COCONUT WATER AS AN ALTERNATIVE OF RADIOGRAPHIC CONTRAST MEDIA: A PRELIMINARY STUDY

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ABSTRACT

Introduction: Radiographic contrast medium is primarily used to enhance the contrast of the internal structure in diagnostic imaging. However, the adverse reactions of administration of contrast media have become a great concern and challenge since it can affect the life of patient. Even though some safety measurements have been highlighted by several studies, still, the occurrence of adverse effects of contrast media is one of the issues in medical imaging. There are several similar properties between the young coconut water and contrast media used in radiography. Thus, the objective of this research was to investigate whether the young coconut water be used as an alternative to contrast media. **Methods:** Polyvinyl chloride tubes with equal internal diameter labeled A and B were inserted into a small tunnel of contiguous slices of Art Phantom. In the tube A contrast medium of Omnipaque 350 mgI/ml and in B tube young coconut water was filled. The phantom was exposed using general x-ray system Siemens MULTIX Top with two different parameter settings, i.e., 73 kVp @ 1.89 mAs and 81 kVp @ 1.85 mAs. Image quality criteria scoring were performed to evaluate the image quality of radiographs. **Results:** Findings of this study showed no improvement and poor detectability of tube B in the radiograph with the coconut water as compared to contrast medium. **Conclusions:** It is concluded that the coconut water specifically used in this study could not be used as an alternative to contrast media. However, more research could be conducted with the use of similar viscosity of the coconut water as contrast media as an alternative contrast agent.

KEYWORDS: Medical imaging, Radiography, Contrast media, Coconut water, Image quality

INTRODUCTION

The use of contrast media in medical imaging departments is continuously increasing. Administration of contrast media into a patient body may help the healthcare practitioner to study any abnormalities or physiological changes in the organ structure. Contrast material is a substance that is primarily used to outline the body's structure which alter the attenuation properties of the structures once it is injected into the body. Usually, contrast media is used in a special radiography procedure involving sophisticated imaging modalities setting such as MRI and CT scan. The use of different type of contrast media depends on several factors which include the type of examination, different categories of patients and patient's history. There are two type of contrast media used in the clinical setting named as positive contrast media and negative contrast media. The primary function of contrast media is to improve the visibility of internal organs and structures in X-ray base imaging techniques (Andreucci, et al., 2014).

Even though the use of contrast media has many advantages towards the finding of the examinations, it poses the adverse reactions on patients. Ives, et al., (2014) reported that the incidence of adverse contrast media reactions can become the main concern lately. The adverse effect of contrast media can be categorized into two which is acute adverse reaction and delay reaction. In general, different categories of contrast media might give different adverse effects depending on patient susceptibility. Literature show that the side effects of contrast media range from mild to a life-threatening depending on the patient consideration while injecting the contrast media in the clinical procedure (O'Donnell et al., 2010; Pasternak and Williamson, 2012; Chand, et al., 2013). According to Bottinor, et al., (2013), an individual with a previous history of iodinated contrast media may experience up to 44% risk of reaction upon re-exposure to iodinated contrast media and asthma patient might have a tendency of 10 times higher risk of a severe reaction.

Concerning to the adverse effects of contrast media, we assume that the young coconut (*Cocos nucifera L*) water might be useful as an alternative to contrast media. Since, the coconut water has some similarities with contrast media in terms of several factors such as; potential of hydrogen (pH) value, viscosity at 25 °C, the sensitivity factors and the color as shown in Table I. This suggest that the coconut water may provide the useful structural information of the patient body as same as that contrast media once it is injected into the patient's body.

In addition, this liquid has some resemblances with the human plasma (Cheuvront, et al., 2014). DebMandal and Mandal (2011) highlighted that the osmotic pressure of plasma and coconut water is almost similar due to the same electrolyte concentration it does not affect plasma coagulation. Campbell-falck, et al., (2000) reported that the electrolyte composition of coconut water resembles intracellular fluid more closely than extracellular plasma. According to Dandin, et al., (2015) coconut water can be injected intravenously in the case of emergency which is readily accepted by the body since it does not destroy the red blood cells. Furthermore, the coconut water is a natural product that has many applications in health, such as; consumption of coconut water within a certain period can control hypertension and hypercholesterolemia diseases (Dandin et al., 2015). Brown (2014) as cited in Saif Alyaqoubi et al., 2015, stated that the presence of lauric acid in coconut water helps in reducing the possibility of high cholesterol level, heart disease and stroke risks. In addition, coconut water is rich in its multiple biochemical composition and vitamins which are good and beneficial for a human use.

Table 1 Show the properties of contrast media and coconut water

Properties	Contrast media	Coconut water
pH value	6.8 to 7.7 (GE healthcare, 2015)	5.5 ± 0.5 (Chidambaram et al., 2013)
Viscosity at 25° C	5.1 mPa.s for Iopamidol (510) 8.8 mPa.s for Iopamidol (612) (ACR committee on drugs and contrast media, 2016)	(5.13±0.01) mPa.s at 5.3 °Brix, 0.982 a^{w} (8.82±0.01) mPa.s at 36.4 °Brix, 0.935 a^{w} (Manjunatha and Raju, 2013)
Color of the solution	Pure and colourless	Pure and colourless
Sensitivity depending on	Temperature Concentration (GE Healthcare, 2015)	Temperature Total soluble solid content Water activity (Manjunatha and Raju, 2013)

However, no research has been conducted yet that uses coconut water as the alternative to contrast media. Therefore, this work investigates the use of young coconut water as an alternative of a contrast media in conventional X-ray imaging.

METHODS

General X-ray System and Phantom

The research was conducted by using general X-ray system of Siemens MULTIX Top. In this study, a large focal spot was selected since the region of interest was the lumbar part of the phantom (the Art Phantom). The art phantom is comprised on 35 contiguous sections from the head to torso section. There are several sets of tie rods located within a slice of phantom to provide more compact assembly as shown in Figure 1.

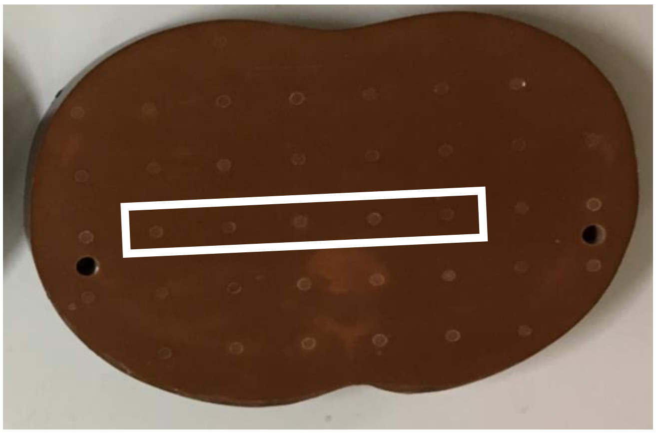

Figure 1 Several sets of tie rods located within the Art Phantom as shown in the white box.

Each section has the same thickness which is approximately 2.5 cm but different in size. For example, the size of head section is rather smaller as compared to the chest section. In this study, section 20 to 22 were chosen as these sections represent the lumbar region. Lumbar region was preferred since it has the softest tissue area such as the retroperitoneal organ (Figure 2). The reason for the selection of this section is that these sections can provide better visualization of the image of tubes containing coconut water and contrast media without superimposition of bones.

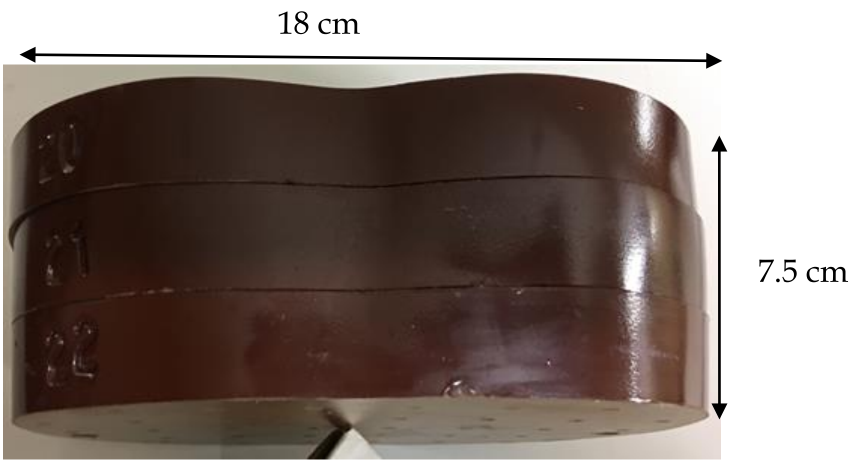

Figure 2 Section 20, 21 and 22 of the lumbar region with measurement of 18 cm width and 7.5cm length.

The beam used was in the vertical direction with the phantom which was positioned on the floating table-top. Moreover, 73 kVp @ 1.89 mAs and 81 kVp @ 1.85 mAs were the selected parameters. In this work, AEC and table grid were also utilized. The quality control of the x-ray system was performed.

Computed Radiography System

In this study computed radiography (CR) system CR Console (CR-1R 348CL) with 12-bits grayscale monitor was used. Imaging plate reader FRC CAPSULA XLII Image Reader Unit (CR-IR 359) was employed. FCR FUJI IP CASSETTE by FUJIFILM Corporation of the size 35×43 cm cassette with a crosswise orientation was chosen to accommodate the lumbar region of the phantom.

Preparation of Phantom for Imaging

The contrast medium (Omnipaque 350 mgI/ml) and coconut water was injected into polyvinyl chloride (PVC) tubes. The diameter of each tube was 0.5 cm and 10 cm long. Two syringes of 5cc/mL were labelled individually as contrast medium and coconut water. For each solution, only 5 ml was inserted inside the syringes. Then, each volume of solution was injected into the designated tube. The tubes then were labelled as A and B. The tube A was filled with contrast medium and tube B was filled with coconut water. Modelling clay was used and placed at the end of each tube to block the flow/leakage of the solution. In order to avoid any error, it is a must to ensure that the tube is free from air or impurities inside the tube such as any form of liquid that would affect the overall image quality. The tubes were then inserted into the selected holes of the art phantom. The anatomical markers were used to label and indicate the appropriate place of the region of interest. Then, all the tubes containing solution were exposed to the radiation using general x-ray.

Image Acquisition

The most appropriate values used of kVp and mAs were 73 kVp @ 1.89 mAs and 81 kVp @ 1.85 mAs. The source-image distance was set at 100 cm. The region of interest covered several contiguous phantom slices from 20 until 22. The phantom was placed on the moving table of the general x-ray system. Then, imaging was adjusted at the center of the x-ray beam. This consideration is to avoid any error such as cut off the region of interest. Table bucky was also used in this study. This table bucky was located in between the art phantom and the imaging plate. Usually it is used to improve image quality by removing scattered radiation from reaching the image receptor. Furthermore, the right anatomical marker was placed within the collimation area to indicate the correct right side of images. The phantom was exposed twice using selected technical exposure settings. Images were taken at Anteroposterior (AP) view. Overall, two radiographic images were produced with two sets of exposure settings. Upon completion of the radiographic study, images were printed for visual evaluation.

Image Quality Criteria Scoring

The image quality criteria scoring (ICS) were adopted from the European guidelines on quality criteria for diagnostic radiographic images (1995). ICS evaluation form consisted of three parts; A, B and C. Part A consisted of the information sheet regarding the conduct of research. Part B was comprised on the demographic information and part C consisted of image quality criteria scoring. The printed evaluation form was distributed among the radiographers once the respondent agreed to join in the study. A total of three evaluation forms were given out and two assessors were able to respond.

RESULTS

Radiographs shown in Figure 3 were analyzed qualitatively. Two selected exposure parameters were 73 kVp @ 1.89 mAs and 81 kVp @ 1.85 mAs as represented by Y and Z, respectively. Each individual radiograph contained two polyvinyl tubes which are represented as A and B. Polyvinyl tube A contained contrast media and polyvinyl tube B filled with young coconut water. Although tube C is presented on the radiograph, but it was excluded from the data analysis since it was filled with saline solution. There is a significant difference in visibility between image of tube A and B in both radiographs (Y and Z). The visibility of tube A can be appreciated in radiograph Y and Z (Figure 3).

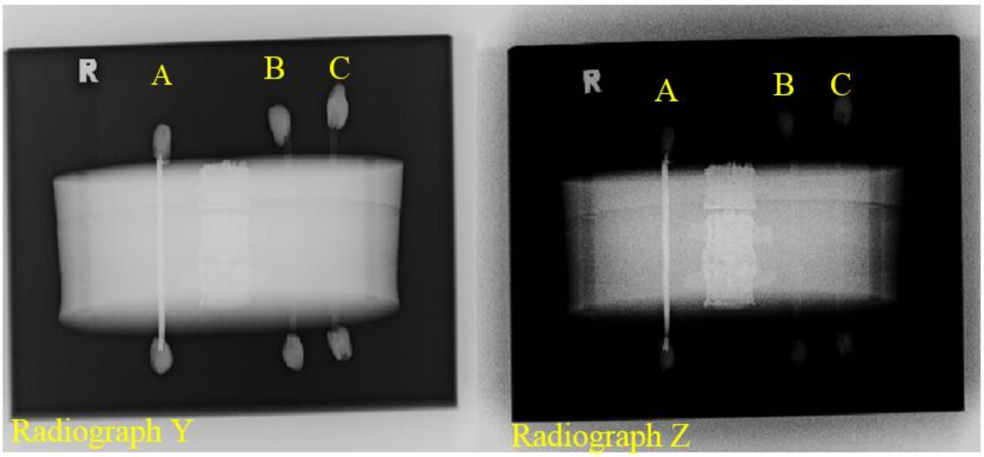

Figure 3 Radiograph Y (73 kVp @ 1.89 mAs) and Radiograph (81 kVp @ 1.85 mAs)

Image Quality Criteria Scoring evaluation was performed by the radiographers in terms of the bony trabecular pattern (BTP) and bony cortical outline (BCO) of the individual tube. This method is considered as a subjective since each radiographer was required to analyse the image quality based on their perception. This guideline is primarily focused on the clinical setting but, yet it is still relevant to be implemented in this study.

Based on Table II, both radiographs with two selected parameters were accepted as a general. Furthermore, in Figure 4a and b, two parameters were used for the visibility of image of tube A and B based upon the criteria of BTP and BCO. The y-axis of the column chart shows the image acceptability while the x-axis represented the image quality of tube A and B accordingly. Tube A denoted as the contrast media solution meanwhile tube B denoted as young coconut water. The greater acceptability of the tube was proven based on the higher number of scoring given by the radiographers.

Table 2 Evaluation of film acceptability using two different parameters

	73 kVp @ 1.89 mAs	81 kVp @ 1.85 mAs
Appropriate overall film density (blackening)*	75% for tube A 25% for tube B	75% for tube A 25% for tube B

Appropriate overall film contrast	75% for tube A 25% for tube B	75% for tube A 25% for tube B
Film acceptability	100%	100%

Overall, both selected parameters were acceptable for the visualization of BTP and BCO of tube A with the highest scoring of three. As in Figure 4a and b, tube A scored the highest image acceptability based upon the evaluation of BTP and BCO as compared to tube B. The visibility of tube A in terms of the BTP and BCO can be appreciated with the use of two different parameters. However, the score for image acceptability of tube B is rather poor as compared to tube A. Furthermore, the score for image acceptability of tube B was rather lower as compared to tube A which only scored 25%.

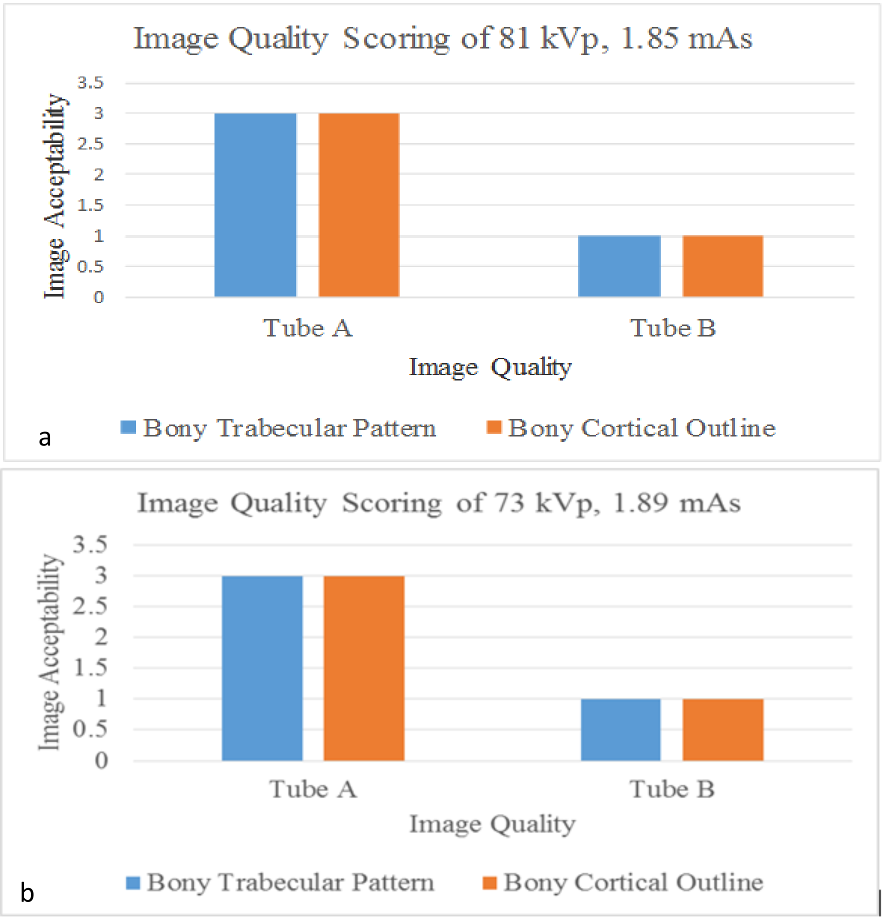

Figure 4 Image quality score of two exposure settings (a) 73 kVp @ 1.89 mAs and (b) 81 kVp @ 1.85 mAs

DISCUSSION

This study was conducted to determine the suitability of young coconut water as an alternative to contrast media. The difference in the image quality at different kVp and mAs settings was investigated. The qualitative analysis was done using Image Quality Criteria Scoring. For ICS, the criteria chosen were taken from image quality criteria as proposed in European guidelines on quality criteria for diagnostic radiographic images, 1995. ICS approach that graded the image quality according to three scales, i.e., poor, equivalent and good. This approach was used to evaluate the image quality of the selected radiographs in terms BTP and BCO of the visibility of image of tube A and B, of images shown in Figure 4a and b.

The visualization of the image of tube B could not be appreciated much due to its attenuation properties which somehow differ from the contrast media. Attenuation is the reduction in certain percentage of x-ray photon after passing through a material (Carlton & Adler, 2013). Attenuation process is influenced by the amount and type of irradiated material. For example, positive contrast media has higher atomic number as compared to the surrounding tissue which result higher attenuation and brighter appearance in radiographic film (Zainul Ibrahim, 2014). The reason for not achieving the equal image as that was obtained with the contrast medium could be the lower viscosity of young coconut water. Since, the viscosity of any contrast media plays an important role in providing the quality of radiographic images. In this work, we were unable to measure the viscosity of the coconut water samples due to the time constraint. Therefore, it is highly recommended to conduct the research using the coconut water of different places. Furthermore, it would be better to measure the viscosity of the samples before conducting the experiment. In addition, the number of assessors for evaluating the overall data must be large to avoid bias in findings of the study.

CONCLUSION(S)

Based on the quantitative and qualitative method used in this study, all the finding show that the visibility of coconut water is poor as compared to contrast media. It is proven that the appearance of coconut water could not be appreciated by the application of ICS. Even though both technical exposures were accepted to demonstrate tube A and tube B, still, the visibility of tube B was poor as compared to tube A. Therefore, the coconut water specifically used in this study could not be used as an alternative to contrast media. However, more research could be conducted with the use of similar viscosity of the coconut water as contrast media as an alternative contrast agent.

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