Alternative gel based material red seaweed for ultrasonography examination

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Received March 2017
Accepted as revised May 2017

Abstract

Background: Red seaweed extract of kappa and iota carrageenan is commonly used as a gel base. Kappa carrageenan is stiffed or breakable that may experience syneresis. Iota carrageenan has a softer gel texture, elastic, and has less possibility of syneresis, but not as strong as kappa carrageenan gel. Therefore, kappa and iota carrageenan can be mixed to obtain better gel properties and water-soluble. It will be proposed as a carrageenan-based ultrasound gel as acoustics connector, certainly in renal ultrasonography (USG) examination.

Objectives: To demonstrate the ability of gel made from red seaweed extract as an intermediary for ultrasonic waves in ultrasound examination.

Materials and methods: A quasi-experimental study with post-test only control group design to reveal the potency of red seaweed (carrageenan) extract as an alternative gel in renal USG examination. A total of 22 voluntary respondents were included in this present study.

Results: Red seaweed extract based gel can be used as an intermediary for ultrasonic waves in ultrasound examination. Quality of renal ultrasound image by a well-known manufactured carbomer-based ultrasound gel product (Gel A) compared to alternative carrageenan-based ultrasound gel (Gel B) was not different.

Conclusion: The finding is carrying an expectation to lift the potency of red seaweed extract as carrageenan-based ultrasound gel in renal ultrasonography (USG) examination. Considering its environmental friendly and inexpensive nature, carrageenan-based gel extracted from red seaweed can be proposed as an alternative ultrasound gel in renal ultrasonography (USG) examination

Journal of Associated Medical Sciences 2017; 50(2): 307-313. Doi: 10.14456/jams.2017.31

Keywords: Red seaweed, carrageenan, ultrasound gels, radiology, USG examination.

Introduction

In general, seaweed grows attached to certain substrates, has no roots, stems and true leaves which then called talus. Seaweed taxonomically grouped into *Thallophyta* division, with four major classes, namely: *Chlorophyceae* (green algae), *Phaeophyceae* (brown algae), *Rhodophyceae* (red algae) and *Cyanophyceae* (blue-green algae).[1] Beside it has good potential for health,[2] seaweed has high economic values since it produces primary metabolites of hydrocolloid compound. Several species such as *Glacelaria sp* and *Gelidium sp/agarophyte, Sargassum sp/alginophyte* are well-known as primary sources for metabolites called alginate which widely used as a thickener/viscosity regulators, gelling agent, stabilizer, body shaper, emulsifiers, and suspending agents.[3,4]

Carrageenan, a natural carbohydrate (polysaccharide), derived from red seaweed, *Hypnea* sp, and *Eucheuna sp/ carrageenophyte*,[5] has been used in food industry as a viscosity controller, gelling agent, stabilizer.[6] Carrageenan Kappa and iota can also be sources of fiber to improve elasticity of dry noodles.[7] Furthermore, in non-food industries, *Carrageenan* has also been widely used in pharmaceuticals, cosmetics and textiles as stabilizer, toothpaste, liquid absorbent in wound closure and as drug packaging materials.[8] Other study found Carrageenan can also be used as hydrogel raw material.[9]

The gel is defined as a semi-solid system comprising a dispersion composed of either small inorganic particles or large organic molecules or accompanied by liquids.[10] Gel has viscous properties, does not leave a layer of oil on skin and provides a cooling effect when applied to skin surface.[11] Since gel is made from cornstarch and water, it can be used as a coupling medium which provided better images compared to commercial ultrasound gel.[12] Ultrasound gel serves as an intermediary for ultrasonic waves from transducer to body surface in the form of semi-solid/gel. A gel as a conductor of ultrasonic wave's media will reduce the constraints caused by air that forms a barrier which can reflect ultrasonic waves so that penetration of waves on the body will be hindered.[13] In many cases, using insufficient gel will cause the occurrence of artifacts that affect the quality of ultrasound image.

Indonesia is an archipelago comprises of 17,508 islands with a coastline of 81,000 km (the second longest after Canada) and sea area of about 5 million km^2 or 62% of the total area of Indonesia leaving a potential of marine resources to be explored.[14] Seaweed, as one of the marine biological resources is often used as a useful gelling agent, stabilizer, emulsifier agent, suspending agent, dispersants in various industries, especially the pharmaceutical and healthcare.[4] In the reproductive health industry, red seaweed extract of kappa and iota carrageenan is commonly used as a gel base. Kappa carrageenan has a stiffed or breakable gel properties that may experience syneresis while iota carrageenan has a softer gel texture, elastic, and has less possibility of syneresis, but not as strong as kappa carrageenan gel.[15] Therefore, kappa and iota carrageenan can be mixed to obtain better gel properties[16] with water-soluble gel as acoustics connector in the preparation.[17] In addition, kappa carrageenan gel has its advantage because it's originally derived from the natural polymer which is an environmental friendly compared to carbomer 940 that widely used in Indonesia. Compared to the imported synthetic carbomer 940, kappa carrageenan is also known as non-toxic material and renewable bio-source which is inexpensive and can be found easily as a local resource. Therefore, this study aims to demonstrate the ability of gel made from red seaweed extract as an intermediary for the ultrasonic waves in ultrasound examination.

Materials and methods

Study design

This is a quasi-experimental study with post-test only control group design to reveal the potency of red seaweed (carrageenan) extract as an alternative gel in renal USG examination. A total of 22 respondents were involved in the study. Number of samples was determined by Slovin formula with error tolerance limit of 5%. A manufactured ultrasound gel product (carbomer-based), often used for USG examination, was applied to the respondents. Figure 1 presents the protocols of the study, including the steps of preparation until the ultrasound examination.

Carrageenan-based gel preparation

Kappa-carrageenan powder, extracted from red seaweed, was mixed with iota-carrageenan powder (1:1, w/w) to formulate carrageenan-based gel. Kappa carrageenan has its limitation with high possibility of elasticity while iota itself is an elastic gel with low elasticity possibility. Therefore, a 1:1 formulation was found as an optimal composition to produce the best quality of gel by eliminating the kappa and iota weaknesses.6 A total of 3.0 gm composited carrageenan powder was mixed subsequently with 100 mL of distillation water and 10.0 gm of glycerin and stirred during the process (100-150 rpm).

Ultrasound gel application

A total of 10 mL of gel was applied subsequently at the right area of respondents' abdomen. At the subcostal area of subjects, an acrylic print was placed to indicate area of ultrasound transducer. After measurement, the applied area was cleaned properly before administered with another gel.

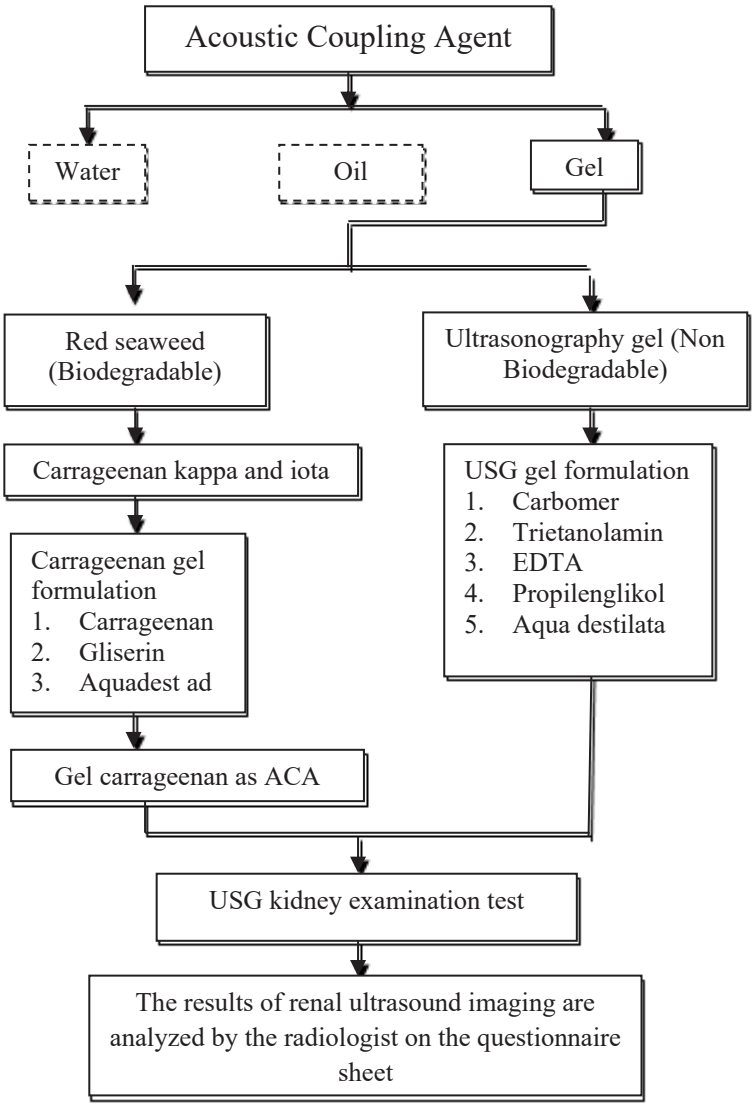


Figure 1. *Study protocols and procedures.*

Renal ultrasonography (USG) examination

Ultrasound gel trial and examination were conducted at the Integrated Laboratory of Health Polytechnic Semarang (POLTEKKES Kemenkes Semarang), Indonesia. A convex transducer was set at a frequency of 4.0 MHz. Respondent was instructed to hold his or her breath before examination. Ultrasound transducer was positioned transversal with no angle to obtain the desired ultrasound visualization results and then freeze button was pressed.

Analysis instruments

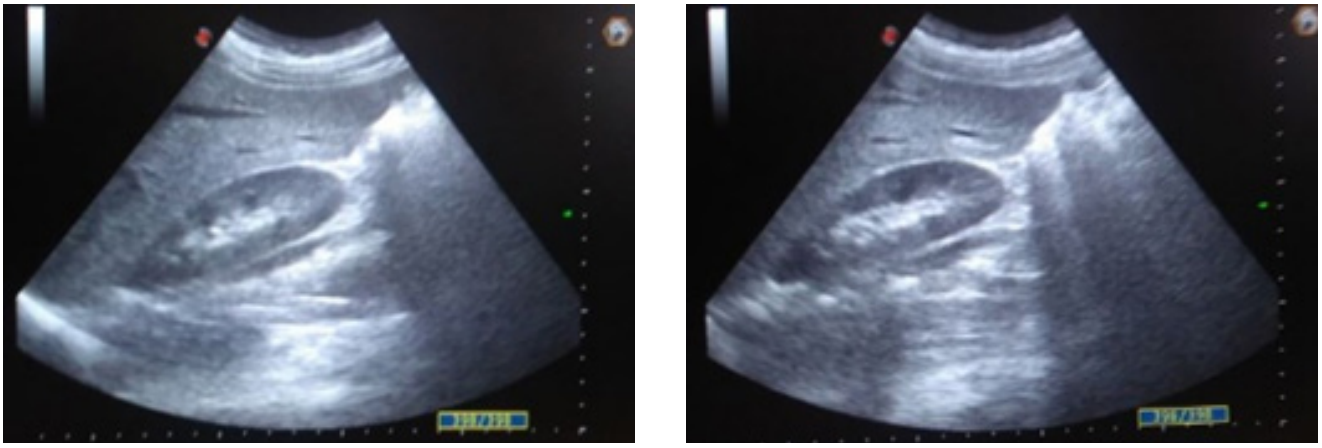
Quality of renal ultrasound image was assessed by two radiologists using a questionnaire. From the results of renal USG examination, McNemar test was used to determine whether carrageenan-based gel formulation yields different effectiveness to renal USG examination, compared to manufactured ultrasound gel product. Kappa test was employed to validate the reliability of assessors' perception to the results.

Ethical consideration

Treatment and handling procedures were approved by Ethical Commission for Health Research (KEPK) of Politeknik Kesehatan Kemenkes Semarang, Indonesia, on December 1st, 2016, (Reference number: 243/KEPK/Poltekkes-Smg/EC/2016).

Results

This present study compared the result of renal USG image using a well-known manufactured ultrasound gel product, later mentioned as Gel A, and carrageenan-based gel (Gel B). As shown in Figure 1, carrageenan-based ultrasound gel results in a relatively accepted 2 dimension (2D) image of renal ultrasonography (USG) examination.



(a) (b)

Figure 1. *Renal ultrasonography (USG) image using a well-known manufactured carbomer-based ultrasound gel product (a) and a proposed alternative carrageenan-based ultrasound gel (b).*

The findings proved that carrageenan-based gel extracted from red seaweed, can be proposed as an alternative ultrasound gel in renal ultrasonography (USG) examination. From Table 1, it was found that quality of renal ultrasound image by a well-known manufactured carbomer-based ultrasound gel product (Gel A) and a proposed alternative carrageenan-based ultrasound gel (Gel B) was not different. McNemar test supported the data orchestrating there was no different quality of renal ultrasound image using two tested gels (p value = 0.180). From 22 tests, radiologists declared that by applying the manufactured carbomer-based ultrasound gel product (Gel A) in renal ultrasonography (USG) examination resulted with 10 good outputs. In another hand, 16 of 22 images were categorized good when administered the proposed carrageenan-based gel in the renal USG examination. The data, moreover, exhibits carrageenan-based ultrasound gel (Gel B) yielded more images with good quality.

Table 1 The quality of renal ultrasound image by a well-known manufactured carbomer-based ultrasound gel product (Gel A) and a proposed alternative carrageenan-based ultrasound gel (Gel B). (N=22)

Ultrasound gels	Quality of renal ultrasound image				*p*-value
	Moderate		Good		
	Number	Percentage (%)	Number	Percentage (%)	
Gel A	12	54.5	10	45.5	0.180
Gel B	6	27.3	16	72.7	

The quality of renal ultrasound images was determined by two independent radiologists. By Kappa test, reliability of the two radiologists' view to two categorical variables (moderate and good) was not different. Two radiologists admitted similar agreement and perception determining the quality of renal ultrasound images at p value = 0.137 and Cohen's kappa (percent agreement) of 79.2% to the results either applied by well-known manufactured carbomer-based ultrasound gel product (Gel A) or proposed alternative carrageenan-based ultrasound gel (Gel B).

Discussion

Carrageenan is a hydrocolloid compound of a long chain polysaccharide extracted from red seaweed. It is composed of D-galactose and L-galactose 3.6 a hydro galactose linked by glycosidic bonds 1-4. Degree of viscosity of carrageenan is affected by its concentration, temperature and other soluble molecules in mixture.[6] Carrageenan has a molecular weight of about 400-600 kDa and a high polydispersity.[18] By its physical appearance, carrageenan is yellow, brown to white, tasteless and odorless. It is a fibrous course to smooth powder with a viscosity of ± 5 cP at a temperature of 75ºC.[19] Carrageenan, a viscosifying polysaccharide, has been studied widely as a gel-forming material in food industry, pharmaceutical or other commercial purposes.[5] In food industry, carrageenan is common in making of vinegar and ethanol production from pineapple cannery waste.[5] Carrageenan has very low toxicity and been shown not to be teratogenic. Carrageenan is also well-known as emulsifier and stabilizer in the production of soymilk, chocolate and other flavored milk, dairy products, infant formulas, and nutritional supplement beverages. In pharmaceutical industry, the carrageenan gel beads which hardened with glutaraldehyde is also frequently used for the synthesis of amoxicillin and cefadroxil.[5]

In this study, carrageenan-based gel formulation from red seaweed extract was examined. A composite of kappa-carrageenan and iota-carrageenan with an optimal ratio of 1:1 was used considering the differences in physical and chemical configuration of two structures. Kappa carrageenan has stiffed gel properties that may experience syneresis while iota carrageenan with its softer gel texture and elasticity has an advantage over gelatin gels with a higher melting point which more suitable in tropical climates or where refrigeration is not available. By mixing kappa and iota, the weaknesses nature of kappa and iota carrageenan was covered. It is true that water may perform as an acoustic connector between the transducer and the body surface. But given that water will quickly evaporate as a result of body heat, especially when the transducer is moved, therefore water is not recommended to be used. Instead, water-soluble gel is considered as the best acoustic connector.[17]

The present study compared USG examination using two different gels, namely gel A (manufactured, carbomer-based) and gel B (made from red seaweed/ carrageenan). Both carbomer-based ultrasound gel and seaweed extract based gel can display good results of ultrasound images. From analysis, it was shown that there was no significant difference between gel A and gel B in producing an ultrasound image. Gel A in the study was a manufactured ultrasound gel component comprises of Carbomer 940, triethanolamine, EDTA, propilenglikol and

distilled aqua. Carbomer 940 itself is a synthetic polymer of acrylic acid which has a crosslink with allyl ether sucrose or an allyl ether of pentaerythritol. Carbomer (Carbopol) is a hydrophilic colloidal material that can be thickened and served better than natural gum. Dispersing carbomer into water will form a turbid acid solution which then neutralized with a strong base such as sodium hydroxide, with amines e.g. triethanolamine or weak inorganic alkali for example ammonium hydroxide, to improve consistency and reduce turbidity.[20] It is already well-recognized that Carbomer and red seaweed extract/carrageenan have the same function in turning water into a semi-solid or gel preparations, whilst gel on ultrasound examination will reduce the barrier that caused by air. Therefore, gel can be considered as a conductive medium for ultrasonic waves between transducer and skin surface. From results, ultrasound examination used carbomer-based gel (manufactured) and red seaweed/carrageenan extract gel could produce ultrasound images well. This proved that carbomer-based gel (manufactured) and red seaweed/carrageenan extract gel were similar in reducing the barrier caused by air so that ultrasonic waves can be transmitted from transducer to patient's body (the respondent).

Conclusion

Red seaweed extract based gel can be used as an intermediary for ultrasonic waves in ultrasound examination. USG images, produced by using gel made from red seaweed extract/carrageenan, were not different with manufactured carbomer-based gel in Indonesia. Considering its environmental friendly and inexpensive nature, carrageenan-based gel extracted from red seaweed can be proposed as an alternative ultrasound gel in renal ultrasonography (USG) examination.

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