Jasmine tea as a negative oral contrast agent in magnetic resonance cholangiopancreatography (MRCP)

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Abstract. Fluids of gastrointestinal system produce a high signal in 2D T2 Half-Fourier Acquisition Single-shot Turbo Spin Echo (HASTE) thick-slab MRCP which can overlap the biliary system image. This is the first experimental study use jasmine tea as oral contrast agent and aimed to evaluate it in improving the image quality of MRCP. This study was tested by phantom and healthy volunteers. Different types of tea phantom were tested which then calculated its signal-to-noise ratio (SNR) value and analyzed the manganese content. 15 healthy volunteers performed 2D T2 HASTE thick-slab MRCP scanning before and after administration of jasmine tea with a variation of 3 minutes, 6 minutes and 9 minutes scanning time. Qualitative analysis was carried out by MRCP questionnaire which was examined by radiologist and quantitative analysis was conducted by measuring the contrast-to-noise ratio (CNR) values. After jasmine tea administration, the image information was significantly different and CNR MRCP was increased compared to before giving negative oral contrast agent. The most optimal time to start scanning was 3 minutes after administration of jasmine tea with a volume of 300 ml (0.648 mg/dl manganese). Jasmine tea can be used as an alternative safe natural negative oral contrast agent and can improve MRCP image quality and reduce the intensity of gastrointestinal signals.

1. Introduction

The implementation of magnetic resonance imaging (MRI) modalities is effective in examining internal body and is able to make cross-sectional imaging and a detailed and accurate diagnosis, one of which is the magnetic resonance cholangiopancreatography (MRCP) in supporting the abnormalities diagnosis in the biliary system [1]. MRCP is proven to have a number of advantages in the clinical biliary system compared to endoscopic retrograde cholangiopancreatography (ERCP) which is the common reference for imaging the pancreatobiliary system. MRCP has a high sensitivity and specificity, almost the same as ERCP, to assess the level and morphology of biliary stricture. MRCP examination has 96% sensitivity, 86% specificity and 90% accuracy in determining obstruction in the bile duct, while in detecting choledocholithiasis, MRCP examination has 86% sensitivity, 90% specificity and 89% accuracy [2]. In the diagnosis of soft tissue disease, MRCP is 100% sensitive compared to ultrasound (80.77%), which is more sensitive than computed tomography (CT) scan (54.55%), so MRCP is an important non-invasive imaging in the evaluation of pre-operative patients with obstructive jaundice [3].
MRCP procedures generally utilize two or three dimensional (2D/3D) T2-weighted (T2W) fast imaging sequence with breath-hold or trigger navigator and are performed without contrast agent. Fluid in the gastrointestinal system can overlap with the biliary system so that it can produce pseudo-strictures. Fluid in the stomach or duodenum can also produce pseudolesion in the biliary tract due to close anatomic structures. Fluid located in the stomach may be misunderstood as fluid in the pancreatic duct irregular ectasia. If there is fluid and air in the duodenum, there may be an error in reading the pathology of gallbladder stone images, and if there is a duodenal diverticulum, the image can be like a cystic mass in the pancreas [4][5]. The overlapping problem can be overcome through negative oral contrast agent. The content of manganese (Mn) on negative contrast agent can be used to shorten the T2 relaxation time thereby reducing the intensity of the fluid T2 signal which is in the gastrointestinal system and the biliary system [6][7].

Negative oral contrast agents used for abdominal examination are gadopentetate dimeglumine, ferric ammonium citrate, manganese chloride, superparamagnetic iron oxide, ferumoxsil, barium sulphate and ferric particles. However, some of them are difficult to find and the price is relatively high and tastes bad although they can produce good hypointense on T2W [8]. Several studies have been conducted to find alternatives to natural negative oral contrast agent which are safer for patients and minimize the effects of allergies to chemicals on MRI examination by fruit and tea which contain a lot of manganese. The uses of natural contrast agent from blueberry and pineapple juice are relatively expensive and not available in all countries [7].

Tea beverage is the most common beverage which has a high number of mineral content, especially manganese [9] and has a relatively low price and easy to serve so that it can be used as an alternative to negative oral contrast agent for MRCP [7]. Jasmine tea is the combination of green tea with jasmine flowers through a mixing process with a dose that is able to produce a distinctive tea aroma and the most popular type of tea. In addition, jasmine tea has many advantages which affect health [10].

This study is expected to provide a safe, affordable, and easily accessible alternative to natural oral negative MRCP. Also, this study was able to find the best scanning start time of that alternative negative oral contrast agent.

2. Methods

This study implemented 2D T2 half-fourier acquisition single-shot turbo spin echo (HASTE) thick-slab MRCP sequence with time repetition (TR) 4500 ms; time echo (TE) 851 ms; field-of-view (FOV) 250 mm; slice thickness of 60 mm; slice gap of 50%; 320 x 224 matrix; flip angle 180° inspection parameters and used breath hold and fat saturation techniques. This parameters of 2D T2 HASTE thick-slab MRCP sequence were used in phantom study and volunteer study.

2.1. Phantom study

Phantom studies of various tea variations were carried out to 6 phantoms, namely water (control), black tea, oolong tea, green tea, jasmine tea, and vanilla aroma black tea. Each phantom of tea is filled with 2 grams of tea brewed with hot water (temperature of 98°C) 150 ml for 10 minutes. Then scanning was conducted with 2D T2 HASTE thick-slab MRCP sequence. The results of the image were measured by region of interest (ROI) signal (area 1 cm²) and compared with background noise. The selected image is the lowest signal-to-noise ratio (SNR) image or signal intensity equal to the noise level.

2.2. Volunteer study

The subjects of this study were volunteers with healthy inclusion criteria, young adults 18-35 years old, normal body mass index (BMI) 18.5-24.9 kg/m², normal abdominal circumference in Asia (men <90 cm and women <80 cm). The number of samples were 15 healthy volunteers, who underwent an MRCP with standard preparation for each fasting 6 hours before the examination. This study was carried out by administrering 4 gram selected tea drinks orally brewed with hot water (temperature 98°C) 300 ml for 10 minutes. The scanning time variations used were 3 minutes, 6 minutes and 9 minutes. Then the MRCP
image information was assessed before and after the administration of selected tea orally and was expected to obtain an optimal scanning time in enhancing the MRCP image.

The qualitative assessment of MRCP image was carried out through a questionnaire which was examined by three radiology specialists, and the data of the image assessment results were analyzed using the Friedman test. Questionnaires on the anatomy of the biliary system include gall bladder (GB), cystic duct (CD), common bile duct (CBD), common hepatic duct (CHD), intrahepatic duct (IHD), ampulla vateri (AV) and main pancreatic duct (MPD) as well as the intensity of the gastric and duodenal signals was done by the following Likert scale in Table 1 [14]:

Table 1. The evaluation standard of intensity of gastrointestinal tract and visibility of biliary system

| Biliary System | Gastrointestinal |
|----------------|------------------|
| scale 3 = good (the anatomy of biliary system and bile appeared very clear, bright and firm); | scale 3 = good (intensity of the gastric and duodenal signal at image were invisible); |
| scale 2 = sufficient (structure and boundaries of the anatomical wall of the biliary system and bile were quite clear, bright and firm but not as clear as those with score 3); | scale 2 = sufficient (parts of the stomach and duodenum appeared to have a high signal intensity but it did not interfere to read the image); |
| scale 1 = poor (structure and borderline of the anatomical wall of the biliary system and bile were not clear, bright and firm so it was difficult to find observed/unvisualized information) | scale 1 = poor (parts of the stomach and duodenum appeared to have high signal intensity and interfere to read images). |

Quantitative image assessment was conducted by calculating the anatomical SNR value by the formula as follows [7]:

\[
\text{SNR}_{\text{standard}} = \frac{\text{average signal of the organ}}{\text{standard deviation of noise}}
\]  

The area of anatomical ROI and background noise was 1 cm², while the ROI of the bile duct corresponded to the size of the duct. Then, the contrast-to-noise ratio (CNR) values of the gallbladder-duodenum, CBD-duodenum, CHD-duodenum, AV-duodenum and MPD-stomach were calculated. The image assessment data were analyzed through Repeated Measures Anova test.

3. Results

The selection of optimal teabag concentrations as MRCP negative oral contrast agent was carried out by tea scanning phantom and measured SNR values and tested in the Atomic Absorption Spectrophotometry (AAS) method laboratory on the Mn content of each tea type. Each type of the tea as shown in figure 1 and the result of SNR and Mn of each type as shown in table 2.

Figure 1. Five types of phantom tea images and water (control) on 2D T2W HASTE thickslab MRCP
Table 2. SNR of phantoms and Mn concentrations of tea

| Variants            | SNR     | Mn (mg/dl) |
|---------------------|---------|------------|
| Water (control)     | 2914.98±92.14 | -          |
| Black tea           | 175.71±5.17  | 0.231      |
| Green tea           | 1033.12±7.86 | 0.065      |
| Oolong tea          | 595.76±2.47  | 0.143      |
| Jasmine tea         | 58.53±2.59   | 0.648      |
| Vanilla black tea   | 423.31±16.77 | 0.227      |

SNR and Mn test results on various types of tea showed that the lowest SNR value and the highest Mn content were found in jasmine tea. Then jasmine tea was used for healthy volunteers.

Table 3. Comparison interobserver grading of MRCP images implemented Friedman test

| Criteria | Mean rank | p-value |
|----------|-----------|---------|
| GB       | 2.30      | 2.57    | 2.57    | 2.57    | 0.308    |
| CD       | 1.30      | 3.00    | 2.87    | 2.83    | p < 0.001<sup>a</sup>  |
| CBD      | 1.17      | 3.03    | 2.90    | 2.90    | p < 0.001<sup>b</sup>  |
| CHD      | 1.87      | 2.77    | 2.73    | 2.63    | 0.003<sup>a</sup>  |
| IHD      | 2.43      | 2.57    | 2.57    | 2.43    | 0.836    |
| AV       | 1.30      | 2.80    | 3.00    | 2.90    | p < 0.001<sup>b</sup>  |
| MPD      | 1.57      | 3.03    | 2.77    | 2.63    | p < 0.001<sup>b</sup>  |
| Stomach  | 1.00      | 3.13    | 3.03    | 2.83    | p < 0.001<sup>b</sup>  |
| Duodenum | 1.00      | 3.00    | 3.00    | 3.00    | p < 0.001<sup>b</sup>  |

<sup>a</sup> = p < 0.05, there was a significant difference between pre and post administration of jasmine tea

<sup>b</sup> = p < 0.001, there was a significant difference between pre and post administration of jasmine tea

GB= gallbladder; CD= cystic duct; CBD= common bile duct; CHD= common hepatic duct, IHD= intrahepatic duct; AV= ampula vateri; MPD= main pancreatic duct

Figure 2. The comparison of before and after administration of jasmine tea of MRCP images

The interobserver's assessment of the biliary tract images was illustrated in the graph as shown in figure 2. In that figure, before jasmine tea administration, the majority of the biliary tract had a value of poor whereas after jasmine tea administration, dominant obtained value of good.

There was a decrease in the signal intensity of gastrointestinal in MRCP images before and after administration of jasmine tea at variation start time scanning of 3 minutes as shown in Figure 3, and the comparison of the anatomy biliary tract of pre-, 3, 6 and minutes after administration of jasmine tea as shown in figure 4.
Figure 3. Comparison of gastrointestinal tract signal intensity in MRCP images between pre- (a) and after 3 minutes scanning of jasmine tea administration (b)

Figure 4. 2D T2 HASTE thick-slab MRCP of pre- (a), 3 minutes (b), 6 minutes (c) and 9 minutes (d) after administration of jasmine tea

The following were the results of image quality in the CNR. The difference between the anatomy of the biliary tract and the gastrointestinal tract which was close together of MRCP images before and after administration of jasmine tea. From the results of the table above, the CNR between GB-duodenum, CBD-duodenum, CHD-duodenum, AV-duodenum and MPD-stomach obtained significant differences to $p<0.001$, the results are as shown in Table 4.
Table 4. Comparison of CNR values to MRCP images by Repeated Measures Anova test

| Criteria           | Pre   | post-3' | post-6' | post-9' | p-value |
|--------------------|-------|---------|---------|---------|---------|
| GB – duodenum      | -56.19±1.66 | 223.37±6.42 | 219.88±6.58 | 214±7.29 | p < 0.001 |
| CBD – duodenum     | -249.47±9.9 | 30.41±4.96  | 31.91±8.67  | 29.64±8.61 | p < 0.001 |
| CHD – duodenum     | -232.63±11.09 | 51.89±3.26   | 52.88±1.64   | 50.48±2.03   | p < 0.001 |
| AV – duodenum      | -26.58±13.18 | 23.66±8.52   | 25.37±7.96   | 19.06±7.83   | p < 0.001 |
| MPD – stomach      | -292.38±13.58 | 21.49±1.19   | 21.37±1.03   | 17.04±9.75   | p < 0.001 |

4. Discussion

Tea was not fully tested for its ingredients in Indonesia, therefore it was necessary to evaluate its appearance and ability as a negative oral contrast agent by scanning phantom and testing its mineral content of Mn. Based on the study findings, good negative oral contrast agent used on MRCP were those with the lowest SNR value and the highest Mn content, it was revealed in the phantom of jasmine tea compared to other types of tea. Thus, jasmine tea was used for research volunteer.

There was a difference in MRCP image information before and after the administration of jasmine tea with 3 minutes, 6 minutes and 9 minutes scanning time variation with p <0.001. The difference was identified by a decrease in the intensity of the gastric and duodenal signals. Before the administration of jasmine tea negative oral contrast agent, a high signal was seen in the gastric and duodenal organs so that the biliary system appeared overlapping especially in the anatomy of the gallbladder, CBD, CHD, AV and MPD which produced unclear images. T2 HASTE coronal thick slab was a gold standard sequence in the MRCP which had a long TE value so that the time needed to decay up to 37% of its initial value (spin spin relaxation) which gave a high level of warming in the image of gastric fluid and duodenum when not using negative oral contrast agent.

Maximizing gastrointestinal intensity after negative oral contrast agent could be affected by the use of long TE values. The longer the TE time parameter used, the negative oral contrast agent of jasmine tea would further suppress the intensity of the gastric and duodenal signals. However, if the TE value was too long, it would cause artifacts (noise) in the image. The accuracy to the setting of TE value was very important, the TE value selected in this study was 851 ms. In accordance with previous studies, the optimal HASTE coronal thick-slab T2 sequence TE values was between 800-1000 ms to suppress the intensity of gastrointestinal signals by rosella tea [11]. Riordan et al selected TE 800 ms with negative oral contrast juice from pineapple juice [6] and Govindarajan et al also took TE of 800 ms by date syrup [12]. Hiraishi et al used a 70 ms short TE which produced MRCP images which were quite optimal but required a high concentration of blueberry juice manganese content [6].

The formulation of negative oral contrast agent per oral of jasmine tea contained manganese, resulting in a decrease in the level of signal intensity in the gastrointestinal lumen of the stomach and duodenum which were the main route of manganese mineral absorption. Manganese contained paramagnetic properties such as commonly used artificial contrast agent namely gadolinium, the contrast agent could shorten the relaxation time of the T2W sequence and reduce the signal intensity to produce dark signals in the image. Although gadolinium had become the most popular choice among paramagnetic metals and could be used as an oral contrast agent for MRCP, it was associated with potentially dangerous adverse effects of nephrogenic systemic fibrosis (NSF) in some patients [13].

The manganese content in the negative oral contrast agent of jasmine tea (4 grams) which was based on laboratory testing of the AAS method in 300 ml was 1,944 mg (0.648 mg/dl) which was proven to be able to suppress the intensity of the gastric and duodenal signals. The volume of jasmine tea was 300 ml because the average study volunteers were able to tolerate drinking jasmine tea in that volume range, even though the average stomach capacity of adults was around 1500 ml.
The results of previous studies which selected manganese-based natural negative oral contrast agent on MRCP conducted by Hiraishi et al on 300-500 ml blueberry juice were 9-15 mg (3.0 mg/dl) and Riordan et al in 400 ml pineapple juice was 11.04 mg (2.76 mg/dl) [6]. While the amount of manganese content of negative oral contrast agent study by tea beverage ingredients, namely in rosella flower tea (4 grams) in 480 ml was 1.28 mg Mn (0.267 mg/dl), black tea (6 grams) in 250 ml was 2.345 mg Mn (0.938 mg/dl) and oolong tea in 400 ml was 0.9 mg Mn (0.225 mg/dl) could describe the image of the biliary system and reduce high signal intensity in the gastrointestinal [11], [14], [15].

Significant differences between before and after administration of contrast agent on MRCP images are due to suppression of the intensity of the gastric and duodenal signals which previously appeared hyperintense to hypointense. However, there was no significant difference between variations in the scanning time of 3 minutes, 6 minutes, and 9 minutes after administration of contrast agent. In the 3 minutes variation, the negative oral contrast agent appeared to have entered the stomach and duodenum which was marked by a decrease in intensity so that the biliary system appeared clearer and did not overlap with the gastrointestinal tract. Whereas in the 6 minutes, the jasmine tea contrast agent appeared to have passed to the inferior duodenum and the stomach looked a little more grayish than the 3 minutes. At the 9 minutes scanning time variation, the stomach appeared more hyperintense than the 6 minutes. The intensity of the stomach which looked a little more grayish again due to the negative contrast agent of jasmine tea which had begun to go down from the stomach to the duodenum. Meanwhile, the presence of fluid produced by the stomach and the reflex of saliva which was ingested into the stomach could cause the intensity of bright signals in the stomach.

There was no difference in the images between before and after administration of jasmine tea by oral on the anatomy of the gallbladder and IHD, while on CD, CBD, CHD, AV and MPD presented significant differences. The gall bladder contained a bile so that both pre- and post- appeared hyperintense. Meanwhile, the anatomy of IHD was not too close to the gastrointestinal so that the image in pre- did not appear to overlap with the anatomy of the stomach or duodenum. The anatomy of CD, CBD, CHD, AV, and MPD on the image pre- sometimes did not appear due to its thin and homogeneous size and overlapping with the stomach and duodenum, but after administration of the negative oral contrast agent the jasmine tea, image appeared clearer. An increase in CNR value was due to dynamic signal compression in the gastrointestinal so that the anatomy of the biliary system which was relatively hyperintense would experience a CNR value which was significantly increased compared to no administration of negative oral contrast agent of jasmine tea.

5. Conclusion
Jasmine tea is effective as an alternative to negative oral contrast agent with a scanning time of 3 minutes after administration, it can reduce the intensity of the gastric and duodenal signals so that the anatomical information of the biliary system and CNR quality on MRCP images is increasing. Future studies are recommended to conduct MRCP studies with jasmine tea negative oral contrast agent in patients with specific indications/pathologies in the biliary system.

References
[1] Frisch A, Walter T C, Hamm B and Denecke T 2017 Acta Radiol. Open 6 9 1–7
[2] Pressacco J, Reinhold C, Barkun A N, Barkun J S, Valois E and Joseph L 2003 Proc. Int. Soc. Mag. Reson. Med 11 412
[3] Singh A, Mann H S, Thukral C L and Singh N R 2014 J. Clin. Diagnostic Res. 8 3 103–107
[4] Vitellas K M, Keogan M T, Spritzer C E and Nelson R C 2000 RSNA 20(4) pp 939–957
[5] Irie H, Honda H, Kuroiwa T, Kengo Y, Aibe H, Shinozaki K and Kouji M 2001 RSNA 21 1 23–37
[6] Riordan R D, Khonsari M, Jeffries J, Maskell G F and Cook P G 2004 Br. J. Radiol. 77 991–999
[7] Ghanaati H, Yazdi H R, Jalali A H, Abahashemi F, Shakiba M and Firouznia K 2011 Eur. Radiol. 21 25 51–57
[8] Sharip H, Azmi N N and Supar R 2016 Int. J. Heal. Sci. Res. 6 7 281–285
[9] Wrobel K, Wrobel K and Urbina E M C 2000 Biol. Trace Elem. Res. 78 271–280
[10] Gebretsadik D W and Chandravanshi B S 2010 Bull. Chem. Soc. Ethiop. 24 3 339–349
[11] Varavithya V, Phongkitkarun S, Jatchavala J, Ngeonthom S, Sumetchotimaytha W and Leelasithorn V 2005 J. Med. Assoc. Thail. 88 S35–S41
[12] Govindarajan A, Lakshmanan P M, Sarawagi R and Prabhakaran V 2014 AJR 203 1001–05
[13] Martin D R 2010 Am. J. Kidney Dis. 56 3 427–430
[14] Tang H H, Song B, Huang Z X and Yao H 2013 J. Sichuan Univ. (Medical Sci. Ed. 44 3 476–480
[15] Fatimah, Ari S, Sugiyanto and Ismi R 2018 Indian J. Public Heal. Res. Dev. 9 9 224–228