Reconsideration of the primary and secondary diagnostic criteria of Meckel's diverticulum scintigraphy. A study of 93 confirmed cases

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Abstract

Objective: Meckel's diverticulum scintigraphy (MDS) is a common method for diagnosing ectopic gastric mucosa (EGM), but atypical images are difficult to diagnose. This study aimed to improve the understanding of the existing diagnostic criteria through a review of confirmed cases. **Subjects and Methods:** A total of 352 patients underwent MDS. Among 120 patients with a positive diagnosis, 106 underwent surgery. This study analyzed the imaging presentation, surgical records, and pathological results. The existing diagnostic criteria included the location, shape, and radioactive appearance of the lesions. Data from surgical records with typical or atypical images were compared. **Results:** One hundred cases (100/106) were surgically confirmed to be Meckel's diverticulum (MD). The remaining 6 were intestinal polyps, intestinal duplication, duodenal ulcer, non-Hodgkin's lymphoma (NHL) and hiatal hernia. Out of the 100 MD cases, 93 had complete operation records and 59/93 of the MDS 63.4% MD were located in the right lower quadrant, and 81.7% had a round shape in the scintiscan. The onset of the lesions activity in 96.8% (90/93) of the cases corresponded with the onset of the gastric activity. The radioactivity of 97.8% (91/93) of the lesions gradually increased during the examination. There were no significant differences between the typical and atypical scintiscan images: in the distance of MD from the ileocecal valve, in the MD length, and the basal diameter of MD for lesions at different scintiscans (P>0.05), or of different shapes (P>0.05).**Conclusion:** Location in the right lower quadrant and round shape of the lesions are not the primary diagnostic factors for Meckel's diverticulum. The establishment of the diagnosis of MD requires careful consideration of other imaging characteristics such as: a) The onset of lesions' radioactivity to correspond with the onset of the gastric activity and b) The lesions' radioactivity to gradually increase during the scan procedure.

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Introduction

Meckel's diverticulum (MD), also known as the distal ileum diverticulum, is a blind segment formed at the end of the ileum due to closure of the proximal end of the vitelline duct which is in incomplete degeneration, during early embryonic development. The diverticulum containing ectopic gastric mucosa (EGM) is often associated with complications, such as bleeding. Since Harden and Alexander first proposed abdominal technetium-99m pertechnetate imaging in 1967 [1], there have been many reports of its use in the diagnosis of MD. Although imaging techniques continue to advance rapidly, pertechnetate imaging is still the most effective diagnostic tool for EGM [2]. Meckel's diverticulum scintigraphy images the EGM. The corresponding diagnostic criteria are recommended by the Society of Nuclear Medicine and Molecular Imaging (SNMMI) and The European Association of Nuclear Medicine (EANM). However, atypical images, which are often seen during daily practice, have become confounding factors for the diagnosis. Although there have been reports on MD cases presented with atypical images or false positive cases in the past [3-9], the relevant data to support the results are lacking. In our department, MDS is performed routinely. This study reviewed MD cases that have been confirmed by surgery and histopathology, and are analyzed and compared as for their imaging findings on MDS. Our aim was to enhance our understanding on the diagnostic criteria regarding MDS.

Subjects and Methods

Study design and patients

In the past 5 years (August, 2011–July, 2016), 352 pediatric patients (aged 3 weeks-16 years; mean age, 55 months) clinically suspected with MD, underwent MDS. Surgery was performed for 106 cases among those who were considered as positive based on the mds resuilts in the General Surgery Department of our hospital. Analysis included the following: imaging presentation including location, shape of the lesion, the onset time of lesion activity and of gatric activity, the changes in the lesion radioactivity, the pathology results, and the three anatomical indices of the surgical records: distance of MD from the ileocecal valve, MD length, and MD basal diameter. The imaging presentation of false positive cases was also analyzed. Cases confirmed with MD were divided into typical and atypical groups based on their imaging presentation in combination with the diagnostic criteria. The three above anatomical indices from the two groups were compared. The imaging data were from the original images stored archives in the department. The surgical records and pathology data were from an electronic medical record system (GE Healthcare-Centricity RIS CE V2.0). This study was registered, reviewed, and approved by the hospital ethical committee and has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Based on a retrospective study, the present study was exempt from patients' informed consent.

Meckel's diverticulum scintigraphy

Pediatric patients were given H_2 blockers or proton pump inhibitors in a conventional dose, orally administrated for 3 days or in a single intravenous (i.v) infusion on the day of imaging). After fasting for 4-6 hours, pediatric patients were positioned supine on the examination bed. Sodium Pertechnetate, 3.7MBq/kg (range, 7.4-370MBq), was injected i.v. Immediately afterwards, serial 12 frames of anterior images were acquired at 5seconds per frame for 60 minutes (low-energy high-resolution collimator, matrix size of 256×256, patient-specific zoom, peak value of 140keV, window width of 20%). The cardiac blood pool, stomach, and bladder were included in this field of view. For cases presenting suspicious urinary-tract activity, right-lateral view static images were acquired after cine imaging (matrix size: 256×256, 500ks, reasonable zoom). If necessary, furosemide 0.5-1mg/kg was administered i.v. for better image interpretation. A self-made point radioactive source (a small drop of radioactive source at the end of the syringe needle cap) was placed at the navel for localization, when needed. Imaging was performed using Siemens E-CAM dual-head single-photon emission tomography (SPET, USA). One detector was used during the examination. During imaging, pediatric patients were asked to maintain their posture and not move. Their guardians were present during the examination to improve their compliance. Patients who could not cooperate were sedated (oral chloral hydrate or intramuscular phenobarbital) and imaged after they were unconscious.

Interpretation criteria

A negative image included the following: normal physiological appearance of the cardiac blood pool, stomach, and urinary system, and the migration of the imaging contrast agent seen in the intestine. The diagnostic criteria for positive MD [10] included the following: an abnormal, focal (usually round dot shape), dense radioactive lesion in the right lower quadrant (RLQ), synchronized with the appearance and the gradual increase of gastric activity. A gradual increase in lesion radioactivity was also considered.

Images that met the above diagnostic criteria for positive MD were considered typical images. If a criterion was not met e.g., if the lesion was not present in the RLQ or if the lesion was flattened, irregular, or consistent with other non-focal morphologies, or if the lesion and the stomach were not observed simultaneously or if the radioactivity in the lesion gradually decreased or was quenched, the image was considered atypical. Image reading was performed by nuclear medicine radiologists. The abdomen was divided into four quadrants using the common four-region scheme. This included the right lower quadrant (RLQ), right upper quadrant (RUQ), left lower quadrant (LLQ), and the left upper quadrant (LUQ) with the navel as the center.

Statistical analysis

The three mentioned above anatomical indices of MD in the surgical records were analyzed in the scintiscans and found to be normally distributed. Analysis of variance (ANOVA) was conducted to compare the data from the two groups. When analyzing the differences in lesion morphology, Student's t-test was performed to compare MD length and basal diameter from the two groups. A P-value of less than 0.05 was considered significant. All statistical work was done using Minitab17 software (Minitab Ltd, USA).

Results

General results

Meckel's diverticulum scintigraphy was conducted for 352 pediatric patients, with a positive imaging rate of 34.1% (120/352). Surgery was performed on 106 cases that had a positive result during preliminary examination in our hospital. One hundred cases were surgically confirmed as MD, with a positive predictive value of 94.3% (100/106), of which 96% (96/100) were due to EGM based on MD histopathology (Table 1). The other 6 cases (6/106) were the following: small intestine polyps (1 case; Figure 1), duodenal ulcer (1 case), non-Hodgkin's lymphoma (NHL; 1 case; Figure 1), hiatal hernia (1 case), and two intestinal duplication (2 cases; Figure 1; Table 2). The cases of intestinal duplication differed on the basis of diagnostic criteria for lesion morphology; there were >3 mismatches with the diagnostic criteria for the false positive cases.

Ninety-three cases (93/100), aged 4 months to 12 years; mean age, 45 months had a complete surgical record for the three anatomical indices, in which 63.4% (59/93) of the lesions were localized in the RLQ. Based on the probability of occurrence from high to low, the locations of each lesion could be sorted as follow: RLQ, LLQ, RUQ, and LUQ (Figure 2). Additionally, 81.7% (76/93) of the lesions were round in shape. Other lesion morphologies were flattened, oblong,

and irregular (Figure 3). The appearance of 96.8% (90/93) of the lesions corresponded with gastric activity. During imaging, radioactivity in 97.8% (91/93) of the lesions gradually increased (Table 3). Figure 4 showed a case with typical image exactly matching the diagnostic criteria

Table 1. *General results*

Results	Number of cases
Positive image	120 (120/352)
Underwent surgery	106 (106/120)
Surgically and pathologically confirmed MD with complete surgical record	100 (100/106) 93 (93/100)
EGM	94 (94/100)
EGM mixed with pancreatic tissue	2 (2/100)
Only with inflammatory cell infiltration	4 (4/100)

MD: Meckel's diverticulum; EGM: Ectopic gastric mucosa

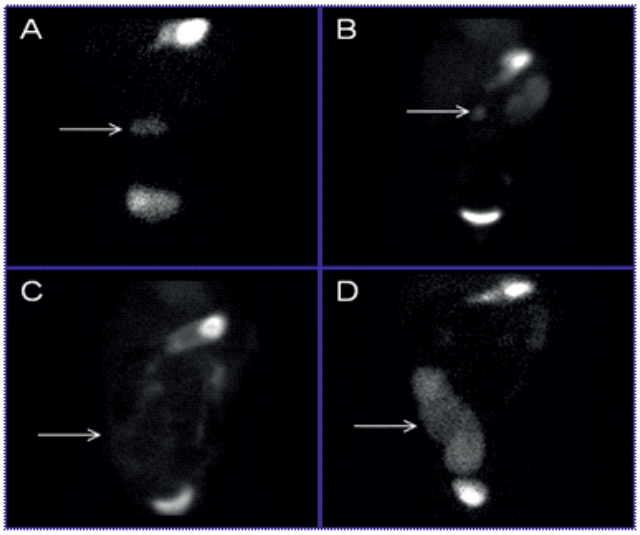

Figure 1. Four special cases are as following: small intestine polyps (A), duodenal ulcer (B), non-Hodgkin's lymphoma (C), and intestinal duplication (D). There were multiple mismatches with the diagnostic criteria.

Comparison of anatomical data in different image groups

The three MD anatomical indices measured during surgery and imaging presentation are presented in Table 4 and Table 5, respectively. Analysis of varience (ANOVA) of the three anatomical indices from typical and atypical groups for lesion

Table 2. *Imaging characteristics of the special cases*

Cases	Lesion position	Lesion shape	Appeared together with gastric activity	Increased activity	Number of the atypical imaging presentations
False positive: 3 causes					
Small intestine polyps	LUQ	Large sheet	Yes	No	3
Duodenal ulcer	RUQ	Small sheet	No	>>	4
NHL	RLQ+LLQ	Irregular	Yes	>>	3
Other diseases: 3 cases					
Hiatal hernia	-	Dumbbell-shaped stomach	-	-	-
Intestinal duplication No.1	RLQ	Intestinal shape	Yes	Yes	1
Intestinal duplication No.2	RLQ	oblong	>>	>>	1
Four cases with only inflammatory cell infiltration					
No.1	LLQ	Round dot	Yes	Yes	1
No.2	LLQ	Round Dot	>>	>>	1
No.3	RUQ	Small sheet	>>	>>	2
No.4	RLQ	Round dot	>>	>>	1

LLQ: left lower quadrant; LUQ: left upper quadrant; RLQ: right lower quadrant; RUQ: right upper quadrant; NHL: non-Hodgkin's lymphoma

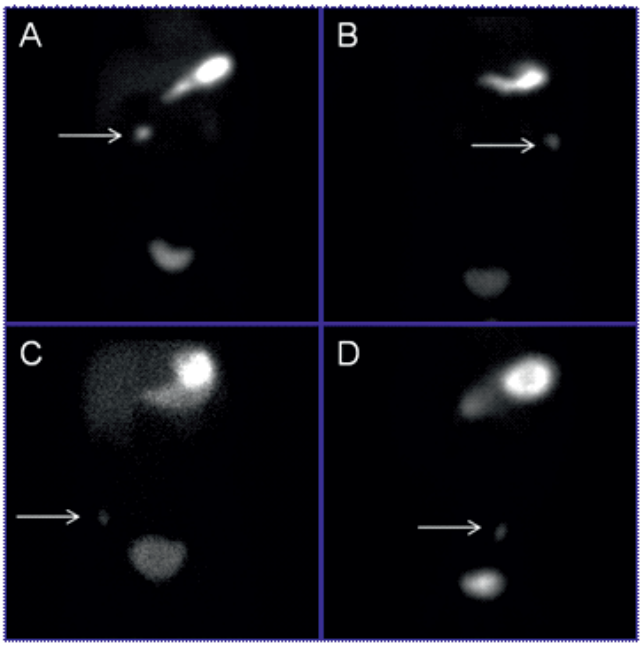

Figure 2. The lesion was detected in the RUQ (A), LUQ (B), RLQ (C), and LLQ (D), respectively.

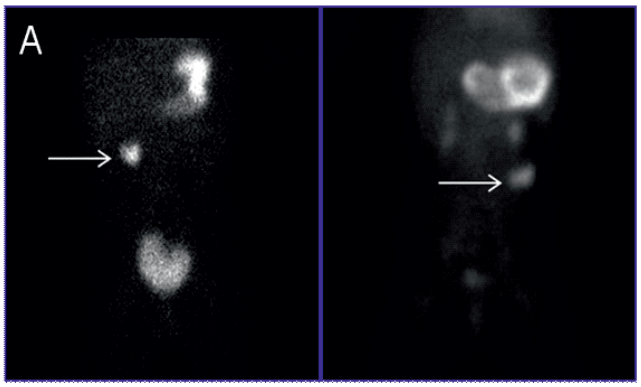

Figure 3. Other lesion morphologies were showed (flattened, A; oblong, B).

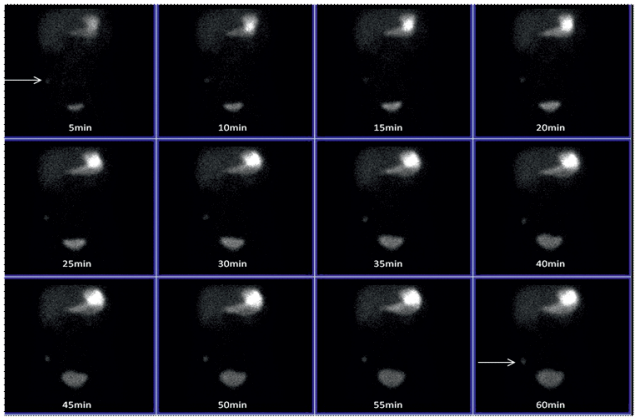

Figure 4. A 4 years old girl with hematochezia. The images showed a focal dense activity lesion in the RLQ, the lesion and stomach appeared together and gradual increase in lesion activity.

location showed that the P-values were greater than 0.05 (0.554, 0.788, and 0.807, respectively). There was no significant difference between the groups, and there were two cases with lesions located in the LUQ (Table 4). The number of samples was small. When comparing the real data (35, 4.5, and 1.2cm; and 55, 4, and 2cm) with the mean values from the typical group, the differences could still not be discerned. When comparing the lesion shape, the P-values were greater than 0.05 (P=0.666 for length and P=0.266 for diameter). There were no significant differences in the MD length and basal diameter between the typical and atypical groups (Table 5).

Table 3. *The imaging presentation of the confirmed cases*

Imaging presentation	Percentage
Lesion position	
RLQ	63.4% (59/93 cases))
LLQ	23.7% (22/93 cases)
RUQ	10.8% (10/93 cases)
LUQ	2.2% (2/93 cases)
Round dot lesion	81.7% (76/93 cases)
Lesion and stomach appeared together	96.8% (90/93 cases)
Lesion activity gradually increased	97.8% (91/93 cases)

LLQ: left lower quadrant; LUQ: left upper quadrant; RLQ: right lower quadrant; RUQ: right upper quadrant

Discussion

Pediatric patients with MD often visit the hospital for the treatment of gastrointestinal bleeding. Meckel's diverticulum scintigraphy is considered an accurate tool for the diagnosis of MD with EGM [11]. At our hospital, MDS was not conducted for certain severe cases because laparotomy had already been performed in the emergency room. For other cases, adjunctive, symptomatic treatment was initially provided, and MDS was then performed. Prior to imaging, the patient was given a H_2 blocker or a proton pump inhibitor to increase the sensitivity of the examination [12, 13]. Another study reported a positive predictive value of 64% and prevalence of ectopic gastric mucosa in histological specimens 84% [14].which are lower than the values reported in this study. This was most likely due to the variability in the clinicians' understanding of the clinical indications prior to imaging examination.

The location and the shape of the lesion in the scintiscan image are only indicative of its anatomical characteristics. Therefore, other indices for MD were selected for this study, measured during surgery and analyzed for their relation to the scintiscan image characteristics. Some studies pointed

Table 4. *The comparison of the three anatomical indices between the typical and atypical groups (lesion location)*

Operation record	Typical image group	Atypical image group			P-value (ANOVA)
	RLQ (n=59)	LLQ (n=22)	RUQ (n=10)	LUQ (n=2)	
Distance from ileocecal valve (cm)	41.5±16.4	39.0±16.6	34.0±16.1	45.0±14.1	0.554
Length (cm)	3.9±1.5	4.2±1.7	3.7±2.0	4.3±0.4	0.788
Diameter (cm)	1.5±0.6	1.5±0.5	1.3±0.5	1.6±0.6	0.807

ANOVA: Analysis of variance; LLQ: left lower quadrant; LUQ: left upper quadrant; RLQ: right lower quadrant; RUQ: right upper quadrant

that the incidence of EGM showed predominant distribution at the top of the diverticulum [15, 16]. Our results suggested that the location of the lesions was diverse and that it should not be the primary diagnostic factor. This may be due to the interference and displacement of the small intestine [17, 18]. In terms of anatomical relations, MD is always located at the contralateral edge of the mesentery, and is not necessarily perpendicular to the longitudinal axis of the bowel. This can also be a factor to support our method of study. In addition, the three anatomical indices also showed no significant difference between the different shape groups for lesion location. In another study, 11/21 of lesions cases were identified at the umbilical quadrant and the rest at other locations [19]. This result, which is similar to ours, demonstrates that location of MD is not necessarily a diagnostic criterion.

Table 5. *The imaging presentation of the confirmed cases*

Operation record	Typical image group	Atypical image group	P-value (t Test)
	Round dot activity (n=76)	Other shape activity (n=17)	
Length (cm)	3.9±1.6	4.1±1.6	0.666
Diameter (cm)	1.4±0.6	1.6±0.6	0.266

Another study showed that the distribution of EGM in MD was related to the shape of MD. The EGM always grew at the distal end of the long diverticula, but in almost any area of the short diverticula [15]. We considered that this anatomical pattern may cause the lesion to show different image shapes such as a dot, an oblong or other shapes. However, in our study, there were no significant differences in MD size (length and basal diameter) between the typical and atypical shape groups. This indicated that the appearance of a round dot-like lesion should not be a decisive diagnostic factor. In addition, we should have in mind that the size of the active EGM in MD determines the radioactive sensitivity [20], rather than the shape of the image.

Notably, lesion shapes (large sheet, and irregular) in false positive cases were quite different from those observed in the typical positive image group. The atypical cases were also accompanied by other atypical findings, such as the gradually decreasing radioactivity in the lesion. In this study, only 4 cases of MD diagnosed by MDS did not show in the pathology results EGM but showed only inflammatory cells infiltration, while the MDS results were positive. Such cases were rarely observed and indicate that the MDS is not a decisive diagnostic tool for EGM.

In this study, the two diagnostic criteria: the onset of lesion activity coinciding with that of gastric activity and the gradual increase of this activity were clinically relevant in >95% of the confirmed cases. Therefore, these diagnostic criteria were indicative of the common origin of the ectopic and the normal gastric mucosa and demonstrated the efficacy of the MDS. The incidence of lesions in the RLQ and of dot-shaped lesions was not so high. Based on this finding, we should understand which diagnostic criteria are of primary and which of secondary importance.

In conclusion, Meckel's diverticulum scintigraphy image evaluation and the establishment of diagnosis of Meckel's diverticulum require careful consideration of imaging characteristics. The location and shape of the lesions are not primary diagnostic characteristics. Primary diagnostic findings are a) the onset of lesions' activity coinciding with that of gastric activity, and b) the gradual increase of this activity. Atypical images, may indicate false positive cases.

The authors declare that they have no conflicts of interest

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