

Meckel's Scan for patient groups with and without gastrointestinal bleeding: A 15 years local review

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ABSTRACT

Introduction: To retrospectively analyze the outcome of patients who underwent Meckel's scan in a local centre in Hong Kong over the past fifteen years. Diagnostic values in different referring indications were also reviewed.

Methods: All patients who referred for Meckel's scan in a local hospital in Hong Kong from 1/1/1996 to 31/12/2010 were identified. Patients' demographic data, presenting symptoms, imaging and clinical findings were reviewed and analyzed.

Results: A total of 105 patients were recruited, including 62 children and 43 adults. There were eight patients with positive Meckel's scans and 97 patients with negative scans. Eight Meckel's diverticula were confirmed surgically. The sensitivity and specificity were 75% and 97.9% respectively. The positive and negative predictive values were 75% and 97.9% respectively. Accuracy was 96.2%. Performance was further improved if only patients with gastrointestinal bleeding were selected. Sensitivity (85.7%) and negative predictive value (98.6%) were higher when compared to all indications, while specificity, accuracy and positive predictive value remained similar (97.3%, 96.3% and 75% respectively).

Conclusion: Meckel's scan is an accurate and useful test if the patient was referred for gastrointestinal bleeding. However its role is in doubt for non-gastrointestinal bleeding cases.

Key words: Meckel's scan; Meckel's diverticulum; Gastrointestinal bleeding; Technetium pertechnetate scintigraphy

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INTRODUCTION

Meckel's diverticulum is the commonest cause of significant lower gastrointestinal bleeding (GIB) in children [1]. ^{99m}Tc-pertechnetate scintigraphy (Meckel's scan) is the most widely used investigation for detection of the Meckel's diverticulum because the radioisotope would localize to the site of ectopic gastric mucosa, which is present in less than 50% of the diverticulum [2, 3]. However Meckel's scan does have a few drawbacks. Previous literature reported that Meckel's scan had a low negative predictive value [4]. Sensitivity of the study ranged from 50-92% according to different reports [3, 5]. Various abdominal diseases and pathologies have been proven to cause false positive or false negative findings, and as a result, causes diagnostic problems [6, 7]. The purpose of our study was to evaluate the performance and usefulness of Meckel's scan in a local center in Hong Kong, with their referring indications, scintigraphic findings and clinical outcomes being reviewed.

METHODS

This retrospective study had been approved by the local institutional review board.

Subjects

Case records of all patients who were referred for Meckel's scan in a local hospital in Hong Kong for a 15-year period from 1/1/1996 to 31/12/2010 were identified.

Exclusion criteria

Patients who defaulted follow up were excluded from the study. Patients with incomplete medical records were also excluded. For the purpose of the study, if operation was offered by surgeons but refused by patient, these patients were also excluded from our analysis.

Imaging studies guidelines

In our centre, patients were instructed to fast for six hours before the study. For pre-medication, 150mg ranitidine had to be taken twice per day for two days before the study. The dose would be reduced to 4mg/kg/day if the patient was younger than 16. If the patient was below the age of one, 1mg/kg of ranitidine in 20mL of saline would be infused intravenously. During the scintigraphy, 10mCi of ^{99m}Tc-pertechnetate was injected intravenously for adult patient, while the dosage of technetium would be adjusted according to the body surface area for paediatric patients. Scintigraphy

images were acquired by two phases. The first phase consisted of 60 images of one-second acquisition, while the second phase consisted of 60 images of 60-second acquisition, in a continuous mode with a matrix of 128 x 128 using the Siemens Symbia T6 (Erlangen, Germany) or Picker Prism100 machine (Cleveland, Ohio, USA). Post-void anterior, posterior and lateral images were also obtained. Positive Meckel's scan was defined as presence of focal tracer activity appearing at the same time or shortly after gastric activity, and that tracer activity increased in intensity with time parallel to that of stomach (Figure 1).

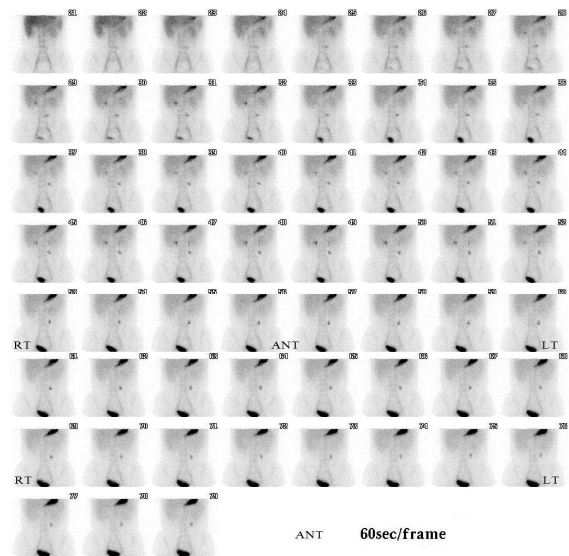


Fig 1. Presence of focal tracer activity over left side of abdomen, which appeared at the same time with gastric activity. This was a positive Meckel's scan.

Methodology and definitions

Results and findings of all Meckel's scans were reviewed by two radiologists in our department independently, one being a radiologist specialist who specialized in nuclear medicine for 15 years. Any discrepancy was resolved by consensus. Demographic data (sex and age of patient at the time of the study), major presenting symptoms (gastrointestinal bleeding, anemia, abdominal pain or others), operative records (if any), alternative investigations results, and clinical outcome during follow-up period were all recorded and reviewed.

Results of the Meckel's scan were then compared with the gold standard. Since besides Meckel's scan, there was no other widely-accepted gold-standard investigation for the diagnosis of Meckel's diverticulum, operative diagnosis with histological correlation would be our ultimate gold standard. However obviously it would be impractical to operate

on all cases in order to confirm or exclude the presence of the diverticulum, especially for the scan negative and clinically stable cases. We believed that clinical follow-up to see whether the symptoms of patients persisted or not would be an acceptable alternative. The period of follow-up would be at least one year in our study (range 1 to 16 years).

In our study, true positive case was defined as a positive Meckel's scan being confirmed operatively and histologically, while a false positive case was defined as a patient with positive Meckel's scan, but proved not to have Meckel's diverticulum surgically. False negative case was defined as a surgical-proven Meckel's diverticulum but was missed by a prior Meckel's scan. For true negative cases, if a patient satisfied one of the following three criteria, it would be considered as true negative: (1) negative Meckel's scan, confirmed subsequently during operation; (2) patient did not undergo surgery but an alternative diagnosis was identified clinically, radiologically or endoscopically, that could fully explain the clinical presentation; (3) clinically patient remained stable without relapse of the presenting symptoms throughout the follow-up period despite no definite diagnosis. The first criterion was based on surgical findings, while the latter two criteria were based on clinical outcome.

Statistical analysis

Findings of the Meckel's scan were compared with operative or clinical outcome using a 2x2 Chi-square table. The sensitivity, specificity, accuracy, positive and negative predictive values of the Meckel's scan were calculated and documented.

RESULTS

Over the period of 15 years, a total 134 patients were referred for Meckel's scan. Fifteen of them were excluded due to incomplete medical records. Number of patients excluded due to refusal to operation or lost to follow-up was two and twelve respectively. Remaining 105 patients were recruited into the study. Forty of them are female, while 65 of them are male. Mean age at presentation was 17.6 years old, with

median value being 15 years old. There were 62 paediatric patients (aged 16 or below) and 43 adults (above 16 years old)

Out of these 105 patients, there were eight cases (7.6%) with positive findings in Meckel's scan. Remaining 97 scans were negative (92.4%). Of the eight scan positive patients, two of them were adult, while six of them were children. All the scan positive cases underwent operation eventually. For the six paediatric patients, the operations were done within one week, while for the adult group, time interval between imaging and operation was up to three months due to non-acute presentation. During operation, no Meckel's diverticulum was found in two of the paediatric cases (false positive, n=2). For the remaining six cases, the Meckel's diverticulum was identified, resected and confirmed histologically (true positive, n=6).

From the 97 scan negative cases, six underwent immediate surgery due to persistent symptoms. None had a Meckel's diverticulum identified. The remaining 91 patients were followed-up clinically, five of them were operated eventually due to persistence or relapse of symptoms. Meckel's diverticulum was identified in one adult and one child (false negative, n=2). Alternative diagnosis was able to be identified in 33 patients clinically, radiologically or endoscopically, that could fully explain their clinical presentations. Fifty-three patients remained stable without relapse of the symptoms during follow-up period (total true negative, n = 95). Overall findings were summarized in Table 1. The sensitivity and specificity were 75% and 97.9% respectively. The positive predictive value and negative predictive value were 75% and 97.9% respectively. Accuracy was 96.2%.

If divided into different age groups, for paediatric patients, the sensitivity and specificity were 80% and 96.5% respectively. The positive predictive value and negative predictive value were 67% and 98.2% respectively. Accuracy was 95.2%. For adult patients, the sensitivity and specificity were 67% and 100% respectively. The positive predictive value and negative predictive value were 100% and 97.6% respectively. Accuracy was 97.7%.

Table 1. Results of Meckel's scan compared with clinical or operative findings together with age distribution.

	Confirmed Meckel's diverticulum	No Meckel's diverticulum surgically or clinically	Total
Positive Meckel's scan	6 (2 adults, 4 children)	2 (0 adult, 2 children)	8
Negative Meckel's scan	2 (1 adult, 1 child)	95 (40 adults, 55 children)	97
Total	8	97	105

(Adult: 16 years above, Children: 16 years or below)

Table 2. Indications of the Meckel's scan with the clinical outcome.

Indication	Number	Normal Scan (%)	Abnormal Scan (%)	True positive	False positive	True negative	False negative
Gastrointestinal bleeding	82	74(90.2)	8 (9.8)	6	2	73	1
Non-Gastrointestinal bleeding	23	23 (100)	0 (0)	0	0	22	1
-Anemia	16	16 (100)	0 (0)	0	0	16	0
-Abdominal pain	4	4 (100)	0 (0)	0	0	3	1
-Suspicious SBE findings*	2	2 (100)	0 (0)	0	0	2	0
-Umbilical discharge	1	1 (100)	0 (0)	0	0	1	0
Total	105	97(92.3)	8 (7.6)	6	2	95	2

*SBE=Small bowel enema

We further analyzed our results by comparing various referring indications. The majority of them were referred for gastrointestinal bleeding (GIB) (82 cases, 78.1%). This bleeding could be either macroscopically, presented by per-rectal bleeding or melena, or could be microscopically, detected by a positive fecal occult blood test (FOB). The rest belonged to the non-GIB group (23 cases, 21.9%). It consisted of various different indications, including unexplained anemia (n=16), abdominal pain (n=4), umbilical discharge (n=1) and suspicious findings in small bowel enema study (n=2). All cases from non-GIB group had no clinical symptoms of GIB, and also with negative FOB tests. Findings and outcomes in both groups were summarized in Table 2.

In GIB group, there were six true positive cases. However there were also one false negative and two false positive cases respectively. The sensitivity and specificity were 85.7% and 97.3% respectively. The positive predictive value and negative predictive value were 75% and 98.6% respectively. Accuracy was 96.3%

In non-GIB group, there was not a single scan positive case. The entire 23 scan were negative. However there was one false negative case.

DISCUSSION

Meckel's diverticulum is a remnant of the omphalomesenteric (vitelline) duct which connects the yolk sac to the embryo (Figure 2). It was first described by the German anatomist Johann Friedrich Meckel in the 19th century [8]. Meckel's diverticulum is the most common congenital anomaly of the gastrointestinal tract involving the small bowel [3], and the estimated prevalence is about 1-4% in the general population [9-11]. It represents a true diverticulum and may contain heterotopic gastric or pancreatic tissue [3].

Not all Meckel's diverticula are symptomatic. The majority remain undiscovered, with a lifetime risk of complications reported as between 4 and 40% [10, 12]. They may present with small bowel obstruction

related to volvulus or intussusceptions, or abdominal pain [10]. Only less than 50% of the Meckel's diverticula contain ectopic gastric tissue [3] (Figure 3), and they are at a higher risk of gastrointestinal bleeding [13]. In fact Meckel's diverticulum is the most common cause of significant lower GIB in children [1]. This type of bleeding may be profuse and blood transfusion is not infrequently required.

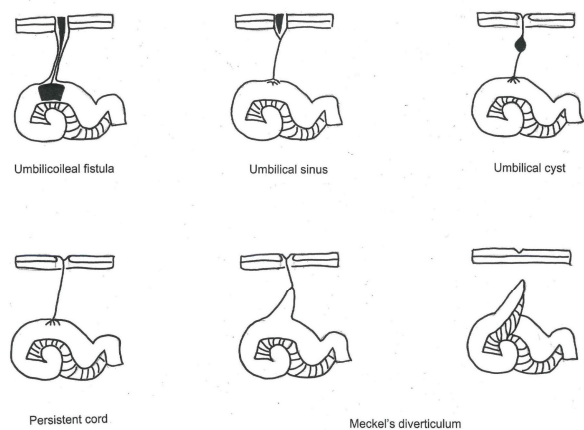


Fig 2. Schematic diagram showing Meckel's diverticulum and other variants of Vitelline duct remnants.

For detection of Meckel's diverticulum, previous studies reported that abdominal radiograph, Barium studies, abdominal ultrasound, and CT were of limited usefulness [3, 14, 15]. 99m-Tc pertechnetate was first utilized for detection of Meckel's diverticulum in 1970 [7]. Since the tracer was taken up and secreted by gastric mucosa, Meckel's scan was useful in detection of Meckel's diverticulum that contains ectopic gastric mucosa. The reported sensitivity of Meckel's scan varied from 50-92% according to different studies. Cumulative sensitivity from multicentre studies was reported to be 85% [5, 9]. However sensitivity was found to be lower in adult populations [16, 17]. On the other hand, specificity and positive predictive value could be both as high as 95% [3, 9, 18, 19] in all age groups. Different preparations and modifications like premedication with a histamine receptor antagonist

with or without pentagastrin, bladder lavage, or nasogastric suction, had been used to improve the yield of the study [17, 20-24].

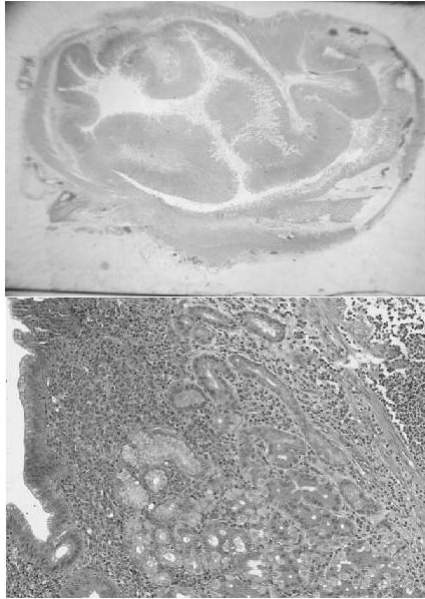


Fig 3. (Upper) Cross section of a Meckel's diverticulum. (Lower) Microscopy showing this Meckel's diverticulum was lined by gastric mucosa with gastric glands.

In our study, 105 cases were recruited over a period of 15 years. A total number of eight Meckel's diverticula were confirmed surgically and histologically. Six of them were from male patients (75%), which was compatible with previous studies that symptomatic Meckel's diverticula were more commonly found in males [25-27]. Sensitivity of the scan was 75% while positive predictive value being 75%, which was slightly lower than the value reported in the literature [9, 18, 19]. This was probably due to a relatively low positive rate in our cases. Specificity was found to be higher, 97.9% in our study. Overall accuracy was 96.2%. Our local experience proved that Meckel's scan was a useful and accurate investigation for detection of Meckel's diverticulum in general.

When compared between paediatric and adult groups, it was found that sensitivity in adult group was lower than the paediatric group, which was compatible with findings from prior studies. Specificity and negative predictive value were comparable, while positive predictive value was significantly higher in adult group. Overall accuracy in adult group was slightly higher than the paediatric group (97.7% and 95.2% respectively).

There were two false positive cases in our study. Both of them were paediatric patients referred for per-rectal bleeding (a 6 year-old boy and a 13 year-

old girl). Both Meckel's scans showed focal tracer activity at right lower abdomen around the time of gastric activity appearance. Urgent operation however revealed no Meckel's diverticulum in both cases. After the laparoscopy, the boy was treated as ileitis due to thickened ileum noted during surgery, while for the teenage girl no particular cause of bleeding could be found. Both patients were treated conservatively with spontaneous recovery. Retrospective review of both studies was made. For the 6-year-old boy, the abnormal tracer activity located right lateral to the urinary bladder. It was parallel to the gastric activity and persisted at post-void phase (Figure 4).

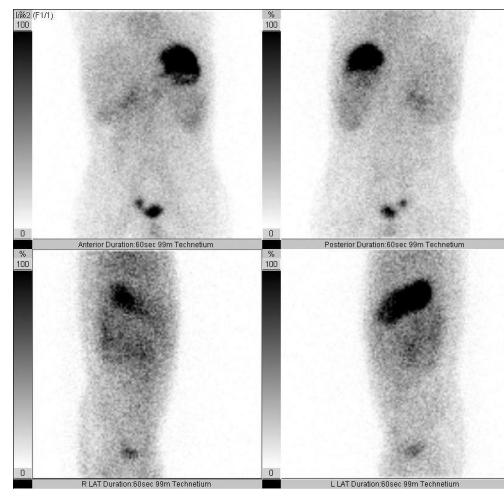


Fig 4. Focal tracer activity was detected over the right lower abdomen and persisted during post void phase. It was interpreted as a positive scan. Urgent operation in this patient however revealed no Meckel's diverticulum but only local ileitis. This shows that inflammation of the bowel is one of the causes of a false positive Meckel's scan.

Retrospectively we believed this activity might be due to ileitis, which was known to be a cause of false positive scan [28]. For the 13 year-old girl, the abnormal tracer activity first appeared during perfusion phase, and persisted until delayed post-voiding phase. Since no pathology was detected intra-operatively, we thought this might represent uterine blush, which was also one of the potential causes of false positive [29]. Concerning these false positive cases, we believed with the recent advancement of nuclear medicine, modification of scan using SPECT and CT correlation might have a new role in improving diagnostic accuracy and reducing false positive rate of standard Meckel's scans [30].

There were also two false negative cases in our study. The first case was a 4-year-old child presented with tarry stool without an identifiable cause. Meckel's scan done was negative. Exploratory laparotomy was

performed due to ongoing bleeding and a bleeding Meckel's diverticulum was found intra-operatively. The diverticulum was resected and ectopic gastric mucosa was confirmed histologically. The second case was a 17-year-old teenage boy, presented with acute abdominal pain without evidence of gastrointestinal bleeding. The boy was treated conservatively after a negative Meckel's scan. Four months later, he again presented with acute abdominal pain, and urgent operation revealed acute small bowel volvulus with a non-bleeding Meckel's diverticulum as a lead point. The diverticulum was resected and ectopic gastric mucosa was not detected upon histological analysis. Retrospective review of the earlier Meckel's scans failed to identify any abnormal tracer accumulation in both cases.

Our study also suggested that Meckel's scan had different yield in different indications. For GIB group, sensitivity and negative predictive value of Meckel's scan were improved when compared to all indications, while specificity and positive value remained similar. Meckel's scan is therefore a useful test in patients with unexplained gastrointestinal bleeding.

For non-GIB group, there was no scan positive case. On the contrary, one non-bleeding Meckel's diverticulum was missed by Meckel's scan, which latter presented with acute volvulus. Meckel's scan could only detect ectopic gastric mucosa of the diverticulum. Therefore, obviously the scan would be negative if the diverticulum did not contain any ectopic gastric mucosa, which was only present in less than 50% [3]. However it seemed that quite a number of clinicians had overlooked this fact and was referring patients without gastrointestinal bleeding to us for Meckel's scan. This group of patients comprised 20% of our total referrals. Not only performing a non-useful examination in the expense of unnecessary radiation to the patient, the major issue was that a Meckel's diverticulum without ectopic gastric mucosa could also present with acute symptoms other than gastrointestinal bleeding, like diverticulitis, intussusception or volvulus like our case [10]. A negative Meckel's scan did not exclude these complications, and might give the clinician a false "sense of security" and lowered their threshold in considering operations. As a result, clinicians should bear in mind that Meckel's scan was not useful for non-gastrointestinal bleeding indications, and such referrals should be avoided.

The major limitation of our study was related to its retrospective nature. Besides operation to obtain histological proof, there were no other gold standard methods available in diagnosing Meckel's diverticulum. Since it was impossible and impractical to operate on every case, in the majority of cases, we could only compare the results of the Meckel's

scan with the clinical outcome. We assumed if the patient remained asymptomatic within one year, he or she was likely not having a Meckel's diverticulum. This might miss a few silent Meckel's diverticula and under-estimate the number of false negative cases. Percentage of positive studies was only 7.6% in our study, which was a bit low when compared to similar studies. We believed it was because we were receiving different referrals for various indications for Meckel's scan from clinicians, while some indications were proved to have low yield in our studies. This again emphasized the importance of selecting suitable cases for Meckel's scan in order to avoid over-investigation and allow better utilization of the limited medical resources. Finally, it was also noted that two cases of positive Meckel's scan had already been excluded from our study during recruitment stage, because of refusal to operate after the scan. For the purpose of our study, these two cases were being excluded because we were unable to know whether the scans were true positive or false positive without a surgical and histological diagnosis. However this would reduce the rate of positive detection in our study.

CONCLUSION

Meckel's scan was a useful test in detecting Meckel's diverticulum, especially if the referring indication was gastrointestinal bleeding. However in other indications like abdominal pain, or anemia alone, the scan had doubtful usefulness since the radiotracer could only detect ectopic gastric mucosa, which was not present in all Meckel's diverticula. Clinicians should bear in mind that such referrals should be avoided.

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