Image Quality Evaluation of Liver Ultrasound Images Acquired Using a Cassava Starch-Based Coupling Gel

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Abstract: The increasing demand for a safe and cost effective procedure in disease diagnosis makes ultrasound the modality of choice in modern diagnostic imaging. Diagnostic ultrasound uses high frequency sound waves to recreate images of the organ of interest inside the body. In this study, the image quality of ultrasound images derived from using a cassava-starch based coupling gel is compared to the images acquired using a commercial coupling gel. Two sets of ultrasound images, one using cassava gel and the other a commercial gel, of routine liver examinations of 20 adult patients were compared and evaluated. Result of this study shows that the sonographic images acquired using the experimental coupling gel are not significantly different from the images derived from commercial gels. This suggests that, as far as image quality is concerned, the starch-based coupling gel prepared in this study has a very good potential for clinical applications in ultrasound examinations.

Keywords: *Cassava Starch, Coupling Gel, Ultrasound, Image quality performance*

INTRODUCTION

Diagnostic ultrasound's primary purpose is to precisely localize and characterize internal body structures in real time images. It is clinically established for routine screening examinations of breast, abdomen, neck, and other soft tissues. It is also used as well as for therapy procedures monitoring. Ultrasound is one of the most widely used modalities in diagnostic imaging.

There are two components of the ultrasound machine that are very essential in order for the machine to function and to

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perform the needed procedures. These are the transducer and the coupling gel. Coupling gels are necessary to ensure a good contact between the transducer and the skin. This is essential to avoid image artifacts caused by the presence of air between them. Commercially available coupling gels are made from water-soluble materials such carbomer, ethylenediaminetetraacetic acid (EDTA), propylene glycol, trolamine and up to 500 ml demineralized water (Lutz & Gharbi, 2006).

The need for a relatively cost effective, naturally produced, occupationally safe and readily available material for routine diagnostic examination is very essential in resource-disadvantaged setting. This is primarily observed in small clinics and relatively poor facilities in developing countries (Salmon, et al., 2015).

Salmon et al. (2015) reported the development of an alternative coupling gel prepared from cornstarch. Their result showed that the quality of the images acquired from this alternative gel is comparable to images taken from commercial gel. Furthermore, because of the wide availability of cornstarch, it is reported that this alternative gel is several times cheaper than the commercially available gels.

Taking off from the work of Salmon, et al (2015), this study investigated the feasibility of using cassava starch as the primary based material for an experimental coupling gel. As far as the purpose of a coupling gel is concerned, a starch-based gel has the same properties with the commercial ones.

In diagnostic medicine, the main purpose of a diagnostic procedure is to provide diagnostically acceptable images that will help in providing the appropriate medical diagnosis. This research claims that our starch-based coupling gel will aid in the production of diagnostically-acceptable images.

The general objective of this research is to prepare and test the applicability of a starch-based coupling gel in routine ultrasound examinations. Specifically, this research evaluates and compares the image quality of ultrasound images acquired using the experimental gels with the images derived from the standard gel.

MATERIALS AND METHODS

Preparation of the gel

The experimental coupling is prepared from 8 g of cassava starch mixed with 2 g of salt was and 500 mL of tap water. The mixture was continuously stirred in the boiling water (100ºC)

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for around five minutes until the mixture is homogenous enough. 10 mL of vinegar is poured into the mixture to serve as coupling gel preservative. The prepared mixture is allowed to cool down and then poured into a coupling gel container.

Research Participants

Twenty patients who are undergoing routine liver ultrasound examination were included in this study. The patients are informed about the purpose of the study, the procedures that will be performed on them, and the risk and benefits of participating in the study. The consent of the patients were secured before they are included in the research. The use of human participants in the study was approved by the Lyceum of the Philippines University Institutional Review Board. Patients who were hyperstenic, hyposthenic, minors, those with cognitive disorders, and with body habitus were excluded in the study.

Each patient underwent at least two ultrasound procedures: the first one uses the standard gel (Aquasonic) and the other one used the experimental gel. Both procedures are identical except for the type of the coupling gel used. All procedures are conducted by the same license ultrasound technologist.

The equipment used in this study is a The Medison (Samsung) Sonoace X4 ultrasound machine. The standard protocol for the routine liver examination is employed in this work.

Evaluation of the Images

Five practicing radiologists evaluated the ultrasound images derived in this study. The images were evaluated in terms of the following criteria: image clarity, Accuracy of image details, presence of artifacts, image contrast resolution, spatial resolution, overall image quality, and the overall diagnostic acceptability of the image. A likert-scale like evaluation sheet was used for evaluation. The criteria for the evaluation are adapted from the work of Mendoza, et al (2015). The images are evaluated blindly, that is the evaluators are not informed regarding the type of coupling gel used for each image.

The results of the evaluation were analyzed using the non-parametric Wilcoxon-Mann Whitney test for statistical significance.

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RESULTS AND DISCUSSION

Coupling gels are, in general, used to eliminate the power loss of the acoustic signal at air-tissue interface. In the absence of a coupling gel, sound wave travelling through this interface is easily reflected back because of the extremely low acoustic impedance of air. The coupling gel's main purpose is to overcome the low acoustic impedance in this region and to penetrate towards the tissues in intended to derive information from. A gel is an effective coupling material if it can effectively break through this interface and successfully reflect back diagnostically important signals.

A sample of ultrasound images derived in this study is shown in figure 1. This figure shows two images, one acquired using the standard gel, and the other one derived using the alternative gel. Inspecting the figure will show that the organ of interest (liver) is clearly observable for both types of coupling gel. It can be safely argued that the ultrasound waves successfully penetrated the air-tissue interface and reflected back diagnostically important information. From these images, we can safely affirm that the experimental coupling gel successfully served its intended purpose.

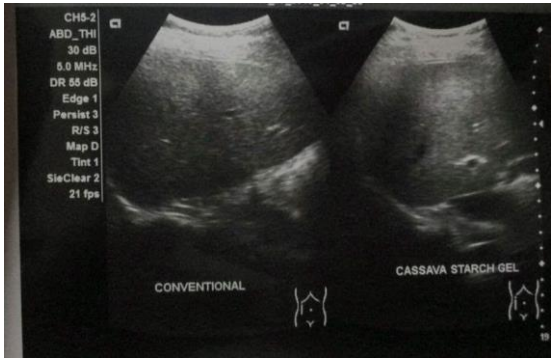

Figure 1. Ultrasound images of the liver acquired using both experimental and standard coupling gels

To fully evaluate the possible the possible clinical application of this alternative gel, the acquired images were sent to five practicing radiologists for full clinical evaluation. This stage is very essential because interpretation of the diagnostic information is professionally conducted by a radiologist. They are legally tasked to interpret the images and provide the diagnostic

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information needed for the medical diagnosis. The primary purpose of conducting diagnostic examination is to derive the information needed for medical diagnosis. In this aspect, the most important criterion is the diagnostic acceptability of the images.

Summary of the radiologists' evaluation of the quality scores of the images are shown in the figure below (figure 2).

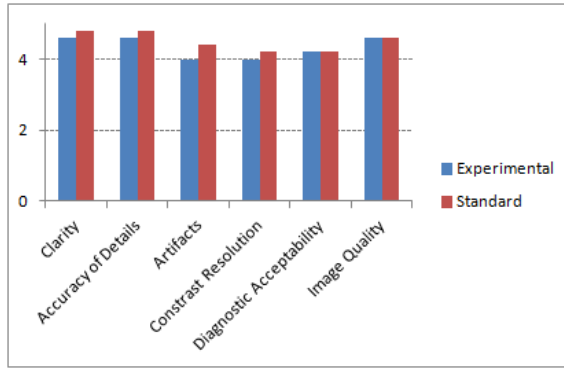

Figure 2. Summary of radiologist evaluation score for images acquired using the experimental (blue) and standard (red) coupling gels

Analysis of the graph indicates that, in general, the quality scores of the images derived from both coupling gels are very close to each other. Although the quality scores of images taken using the standard gel has generally higher scores compared that of the experimental gel it is worth noting, however, that the scores are not significantly different from each other. It is worth mentioning that the diagnostic acceptability scores of the images acquired from both types of coupling gels are equal. It should be remembered that diagnostic acceptability is the most important criterion in evaluating diagnostic information.

To fully determine whether the differences in quality criteria scores of the images are statistically significant, a two sample non-parametric test of statistical significance (Wilcoxon Mann-Whitney) is conducted. The result of the test is shown in table 1.

Table 1. Result of the Wilcoxon Mann-Whitney test of statistical difference between image quality scores of the images acquired from experimental and standard coupling gels. Test are conducted at 95% confidence interval.

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Quality Criteria	p-value
Clarity	0.13
Accuracy of Details	0.13
Artifacts	0.17
Contrast Resolution	0.34
Spatial Resoltion	0.9
Image Quality	0.55
Diagnostic Acceptability	0.51

α=0.05,

The results presented in table 1 show that median score of the all the quality criteria of images derived from both experimental and standard coupling gels are statistically not significant.

These results mean that using the cassava starch-based coupling gel can successfully provide images that (a) one can distinguish two separate objects that are close (Spatial contrast), (b) view structures without unnecessary artifacts, (c) has a clear visualization of contrast between structures (contrast resolution), (d) good image quality, and lastly, and the most important, (e) can provide the necessary diagnostic information.

These results suggest that the experimental gel derived from cassava starch can be successfully used for clinical ultrasound applications. The results imply that the experimental coupling gel can provide the same level of image quality comparable to one acquired using a standard gel.

CONCLUSION

This research successfully prepared an alternative coupling gel derived from cassava starch. The experimental coupling gel successfully produced diagnostically acceptable ultrasound images. In addition, based on the evaluation of practicing radiologists, the quality scores of the images acquired using the cassava-based coupling gel are not statistically different from quality scores of the images derived from using the standard coupling gel. The results of this study imply that the coupling derived from cassava starch has a very good potential for direct clinical application.

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