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Impact of Surrounding Colonic Tissue on Ultrasound Image Analysis of Retained Stool

Wanjing Bu[1†], Shinryu Matsuoka[2], Junko Yotsuya[3], and Masayuki Tanabe[4*]
([1]Kumamoto University; [2]Grad. School Sci. Technol., Kumamoto University; [3]Dept. Medicine, Fukui Univ.; [4]Fac. Adv. Sci. Technol., Kumamoto University)

1. Introduction

The prevalence of gastrointestinal disorders, such as constipation, diarrhea, and flatulence, is particularly significant in the aging population. As people age, they become more susceptible to these conditions due to factors like inactivity, inappropriate diet, and impaired rectal sensation[1)]. Ultrasound imaging provides a non-invasive and safe method to visualize and study the characteristics and location of retained stools. However, the accuracy of ultrasound image analysis relies on the operator's familiarity with interpreting the images, making it challenging for less experienced personnel to conduct precise assessments.

Previous studies have used descending colon ultrasonography to classify stool features and investigated the significance of the dataset[2,3)]. Conventional analytical approaches tend to concentrate on the inherent traits of retained fecal matter, often disregarding the plausible impact stemming from the neighboring colonic tissue during analysis. Therefore, to bridge this research gap, this study undertook adjustments in the colon image's detection range and extracted acoustic characteristic parameters to delineate the specific region. The study aims to evaluate the potential influence of encircling colonic tissue on the precision and dependability of ultrasound-based measurements pertaining to retained stool.

2. Method

The experimental conditions are listed in **Table I**. In this study, ten male participants exhibiting hard stools are utilized, and their colon ultrasound images are acquired. Subsequently, for each image, attention is directed towards specific regions through adjustments in cropping ranges.

By calculating the mean value in the horizontal direction, this study obtains the brightness attenuation slope in the vertical depth direction. Mean slope values and standard deviations show the effect of different tissue regions on the attenuation coefficient.

Table I. Experimental Conditions.

Patients	10 healthy males in their 20s
Stool type	hard
Image resolution	0.2 mm/pixel
Trimming size	horizontal: 60-80 mm vertical: 30, 40, 50 mm
Programing language	Python 3.11, OpenCV-Python (4.7.0)

3. Result

An example B-mode image with the bounding box is shown in **Fig. 1**. The red bounding box in the images was detected and labeled using a deep learning model based on YOLOv5. The size of the bounding box was 73 mm wide and 33 mm length. The tissue above the image corresponds to the colon wall, which is usually clearly delineated in ultrasound images, making it relatively easy to identify. Thus, this study mainly focuses on the effects of deeper tissue within the images.

In this experiment, the vertical range of 30, 40, and 50 mm was adjusted based on the horizontal line on the top of the bounding box, and the horizontal range was maintained.

Figure 2 shows the comparison of brightness attenuation coefficient differences across different depths. The absolute value of the slope decreases with increasing depth, indicating that changes in attenuation become less pronounced at greater depths. Concurrently, a reduction in the standard deviation implies greater consistency in attenuation values.

Comparatively, the mean brightness attenuation coefficient difference between 30 and 40 mm remained subtle, while the significantly lower standard deviation at 40 mm underscored its greater data stability. Simultaneously, the standard deviation

E-mail: †c0277@st.cs.kumamoto-u.ac.jp,
*mtanabe@cs.kumamoto-u.ac.jp

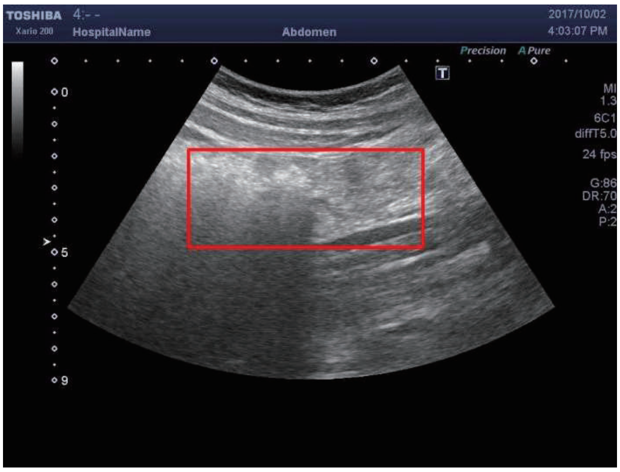

Fig. 1. Example of original B-mode image.

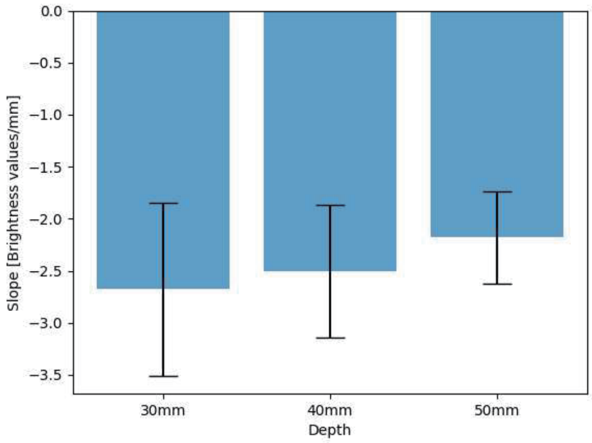

Fig. 2. Attenuation coefficient in different depths.

at a depth of 50 mm was reduced, and the mean slope notably diminished. The influence of the surrounding tissue became more pronounced as depth increased.

4. Conclusion

In this study, we introduced a method to analyze the influence of colon tissue on stool extent. The study determined stool retention area, adjusting area coordinates, simultaneously measuring attenuation coefficients of distinct regions, and conducted a comprehensive analysis of the acquired outcomes.

While the current study focuses on hard stools, forthcoming research will encompass soft, gas, and other stool types to comprehensively understand their characteristics and attenuation behavior. This research holds potential for refining the precision of ultrasound image interpretation and holds promise for clinical applications.

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