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Comparison of accuracy and time-efficiency of CT colonography between conventional and panoramic 3D interpretation methods: An anthropomorphic phantom study

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ABSTRACT

Purpose: To retrospectively compare the conventional three-dimensional (3D) interpretation method with the panoramic 3D method with regard to accuracy and time-efficiency in the detection of colonic polyps, using pig colonic phantoms as the standard of reference.

Materials and methods: One-hundred and sixty-two polyps were created in 18 pig colonic phantoms. CT colonography was performed with a 64-row detector CT scanner. Two-week interval reviews for the CTC image dataset with both the conventional and the panoramic 3D interpretation method were independently performed by three radiologists. The sensitivities of both methods were compared with the McNemar test. The mean interpretation time for each interpretation method was also assessed and compared with the Wilcoxon signed-rank test.

Results: Compared with the conventional 3D method (0.96 for reader 1, 0.89 for reader 2, and 0.97 for reader 3), the panoramic method revealed comparable sensitivities (0.91 for reader 1, 0.86 for reader 2, and 0.93 for reader 3) ($p > 0.05$). Interpretation time was significantly shorter with the panoramic method (115.1 ± 32.7 s for reader 1, 229.7 ± 72.2 s for reader 2, and 282.6 ± 113.7 s for reader 3) than with the conventional method (218.9 ± 59.9 s for reader 1, 379.4 ± 117.0 s for reader 2, and 458.7 ± 149.4 s for reader 3) for all readers ($p < 0.05$).

Conclusion: Compared with the conventional 3D interpretation method, the panoramic 3D interpretation method shows improved time-efficiency and comparable sensitivity in the detection of colonic polyps.

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1. Introduction

Colorectal cancer is the third most common cancer and the second leading cause of cancer-related death in Western countries. As with other malignancies, screening and early detection is essential for successful treatment of colorectal cancer. CT colonography is being increasingly adopted as a routine screening test for the detection of colorectal cancer in the last decade because it is more convenient and less invasive than colonoscopy. Indeed, a recent large trial of an asymptomatic population showed comparable sensitivity to that of colonoscopy for the detection of clinically significant polyps [1]. However, inconsistencies in the results have since been reported [2–4]. Image interpretation method is one of the factors influencing the quality of CT colonography.

Two different approaches have been adopted in the interpretation of CT colonography data; primary 2D and primary 3D. Although many interpreters prefer a primary 2D approach [5], the primary 3D approach has also shown promise and young radiologists who began image interpretation recently prefer the primary 3D approach as it is more intuitive and less reader-intensive [6]. Recently, Pickhardt et al. have reported the superior sensitivity of the primary 3D approach in detecting colonic polyps [7].

However, the primary 3D approach has some disadvantages. Among them, worse time-efficiency than the primary 2D method

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is considered as a major barrier to prevent radiologists use the primary 3D method in a clinical practice [8]. The main cause of the inferiority of the primary 3D method in time-efficiency is the existence of “blind areas” during the interpretation. Blind areas are the parts of the mucosa that are hidden by the colonic folds. To reduce blind spots, bidirectional fly-through navigations are needed, inevitably increasing interpretation time. Even after bidirectional review, blind areas might still remain with the conventional 3D interpretation method. Therefore, a special function of 3D workstation is mandatory to display such blind areas remained even after bidirectional fly-through navigations.

To overcome this limitation, various modified 3D interpretation methods including panoramic view have been developed [9–15]. Some investigators reported the usefulness of wide-angle field-of-view techniques, such as 120° or 140° compared to conventional 90° field-of-view [9,10]. However, to the best of our knowledge, previous studies regarding the diagnostic performance and time-efficiency of the panoramic 3D interpretation method have not been reported with definite standards of reference and large data sets.

Therefore, the purpose of our study was to retrospectively compare the conventional 3D interpretation method with the panoramic 3D interpretation method in terms of accuracy and time-effectiveness in the detection of colonic polyps, using pig colonic phantoms as the standard of reference.

2. Materials and methods

2.1. Preparation of pig colonic specimens

The authors had full control of the data and information included in this study. Approval was not required from the Institutional Animal Care and Use Committee of the hospital because the colonic phantoms were from previously butchered pigs. Eighteen pig colonic phantoms of approximately 120 cm length were prepared from fresh pig colons obtained from a commercial abattoir. All colon specimens were turned inside-out and cleansed of fecal material and the mucosal surface was checked for the absence of polyp-like lesions. On the basis of a previous study by Kim et al. [12], the number of the simulated polyps was determined as 156 for the equivalence test of the two different 3D interpretation methods. Type I error was 0.1 and type II error 0.2 (statistical power = 0.8) with 10% of the equivalence acceptance limit. PASS (Power Analysis and Sample Size) software (PASS software BV, Amersfoort, The Netherlands) was applied to calculate the number of polyps needed to prove the equivalence of the two 3D interpretation methods. Foreseeing the detachment of polyps during the experiment, we decided to make a total of 180 polyps for each colonic phantom, with 24 polyps as ‘spares’. A research fellow created 180 simulated polyps using small bowel, stomach, and lymph nodes tissue from pigs, and these simulated polyps were attached to the colonic mucosa with glue. Lymph nodes are practically good for simulating sessile polyps because two polyps in sessile morphology can be created when the lymph node is cut at its center. In addition, stomach or small bowel mucosa is appropriate for making flat or pedunculated polyps because it can be easily cut to make those shapes. The detailed methodology is well described in our previous publications [16,17]. Ninety-eight polyps were sessile, 57 pedunculated, and 26 flat. The height of the flat polyps did not exceed 2 mm. Fifty-two polyps were 5.0–6.9 mm in diameter, 46 were 7.0–8.9 mm, 41 were 9.0–10.9 mm and 41 were 11.0–12.9 mm. We made polyps sized between 5 and 13 mm because polyps lesser than 5 mm have little clinical significance and the sensitivities for polyps greater than 15 mm are reported as near 100%. All 180 polyps were distributed randomly through the 18 phantoms and the number of the

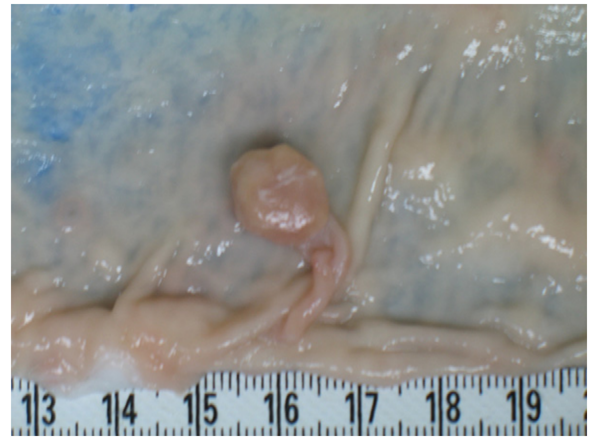

Fig. 1. Preparation of the simulated polyps. A pedunculated polyp was attached to colonic mucosa with glue. The location of the simulated polyp is marked with a measuring tape, located just inferior to the lesion.

polyps per colonic specimen varied from 3 to 14. Randomization of the locations of the polyps was performed by the study coordinator, using Excel Software (Microsoft, Seattle, WA). The research fellow recorded the size and shape of the polyps and the distance of the polyps from one end of the colon using a measuring tape (Fig. 1). The colon was then reinverted, with careful attention paid to avoid detaching the polyps from the colon specimens. After reinversion, one end of the colonic segment was double tied with a 1-0 suture. A 14-F Foley catheter was then inserted into the open end of the segment, the balloon inflated, and the open end closed with a double-tied suture.

2.2. CT colonography acquisition

All colon specimens were imaged on the same day they were prepared to minimize decay of the pig colons. The colonic specimens were placed in a large plastic bath filled with water. To make the curvatures of the colonic specimens similar to those of human colons, we used fine net and Velcro tapes to secure each specimen to a pre-designed route and to prevent floatation (Fig. 2). Room air was injected into the phantoms by the automated insufflator through a 14-F Foley catheter to maintain the colonic pressure between 10 and 15 mm Hg. This pressure was determined on the basis of preliminary study to ensure adequate

Fig. 2. A colonic specimen fixed in a water bath with fine nets and velcro tapes. The colonic specimens were placed in a large, plastic bath filled with water. To make the curvature of the colonic specimens similar to those of human colons, we used fine net and Velcro tapes to secure the specimen to a pre-designed route and to prevent flotation.

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