Diagnostic Accuracy of ^{99m}Tc-Pertechnetate Scintigraphy Among Patients with Suspected Meckel's Diverticulum – One-Year Experience in NINMAS

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ABSTRACT

Background: The reported accuracy of pertechnetate scintigraphy (Meckel scan) for evaluating children with Meckel's diverticulum has steadily increased since its introduction into clinical practice in 1970. In our study, we retrospectively analyze the accuracy of Tc-99 m pertechnetate scintigraphy in NINMAS over 01 year.

Objective: This study aimed to evaluate the accuracy of pertechnetate scintigraphy performed at the National Institute of Nuclear Medicine & Allied Sciences (NINMAS) in pediatric patients with suspected Meckel's Diverticulum**.**

Methods: A retrospective study was conducted of 60 pediatric patients who presented with symptoms suggestive of MD and underwent ^{99m}Tc-pertechnetate scintigraphy at NINMAS over a 1-year period. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated by comparing scintigraphic results with surgical and histopathological findings.

Result: Six patients were diagnosed with MD on ^{99m}Tc-pertechnetate scintigraphy, all confirmed histopathologically as true positives. Among 54 patients with negative scans, one was a false negative, and 53 were confirmed as true negatives through clinical, imaging, endoscopic, and laparoscopic evaluation. Accordingly, ^{99m}Tc-pertechnetate scintigraphy showed a sensitivity of 85.7% (6/7), specificity of 100.0% (53/53), positive predictive value of 100.0% (6/6), negative predictive value of 98.1% (53/54), and overall diagnostic accuracy of 98.3% (59/60) for MD. Receiver operating characteristic analysis revealed an area under the curve of 0.929 (standard error, 0.079; $p < 0.001$; 95% confidence interval, 0.775–1.082), indicating excellent diagnostic performance.

Conclusion: We find that Meckel scanning is a non-invasive procedure with low radiation exposure. It is a highly specific and accurate method for diagnosing MD in pediatric patients.

Keywords: ^{99m}Tc-pertechnetate scintigraphy, Meckel's diverticulum, ectopic gastric mucosa, gastrointestinal bleeding**.**

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INTRODUCTION

German anatomist Johann Meckel first described Meckel's Diverticulum (MD) in 1812 (1). It is the most common congenital anomaly of the gastrointestinal tract, caused by incomplete regression of the embryonic omphalomesenteric duct (Figure 1). It is also known as the vitelline duct, which provides nutrition to the embryo in early gestation and connects the midgut to the yolk sac. This duct is usually obliterated around 6 weeks of gestation, but incomplete breakdown leaves an outpouching in the bowel wall. The prevalence of Meckel's Diverticulum is 2–3% in the population (2). It is located at the antimesenteric border of the ileum, typically within approximately 100 cm of the ileocecal valve (3). Most cases of MD remain asymptomatic throughout life and are found incidentally during abdominal surgery. However, about 15% of cases develop complications such as hemorrhage, obstruction, diverticulitis, and perforation. Hemorrhage often results from ectopic gastric mucosa within the MD, leading to ulceration of the bowel wall and causing rectal bleeding and/or anemia. In 50% of cases, this occurs within the first two years of life. Diagnosing symptomatic MD can be challenging, but ^{99m}Tc-pertechnetate scintigraphy (also known as Meckel's scan) can detect ectopic gastric mucosa. Approximately 90% of bleeding MD cases contain ectopic mucosa, highlighting the utility of ^{99m}Tc-pertechnetate scintigraphy as a non- invasive diagnostic tool since its introduction in 1970 (4). In cases of MD bleeding, typical scintigraphic findings include a focal area of abnormal radiotracer accumulation in the right lower abdomen, often with

concurrent uptake in the normal gastric mucosa and no change in appearance on sequential images (5). Small patches of ectopic gastric mucosa may be missed. However, because ectopic gastric mucosa occurs in 50–60% of MD cases, ^{99m}Tc-pertechnetate scintigraphy is an ideal radiological investigation (6,7). Intravenous ^{99m}Tc-pertechnetate has a low radiation dose and is absorbed by mucous cells of the gastric mucosa, then excreted into the bowel lumen. Abnormal uptake can also be seen in other conditions, such as duplication cysts containing ectopic gastric mucosa, angiodysplasia, intussusception, or inflammatory bowel disease. However, uptake in a bleeding MD tends to be more focal and intense.

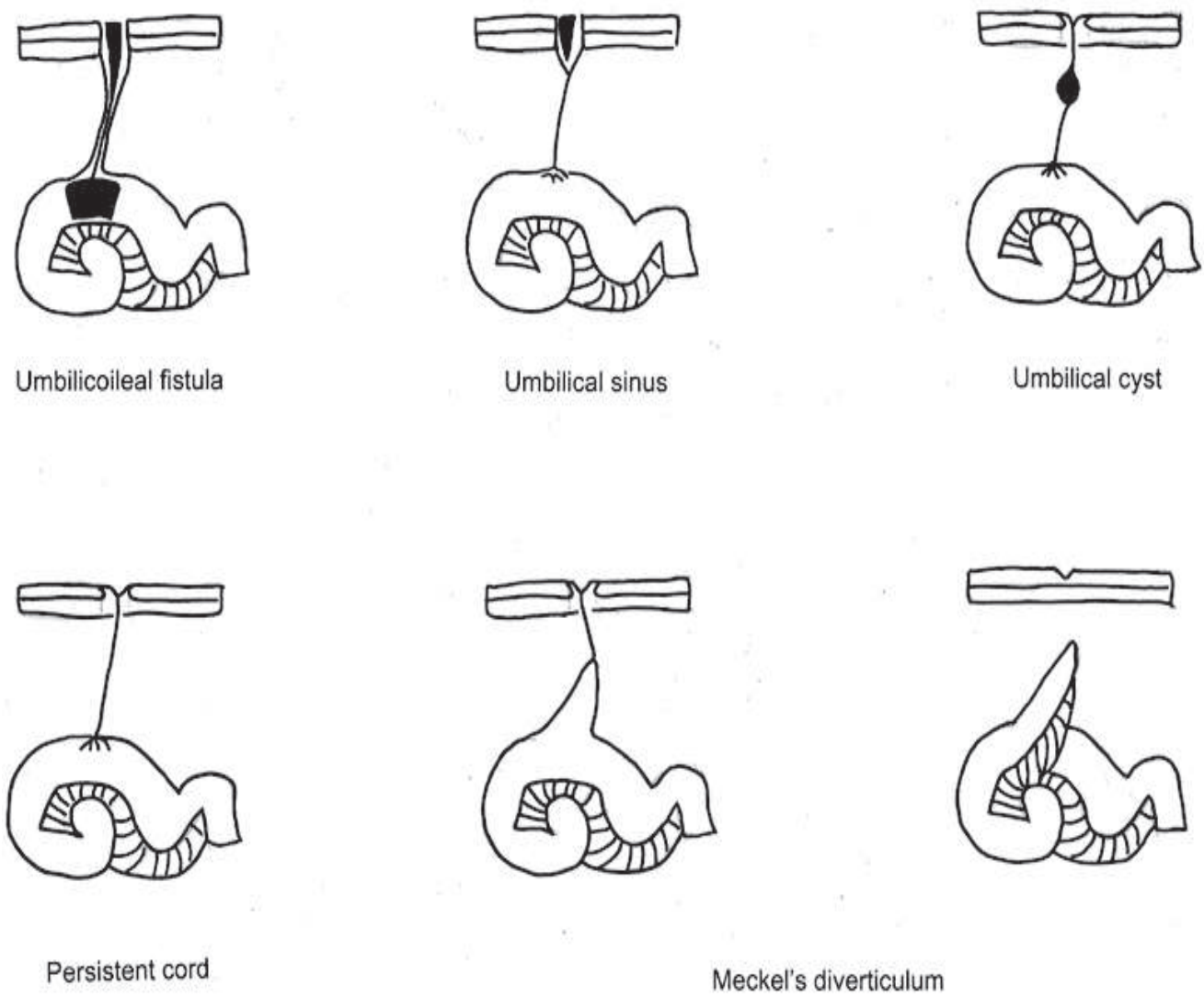

Figure 1: Schematic diagram showing Meckel's diverticulum and other variants of Vitelline duct remnants. Adapted from (8).

A retrospective study was conducted at NINMAS between January 2025 and December 2025 to assess the diagnostic accuracy of ^{99m}Tc-pertechnetate scintigraphy in pediatric patients with suspected MD. The study included detailed clinical history, scintigraphic findings, endoscopic findings, and histopathological confirmation. Various parameters, including age, gender, symptoms, and hemoglobin level, were recorded to evaluate the accuracy of ^{99m}Tc-pertechnetate, and the results were classified as positive or negative.

PATIENTS AND METHODS

Patients

A retrospective study was conducted on 60 patients presenting with symptoms such as melena, abdominal pain, and other signs of lower gastrointestinal bleeding, suspected to be caused by MD. These patients underwent ^{99m}Tc-pertechnetate scintigraphy at the National Institute of Nuclear Medicine and Allied Sciences between January 2025 and February 2026. Data were retrieved from comprehensive medical records, including clinical notes, diagnostic imaging reports, pathology reports, endoscopy results, and histopathology reports. Patients were excluded if they were older than 18 years, had unclear clinical diagnoses, or had insufficient pathological data. The study summarizes the patients' age at onset, gender, hemoglobin levels, primary symptoms (hematochezia, melena, abdominal pain, or severe anemia), histopathology, and ^{99m}Tc-pertechnetate scintigraphy results.

^{99m}Tc-pertechnetate scintigraphy

Pediatric patients were instructed to fast for three to six hours before scanning to reduce gastric volume. The use of perchlorate or laxatives was avoided before scintigraphy. No pharmacological interventions, such as pentagastrin, histamine, glucagon, or H2-receptor antagonists, were used to enhance ^{99m}Tc-pertechnetate imaging in this study. After intravenous injection of ^{99m}Tc-pertechnetate (1.1-3.7 MBq/kg for children and 185-370 MBq for adults), anterior and posterior planar images of the abdomen and pelvis were obtained at five minutes interval upto 30 minutes, then 90 minutes and 120 minutes post-injection using a low-energy high-resolution parallel-hole collimator (Siemens Symbia True Point SPECT-CT). Images were acquired with a 64 × 64 matrix over 120 seconds per matrix, using an age-appropriate zoom. Lateral images were taken as needed to help localize renal pelvis activity. A positive ^{99m}Tc-pertechnetate scan was indicated by abnormal focal tracer activity seen in early and delayed anterior images, not caused by physiological activity, with intensity increasing over time in parallel with normal gastric mucosa activity.

Statistical analysis

Data distribution was assessed using the Shapiro-Wilk test. Normally distributed continuous variables were presented as means and standard deviations (SD), non-normally distributed continuous variables as medians and interquartile ranges (IQR), and categorical variables as frequencies and percentages. Continuous variables were analyzed using Student's *t*-test, and categorical variables were analyzed using the chi-square test. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of ^{99m}Tc□pertechnetate scintigraphy for MD were calculated with histopathology as the reference standard, and diagnostic performance was further evaluated using receiver operating characteristic (ROC) curve analysis. A p□ value < 0.05 was considered statistically significant, and all analyses were conducted using SPSS version 26.

RESULTS

Patient characteristics and final diagnosis

Over a period of more than one year, a total of 60 pediatric patients underwent ^{99m}Tc-pertechnetate scintigraphy due to suspected MD. Of these patients, 33 (55%) were boys, and 27 (45%) were girls, with a median age of 3 years (IQR: 1.7-7.0). 26.6% of the children were under 2 years old at the time of the scan, with 31.25% of them ultimately diagnosed with MD. Among all patients who underwent ^{99m}Tc-pertechnetate scans, hematochezia and melena were the presenting symptoms in 54 (90%), abdominal pain in 8 (13.3%), hematemesis in 5 (8.3%), vomiting in 1 (1.7%), and anemia in 12 (20 %). Of the 6 patients with positive scans (10%), all presented with hematochezia or melena, and 3 had anemia. Among the 54 patients with negative scans, 48 (88.8%) presented with hematochezia or melena, 8 (14.82%) with abdominal pain, and 9 (16.67%) with anemia. All 6 patients (10%) with positive scintigraphy, all male, underwent surgery, and each was confirmed to have MD by histopathology. Among the 54 patients with negative scans, one was diagnosed with MD during surgery.

Table 1: Patient demographics and baseline characteristics

Characteristics	N=60
[a]Age (year)	3 (1.7, 7.0)
Gender	
[b]Male	33 (55%)
[b]Female	27 (45%)
Primary symptom	
[b]Hematochezia or Melena	54 (90%)
[b]Hematomesis	5 (8.3%)
[b]Abdominal pain	8 (13.3%)
[b]Vomiting	1(1.7%)
[b]Anemia	12 (20%)

a Data were expressed as median (Interquartile range)
b Data were expressed as frequency (percentages over total)

Diagnostic accuracy of ^{99m}Tc-pertechnetate scintigraphy

All six positive ^{99m}Tc-pertechnetate scintigraphy results were confirmed as true positives through histopathological examination. Of the 54 negative scintigraphies, one was identified as a false negative on postoperative histopathology, while the remaining 53 were verified as true negatives by clinical evaluation, imaging studies, and endoscopic and laparoscopic assessments. Therefore, the sensitivity, specificity, PPV, and NPV of ^{99m}Tc-pertechnetate scintigraphy for diagnosing MD were 85.71% (6/7), 100.0% (53/53), 100.0% (6/6), and 98.1% (53/54), respectively. The overall diagnostic accuracy was 98.3% (59/60). Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the diagnostic performance of ^{99m}Tc-pertechnetate scintigraphy in detecting Meckel's diverticulum. The area under the ROC curve (AUC) was 0.929 (standard error: 0.079, $p < 0.001$), indicating excellent diagnostic accuracy. The 95% confidence interval for the AUC ranged from 0.775 to 1.082, indicating the test's strong discriminative ability to differentiate patients with and without Meckel's diverticulum. (Figure 2)

Table 2: Diagnostic accuracy of ^{99m}Tc-pertechnetate scintigraphy in the diagnosis of Meckel's diverticulum.

^{99m}Tc-pertechnetate scintigraphy	Final diagnosis		Index
	MD, n (%)	Non-MD, n (%)	
Positive, n (%)	6	0	PPV = 100.0%
Negative, n (%)	1	53	NPV = 98.1%
Index	Se = **85.7%**	Sp = **100.0%**	Ac = 98.3%

Se, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value; Ac, accuracy; MD, Meckel's Diverticulum

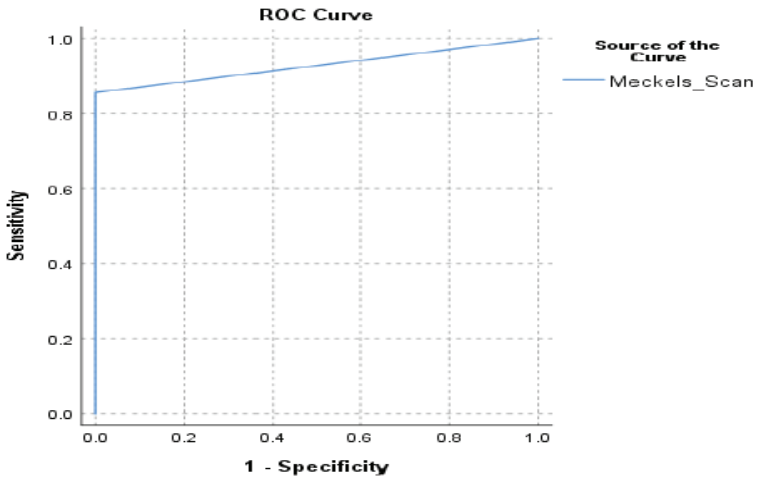

Figure 2: Receiver operating characteristic curve evaluating 99mTc-pertechnetate scintigraphy in predicting Meckel's diverticulum.

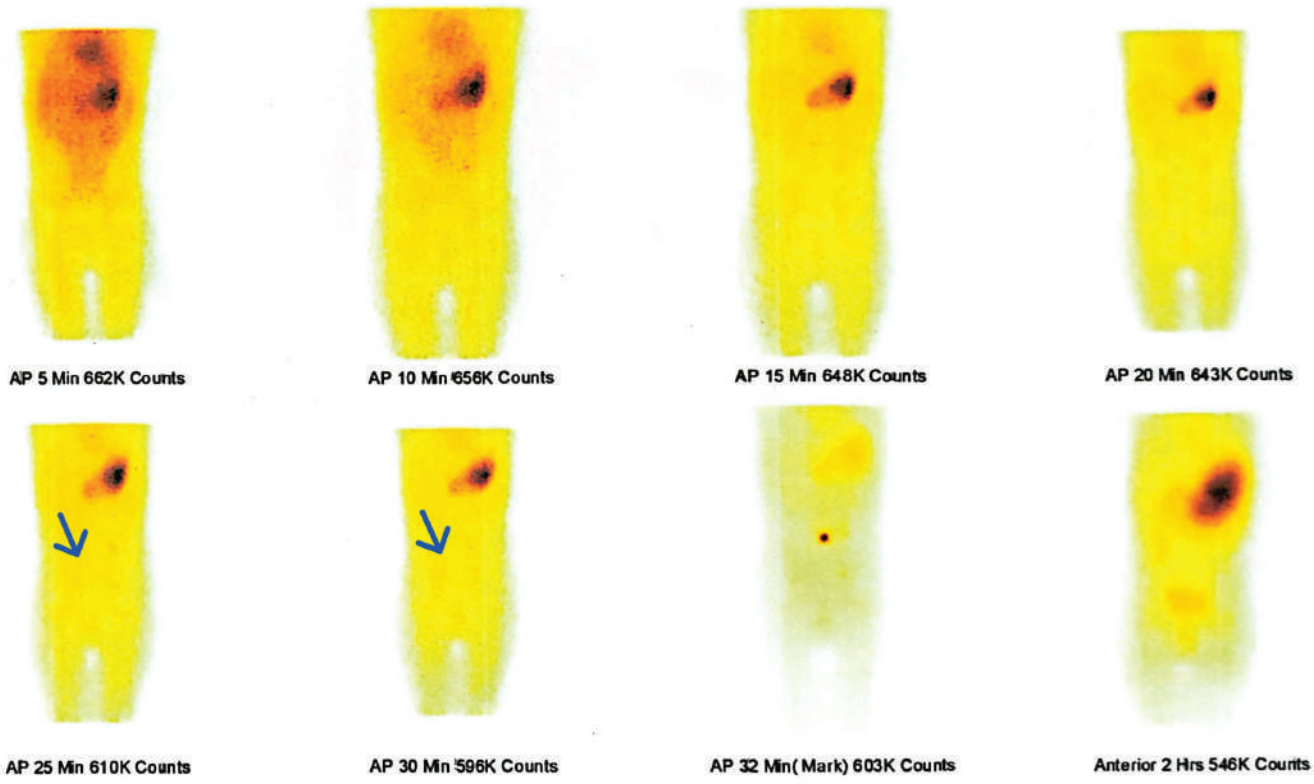

Figure 3: ^{99m}Tc-pertechnetate scintigraphy for MD revealed no focal tracer activity over the right side of the abdomen, with the appearance of the gastric activity (blue arrow).

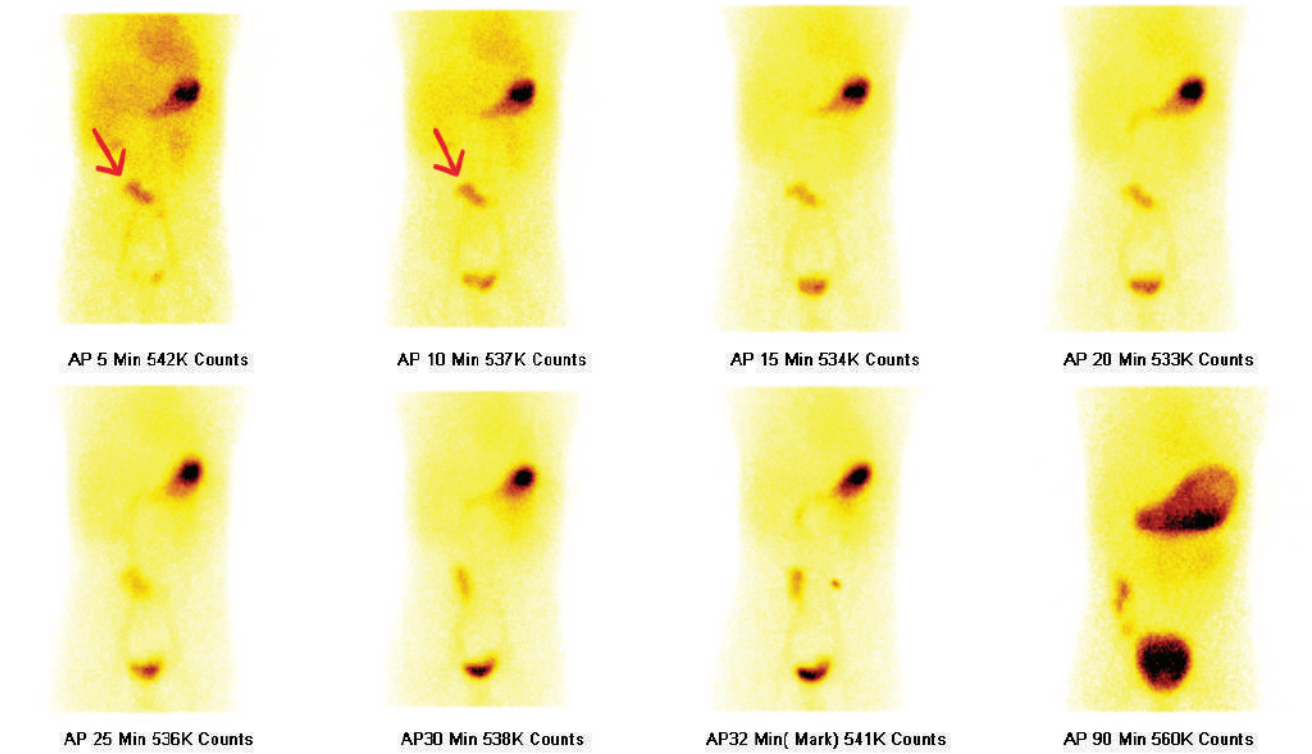

Figure 4: ^{99m}Tc-pertechnetate scintigraphy for MD revealed the presence of focal tracer activity over the right side of the abdomen, which appeared at the same time as gastric activity. This was a positive Meckel's scan (red arrow).

DISCUSSION

Meckel's diverticulum is a true diverticulum and may contain heterotopic gastric or pancreatic tissue (6). Not all Meckel's diverticula are symptomatic. Most remain undiscovered, with a lifetime risk of complications reported to range from 4 to 40% (9, 10). They can present with small bowel obstruction due to volvulus or intussusception, or with abdominal pain (9). Less than 50% of Meckel's diverticula contain ectopic gastric tissue (6), and they have a higher risk of gastrointestinal bleeding (11). Previous studies have reported that abdominal radiograph, barium studies, abdominal ultrasound, and CT are of limited use in detecting Meckel's diverticulum (6, 12, 13). Before pertechnetate scintigraphy was introduced, diagnosing bleeding MD preoperatively was very difficult. In 1933, Charles Mayo described the MD as "a diagnosis that is frequently suspected, often looked for, but seldom found" (14). Pertechnetate scintigraphy has been used in clinical practice since 1970. An early study, six years later, reported a sensitivity of 75% and a specificity of 79% (15). After refinements and standardization of the technique, a subsequent 10-year review in 1981 reported sensitivities and specificities of 85% and 95%, respectively (16). However, sensitivity was lower in adult populations (17, 18). Conversely, specificity and positive predictive value can both reach 95% across all age groups (6, 19, 20, 21).

In this study, 60 cases were recruited over 1 year. A total of seven Meckel's diverticula were confirmed surgically and histologically. All were male patients (100%), consistent with previous studies reporting that symptomatic Meckel's diverticula are more commonly found in males (22-24). The scan's sensitivity was 85.7%, and its positive predictive value was 100%. Specificity was 100% in our study. Overall accuracy was 98.3%. Our local experience indicates that Meckel's scan is a useful and accurate method for detecting Meckel's diverticulum.

There was one false negative case in the study, who was a pediatric patient referred for perirectal bleeding (a 01-year-old boy) for 03 months. Meckel's scan showed no focal tracer activity in the right lower abdomen around the time of gastric activity appearance. But the patient's symptom of per-rectal bleeding persisted, and there were no signs of improvement. The patient then traveled to India for better management, but the Mickels scan was also negative there. Then the patient was advised to have a CT abdominal angiogram, & it revealed no abnormality. After that, the patient was advised to undergo a contrast UGI study, which revealed a dilated bowel segment in the region of the hepatic flexure; the appearance raises the possibility of tubular gut duplication. The surgeons did an urgent exploratory laparotomy, and Meckel's diverticulum was found intra-operative. The diverticulum was resected, and ectopic gastric mucosa was confirmed histologically.

CONCLUSION

The study indicates that Meckel scanning is a safe, non-invasive procedure that exposes patients to minimal radiation. It is recommended as the first-line investigation for children with obvious hematochezia, irrespective of anemia, before considering more invasive options like endoscopy or laparoscopy, which necessitate general anesthesia.

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