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Single-Photon Emission Computed Tomography for A Difficult Diagnosis of Acute Cholecystitis

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Background	The diagnosis of acute cholecystitis can be challenging when initial imaging modalities, such as conventional planar hepatobiliary iminodiacetic acid (HIDA) scintigraphy, yield equivocal results. Single-photon emission computed tomography/computed tomography (SPECT/CT) can serve as a valuable adjunctive imaging technique in such scenarios. We describe the case of a 70-year-old female in whom SPECT/CT was instrumental in confirming acute cholecystitis after indeterminate planar HIDA findings.
Summary	A 70-year-old female presented with acute-onset epigastric pain, nausea, and vomiting. Initial workup revealed a mild leukocytosis, while right upper quadrant ultrasonography demonstrated gallbladder sludge without definitive sonographic signs of acute cholecystitis (wall thickening or pericholecystic fluid). Due to persistent severe pain despite conservative measures, HIDA scintigraphy was performed. Conventional planar images were equivocal for radiotracer filling of the gallbladder, precluding a definitive diagnosis. Subsequent SPECT/CT imaging provided improved anatomical delineation and unequivocally confirmed the absence of radiotracer accumulation within the gallbladder, consistent with cystic duct obstruction and acute cholecystitis. The patient underwent operative intervention, which revealed a severely inflamed gallbladder necessitating a subtotal cholecystectomy.
Conclusion	This case underscores the utility of SPECT/CT as a valuable problem-solving adjunct to conventional HIDA scintigraphy when planar images are inconclusive or difficult to interpret in patients with suspected acute cholecystitis. The enhanced anatomical localization provided by SPECT/CT can aid in confirming or refuting the diagnosis, thereby guiding appropriate and timely clinical management.

Key Words | acute cholecystitis; ultrasound; SPECT/CT; HIDA; cholecystectomy; surgery

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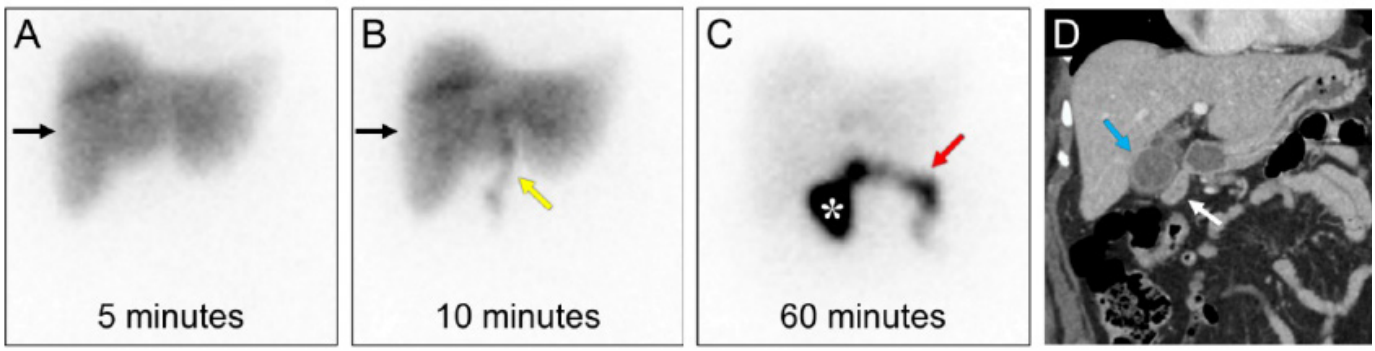
Case Description

A 70-year-old female with a past medical history of hyperlipidemia, pre-diabetes, gastritis, and obesity presented with the sudden onset of severe epigastric pain, nausea, and vomiting, which began within an hour of consuming a meal of spicy chicken wings. She initially attributed her symptoms to a gastritis flare, a condition for which she was under gastroenterological care and had recently undergone an esophagogastroduodenoscopy with biopsies negative for *H. pylori*. However, as the pain persisted and intensified, she sought emergency medical evaluation. She reported a similar, though self-limited, episode approximately one year prior while traveling, at which time a right upper quadrant ultrasound had revealed small gallstones, but no further interventions were pursued.

In the emergency department, the patient was afebrile and hemodynamically stable. On exam, she was exquisitely tender in the epigastrium with voluntary guarding, but without definitive signs of peritonitis. Laboratory investigations revealed a mildly elevated white blood cell count of 11.4 × 10^9/L, with normal serum lipase and liver function tests. An abdominal ultrasound demonstrated gallbladder sludge but lacked specific sonographic findings of acute cholecystitis, such as gallbladder wall thickening or pericholecystic fluid. Despite intravenous opioids and a gastrointestinal cocktail, her pain remained severe and had persisted for over six hours, raising strong clinical suspicion for acute cholecystitis warranting cholecystectomy. This recommendation was discussed with the patient, who expressed reluctance to proceed with surgery without a more definitive radiographic diagnosis. Consequently, further imaging with hepatobiliary iminodiacetic acid (HIDA) scintigraphy was performed.

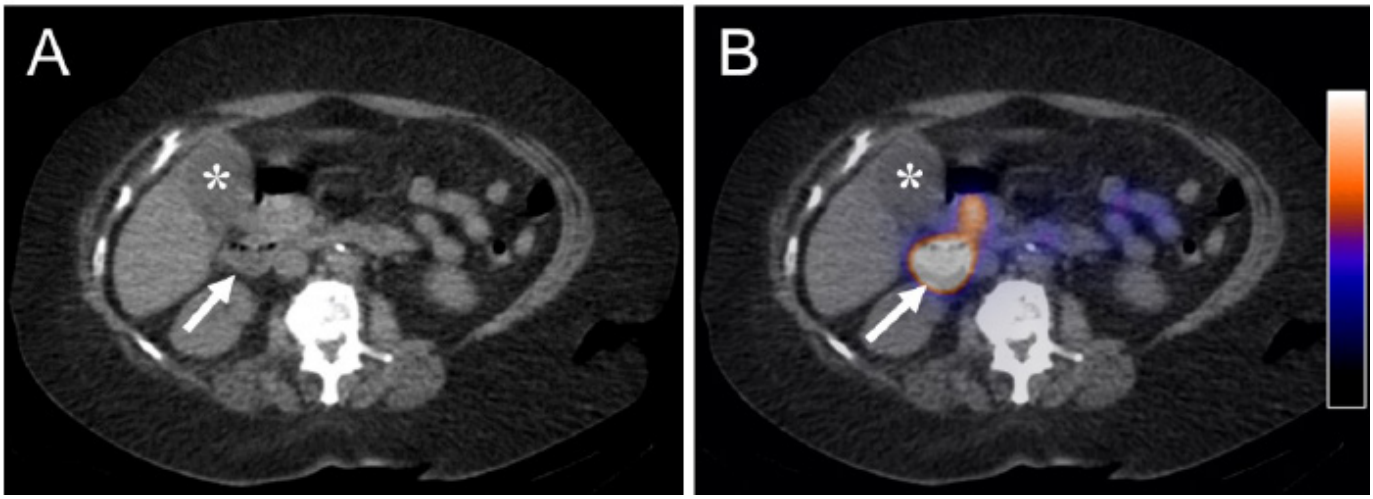
Dynamic anterior planar images obtained over 60 minutes following intravenous administration of 5.36 mCi of 99mTc-Mebrofenin demonstrated adequate hepatic uptake and clearance of the radiotracer from the blood pool, with timely excretion into the common bile duct (CBD) and duodenum (Figure 1). However, based on a prior CT scan, it was known that the patient's gallbladder was situated adjacent to the second portion of the duodenum. This anatomical relationship made definitive interpretation of radiotracer filling of the gallbladder on anterior planar views challenging, even on delayed images obtained at 4 hours (Figure 1). Additional right lateral and left anterior oblique planar views were acquired but remained inconclusive regarding the presence or absence of radiotracer within the gallbladder. Given the high clinical suspicion for acute cholecystitis and the patient's desire for diagnostic certainty to avoid potentially unnecessary surgery, the decision was made to perform single-photon emission computed tomography/computed tomography (SPECT/CT). This hybrid imaging technique utilizes the previously administered HIDA radiotracer to generate cross-sectional scintigraphy images fused with CT data, allowing for improved anatomical localization. The SPECT/CT images unequivocally confirmed the absence of radiotracer accumulation within the gallbladder lumen, while demonstrating excreted radiotracer in the adjacent duodenum, findings concordant with cystic duct obstruction and the clinically suspected diagnosis of acute cholecystitis (Figure 2).

Figure 1. Planar HIDA Scintigraphy Demonstrating Equivocal Gallbladder Filling. Published with Permission



Sequential anterior planar images from HIDA scintigraphy at 5 minutes ***(A)****, 10 minutes* ***(B)****, and 60 minutes* ***(C)*** *post-intravenous 99mTc-Mebrofenin administration. Images* ***(A-C)*** *show normal hepatic uptake (black arrows) and excretion of radiotracer into the common bile duct (yellow arrow in C) and small bowel (red arrow in C).* ***(D)*** *A prior axial CT image illustrates the anatomical proximity of the gallbladder (blue arrow) to the duodenum (white arrow). This proximity makes the area of radiotracer activity near the gallbladder fossa on the 60-minute planar HIDA image (C, asterisk) indeterminate for true gallbladder filling versus duodenal activity.*

Figure 2. SPECT/CT Clarifying Absence of Gallbladder Radiotracer Uptake. Published with Permission



(A) *Axial CT image of the upper abdomen at the level of the gallbladder.* ***(B)*** *Corresponding fused axial SPECT/CT image. The fused image clearly demonstrates excreted radiotracer activity within the lumen of the duodenum (white arrows) without any discernible radiotracer accumulation within the gallbladder, which is located more anteriorly (asterisk). This confirms cystic duct obstruction.*

Based on these definitive SPECT/CT findings, the patient was taken to the operating room for laparoscopic cholecystectomy. Intraoperatively, the gallbladder was found to be severely inflamed with a thickened, edematous wall ("thick rind"). Significant inflammation in the porta hepatis obscured anatomical landmarks, precluding safe dissection and identification of the cystic duct and artery. Consequently, the decision was made to convert to a fenestrated subtotal cholecystectomy. A surgical drain was placed in the gallbladder fossa.

On the first postoperative day, the surgical drain was noted to have bilious output. The patient subsequently underwent an endoscopic retrograde cholangiopancreatography (ERCP), which revealed a cystic duct leak and the presence of debris within the CBD. A biliary stent was placed across the papilla into the CBD. Her subsequent hospital course was complicated by mild post-ERCP pancreatitis. She was discharged on postoperative day three. One week later, at her outpatient clinic visit, the surgical drain was removed. She later developed a superficial wound infection, which was managed appropriately. Ultimately, the patient recovered fully and returned to her baseline functional status approximately one month postoperatively. A repeat ERCP performed two months after the initial procedure allowed for uneventful stent removal, and she has required no further surgical follow-up.

Discussion

Acute cholecystitis is a prevalent surgical diagnosis, affecting approximately 300,000 individuals annually in the United States.[1,2] The diagnosis is typically established based on the Tokyo Guidelines, which integrate local signs of inflammation (e.g., Murphy's sign, right upper quadrant tenderness), systemic inflammatory markers (fever, elevated white blood cell count, or elevated C-reactive protein), and characteristic imaging findings.[3] Ultrasonography or computed tomography are commonly employed as initial imaging modalities. However, when these initial studies are equivocal, HIDA scintigraphy is frequently utilized and is recognized for its high sensitivity in diagnosing acute cholecystitis.[4,5]

HIDA scintigraphy involves the intravenous administration of a radiotracer (e.g., 99mTc-Mebrofenin), which is taken up by hepatocytes and subsequently excreted into the biliary system. In normal physiology, the radiotracer fills the gallbladder and passes into the small bowel via the common bile duct. Visualization of radiotracer within the gallbladder indicates cystic duct patency, effectively ruling out acute calculous cholecystitis. Conversely, persistent non-visualization of the gallbladder, typically assessed up to four hours post-injection, is highly suggestive of cystic duct obstruction, a hallmark of both acute calculous and acalculous cholecystitis.[6]

In challenging cases, standard planar HIDA scintigraphy may include additional views, such as right lateral and oblique projections, to improve diagnostic confidence. Despite these maneuvers, false-negative or indeterminate results can occur, particularly when adjacent structures containing excreted radiotracer, such as the duodenum, are mistaken for or obscure the gallbladder.[7] In such instances of diagnostic uncertainty, the addition of cross-sectional imaging with SPECT can significantly enhance anatomical delineation and diagnostic accuracy.[8] Modern SPECT scanners are typically integrated with CT (SPECT/CT), providing fused images that offer both functional (scintigraphic) and anatomical (CT) information. This co-registration allows for precise localization of radiotracer activity and provides attenuation correction, thereby improving image quality and interpretative confidence. SPECT/CT has been reported to improve intra-observer agreement and overall diagnostic accuracy in various nuclear medicine studies.[9] Beyond biliary imaging, SPECT/CT is widely utilized for diverse clinical applications, including sentinel lymph node mapping, radioactive iodine therapy for thyroid cancer, evaluation of benign and malignant osseous conditions, diagnosis of pulmonary embolism, and myocardial perfusion imaging.[10]

Despite the demonstrable clinical advantages of SPECT/CT in clarifying equivocal HIDA scans, considerations regarding its cost-effectiveness are pertinent, especially since acute cholecystitis can often be diagnosed with less expensive modalities like ultrasound. To date, specific cost-effectiveness analyses for SPECT/CT in the diagnostic algorithm for acute cholecystitis are lacking, likely because it is not a routinely indicated first-line study. However, SPECT/CT has demonstrated cost-saving benefits in other clinical contexts, such as the evaluation of pulmonary embolism,[11] staging of non-small cell lung cancer,[12] and assessment of knee pain after total knee arthroplasty,[13] primarily due to its high sensitivity, specificity, and overall diagnostic accuracy, which can reduce the need for further investigations or inappropriate interventions. It is plausible that similar cost-effectiveness could be observed in select patients presenting with epigastric or right upper quadrant abdominal pain and diagnostic uncertainty if the timely and accurate diagnosis provided by SPECT/CT obviates repeated emergency department visits, prolonged hospital stays, or unnecessary surgical procedures.

This case is highlighted because, although the utility of SPECT/CT in diagnosing acute cholecystitis is recognized within the field of nuclear medicine, it represented a diagnostic adjunct not previously utilized by our surgical team, despite practicing at a high-volume academic center that routinely employs HIDA scintigraphy. The positive impact of SPECT/CT on this patient's management—by providing a correct and timely diagnosis in a challenging clinical scenario—underscores its potential as a powerful tool for surgeons to be aware of and consider when faced with diagnostic uncertainty in suspected acute cholecystitis.

Conclusion

The diagnosis of acute cholecystitis is generally straightforward, relying on a combination of clinical assessment, basic laboratory investigations, and widely accessible imaging modalities. However, in diagnostically challenging or indeterminate cases, particularly when conventional planar HIDA scintigraphy is equivocal, SPECT/CT serves as a useful and effective adjunctive imaging technique, providing enhanced anatomical localization and diagnostic clarity.

Lessons Learned

Discordance between a patient's clinical presentation and initial diagnostic workup can render even common diagnoses, such as acute cholecystitis, challenging. This case effectively highlights the added diagnostic value of SPECT/CT as an adjunct to indeterminate planar HIDA scintigraphy examinations. Its ability to provide definitive anatomical localization of radiotracer activity can be instrumental in resolving diagnostic uncertainty, thereby facilitating appropriate and timely management decisions, particularly in complex presentations of suspected acute cholecystitis.

References

1. Peery AF, Crockett SD, Murphy CC, et al. Burden and cost of gastrointestinal, liver, and pancreatic diseases in the United States: update 2018. *Gastroenterology*. 2019;156(1):254-272.e11. doi:10.1053/j.gastro.2018.08.063
2. Wadhwa V, Jobanputra Y, Garg SK, Patwardhan S, Mehta D, Sanaka MR. Nationwide trends of hospital admissions for acute cholecystitis in the United States. *Gastroenterol Rep (Oxf)*. 2017;5(1):36-42. doi:10.1093/gastro/gow015

3. Yokoe M, Hata J, Takada T, et al. Tokyo Guidelines 2018: diagnostic criteria and severity grading of acute cholecystitis (with videos). *J Hepatobiliary Pancreat Sci*. 2018;25(1):41-54. doi:10.1002/jhbp.515
4. Gallaher JR, Charles A. Acute cholecystitis: a review. *JAMA*. 2022;327(10):965-975. doi:10.1001/jama.2022.2350
5. Kiewiet JJ, Leeuwenburgh MM, Bipat S, Bossuyt PM, Stoker J, Boermeester MA. A systematic review and meta-analysis of diagnostic performance of imaging in acute cholecystitis. *Radiology*. 2012;264(3):708-720. doi:10.1148/radiol.12111561
6. Tulchinsky M, Ciak BW, Delbeke D, et al. SNM practice guideline for hepatobiliary scintigraphy 4.0. *J Nucl Med Technol*. 2010;38(4):210-218. doi:10.2967/jnmt.110.082289
7. Low CS, Ahmed H, Notghi A. Pitfalls and limitations of radionuclide hepatobiliary and gastrointestinal system imaging. *Semin Nucl Med*. 2015;45(6):513-529. doi:10.1053/j.semnuclmed.2015.06.001
8. Ziessman HA, O'Malley JP, Thrall JH. *Nuclear Medicine: The Requisites*. 5th ed. Elsevier; 2024:chap Single-photon emission computed tomography, positron emission tomography, and hybrid imaging.
9. Arabi M, Brown RKJ, Dwamena BA, et al. Single-photon emission computed tomography/computed tomography as a problem-solving tool in patients with suspected acute cholecystitis. *J Comput Assist Tomogr*. 2013;37(6):844-848. doi:10.1097/RCT.0b013e3182a604ae
10. Israel O, Pellet O, Biassoni L, et al. Two decades of SPECT/CT - the coming of age of a technology: an updated review of literature evidence. *Eur J Nucl Med Mol Imaging*. 2019;46(10):1990-2012. doi:10.1007/s00259-019-04404-6
11. Toney LK, Kim RD, Palli SR. The economic value of hybrid single-photon emission computed tomography with computed tomography imaging in pulmonary embolism diagnosis. *Acad Emerg Med*. 2017;24(9):1110-1123. doi:10.1111/acem.13247
12. Romsa J, Imhoff RJ, Palli SR, Inculet R, Mehta S. SPECT/CT versus planar imaging to determine treatment strategy for non-small-cell lung cancer: a cost-effectiveness analysis. *J Comp Eff Res*. 2022;11(4):229-241. doi:10.2217/cer-2021-0139
13. Van den Wyngaert T, Palli SR, Imhoff RJ, Hirschmann MT. Cost-effectiveness of bone SPECT/CT in painful total knee arthroplasty. *J Nucl Med*. 2018;59(11):1742-1750. doi:10.2967/jnumed.117.205567