithm. This GE MUGA data had been validated and can be used as software phantom. Interfile is a software package which is more helpful to share data and compare results between analyzing systems in nuclear medicine. It is available to communicate in interfile format from center to center via network. Software phantom may be useless if that system has no this option, especially the old camera system. Hardware phantom will be needed in this case. Quality assurance in nuclear medicine software must be performed to guarantee quality and reliability.

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