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Radionuclide Tracer Technology in the Diagnosis of Thoracoabdominal Fistula and Localization of Fistula Points: A Pilot Study

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Thoracoabdominal fistula; SPECT/CT; Radioisotope tracing technology

1. Abstract

1.1. Purpose: This study aims to explore the clinical utility of radionuclide tracer technology in the diagnosis and localization of thoracoabdominal fistulas.

1.2. Methods: 99mTc-DTPA was thoroughly mixed with the peritoneal dialysis fluid before continuously being introduced into the peritoneal cavity through a peritoneal dialysis tube. Dynamic acquisition in the supine-anteroposterior position and SPECT/CT fusion imaging were performed simultaneously on the same machine.

1.3. Results: Radioactivity concentration in the right thoracic cavity gradually increased after dynamic collection and was abnormally distributed in 4 min. SPECT/CT tomographic fusion depicted a right chest co-abdominal fistula, and the spot was accurately located.

1.4. Conclusion: Using radioisotope tracing technology of 99mTc-DTPA SPECT and CT tomography on the same machine, a simple, accurate qualitative, and localized diagnosis of pleural effusion can be made caused by abdominal leakage that provides a visualized objective basis for subsequent treatment.

2. Introduction

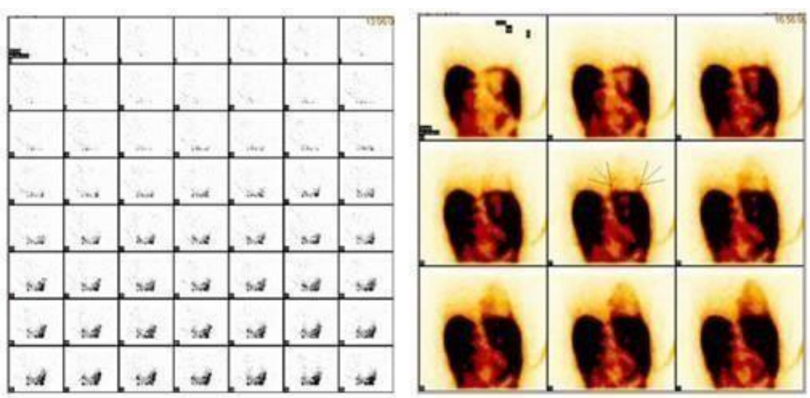
Peritoneal dialysis is one of the main methods of renal replacement therapy for treating patients with end-stage renal disease. Using the peritoneum as a semipermeable membrane, the peritoneal dialysate is continuously replaced to eliminate metabolites and toxin substances and correct water and electrolyte imbalances. The thoracoabdominal fistula is one of the rare but serious complications associated with peritoneal dialysis. Edward and Unger first reported the thoracoabdominal fistula in 1967 [1]. Radionuclide imaging is a medical imaging technique that uses radionuclides or their labeled compounds to determine the function and structure of organs and tissues.

3. Case Data

A 57-year-old woman receiving maintenance peritoneal dialysis for more than a year was admitted to the hospital with abdominal distension and pain for a week. In the beginning, peritoneal dialysis consisted of 1.5% 2 L peritoneal dialysis solutions three times daily. Eventually, due to edema of both lower extremities, the peritoneal dialysis program was changed to a 1.5% 2 L peritoneal dialysis solution, two times a day, and a 2.5% 2 L peritoneal dialysis solution, two times a day, to strengthen the dehydration. A reduction in lower extremity edema was observed. Abdominal ultrasonography revealed that the edema suddenly became prevalent (400 mL/day). While the amount exceeded about 400 mL after adjusting the plan, abdominal distention and discomfort accompanied by nausea and vomiting started one week ago after consuming the liquid. There was right hydrothorax and right pulmonary tissue compression on post-admission thoracic CT. The right thoracic puncture was then performed to drain a clear yellow liquid. A routine biochemical examination of the pleural effusion revealed leakage and elevated glucose levels in the hydrothorax, which was inconsistent with serum glucose levels. There was the possibility that a thoracoabdominal fistula could develop. Based on surgical consultation, the location of ruptured pleural fistula could not be determined, nor could it be effectively repaired. The nuclear medicine department performed a radionuclide localization examination to confirm diagnosis and location of the thoracoabdominal leakage. A concrete inspection method involved thoroughly mixing 10 mCi 99mTc-DTPA with peritoneal dialysis solution and delivering it as a continuous infusion through a peritoneal dialysis tube. The patient was lying on SPECT examination table and the dynamic acquisition of local anteroposterior position was performed (specific parameters were 1 s/frame for 1 min; then 1 min/frame for 15 min). The scanning device is an Infinia Hawkeye 4 SPECT/CT manufactured by GE of America. The scanning device is equipped with a low energy and high-resolution collimator, matrix 64×64, peak 140 Kev, and a window width of 20%. Xeleris, Functional Imaging Workstation software, was used for post-processing analysis.

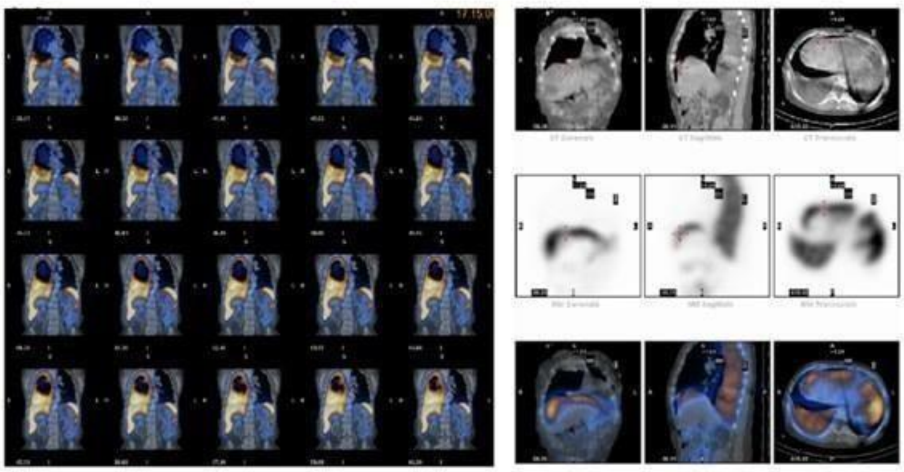
4. Results

After injection, the dynamic collection showed that the perisplenic and abdominal cavities gradually developed and thickened with the diffusion of imaging agent. At 4 min, two strips of radioactive exudation were visible on the right diaphragm. Abnormal accumulation of radioactivity and continuous enrichment in the right thoracic cavity were observed, as shown in Figure 1. SPECT/CT simultaneous tomography fusion imaging was utilized to locate the fistula. No abnormal radioactive accumulation in the left thoracic cavity was observed, as depicted in Figure 2. Conservative treatment has been recommended following a surgical consultation until the chest, and abdominal leaks heal spontaneously. After starting hemodialysis, abdominal pain, nausea, vomiting, and other symptoms gradually subsided. Follow-up abdominal and chest CT showed that the hydrothorax steadily decreased over time.



A B

Figure 1: Picture A is a 1s/frame dynamic scan. On observing that the peritoneal dialysis mixture containing 99mTc-DTPA was injected into the abdomen, it was found that peri-hepatic, peri-splenic, and ascites effusions were observed that were concentrated. The radiation distribution in the bilateral thoracic cavity was essentially symmetric and no abnormal increase in radioactivity was apparent. There was a slight increase in radioactivity in the right thoracic cavity only at the end of the imaging. Picture B is 1 min/frame; with imaging time delay, thoracic radiation distribution gradually increased significantly compared with the contralateral (leak point position shown by arrow).



A B

Figure 2: SPECT/CT simultaneous tomography fusion imaging and increased radioactivity distribution in the right pleural effusion and the right pleural cavity. Conservative treatment has been recommended following a surgical consultation until the chest, and abdominal leaks heal spontaneously. After starting hemodialysis, abdominal pain, nausea, vomiting, and other symptoms gradually subsided. Follow-up abdominal and chest CT showed that the hydrothorax steadily decreased over time.

5. Discussion

According to Liyanage et al. [2] global use of renal replacement therapy (dialysis and kidney transplantation) is predicted to reach 5.439 million (3.899-7.64 million) by 2030. Dialysis is the most common form of renal replacement therapy, except for a very small number of patients who can receive kidney transplantation [3]. Peritoneal dialysis is superior to hemodialysis in reducing adverse reactions, improving nutritional status and quality of life [4,5]. Peritoneal dialysis has a more significant protective effect on residual renal function without adversely impacting hemodynamics 4. Peritoneal dialysis is the best alternative to hemodialysis, including cost and ease of use [6]. Peritoneal dialysis, congenital diaphragm dysplasia, lymphatic drainage disorder, and chest-abdominal pressure difference are also known causes of chest-abdominal fistulas. Hydrothorax is a rare complication in peritoneal dialysis (PD) [7]. The diagnosis of thoracoabdominal fistula on peritoneal dialysis is generally based on biochemistry of pleural effusion, identification of the composition, intraperitoneal injection of methylene blue, plain chest radiographs, and CT or MRI abdominal angiography [8]. Contrast media must be injected into the abdominal cavity through a catheter to perform the above imaging techniques. In addition to being time-consuming and requiring professional training to complete, infusion of contrast media can cause complications such as chemical peritonitis [9]. Safe, noninvasive, simple, and accurate evaluation of pleural effusion caused by thoracoabdominal leakage, and even projection of its trajectory, provides an objective basis for guiding subsequent treatment and prognosis. Radionuclide tracer technology constitutes the essence of functional imaging in nuclear medicine, with high safety and sensitivity and low chemical and radiation doses. This technology corresponds more closely to the physiological state of the human body. Developing nuclear medicine technology has resulted in many advances in molecular imaging and functional imaging [10]. In vitro radionuclide imaging provides a non-invasive in vitro method for observing the distribution of radioactive nuclides in the chest and abdomen in real-time to guide thoracoabdominal fistula diagnosis and localization. In conjunction with radionuclide imaging, the thoracoabdominal fistula can be diagnosed and the fistula can be located by comparing the leakage site and surrounding tissue with radionuclide imaging. Functional imaging in nuclear medicine is a typical application of radionuclide tracing using functional imaging techniques. The results of this study differ from previous reports of direct injection of radioactive tracers into the body. In this study, the unabsorbed 99mTc-DTPA was thoroughly mixed with the dialysis solution and then continuously injected through peritoneal dialysis tubes, allowing not only to improve detection rates but also to more closely match the pathophysiology characteristics of dialysis patients. This study has limitations owing to a substandard leak point display. There may be misalignment, as Tomosynthesis acquisition time is long, and SPECT and CT acquisition are asynchronous. Due to the aging of the model used, the spatial resolution of SPECT and CT is too low. Therefore, there are two leakage points in the dynamic acquisition of the front and rear planes. After dynamic acquisition, the leakage point is not well visualized in SPECT/CT simultaneous tomographyfusion imaging.

6. Conclusions

In this study, 99mTc-DTPA was injected into the abdominal cavity and peritoneal dialysis solution while a SPECT dynamic scan was performed simultaneously. With CT tomography fusion imaging technology, the qualitative diagnosis of thoracoabdominal fistulas can be ascertained, but it also offers the advantages of non-invasiveness, safety, accuracy, and visuality that merit further application.

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