

The additional value of SPECT/CT fusion imaging in the diagnosis of ectopic gastric mucosa

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Abstract

Objective: To evaluate the value of single-photon emission computed tomography/computed tomography fusion alone and in addition to pertechnetate planar imaging in the diagnosis of ectopic gastric mucosa.

Methods: The retrospective study was conducted at the First Affiliated Hospital of Zhengzhou University, Zhengzhou, China, and comprised medical records from May 2014 to April 2015 of children aged <14 years and suspected of ectopic gastric mucosa. All patients underwent both planar imaging and single-photon emission computed tomography/computed tomography fusion imaging, and were followed up for more than 6 months. The final diagnoses were determined based on the results of pathology and clinical follow-up. The sensitivity, specificity, and accuracy of diagnosing ectopic gastric mucosa were compared by using planar imaging, SPECT/CT fusion imaging and a combination of both. Data was analysed using SPSS 21.

Results: Of the 41 patients, ectopic gastric mucosa was diagnosed in 24(58.5%) by pathological results or clinical follow-up. Planar imaging suggested 33(80.5%) positive and 8(19.5%) negative cases, while fusion imaging reported 23(56%) and 18(44%) respectively. The sensitivity, specificity and accuracy of planar imaging were 91.67%, 35.29% and 68.29%, and in fusion imaging they were 91.67%, 94.12% and 89.47% respectively. The corresponding values of the combination of two imaging techniques were 91.67%, 100% and 95.12% respectively ($p=0.006$). Kappa value of the diagnostic consistency between fusion imaging and a combination of two imaging was 0.951 ($p=0.0001$).

Conclusions: Planar imaging had a low specificity compared to fusion imaging and a combination of fusion and planar imaging.

Keywords: Ectopic gastric mucosa, SPECT/CT fusion imaging, Planar imaging, Diagnose. (JPMA 70: 1177; 2020)

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Introduction

Ectopic gastric mucosa (EGM) is one of the most common reasons for gastrointestinal bleeding in children, occurring in the small intestine, commonly in the Meckel's diverticulum (MD).¹ It is reported that 30-80% cases, MD is accompanied by ectopic tissue and has accounted for 70% EGM in symptomatic infants.^{2,3} The key to surgical treatment is preoperative diagnosis and localisation. However, the use of X-ray, endoscopy and other tests limit a clear diagnosis.⁴ In 1967, Harden et al.⁵ proposed the use of the radioindicator (Tc-99m) pertechnetate for non-invasive diagnosis of EGM in MS, since Tc-99m pertechnetate can be taken up and secreted by the tubular glands of the gastric mucosa.⁶ Tc-99m labelled pertechnetate planar dynamic imaging has been used for a long time to diagnose gastrointestinal bleeding caused by EGM.⁷⁻¹⁰ Some studies have suggested that pertechnetate scintigraphy

could provide the highest positive result in diagnosing a bleeding MD in a paediatric population.^{2,9} But the results of planar imaging may be false negative (FN) and false positive (FP).^{11,12} In recent years, some reports have focussed on the value of single-photon emission computed tomography/computed tomography (SPECT/CT) in detecting EGM.¹³⁻¹⁵ The current study was planned to assess the benefits of using SPECT/CT alone or in combination with planar imaging in EGM diagnosis.

Patients and Methods

The retrospective study was conducted at the First Affiliated Hospital of Zhengzhou University, Zhengzhou, China, and comprised medical record from May 2014 to April 2015 of children aged <14 years with suspected EGM on the basis of blood in the stool with abdominal pain or discomfort. After approval from the institutional ethics committee, those with leukaemia or other blood disorders and those with rectal bleeding during the active period were excluded.

Patients received pre-medication with a H2-receptor antagonist for 24 hours prior to the scan and were kept

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fasting for 3 hours. All patients underwent both planar imaging and SPECT/CT fusion imaging (Siemens T16 SPECT/CT) with low-energy high-resolution collimator. The abdomen planar images were captured at 5min, 10min, 15min, 25min, 40min and 60min after intravenous (IV) injection of Tc-99m sodium pertechnetate (3.7MBp/kg). Every frame had a 1-2 min duration, and the counts of each frame was more than 500k. The hybrid SPECT/CT fusion images were captured after the end of 25min planar images post-injection. This was followed by CT scan (Siemens Care Dose4D)¹⁴ with 256 × 256 matrix, 1cm thickness, and 5mm thickness of image reconstruction. After the acquisition, SPECT images and CT images were fused on the same equipment using Integration software (Siemens). All patient's parents had signed an informed consent form.

The positive imaging diagnostic criteria^{9,13} of heterotopic gastric mucosa was used according to which there are abnormal abdominal relatively fixed radioactivity lesions in early imaging (within 30 min). The locations and the shapes of lesions have no significant changes after 60 min. The tomography fusion positive imaging diagnostic criteria of heterotopic gastric mucosa^{9,13} was also employed according to which there are local uptakes in the small intestine lesions (Figure). All diagnoses were confirmed by two nuclear medicine physicians independently. And the disagreements were resolved through consultation. All patients were followed up for more than 6 months. The final diagnoses were determined based on the results of pathology and clinical follow-up.

Data was analysed using SPSS 21. The sensitivity,

specificity, and accuracy of diagnosing EGM were compared by using planar imaging, SPECT/CT fusion imaging and a combination of SPECT/CT fusion imaging with planar imaging. Kappa analyses were used to compare the diagnostic consistency of the three methods.

Results

Of the 41 patients, 26(63.4%) were boys and 15(36.6%) were girls. The overall medial age was 3 years (interquartile range [IQR]: 0.7-14 years). Of the total, EGM was diagnosed in 24(58.5%) by pathological results or clinical follow-up. Planar imaging suggested 33(80.5%) positive and 8(19.5%) negative cases, while fusion imaging reported 23(56%) and 18(44%) respectively. Among the rest, 4(9.75%) were cases of primary intussusception, 4(9.75%) appendicitis, 3(7.3%) mechanical obstruction, 2(4.9%) colitis, 1(2.4%) erosive gastritis, and 3(7.3%) had colorectal polyps.

The sensitivity, specificity and accuracy of planar imaging were 91.67%, 35.29% and 68.29%, and in fusion imaging they were 91.67%, 94.12% and 89.47% respectively. The corresponding values of the combination of two imaging techniques were 91.67%, 100% and 95.12% respectively. Kappa value of the diagnostic consistency between SPECT/CT fusion imaging and planar imaging was 0.468 ($p=0.006$). Kappa value of the diagnostic consistency between SPECT/CT fusion imaging and a combination of SPECT/CT fusion imaging with planar imaging was 0.951 ($p=0.0001$).

Of the 41 cases with SPECT/CT fusion imaging, 12(29.27%) had results different from their planar images (Table).

Table: The follow-up results mismatch the results of planar imaging and Hybrid single-photon emission computed tomography/computed tomography (SPECT / CT) imaging in 12 cases.

No.	Gender	Age (years old)	Planar dynamic imaging	Hybrid SPECT/CT imaging	The Final diagnosis	The reasons for false cases
1	M	8	+	-	Simple intestinal obstruction	Tracer uptake focus in right pelvis
2	M	7	+	-	Postoperative change of appendicitis surgery	Tracer uptake in subcutaneous site of surgical wound
3	F	14	+	-	Erosive gastritis	vitro pollution
4	F	9	+	-	Postoperative change of appendicitis surgery	Tracer uptake in subcutaneous site of surgical wound
5	M	5	+	-	Intussusception	Tracer uptake focus in Ureter - bladder Interface
6	M	1.7	+	-	Intussusception	Tracer uptake focus in right pelvis
7	M	6	+	-	Lymphoma	Tracer uptake focus in right pelvis
8	M	12	+	-	Colorectal polyp	Tracer uptake focus in right pelvis
9	F	12	+	-	Colorectal polyp	vitro pollution
10	M	2	+	-	Simple intestinal obstruction	Tracer uptake focus in right pelvis
11	M	5	+	-	Intussusception	Tracer uptake focus in right pelvis
12	M	0.6	-	+	Intussusception	The physiology excretion of imaging agent

"+" Positive, "-" Negative.

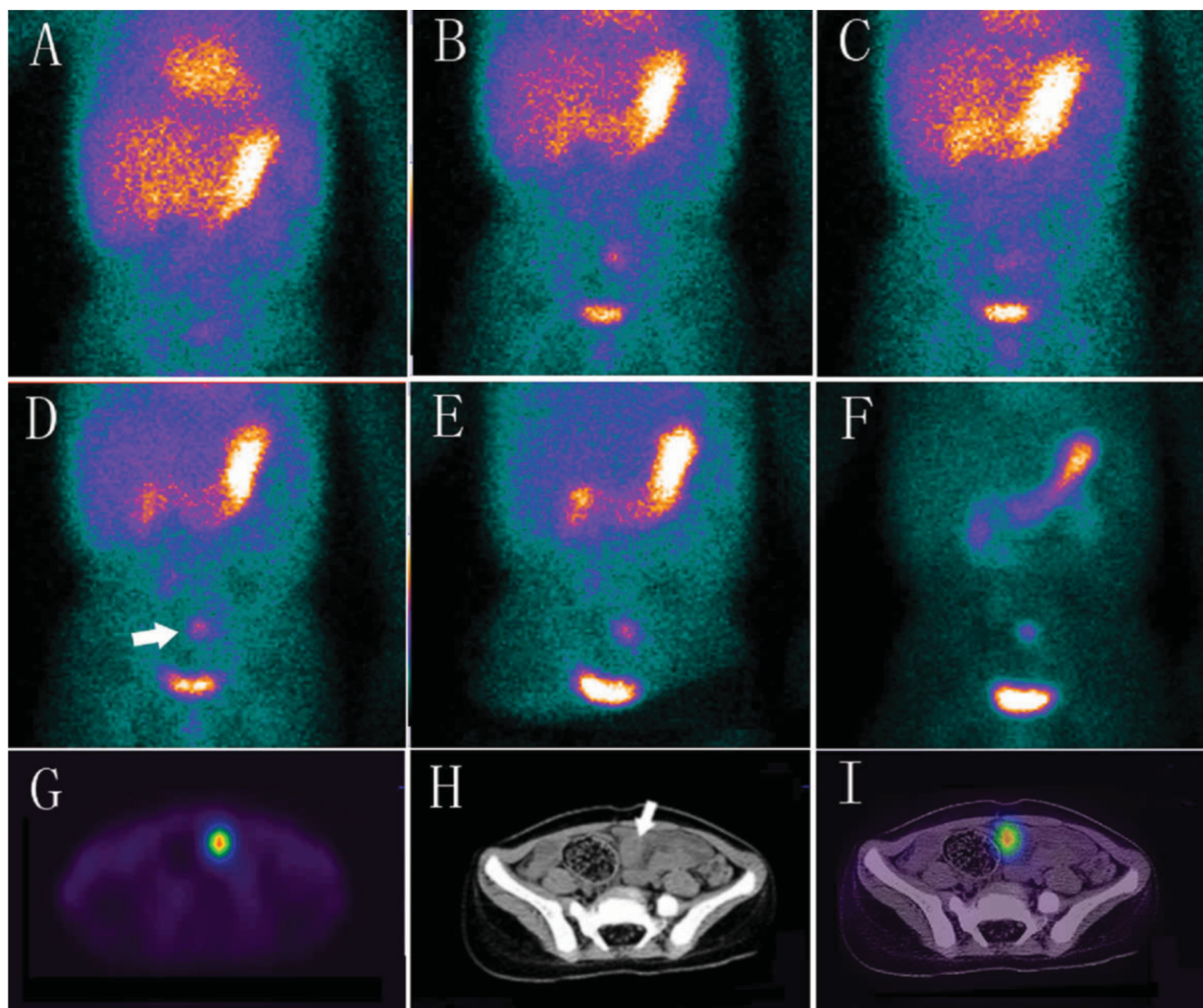


Figure: Planar imaging and single-photon emission computed tomography/computed tomography (SPECT/CT) fusion images from a typical patient with Meckel diverticulum (MD). A 6-year-old-male patient had paroxysmal abdominal pain below the xiphoid for 2 days. The right abdomen positive lesions (arrows) showed by Planar imaging (A, 5 min; B, 10 min; C, 15 min; D, 25 min; E, 40 min; F, 60 min), was identified tracer uptake focus in small intestine (arrows) by fusion SPECT/CT imaging (G, H, I). The final surgical pathology confirmed ectopic gastric mucosa (EGM).

Discussion

Heterotopic gastric mucosa of the small intestine is the common cause of gastrointestinal bleeding in children.^{2,16} Clinically, although fibre endoscopy is the preferred method for the diagnosis of gastrointestinal bleeding, it has its limitations in locating the position of the small intestine with deeper position and large variation.^{4,17,18} In addition, most patients are children with poor compliance, limiting its use. Unlike other imaging tests that make a diagnosis by observing the lesion and surrounding anatomical structures, Tc-99m sodium

pertechnetate ectopic gastric scintigraphy is a functional imaging.⁷⁻⁹ Tc-99m sodium pertechnetate planar imaging in EGM is the preferred imaging method to diagnose the intestinal heterotopic gastric mucosa in children because of the high sensitivity (85-91%), non-invasiveness, convenience and easy-to-use features.^{6,7,19,20} The higher sensitivity (94.44%) of Tc-99m sodium pertechnetate planar imaging in the current study is consistent with literature.^{6,7,19,20}

Some studies suggested that pertechnetate scintigraphy

could provide up to 100% sensitivity in diagnosing a bleeding MD in paediatric population.

However, planar imaging alone has its limitations for the lack of precise positioning capability, though it can be more sensitive to the detection of lesions. SPECT/CT is an integrated device of SPECT combined with multi-slice spiral CT. It provides not only SPECT function information, but also provides diagnostic CT anatomical information, and can be fused, namely tomography fusion imaging. In the current study, SPECT/CT fusion imaging showed not only the location of EGM, but also the relationship between the position of EGM and the adjacent bowel intuitively, and improved diagnostic efficacy.

SPECT/CT fusion imaging can improve the diagnostic specificity, especially for the differential diagnosis of FPs on planar imaging. The FP lesions diagnosed by planar imaging were confirmed by SPECT/CT fusion imaging as foregut duplication cyst,²¹ blue foam rubber nevus syndrome,²² and the misplaced renal pelvis pushed by huge teratoma.²³ In our study, eight cases had positive planar imaging, while SPECT/CT fusion imaging was negative. SPECT/CT fusion imaging discovered the FP lesions caused by the abnormal imaging agent uptake were urinary retention, vitro pollution and surgical trauma. Since Tc-99m sodium pertechnetate can be excreted through the urinary system, the urinary system imaging agent uptake especially affects the results of planar imaging. Due to urinary retention, pelvis and physiological ureteral stenosis tend to form a similar lesion as positive lesions. This is difficult for planar imaging to distinguish. According to diagnostic CT anatomical information, SPECT/CT fusion imaging can show the exact location of FP lesions clearly, thus improving diagnostic specificity.

The cause of FN Tc-99m sodium pertechnetate scintigraphy in EGM imaging may include^{6,24,25} the small size of EGM <1 cm², more necrotic tissue, uncertain location and lower contrast image, bladder uptake covering up the proximate lesion, and EGM concealed by barium residue. The SPECT/CT can improve the accuracy of diagnosis by solving these FN problems. But there will be FN results when the size of EGM is <1 cm² or in the absence of EGM in MD by SPECT/CT fusion imaging.

The current study also found that the diagnostic sensitivity of planar imaging, SPECT/CT fusion imaging and their combination were the same (91.67%). So SPECT/CT fusion imaging does not take obvious advantages of improving the detection of EGM lesions. Therefore, when a planar imaging was negative, further SPECT/CT fusion imaging is not recommended in order to

avoid unnecessary radiation exposure.

SPECT/CT fusion imaging also has its limitations. Though it can provide more intuitive positioning information, it should not be collected at multiple time points in order to reduce patient radiation exposure. The planar imaging acquisition process is relatively easy without additional radiation exposure, and the multiple time points can be dynamically observed. Combining the two advantages of the imaging can improve the specificity and accuracy of diagnosis, and it is more valuable to EGM diagnosis.

EGM is more common in children. The dose of radiation exposure in paediatric treatment process should be reduced, because children are more sensitive to radiation compared to adults.¹² Paediatric imaging agent of heterotopic gastric scintigraphy is pertechnetate, and the effective dose of radiation for scan is below 0.05mSv. The CARE Dose4D (Siemens) mode imaging is switched on when given tomography imaging, and the effective current amount is given automatically according to the patient's condition (height, weight, etc.), to make the dose as low as possible when conduct in a CT scan.²⁶ At the same time, we reduced the scanning parameters such as current and tube voltage accordingly, and obtained images that met the diagnostic requirements. CT has an exposure range of 1.5-2.5 mSv, which is below the annual exposure from natural sources.¹¹ In addition, it is also necessary to protect children with thyroid and genital issues to minimise the absorbed dose. SPECT/CT image fusion may significantly enhance diagnostic outcome as the current study clearly showed.

Conclusion

Planar imaging had a low specificity compared to fusion imaging and a combination of fusion and planar imaging techniques. SPECT/CT fusion imaging could supply more accurate location information and accuracy in the EGM diagnosis and reduce unnecessary surgical treatment.

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Conflict of Interest: None.

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