Introduction

In Korea, the quality assurance of CT, MRI and mammography has been regulated since 2004 by the Korean Institute for Accreditation of Medical Imaging (KIA). The program was to evaluate and to improve the quality of medical images produced in medical examinations for the improvement of national health and achieved quality improvement of CT and MRI mammography successfully. Based on these three modalities, the quality assurance of US imaging has been road-mapped with the high performance group of professionals for their professional reasons, in most cases, there is no legal regulation system for US such as for ionizing diagnostic modalities. Furthermore, the application of ultrasound is not easy because the technical development of US equipment has been rapid. For example, ACR standard for monitoring the technical quality of US system is set by the American College of Radiology (ACR) and the standard for the phantom US system is set by the American Institute of Ultrasound in Medicine (AIUM). Therefore, it is reasonable to establish separate QA standards for each professional group that performs the same specific examinations. In Korea, US examinations are done for the general public as well as for specialized medical examinations. In order to ensure the quality of US examinations, the Korean Institute for Accreditation of Medical Imaging (KIA) performed the quality survey for the general public in 2008, small hospitals other than general hospital in 2009, and private clinic in 2010. The results of these surveys showed that many medical institutions do not have the knowledge about how to operate the US equipment. This study was performed as a follow-up survey to investigate the quality of US examination performed for the screening of HCC in high-risk patients and the preparation of the quality assurance system for US examination in Korea.

Acknowledgement

This study has been supported by the National Cancer Center Research Institute of Korea by the Ministry of Health, Welfare and Family Affairs of Korea. This study was performed by the help of the Korean Society of Radiology, and the Korean Institute for Accreditation of Medical Imaging (KIA).

Investigation Process

The investigation was performed for the medical institute participating in the National Cancer Screening Program for hepatocellular carcinoma all over the country. Questionnaires were distributed to 1,156 medical institutes, general hospitals from 2008 to 2010. General hospitals were investigated in 2008, small hospitals other than general hospital in 2009, and private clinic in 2010. The purpose of this study was to evaluate the knowledge about the US phantoms and the technical knowledge of the medical personnel who performed the ultrasound examination for the screening of HCC. In total, 111 medical institutes cooperated in the study. The results of this study were evaluated by the ultrasound quality assurance criteria established by the Korean Institute for Accreditation of Medical Imaging (KIA).

Phantom Image Evaluation

Both subjective visual methods and objective computer-based approaches may be used to perform the phantom image evaluation. Due to its subjective nature, the subjective quality assessment is less accurate than computational image analysis. However, considering the large number of scanners included in our future survey (more than 2000 US systems in numerous medical institutions), subjective visual assessment would be acceptable. To overcome the subjectivity depending on manual reading and visual assessment, the results were evaluated by using the computer-based methods. After obtaining the mean values of the quality assessment, we proposed the cut-off values. The cut-off values, which means the range of agreement of ‘pass’ or ‘fail’, between two reviewers with the declared cut-off values, were observed in all cases of the phantom image evaluation in 2008 investigation.

Vertical and Horizontal Measurement

The vertical and horizontal measurement were obtained on both parallel and perpendicular to the side of the sound beam. Accuracy measurement of the size, depth and vertical- and horizontal-orientation of line targets. The distance between scan surface and “*” target is the dead zone. In this case, dead zone is 2 mm. Focus is located as near as possible to center of line targets. The discrepancies of vertical and horizontal measurement are 0.4% and 3.5%, respectively.

Figure 3. Vertical measurement

Figure 4. Horizontal measurement

Sensitivity

Sensitivity, which is the test of the penetration depth of HCC, is to evaluate the ability of the HCC to be identified on the image. A standard HCC phantom is used for this test. The presence of HCC is identified by an expert. All medical institutes participating in the investigation were asked to submit the results of this test in order to perform the quality assurance of US imaging in medical institutions. In the previous national survey, 11 medical institutes submitted the results of the sensitivity test. The sensitivity for this test was determined as 75% (0.6 cm).

Figure 5. Sensitivity

Figure 6. Gray scale/dynamic range

Quality Assurance Test of Screening Ultrasound Examination for Hepatocellular Carcinoma: A 3-year Nationwide Survey in Korea

The Korean Society of Radiology

Table 1. Cut-off values for test of phantom US

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Cut-off Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead zone</td>
<td>Less than 2 cm for the dead zone</td>
</tr>
<tr>
<td>Vertical measurement</td>
<td>Within 5% discrepancy (10.0 ± 0.5 cm)</td>
</tr>
<tr>
<td>Horizontal measurement</td>
<td>Within 7.5% discrepancy (5.0 ± 0.5 cm)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>More than 80%</td>
</tr>
<tr>
<td>Gray scale</td>
<td>More than 14 cm</td>
</tr>
<tr>
<td>Gray scale</td>
<td>More than 4 cm</td>
</tr>
</tbody>
</table>

Figure 7. Eight standard images of the clinic image evaluation presented by the Korean Society of Radiology and the Korean Institute for Accreditation of Medical Imaging.
Clinical image evaluation is a key step in the proper performance of screening US scans. It is essential to ensure that each patient receives an accurate and thorough examination. Results of this study have implications for how we design future screening programs.

**Phantom Image Evaluation**

Results of the failure rate according to the groups of medical institutes.

Table 4 summarizes the results of the phantom image evaluation according to the groups of medical institutes. There was no significant difference in the failure rates among the groups based on the personnel who performed US scanning. The highest failure rates were in hospitals other than general hospitals (42.8%), followed by general hospitals (28.3%), private clinics (15.3%), and non-Radiology physicians (4.2%). A comparison among the groups of medical institutes showed that there was a significant difference in the failure rates among the groups. The lowest failure rates were in private clinics (4.2%), followed by non-Radiology physicians (4.2%), general hospitals (28.3%), and hospitals other than general hospitals (42.8%).

**Clinical Image Evaluation**

Results of the failure rate according to the groups of medical institutes.

Table 7 summarizes the results of the clinical image evaluation according to the groups of medical institutes. The highest failure rates were in hospitals other than general hospitals (28.3%), followed by general hospitals (15.3%), private clinics (14.3%), and non-Radiology physicians (6.6%). A comparison among the groups of medical institutes showed that there was a significant difference in the failure rates among the groups. The lowest failure rates were in non-Radiology physicians (6.6%), followed by private clinics (14.3%), general hospitals (15.3%), and hospitals other than general hospitals (28.3%).

**Analysis of ‘passed’ and ‘failed’ cases by artifacts**

Table 8 shows the mean scores of each test item for passed and failed cases. For the personnel who performed US scanning, radiologists showed the best results for the clinical image evaluation, whereas technologists and non-Radiology physicians showed the worst results. For the personnel who performed US scanning, radiologists showed the best results for the clinical image evaluation, whereas technologists and non-Radiology physicians showed the worst results.

**Conclusion**

The current study found that non-Radiology physicians showed significantly lower scores for the clinical image evaluation compared to radiologists. These findings suggest that additional training and education may be needed for non-Radiology physicians to improve their performance in US scanning. However, the limitations of the current study should be considered when interpreting the results. Further research is needed to determine the factors contributing to the lower scores obtained by non-Radiology physicians and to develop strategies to improve their performance in US scanning.

**References**


**Fig. 9** Proportion of causes of the failure for the phantom image evaluation. Numbers are percentages.