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PERFORMANCE TEST OF MAGNETIC RESONANCE IMAGING MACHINE 0,35 TESLA AT KASIH IBU HOSPITAL SABA

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ABSTRACT

Background: This research discusses the performance testing of the Magnetic Resonance Imaging (MRI) machine which was carried out with performance tests on three different parameters at Kasih Ibu Saba Hospital. This research aims to determine the performance of the MRI machine at Kasih Ibu Hospital Saba in Bali Province and establish baseline data for future testing. **Method:** This type of research is quantitative and uses a survey approach. The tools and materials used in this study are a 0.35 Tesla MRI machine, an ACR phantom, and a head coil. Data were collected by conducting nine MRI performance testing procedures using the ACR (2015) guidelines and then analyzed using international standards issued by ACR (2015). **Result:** In the visual checklist testing, all observed parameters were over 30 days and functioned well, For the Artifact Evaluation test, the author evaluated all scanned images and found no artifacts. The author analyzed the measurements from the first slice of T1W and T2W images for the Slice Thickness Accuracy test. The measurement results for the T1W image were 4.6mm, and for the T2W image, they were 5.57mm. The Slice Thickness Accuracy testing standard set by ACR in 2015 is 5mm ± 0.7mm. Therefore, based on the measurement results from the T1W and T2W images, the MRI machine at Kasih Ibu Saba Hospital meets the established international standards. **Conclusion:** Based on the results of the visual checklist test, the following results were obtained: all parameters on the visual checklist functioned well during the 30-day observation. Meanwhile, the two tests conducted with the phantom on the MRI machine at Kasih Ibu Hospital Saba the following results are: the artifact evaluation test and the slice thickness accuracy test met the international standards set by ACR in 2015.

Keyword: Performance Test MRI; Phantom ACR; ACR guideline

Introduction

Magnetic Resonance Imaging (MRI) is an imaging technique that originates from proton radio frequency (RF) signals that are magnetized by a strong magnetic field. These protons usually come from water, fat or metabolites[(1)(2).] Magnetic Resonance Imaging have a very important role in diagnosing disease. The large number of equipment used in MRI modalities at different examination sites will produce different images even with the same patient. This can be caused because the equipment in the MRI modality also has different quality standards. Standardization of image quality in the MRI modality is very important, considering that MRI has become one of the main ways of making a diagnosis like

other equipment based on x-rays, ultrasound and so on. For this reason, a quality assurance program (Quality Assurance) for the quality of MRI images is needed, one of which is by carrying out quality control procedures. QA combines a series of quality control (QC) tests to check the performance of the MRI and detect parameters that affect image quality (3)

Quality Control or quality control is part of a quality assurance program that is used to monitor and maintain technical parts that have an impact on image quality so that when image quality decreases below standard, corrective steps can be taken immediately [(4).] Until now in Indonesia there is no institution or state agency that specifically regulates and supervises MRI diagnostic imaging modalities, so that hospitals that have MRI equipment also do not have the obligation to obtain permits for the use of MRI such as x-ray based equipment. This causes the MRI modality to rarely or even never test aircraft performance [(5).]

According to American College of Radiology[(6)] Tests that can be performed daily or weekly by radiographers include visual checklist, film printer quality control, geometric accuracy, transmitter gain or attenuation, setup and table position, center frequency, high contrast spatial resolution, artifact evaluation and low contrast detectability. Meanwhile, according to Papp [(4)], Magnetic Resonance Imaging (MRI) performance testing can be divided into two parts based on testing frequency, namely daily or weekly testing and annual testing. Annual testing includes radiofrequency coils, slice thickness accuracy, slice position accuracy and magnetic field homogeneity while daily or weekly testing includes artifact evaluation, center frequency, signal to noise ratio (SNR), setup and table positioning accuracy, film quality control, transmit gain and visual checklist.

The next step, the author carried out an initial inspection at Kasih Ibu Hospital Saba. MRI examinations at Kasih Ibu Hospital Saba average every month, namely around 200 patients. Therefore, quality control is needed to ensure that the resulting image complies with standards. While carrying out this review, the author also discovered that the Magnetic Resonance Imaging (MRI) at Kasih Ibu Hospital Saba had never been tested for quality, therefore it was necessary to carry out a quality control (QC) test to assess the performance of the Magnetic Resonance Imaging RI). For this reason, the author feels interested in testing the performance of this modality, so that the author can determine the suitability of the test results with the standard test values that have been determined internationally by the ACR. Based on this, the test that the author carried out in this research was in two ways, namely testing without using a phantom and using an ACR phantom. Tests without using phantom ACR include a visual checklist, while tests carried out using phantom ACR include slice thickness accuracy testing and artifact evaluation. The reason the author uses the ACR phantom is because in the ACR phantom there are several structures that can be used to carry out image quality testing so that the test guide used also uses tests and testing standards that have been set internationally by the American College Radiology (ACR).

Method

The type of research in this test is quantitative research with a survey approach. The independent variables in this research are the slice thickness accuracy, artifact evaluation and visual checklist. The dependent variable in this research is the performance testing results of slice thickness accuracy, artifact evaluation and visual checklist. The controlled variables in this study include T1 and T2 weighting, FOV, TR, TE, Phantom ACR and slice thickness. The population used was the results of ACR phantom images performed at Kasih Ibu Saba Hospital with sequence parameters and weighting in routine brain examinations, while the sample used was data with brain examination parameters and T1 and T2 weighting. The instruments in this research include: 0.35 Tesla MRI machine, camera, phantom ACR, laptop, and writing instruments. The testing procedures carried out are guided by the ACR literature. The first is done by

testing without using a phantom, namely visual checklist testing. Next, testing was carried out using a phantom by placing the phantom on the head coil. After the phantom is placed according to its position, then proceed with selecting the protocol that will be used, namely a brain examination routine with the following parameters: TR = 200ms, TE = 20ms, Slice Thickness = 5mm, FOV = 25 cm, Matrix = 256 x 256, NEX = 1. Then the sagittal localizer is used to make axial image, then the sequence will be used to obtain 11 slices of axial images, namely T1 WI Spin Echo_Tra with TE 20ms, TR 500ms, FOV 25 cm, matrix 256 x 256 and slice thickness 5 mm and T2 WI Fast Spin Echo Axial with TE 20-80 ms, TR 2000ms, FOV 25 cm, matrix 256x256 and slice thickness 5 mm. After obtaining the desired image, artifact evaluation and slice thickness accuracy testing is then carried out. Data analysis in this research is data obtained from the measurement results of each test and then analyzed by comparing it with the international standard values set by the ACR.

Results and Discussion

1. Test procedure without using a phantom
   Testing is carried out by observing each parameter contained in the visual checklist sheet. After these observations have been made, the visual checklist sheet will be filled in with the following conditions: if the parameter being tested is still functioning then the parameter will be filled with the mark **"√"** or **Pass,** whereas if the parameter being tested is not functioning then the parameter will be filled with the mark **"F"** or **Fail.**
2. Test procedure using a phantom
   a. The phantom is placed on the head coil with the **"Nose"** sagittal mark parallel to the vertical plane.

Image 1. Placement of the phantom on the MRI Head Coil

b. Next, the phantom is placed at the center of the MRI magnetic bore by placing the phantom center point and coil at the center point of the indicator light and continuing by pressing the **"Set"** button on the MRI machine

Image 2. Placement of the phantom at the center of the MRI magnet bore

c. Next, scan the sagittal MRI image as a localizer, then continue with taking 11 slices of axial T1W and T2W images.

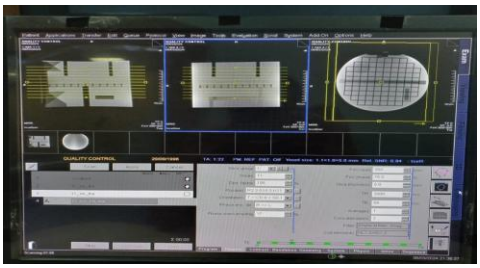

Image 3. Placement of 11 slices on the sagittal localizer

d. Perform axial T1W scanning with 11 slices with T1WI Spin Echo_Tra

parameters with TE 20ms, TR 500ms, FOV 25 cm, matrix 256 x 256 and slice thickness 5 mm, then continue scanning T2WI Fast Spin Echo Axial with 11 slices with TE 20 -80 ms, TR 2000ms, FOV 25 cm, matrix 256x256 and slice thickness 5 mm.

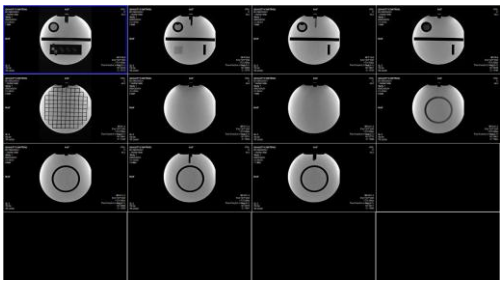

Image 4. Axial T1W scanning results

e. Next, observations and measurements were made on each image obtained.

3. Test Results

a. Visual Checklist testing

This test was carried out for 30 days by observing several parameters contained in the visual checklist sheet.

Image 5. Visual checklist test results

b. Artifact Evaluation testing

Artifact evaluation testing is carried out by checking each image that has been obtained for artifacts and investigating possible causes if there is ghosting, geometric distortion, signal intensity mismatch and others in the resulting T1W and T2W images.

No.	Jenis *Artifact*	Keterangan (coret yang tidak benar)	Slice Ke -
1	*Streak*	~~Ada~~ / Tidak	-
2	*Geometric Distortion*	~~Ada~~ / Tidak	-
3	*Shading*	~~Ada~~ / Tidak	-
4	*Bluring*	~~Ada~~ / Tidak	-
5	*Yang lain-lain (.....)*	~~Ada~~ / Tidak	-

Image 6. Artifact evaluation test results

c. Slice Thickness Accuracy testing

1) Displays the results of the T1W and T2W slice weighted images into 1 axial slice
2) Set the window value so that measurements can be carried out by setting the window width value to the minimum value and setting the window level value to the middle value so that the desired image is obtained.
3) Then in the middle of the image there are two spaces above and below using an image magnification factor of 2 or 4 times. Next, take measurements in both spaces.
4) Then the measurement results from the T1W and T2W images are analyzed using the slice thickness accuracy formula for both spac

$$Hasil\ Pengukuran\ T1W = 0{,}2 \text{ x } \frac{a \text{ x } b}{a + b}$$
$$0{,}2 \text{ x } \frac{44{,}3 \text{ x } 49{,}1}{44{,}3 + 49{,}1}$$
$$0{,}2 \text{ x } \frac{2175{,}13}{93{,}4}$$
$$0{,}2 \text{ x } 23{,}29$$
$$= 4{,}66mm$$
$$Hasil\ Pengukuran\ T2W = 0{,}2 \text{ x } \frac{a \text{ x } b}{a + b}$$
$$0{,}2 \text{ x } \frac{51{,}6 \text{ x } 60{,}6}{51{,}6 + 60{,}6}$$
$$0{,}2 \text{ x } \frac{3126{,}96}{112{,}2}$$
$$0{,}2 \text{ x } 27{,}87$$
$$= 5{,}57mm$$

Image 7. Slice Thickness Accuracy test results

The author has tested 3 MRI performance tests at Kasih Ibu Hospital Saba using the MRI Quality Control Manual Book issued by ACR in 2015 and obtained the following results:

1. Testing without using a phantom in the visual checklist test, all parameters that were observed for 30 days functioned well.
   Image 8. Visual Checklist test results

2. Testing using a phantom
   a. Artifact Evaluation testing
      In the Artifact Evaluation test, the author has evaluated all the scanning images, and the results showed that no artifacts were found so that in this test the MRI at Kasih Ibu Hospital Saba met the international testing standards set by ACR in 2015

Conclusion

The conclusions obtained by the author from the previous discussion are as follows:
Based on the test results without using a phantom, namely visual checklist testing, the following results were obtained: all parameters contained in the visual checklist sheet can function well during 30 days of observation, while the two test results using a phantom were carried out on an MRI machine at Kasih Ibu Hospital Saba, the following results were obtained: evaluation artifact testing and slice thickness accuracy testing have met international standards set by ACR in 2015. In further research, improvements can be made periodically so that the performance of the MRI machine at

   b. Slice Thickness Accuracy testing

In the Slice Thickness Accuracy test, the author has analyzed the measurement results on the 1st slice of the T1W and T2W images. The results obtained from T1W image measurements were 4.6mm while the results obtained from T2W image measurements were 5.57mm. The Slice Thickness Accuracy testing standard set by ACR in 2015 is 5mm + 0.7mm so that based on the measurement results from T1W and T2W images, the MRI machine at Kasih Ibu Hospital Saba meets the established international standard.

Kasih Ibu Saba Hospital can be more optimal and more baseline test data can be obtained than before. In addition, regular maintenance should be carried out on the MRI machine at Kasih Ibu Saba Hospital by related technicians, so that the performance of the MRI machine can always function properly so as not to interfere with MRI

TABEL VISUAL CHECKLIST
BULAN : JUNI 2024

Hari ke-n		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Patient & Transport Magnet	Alignment light	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Bed position and other lights	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	High tension cable / other cables	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Vertical motion smoothness and stability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Filming and Viewing	Light Boxes	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
RF intergerity and control room	RF door contacts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	RF window-screen integrity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Operator console switches / lights / meters	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Patient monitors	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Patient intercom	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Room temperature / Room humidity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Facility safety	Door indicator switch (if installed)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Pass = ✓
Fail = F

patient services.

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