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RadionuclideTracerTechnology inthe Diagnosis of Thoracoabdominal Fistula and Localization of Fistula Points: APilot Study

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1. Abstract

Purpose: This studyaims to explorethe clinical utilityof radionuclide tracer technology in the diagnosis and localization of thoracoabdominal fistulas.

Methods:99mTc-DTPAwasthoroughlymixedwiththeperitoneal dialysis fluid before continuously beingintroducedinto 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 ma-chine.

Results: Radioactivityconcentrationintherightthoraciccav- ity gradually increased after dynamic collection and was abnormallydistributedin4min. SPECT/CTtomographicfusion depict- ed a right chest co-abdominal fistula, and the spot was accurately located.

Conclusion: Using radioisotope tracing technology of 99mTc-DTPA SPECT and CT tomographyon the same machine, a simple, accurate qualitative, and localized diagnosis of pleural effusioncan bemadecausedbyabdominalleakagethatprovidesa visualized objective basis forsubsequent treatment.

2. Introduction

Peritonealdialysisisoneofthemainmethodsofrenalreplacement therapyfortreating patients withend-stagerenal disease. Using

the peritoneum as a semipermeable membrane, the peritoneal di-alysate is continuously replaced to eliminate metabolites and tox- in substances and correct water and electrolyte imbalances. The thoracoabdominal fistula is one of the rare but serious complica- tions associated with peritoneal dialysis. Edward and Unger first reported the thoracoabdominal fistula in 1967 [1]. Radionuclide imagingisa medical imagingtechnique that usesradionuclides or theirlabeled compoundstodeterminethefunction andstructureof organsandtissues.

3. CaseData

A 57-year-old woman receiving maintenance peritoneal dialysis for more than a year was admitted to the hospitalwith abdomi-nal 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 toa 1.5% 2 Lperito-neal 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 preva- lent(400mL/day).Whiletheamountexceeded about400mLafter adjustingthe plan, abdominal distentionanddiscomfort accompa- nied by nausea and vomiting started one week ago after consum- ing the liquid. There was right hydrothorax and right pulmonary

tissue compression on post-admission thoracic CT. The right thoracicpuncturewasthenperformedtodrainaclearyellowliquid.A routine biochemical examination of the pleural effusion revealed leakageandelevatedglucoselevelsinthehydrothorax, whichwas inconsistent with serum glucose levels. There was the possibility that a thoracoabdominal fistula could develop. Basedonsurgi- cal consultation, the location of ruptured pleural fistula could not be determined, nor could it be effectively repaired. The nuclear medicine department performeda radionuclidelocalization examination to confirm diagnosis and location of the thoracoabdominal leakage. A concrete inspection method involved thoroughly mixing10mCi99mTc-DTPAwithperitonealdialysissolutionand delivering it as a continuous infusion through a peritoneal dialysis tube. The patient was lying on SPECT examination table and the dynamicacquisition of local anteroposterior position was performed (specific parameterswere 1 s/framefor 1 min;then 1min/frame for 15 min). The scanning device is an Infinia Hawkeye 4 SPECT/CTmanufacturedbyGE ofAmerica.Thescanningdevice is equipped with a lowenergyandhigh-resolutioncollimator, 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

Afterinjection,thedynamiccollection showedthattheperisplenic and abdominal cavities gradually developed and thickened with the diffusion ofimagingagent. At 4min, twostrips ofradioactive 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 fusionimaging 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 consultationuntilthechest,andabdominalleaksheal spontaneously. After startinghemodialysis, abdominal pain,nausea, vomiting, and other symptoms gradually subsided. Follow-up abdominal and chest CT showed that thehydrothorax steadilydecreased overtime.

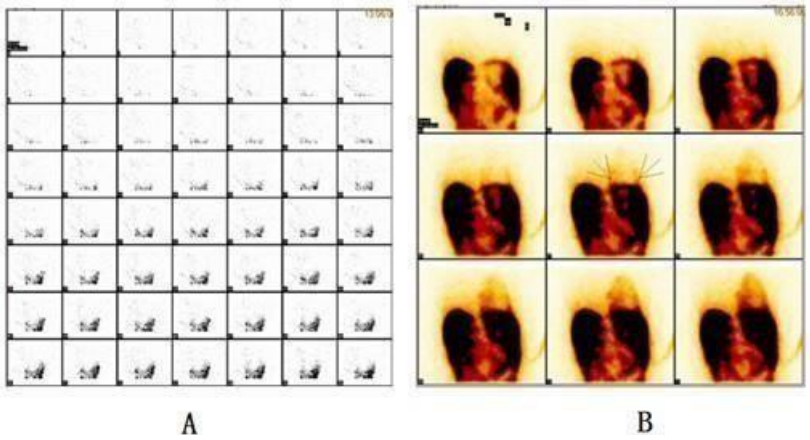

Figure 1: Picture A is a 1s/frame dynamic scan. On observing that the peritoneal dialysis mixture containing 99mTc-DTPA was injected into the abdomen, it was found that peri-hepatic, peri-splenic, and ascites effusions were observed that were concentrated. The radiation distribution in the bilateral thoraciccavitywas essentiallysymmetricandnoabnormal increaseinradioactivitywas apparent. There wasaslight increasein radioactivity in theright thoraciccavityonlyat theend of theimaging. Picture Bis 1 min/frame; withimagingtime delay, thoracicradiation distribution gradually increasedsignificantlycompared withthe contralateral (leak point position shown byarrow).

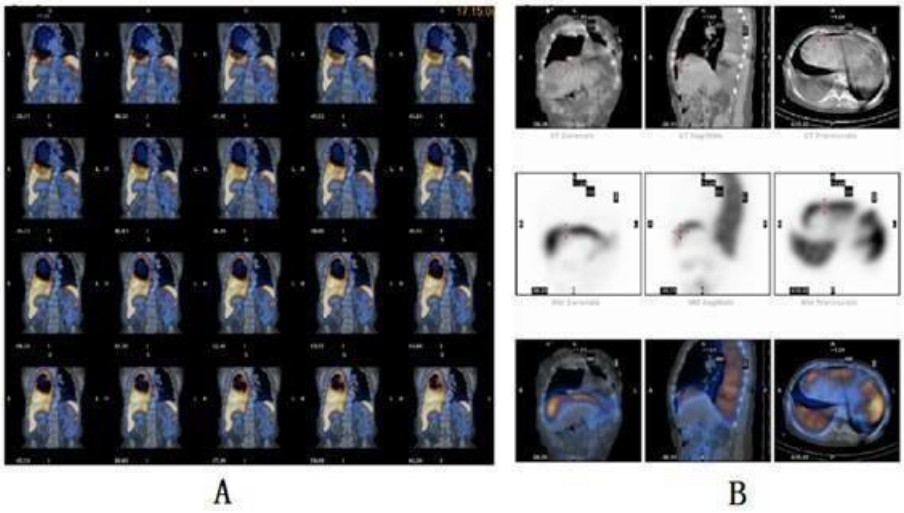

Figure2: SPECT/CTsimultaneous tomographyfusionimagingandincreasedradioactivitydistributionintheright pleural effusion andtheright pleu- ral cavity. Conservative treatment has been recommended following a surgical consultation until the chest, and abdominal leaks heal spontaneously. After starting hemodialysis, abdominal pain, nausea, vomiting, and other symptoms gradually subsided. Follow-up abdominal and chest CT showed that the hydrothorax steadilydecreased over time.

5. Discussion

According to Liyanage et al. [2] global use of renal replacement therapy(dialysis and kidneytransplantation) is predicted toreach 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].Peritonealdialysishasamoresignificantprotectiveeffecton 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 theabdominal cavitythrough a catheter toperform theaboveimagingtechniques. Inadditiontobeingtime-consumingandrequiring professional training to complete, infusion of contrast media can cause complications such as chemical peritonitis [9]. Safe, noninvasive, simple, and accurateevaluation of pleural effusion caused bythoracoabdominalleakage,andevenprojectionofitstrajectory, provides an objective basis for guiding subsequent treatment and prognosis. Radionuclide tracer technologyconstitutes 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 nuclearmedicinetechnology hasresulted in many advances in molecular imaging and functional imaging [10]. In vitro radionuclide imaging provides a non-invasive in vitro method for observing the distributionof radioactive nuclidesinthe chest and abdomen inreal-time to guide thoracoabdomi- nal fistula diagnosis and localization. In conjunction with radio- nuclide 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 imag- ing in nuclear medicine is a typical application of radionuclide tracing using functional imaging techniques. The results of this studydifferfrompreviousreportsofdirectinjectionofradioactive 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 onlyto improve detection rates but also tomore closelymatch the pathophysiologycharacteristicsofdialysis patients.Thisstudyhas 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 themodel used,thespatialresolutionofSPECTandCTistoolow. Therefore, there aretwoleakage pointsinthedynamic acquisition ofthefrontandrearplanes.After dynamicacquisition,theleakage point is not well visualized in SPECT/CT simultaneous tomographyfusion imaging.

6. Conclusions

Inthisstudy,99mTc-DTPAwasinjectedintotheabdominalcavity andperitonealdialysis solution whileaSPECTdynamicscan was performed simultaneously. With CT tomography fusion imaging technology, the qualitative diagnosis ofthoracoabdominal fistulas can be ascertained, but it also offers the advantages of non-invasiveness, safety, accuracy, andvisualitythatmeritfurtherapplica-

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