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The Role of SPECT/CT in Peritoneal Scintigraphy in the Era of Low-Dose Imaging: A Case Report

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Abstract

Peritoneal scintigraphy, although rarely used, plays a vital role in the diagnosis of peritoneal dialysis catheter complications. Reported complications include spontaneous hydrothorax secondary to a pleuroperitoneal fistula, which requires the abandonment of peritoneal dialysis, given that a delay in diagnosis can lead to worsening clinical status. Previously reported peritoneal scintigraphy protocols recommended intraperitoneal instillation of radiotracer and moderate-to-large volumes of dialysate or sterile saline ranging from 350 to 2,000 mL. However, smaller volumes, in conjunction with the use of single-photon emission computed tomography/computed tomography, are not verified in patients receiving peritoneal scintigraphy imaging.

Keywords

- peritoneal scintigraphy
- SPECT/CT
- pleuroperitoneal fistula
- diaphragmatic defect
- peritoneal dialysis catheter

Introduction

Although uncommon, hydrothorax is a recognized complication of peritoneal dialysis first described in 1967, occurring in approximately 2% of continuous ambulatory peritoneal dialysis patients.[1,2] Hydrothorax is usually a clear transudative (mostly right-sided) pleural effusion, which should be differentiated from other sources of pleural effusion, such as heart failure or fluid overload, causing increased hydrostatic pressure in the lungs.[3] Pathogenesis of peritoneal dialysis catheter-associated hydrothorax has been reported to originate from congenital or acquired defects of the diaphragm, defective lymphatic drainage, and pleuroperitoneal communication via a fistulous tract.[4]

Various tools for diagnosing hydrothorax have been evaluated with thoracentesis used to differentiate between transudative and exudative pleural fluid. However, those methods can identify the composition of the fluid but cannot establish the origin of it beyond a doubt. This is where imaging comes into play. Among the various imaging techniques, the ones available for examining the peritoneal cavity include chest radiographs, magnetic resonance imaging (MRI), computed tomography (CT) with iodinated contrast and peritoneal scintigraphy utilizing radiotracer with moderate-to-large volume dialysate or normal saline. The case described here demonstrates the diagnosis of pleuroperitoneal fistula utilizing low-dose single-photon emission computed tomography (SPECT/CT) in peritoneal scintigraphy with low-volume normal saline and radiotracer.

Case Presentation

Our patient is a 39-year-old male with a history of end-stage renal disease secondary to focal segmental glomerulosclerosis on peritoneal dialysis. He presented to the emergency department complaining of 1 week of severe shortness of

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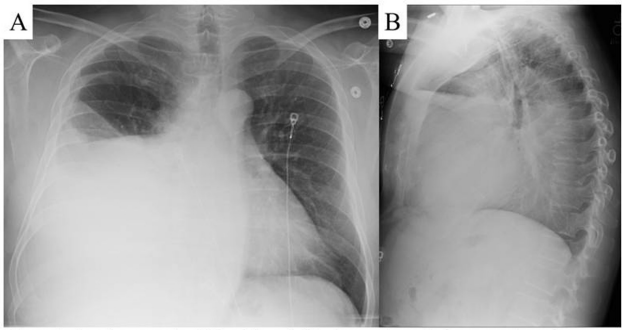

Fig. 1 Anterior–posterior (**A**) and lateral (**B**) chest radiograph demonstrating a large right pleural effusion with adjacent atelectasis before thoracentesis.

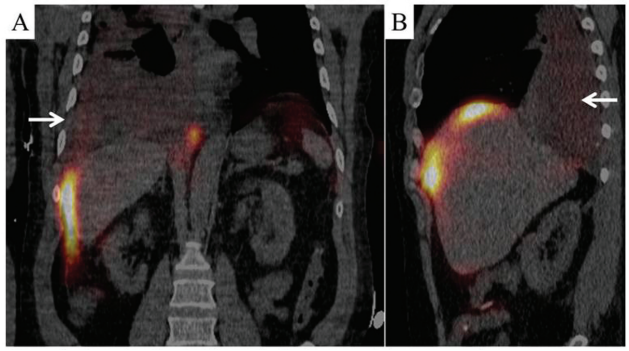

Fig. 3 Coronal and sagittal fused single-photon emission computed tomography/computed tomography images with radiotracer activity in the right hemithorax (arrows).

breath and chest pain with physical exam revealing decreased breath sounds on the right chest. The initial chest radiograph (►**Fig. 1**) demonstrated a large right pleural effusion that prompted an emergent ultrasound-guided thoracentesis with the aid of interventional radiology. Thoracentesis resulted in 1.3 L of clear fluid with further analysis showing the fluid to be transudative demonstrating a pleural fluid to serum creatinine ratio greater than 1.0 and pleural fluid to serum glucose ratio over 5.0. These findings raised suspicions for peritoneal dialysis-related hydrothorax secondary to a pleuroperitoneal fistula.

Next, the patient presented to the nuclear medicine department with a peritoneal dialysis catheter in place. To limit the amount of administered intraperitoneal fluid, 100 mL of normal saline and 3.3 mCi of Tc-99m sulfur colloid (SC) were instilled in the peritoneal cavity. Instead of static imaging, 1-minute anterior and posterior dynamic images of the mid-chest and upper abdomen were acquired for 30 minutes, immediately followed by a low-dose SPECT/CT of the mid-chest and upper abdomen.

The dynamic acquisition (►**Fig. 2**) demonstrated prompt flow of radiotracer in the peritoneal cavity with tracer noted in the subdiaphragmatic space and absence of substantial extravasation into the thorax. Upon separate examination of the SPECT/CT with a significantly narrow window, radiotracer migration was also noted in the right hemithorax (►**Fig. 3**). Following confirmation of pleuroperitoneal fistula, peritoneal dialysis was discontinued, and hemodialysis was immediately initiated.

Discussion

Peritoneal dialysis-associated hydrothorax is an uncommon yet challenging complication that can be severe and life-threatening, making timely diagnosis imperative.[4] Often, the etiology of such effusions remains unclear, despite diagnostic imaging and laboratory analysis of fluid obtained via thoracentesis. Pleural fluid analysis showing a high glucose content can indicate peritoneal fluid, although the origin is not definite.[4,5] Due to this fact, medical imaging plays a crucial role in confirming the source of the pleural fluid.

CT and MR peritoneography are valuable modalities for determining whether an anatomic diaphragmatic defect is present.[3] Between CT and MR, the reference standard is CT peritoneography using intraperitoneal contrast, which has a greater spatial resolution, widespread availability, and relatively low cost capable of depicting the entire peritoneal

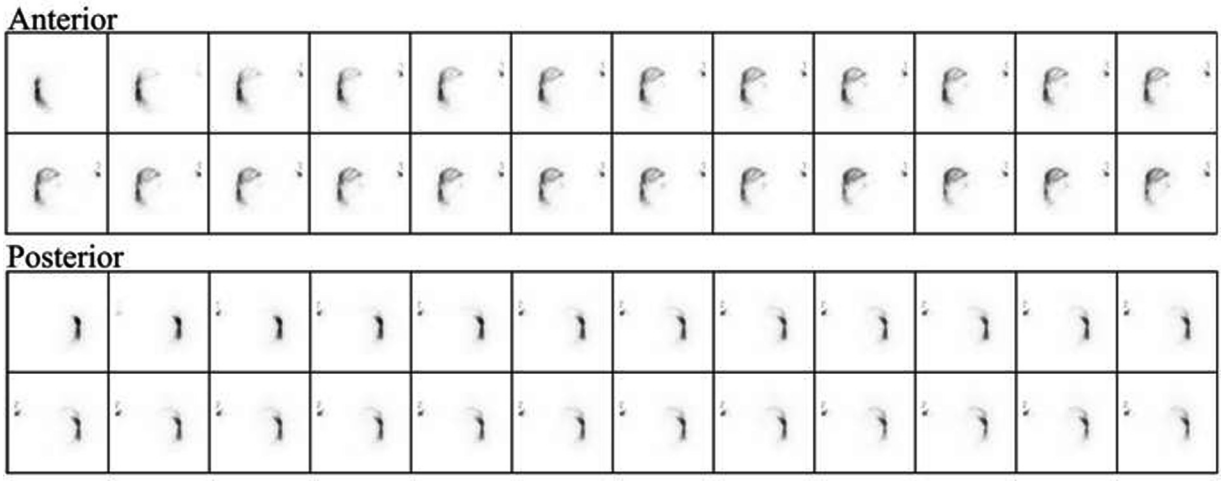

Fig. 2 Anterior and posterior dynamic images that demonstrate the flow of radiotracer in the perihepatic and right subdiaphragmatic space of the peritoneal cavity with the absence of notable extravasation into the thorax.

cavity.[3,6] Primary disadvantages include namely exposure to ionizing radiation and iodinated contrast media, which pose the risk of an allergic reaction and peritonitis. Furthermore, it has been reported that CT peritoneography shows a 33% sensitivity in identifying pleuroperitoneal leak.[3,7–9] MRI peritoneography is an effective method for detecting complications of peritoneal dialysis catheters by evaluating the diaphragm with the absence of radiation exposure, which is its most significant advantage when compared with CT peritoneography or peritoneal scintigraphy. Its disadvantages include a higher cost and limited availability than those typical of other modalities.[6]

Peritoneal scintigraphy using radiopharmaceuticals such as Tc-99m SC, Tc-99m macroaggregated albumin, and Tc-99m albumin colloid has been shown to be efficient methods for showing peritoneal leakage.[7,8,10] Tc-99m SC was the preferred radiopharmaceutical in this case because it was readily available. Most scintigraphic protocols described in the literature obtain initial dynamic planar imaging following the administration of tracer and 350 to 2,500 mL of dialysate or normal saline, without or with delayed images that can be obtained up to 24 hours later.[7,8,10–14] Delayed imaging of leaks is frequently necessary; however, it is not always feasible in CT peritoneography because the prolonged presence of an iodinated contrast medium increases the chance of peritonitis.[15] Although there is some radiation exposure, which is minimal, scintigraphy offers the advantages of low cost, no risk of an allergic reaction, or peritonitis. It is also easy to perform and has a higher degree of sensitivity ranging from 40 to 50% to detect relatively small volumes of leakage without morbidity.[4,9,15,16]

As demonstrated in this case, planar and dynamic images may not have enough spatial resolution to definitively determine the presence of a radiotracer within the pleural fluid, making SPECT/CT an ideal option. The main advantage of SPECT/CT is the increased specificity achieved through more precise characterization of functional findings.[17–19] The low-dose CT in the SPECT/CT imaging is used to localize SPECT lesions with low radiation doses of 1 to 4 mSv.[19]

Lymphatic drainage of the peritoneal space drains to the celiac, superior mesenteric, and periportal lymph node group. The lymph continues via the thoracic duct into the mediastinal nodes.[20] Metastases can reach the mediastinum from the retroperitoneal lymph nodes, and from the peritoneal cavity through the diaphragm, which has a rich subperitoneal lymphatic network.[21] Lymphoscintigraphy is used in gynecologic cancer patients to evaluate transdiaphragmatic lymphatic drainage. Lymph node uptake was excluded because this patient does not have a history of malignancy. SPECT/CT utilization also helped localize whether the uptake was in the pleural space versus the mediastinal nodes.

Conclusion

In summary, peritoneal scintigraphy plays an essential role in diagnosing peritoneal dialysis catheter-related complications such as a pleuroperitoneal fistula leading to hydrothorax, avoiding delay in diagnosis, which can lead to a worsening clinical status. Upon diagnosis, therapeutic options include a therapeutic thoracentesis with discontinuation of peritoneal dialysis or surgical intervention for diaphragmatic repair. In this patient, the pressure gradient between the peritoneum and pleura probably drove dialysate across the diaphragmatic defect. This case demonstrates that in the absence of ascites, the instillation of a small volume normal saline with Tc-99m SC in conjunction with SPECT/CT can definitively determine the etiology of hydrothorax to be due to a pleuroperitoneal communication.

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Conflict of Interest
None declared.

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