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Diagnostic Value of Iodine Mapping Photon-Counting Computed Tomography (PCCT) in Early Small Bowel Ischemia Caused by a Rare Uterine Fibrotic Band

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Abbreviations: CT: Computed Tomography; DECT: Dual energy Computed Tomography; EID-CT:Energy-integrating detector Computed Tomography; PCCT: Photon-Counting Computed Tomography

1. Abstract

1.1. Background

Small bowel ischemia remains difficult to diagnose early, especially when caused by extrinsic mechanical compression rather than vascular occlusion. Photon counting Computed Tomography (PCCT) allows iodine-based perfusion assessment with significantly improved spectral resolution.

1.2. Case Presentation

A 55-year-old woman with multiple comorbidities presented with acute severe lower abdominal pain and vomiting. Conventional imaging revealed a closed-loop small bowel obstruction without definitive evidence of ischemia. PCCT iodine mapping demonstrated a sharply demarcated segment of absent iodine enhancement in a distal ileal loop, indicating loss of perfusion in that segment. Urgent exploratory laparotomy identified a dense fibrous uterine band causing complete obstruction and an ischemic 40 cm ileal loop, which required resection with primary anastomosis.

1.3. Conclusion

PCCT iodine mapping enabled early identification of bowel ischemia when standard CT was nondiagnostic. This case highlights PCCT's growing value in emergency abdominal imaging.

2. Introduction

Small bowel ischemia is a life-threatening condition with reported mortality rates exceeding 50% when diagnosis is delayed. Early symptoms are nonspecific, and laboratory values such as leukocytosis, lactate, and CRP may remain normal until late stages, limiting clinical detection[1]. Conventional CT is the first line modality, yet its early-stage diagnostic sensitivity remains limited, sometimes as low as 64%, particularly before mucosal necrosis or pneumatosis develop[1].

Dual energy CT (DECT) introduced iodine-based perfusion mapping, improving sensitivity in early ischemia[2]. However, DECT detectors are still energy integrating and subject to noise and reduced spectral precision.

Photon counting CT (PCCT) represents a major technological advancement. PCCT directly counts individual X-Ray photons and sorts them by energy, enabling higher spatial resolution, reduced electronic noise, and more accurate iodine quantification[3]. This makes PCCT particularly useful for detecting subtle perfusion changes, including early ischemia.

Fibrotic uterine origin bands represent an exceptionally rare etiology of small bowel obstruction and ischemia. Pelvic adhesions occur in more than 50% of women following

Caesarean delivery[5]. Yet reports of uterine fibrotic bands producing closed loop ischemia are extremely scarce.

This case demonstrates how PCCT iodine maps identified critical ischemia despite standard images appearing inconclusive.

3. Case Presentation

A 55-year-old woman presented to the Emergency Department with acute, severe abdominal pain that had begun earlier that morning. The pain was continuous and predominantly localized in the lower abdomen. She reported two episodes of vomiting and one bowel movement on the day of presentation. There was no history of fever or urinary symptoms. She described experiencing a similar episode of abdominal pain approximately two months earlier.

The patient had multiple chronic comorbidities, including type 2 diabetes mellitus, ischemic heart disease status post percutaneous coronary intervention, hypertension, dyslipidemia, depression, and overweight. She was a lifelong non-smoker.

Her regular medications included Insulin, Ezetimibe / Atorvastatin, Acetylsalicylic acid, Bisoprolol, and Evolocumab.

She had a surgical history of a cesarean section and a laparoscopic sleeve gastrectomy.

On clinical examination, the patient was alert but in moderate distress due to pain. She was hemodynamically stable. Abdominal examination revealed generalized guarding and central abdominal tenderness, with a firm lower abdomen more pronounced on the right side.

Laboratory Investigations showed Potassium of 3.2 mmol/L, Creatinine of 51 µmol/L, Urea of 2.7 mmol/L, WBC count of 12.9 $\times 10^9$/L, Hemoglobin of 13.4 g/dL, CRP of 1.5 mg/L, and Random blood sugar of 159 mg/dL.

Initial non-contrast CT abdomen demonstrated mildly distended, fluid-filled distal ileal loops in the pelvis, measuring up to 2.2 cm, with mild mucosal thickening and associated mesenteric congestion. These findings were concerning for early vascular compromise or a developing small bowel obstruction. A small volume of pelvic free fluid was also notedFigure 1.

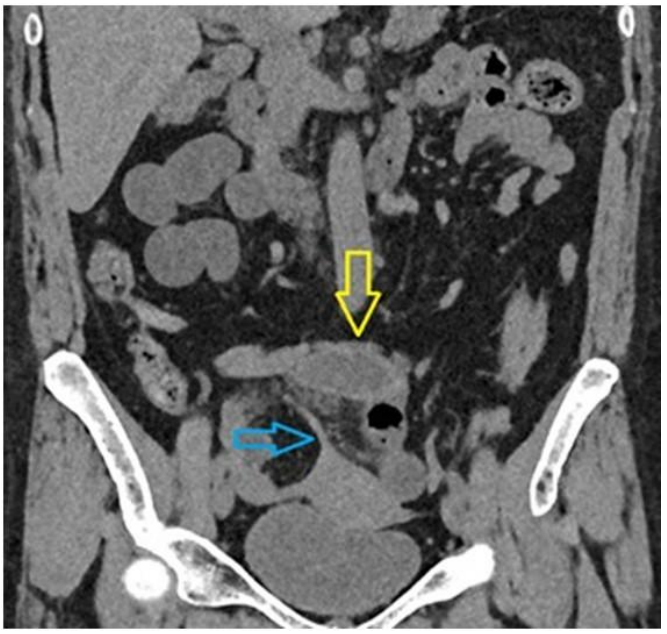

Figure 1: Coronal CT scan (without contrast) showed a fibrotic band extending from the fundus of uterus upward to the site of transitional zone (blue arrow), with focal segment of distal small bowel with early ischemic changes (yellow arrow).

Contrast-enhanced CT abdomen and pelvis with oral and intra-venous contrast revealed Increased free intraperitoneal fluid. Oral contrast limited to the proximal small bowel, which appeared normal. A distal small bowel loop in the left lower abdomen showing significant wall edema and poor enhancement on arterial and venous phases. Marked mesenteric congestion around the affected loop. Fibrotic band extending from the fundus of uterus, up to the site of transitional zone. No pneumatosis or portal venous gas were noted. Patent superior mesenteric artery and superior mesenteric vein. Indeterminate transition point. These findings were equivocal for bowel ischemia. The impression was closed-loop small bowel obstruction with suspected vascular compromise, likely secondary to adhesions, with progressive features concerning for bowel ischemia Figure 2. PCCT Iodine Mapping revealed a 30–50 cm segment of distal ileum with complete absence of iodine enhancement, with a sharply defined cutoff compared to adjacent normally enhanced loops. This pattern strongly suggested severe perfusion failure despite nondiagnostic conventional CT findings. Figure [3-6]. The patient underwent an urgent exploratory laparotomy, which revealed a large volume of serous peritoneal fluid and an ischemic loop of small bowel centrally located within the peritoneal cavity. A dense fibrous band extending from the right posterior uterine wall to the posterior abdominal wall near the right iliac fossa was identified, causing complete small bowel obstruction.

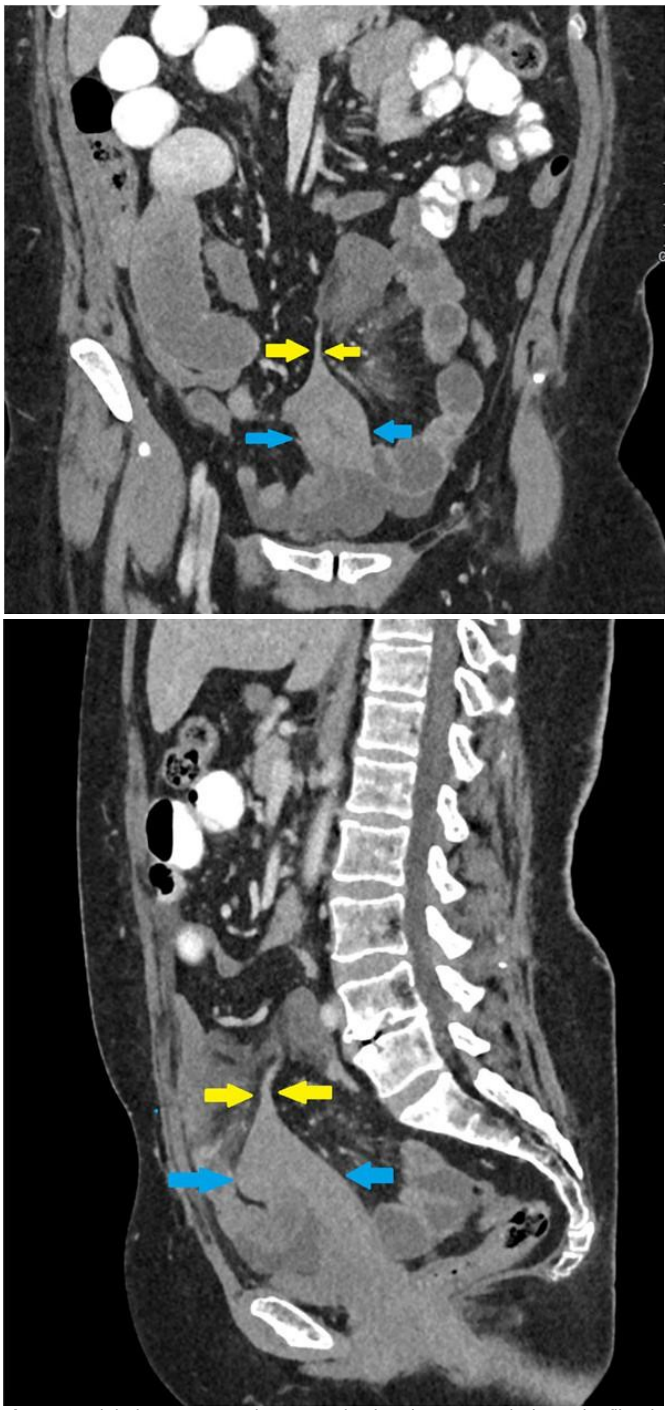

Figure 2: Right image: coronal CT scan (oral and IV contrast) showed a fibrotic band (yellow arrow) extending from the fundus of uterus (blue arrow) upward to the site of transitional zone. Left image: sagittal CT scan (oral and IV contrast) showed a fibrotic band extending from the fundus of uterus upward to the site of transitional zone.

The fibrous band was divided and excised. The compromised small bowel segment measured approximately 40 cm and was located about 1 meter proximal to the ileocecal junction. Despite repeated application of warm saline and observation for 25 minutes, there was no meaningful improvement in perfusion. A resection of the non-viable segment was therefore

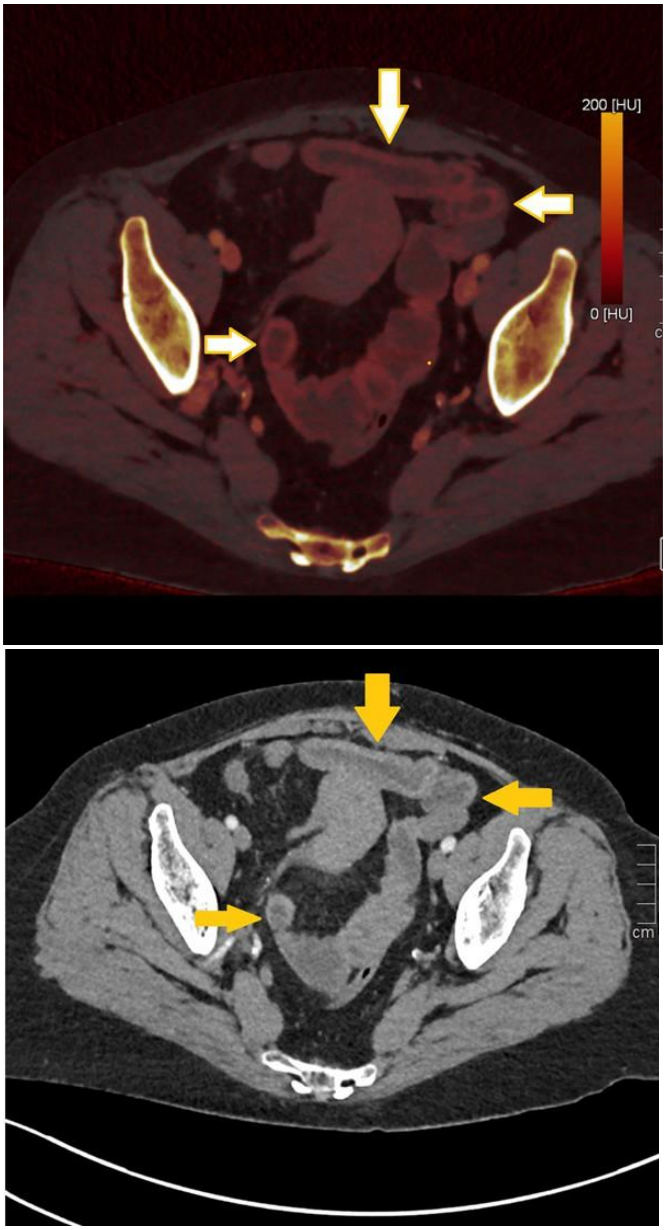

Figure 3:Upper image: axial PCCT scan (oral and IV contrast) iodine mapping showed a normal mucosal iodine uptake (yellow arrow). **Lower image:** axial conventional CT scan (oral and IV contrast) showed faint normal mucosal contrast uptake (yellow arrow).

performed, followed by side-to-side anastomosis using a linear stapler. The staple line was reinforc ed with a second layer of sutures. A pelvic drain was placed. The procedure was completed without intraoperative complications. The patient showed gradual improvement postoperatively. Her nasogastric tube and Foley catheter were removed on postoperative day 1. She passed flatus on postoperative day 2 and had her first bowel movement on day 3. During recovery, she developed a chest infection, which was evaluated and treated by pulmonology, then she was discharged on postoperative day 6 in stable condition.

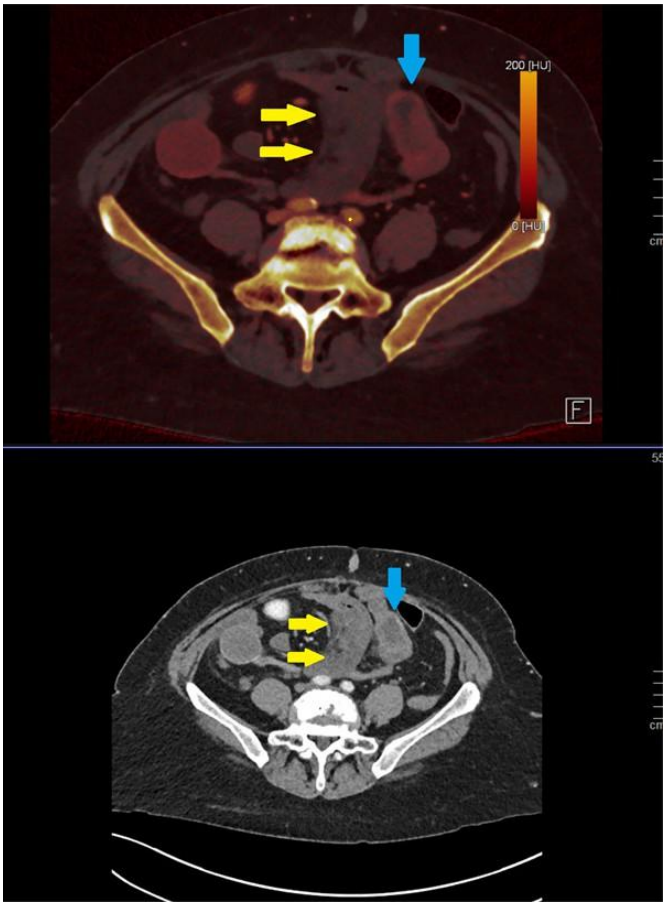

Figure 4: comparative axial images between iodine mapping image **(upper image)** and conventional CT scan image **(lower image)**, yellow arrow showed focal segment of small bowel devoted from iodine /contrast uptake, blue arrow showed normal mucosal enhancement.

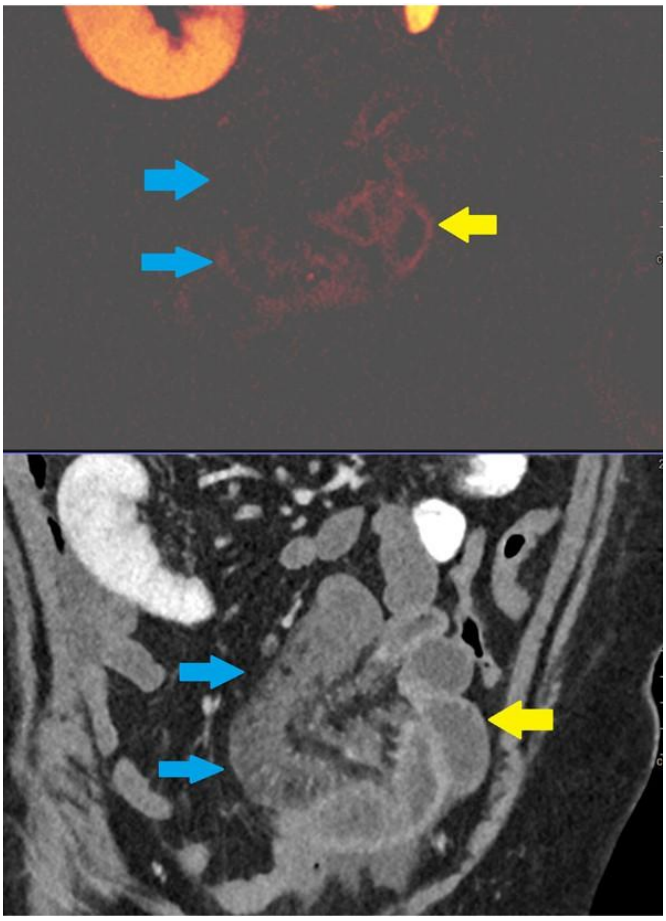

Figure 5: comparative coronal images between iodine mapping image **(Upper image)** and conventional CT scan image **(Lower image)**, blue arrow showed focal segment of small bowel devoted from iodine /contrast uptake, yellow arrow showed normal mucosal enhancement.

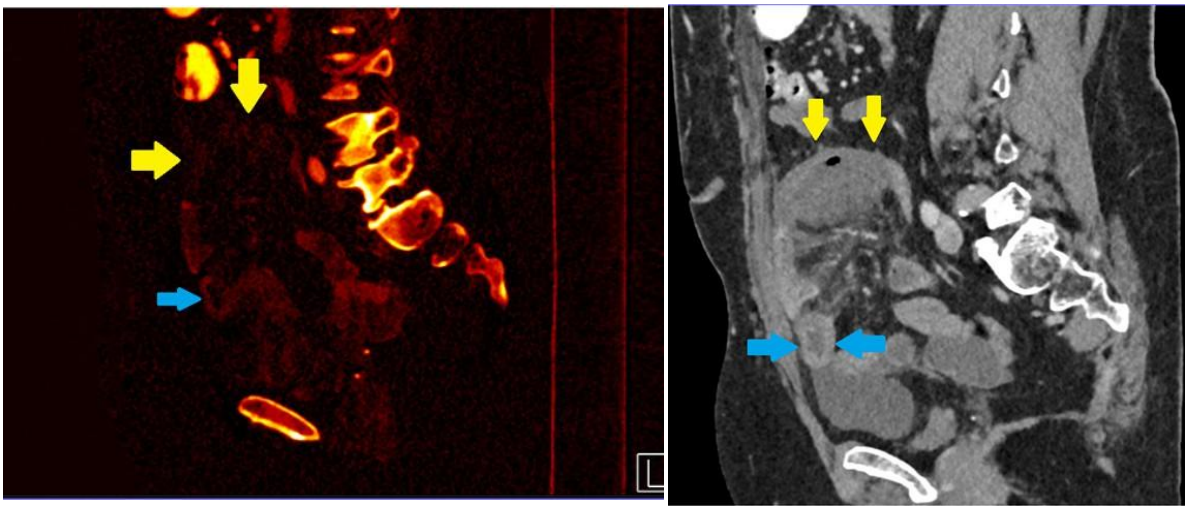

Figure 6: comparative sagittal images between iodine mapping image **(left image)** and conventional CT scan image **(Right image)**, yellow arrow showed focal segment of small bowel devoted from iodine /contrast uptake, blue arrow showed normal mucosal enhancement.

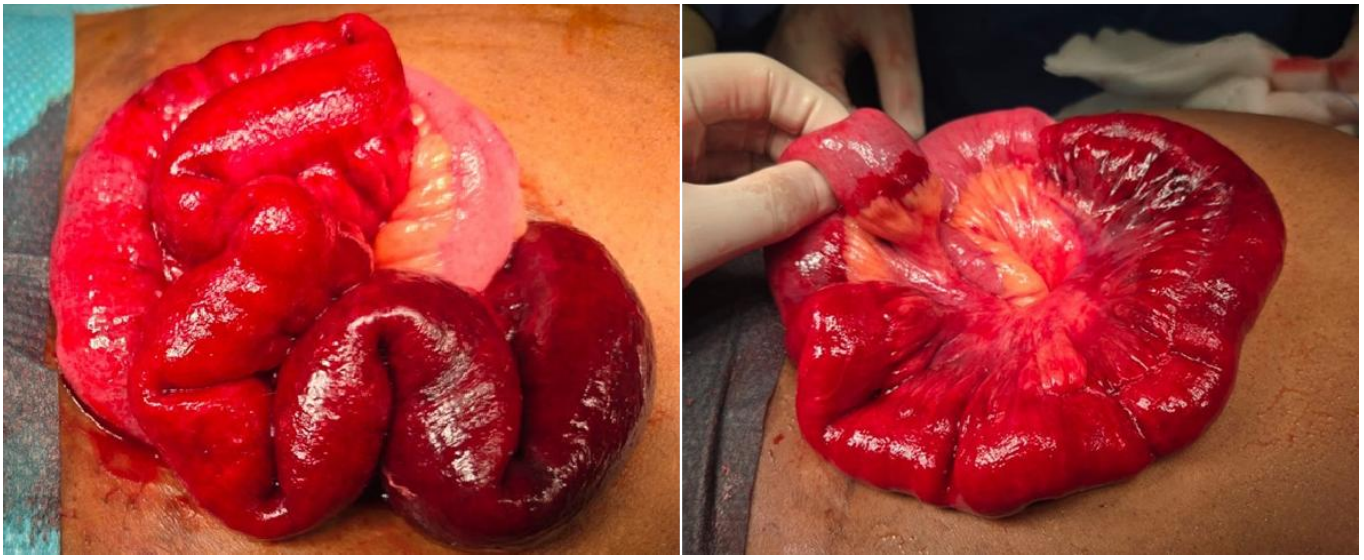

Figure 7: Intraoperative image demonstrating an ischemic segment of small bowel with a clearly defined transition point to adjacent normal-appearing small intestine.

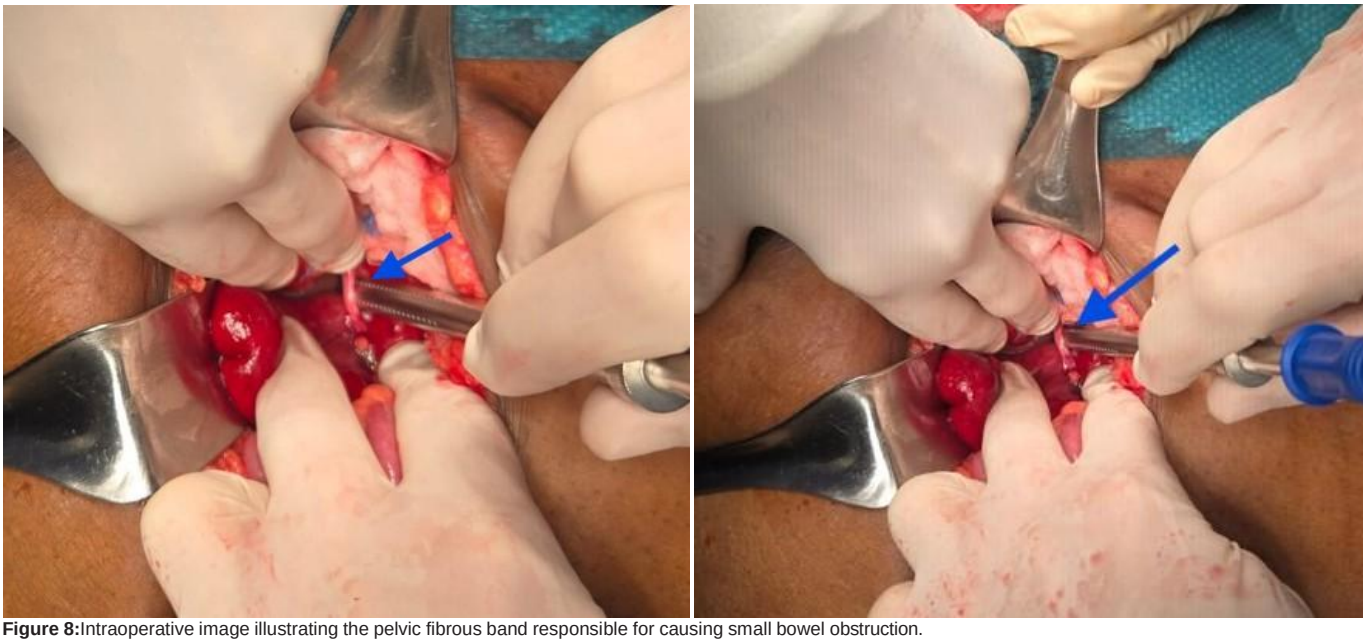

Figure 8: Intraoperative image illustrating the pelvic fibrous band responsible for causing small bowel obstruction.

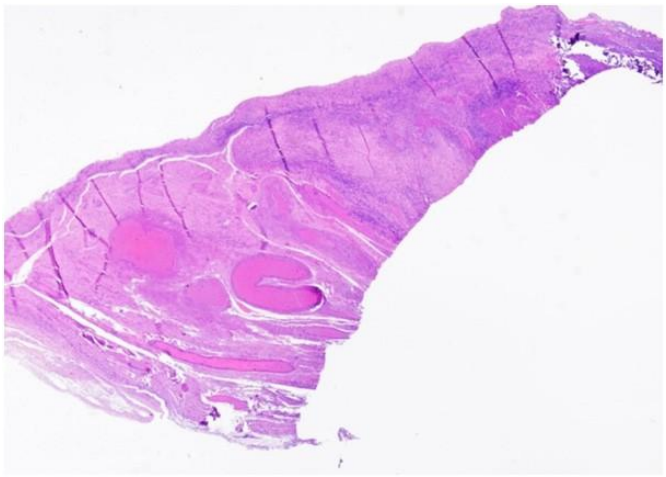

Figure 9: The constricting band (Hematoxylin& Eosin, 4X).

Gross examination of the band revealed an irregular, firm tissue fragment measuring 1.5 x 1 x 0.5 cm. Microscopical examination of the band revealed a vascularized fibrous tissue bandFigure 9.

The microscopic examination of the ischemic small bowel segment revealed small bowel villous mucosa with marked ischemic necrotic changes and inflammation, consistent with the clinical diagnosis of small bowel obstruction Figure10.

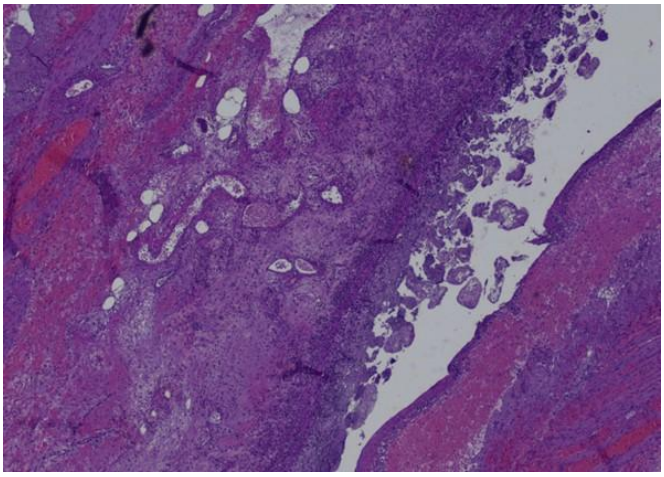

Figure 10: Small bowel wall with ischemic necrosis (Hematoxylin& Eosin, 4X).

4. Discussion

Small bowel ischemia continues to be one of the most challenging abdominal emergencies to diagnose early. Clinical presentation is often nonspecific, and laboratory markers remain limited in sensitivity. Conventional CT, although essential, frequently lacks sensitivity in early stages, as typical hallmarks such as pneumatosis and portal venous gas appear late[1].

PCCT provides significant advantages in this setting due to its ability to detect subtle enhancement differences and quantify iodine concentration with high precision. Compared to DECT, PCCT offers superior energy resolution, reduced noise, and improved contrast to noise ratios. These factors contribute to better visualization of bowel wall perfusion abnormalities[3].

Recent studies demonstrate that PCCT iodine mapping can detect ischemia earlier than conventional CT, particularly in cases where mural enhancement abnormalities are too subtle for standard detectors. Shaheen et al. reported improved visualization of non-enhancing segments in cases of bowel infarction using PCCT iodine maps[4]. Similarly, Giraud et al. showed that iodine quantification improves sensitivity in suspected small bowel ischemia[2].

This case further supports these findings: while conventional PCCT images appeared inconclusive, iodine maps revealed a complete lack of enhancement in a diseased segment, providing diagnostic clarity. This timely detection enabled urgent surgical intervention, preventing perforation and further complications. Fibrotic bands arising from the uterus are exceptionally uncommon. Although pelvic adhesions after Caesarean delivery are common, [5] Fibrotic uterine origin bands producing strangulating obstruction are sparsely documented. Closed loop obstruction from such bands can produce rapid onset ischemia despite preserved mesenteric perfusion, making imaging-based perfusion assessment essential.

The ability of PCCT to distinguish perfused from non-perfused loops makes it uniquely suited for such complex scenarios where mechanical obstruction may not show overt CT signs. This case underscores the emerging role of PCCT as a powerful early diagnostic tool in emergency abdominal radiology.

Photon-counting detector CT (PCCT) provides several advantages over conventional energy-integrating detector CT (EID-CT), particularly for iodine mapping, due to its improved spatial resolution, spectral accuracy, and noise performance. The following key advantages are supported by peer-reviewed literature: The first key advantage is the Improved spatial resolution, achieved through smaller detector pixels and direct photon conversion, resulting in substantially higher spatial resolution, improving visualization of fine structures and small lesions [6]. In addition, PCCT provides superior contrast resolution and iodine quantification as energy-resolving detectors allow highly accurate iodine mapping and improved material decomposition, enhancing lesion detection and characterization[7,8]. The technology also reduces image noise and improved dose efficiency by minimizing the electronic noise and improves contrast-to-noise ratio (CNR), enabling lower radiation dose or lower iodine contrast volumes while maintaining diagnostic quality. [9,10] Moreover, several clinical studies have demonstrated a 20–25% reduction in iodinated contrast media usage with equal or superior diagnostic quality[10]. PCCT further improves spectral imaging, artifact reduction, and material discrimination, as the intrinsic multi-energy data enabling better separation of iodine, calcium, and soft tissue, and reducing beam-hardening and metal artifacts [7,10]. Finally, these advantages translate into enhanced performance across multiple clinical applications, as PCCT improves chest, cardiac, abdominal, musculoskeletal, and pediatric imaging through combined gains in contrast, resolution, and dose efficiency[9].

5. Conclusion

PCCT iodine mapping enabled early recognition of small

bowel ischemia secondary to a rare uterine fibrotic band. When conventional CT is equivocal, PCCT offers critical diagnostic insight by precisely evaluating bowel perfusion. Incorporating PCCT into emergency imaging protocols may significantly improve outcomes in suspected ischemia.

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