

Scintigraphic Detection of Abdominal Wall and Diaphragmatic Peritoneal Leaks in Patients on Continuous Ambulatory Peritoneal Dialysis

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Continuous ambulatory peritoneal dialysis (CAPD) is utilized with increasing frequency for patients with end stage renal disease (ESRD). Several complications have been observed including catheter malfunction due to pericatheter leaks, abdominal wall and inguinal hernias and diaphragmatic leaks. Occasionally special diagnostic procedures are necessary to determine the nature of the abnormality and guide the surgical approach to correction. The four cases herein illustrate the usefulness of radionuclide imaging in diagnosing leakage of dialysate fluid in patients on CAPD.

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In 1985, there were over 90,000 individuals in the United States receiving chronic dialysis, with an estimated 13% on continuous ambulatory peritoneal dialysis (CAPD) (1). While CAPD offers several advantages over hemodialysis, a number of complications have been described with this procedure. Chief among these is peritonitis. Other complications include catheter related abdominal wall infections, pericatheter external leaks, pericatheter interabdominal wall leaks, abdominal wall and inguinal hernias, and diaphragmatic leaks with pleural effusion (2-9). While many of these complications are relatively common and can be diagnosed by physical examination and routine laboratory techniques, some patients may require special techniques or procedures in order to adequately define the specific problem. The purpose of this paper is to illustrate the ease, practicality and diagnostic usefulness of radionuclide imaging in patients on CAPD with suspected leakage of dialysis fluid from the abdominal cavity.

METHOD

Multiview planar imaging was performed on a large field-of-view scintillation camera set at the 140-keV photopeak and 20% window, utilizing a low-energy, all purpose collimator.

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Using a dose of 3-5 mCi of technetium-99m (^{99m}Tc) albumin colloid imaging times of 3-5 min per view resulted in 500,000 to 1,500,000 counts per image. Anterior views were routinely obtained over the abdomen and pelvis (including genital area), or thorax in case of suspected diaphragmatic leak. Lateral views were occasionally utilized for further definition of abnormalities.

The unabsorbable tracer of 3 to 5 mCi [^{99m}Tc]colloid is instilled intraperitoneally via the dialysis catheter along with the usual 2-l volume dialysate exchange in order to reproduce the state of increased intraperitoneal pressure and thereby enhance any abnormality. Initial imaging to include the entire area of interest should begin within 15 min in order to depict the intraperitoneal distribution of the tracer as well as detect the very early movement of activity outside of the peritoneal cavity. One or more additional images over a 2-hr period after tracer administration is usually sufficient to delineate the route and dynamics of a leak when present. The patient is encouraged to remain ambulatory during this period in order to better reproduce the offending pathophysiology.

Careful marking of key normal and abnormal anatomic features including sites of entrance of the dialysis catheter into the skin and peritoneal cavity may be quite useful in the interpretation of the scintiphotos.

Case 1

The patient was a 54-yr-old female with end-stage renal disease due to renal artery stenosis and arteriolar nephrosclerosis. She was started on CAPD in June 1986 after placement of a double cuff Tenckhoff catheter in the subumbilical region. Initial catheter function was excellent. In October 1986 she noted poor dialysate return and edema of the lower abdominal wall. Attempts at continued peritoneal dialysis and increasing ultrafiltration resulted in progressive edema of the lower ab-

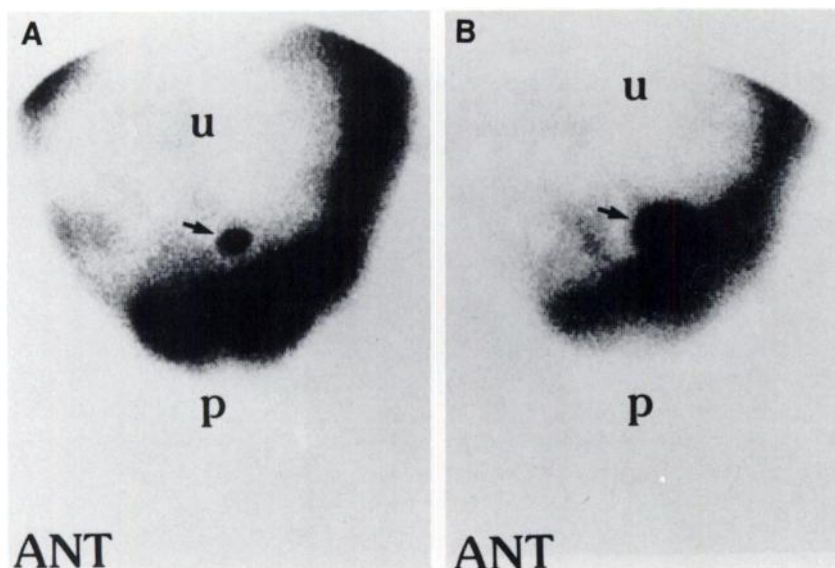


FIGURE 1
Case 1. Abdominal/pelvic scintigraphy post intraperitoneal [^{99m}Tc]albumin colloid. At 15 min (A) a small focal area of leakage (arrow) is noted at the catheters peritoneal exit site. Progressive leakage (arrow) is noted at 2 hr (B). Umbilicus(u), pubis(p).

dominal wall, flanks, buttocks, and external genitalia. No external leak was noted.

Multiview camera scintigraphy of the abdomen and pelvis was performed at 15 minutes and at 2 hr postintraperitoneal instillation of 5 mCi [^{99m}Tc]albumin colloid and 2 l of the dialysate via the Tenckhoff catheter (Fig. 1). Images obtained at 15 min showed a small focal area of intense concentration of activity at the peritoneal exit site of the catheter ~7 cm below the level of the umbilicus near the midline. Repeat imaging at 2 hr showed evidence of progressive leakage at that site.

Surgical exploration revealed subcutaneous fluid and identification of a leak at the site of the internal cuff of the catheter. Revision of the catheter resulted in no further edema or poor dialysate return.

Case 2

The patient was a 30-yr-old male with end-stage renal disease due to chronic glomerulonephritis. After placement of a double cuff Tenckhoff catheter on 7/2/86 he was started on CAPD. Initially catheter function was excellent. However, within 1 mo following return to strenuous activity he noted poor dialysate return and developed scrotal edema. Physical findings were limited to bilateral scrotal edema. There was no evidence of external catheter leakage or abdominal wall edema and no abdominal or inguinal hernia was present. A peritoneal catheterogram on 8/12/86 showed no evidence of a peritoneal leak. Surgical exploration of the abdominal wall revealed no leak and the catheter was revised. Within the following 2 wk poor dialysate return and increasing scrotal edema were again noted. Physical findings were again limited to scrotal edema.

On 8/27/86, 5 mCi of [^{99m}Tc]albumin colloid along with 2 l of dialysate was administered intraperitoneally via the Tenckhoff catheter. Multiview camera scintigraphy was then performed over the abdomen, pelvis, and scrotal area at ~15 min, and 2 hr after tracer administration (Fig. 2). The images obtained at 2 hr demonstrated extraperitoneal leakage of the dialysate into the mid lower anterior abdominal wall with dissection of a small fraction of this fluid into the scrotum.

A repeat peritoneal catheterogram demonstrated a loculated space in the mid lower anterior abdominal wall, however, the exact site of fluid extravasation could not be determined. Surgical exploration identified extraperitoneal fluid, but no obvious peritoneal defect or specific site of leakage. A new peritoneal dialysis catheter was placed with tight peritoneal and fascial closures. Subsequently the patient resumed CAPD and full activity with no further catheter malfunction or edema.

Case 3

The patient was an 81-yr-old male with end stage renal disease of unknown etiology. He was started on CAPD in April 1986 after placement of a double cuff Tenckhoff catheter in the subumbilical region. Initial catheter function was excellent. In September 1986 the patient noted bilateral scrotal swelling; however, he continued to have excellent dialysate return. Physical examination revealed bilateral scrotal edema and a moderate amount of penile edema. A large right indirect inguinal hernia and smaller left inguinal hernia were noted for the first time. There was no external catheter leakage or edema of the abdominal wall. Multiview camera scintigraphy of the abdomen, pelvis, and scrotal areas was performed at 15 min and at 2 hr postintraperitoneal instillation of 5 mCi [^{99m}Tc]albumin colloid and 2l of the dialysate via the Tenckhoff catheter [Fig. 3]. This 15-min scintiphotos demonstrated extension of the labeled fluid in the proximal portion of the right inguinal canal. Repeat imaging at 2 hr revealed passage of the tracer via the patent processus vaginalis into the right scrotum. At that time there was considerable accumulation of activity proximally. The patient underwent an uncomplicated right inguinal hernia repair and has had no subsequent return of scrotal edema.

Case 4

The patient was a 70-yr-old female with end stage renal disease of uncertain etiology. She was started on CAPD in November 1985 after placement of a Tenckhoff catheter in the subumbilical region. Initial catheter function was excellent and a chest roentenogram in January 1986 was normal.

In March 1986 she developed exertional shortness of breath

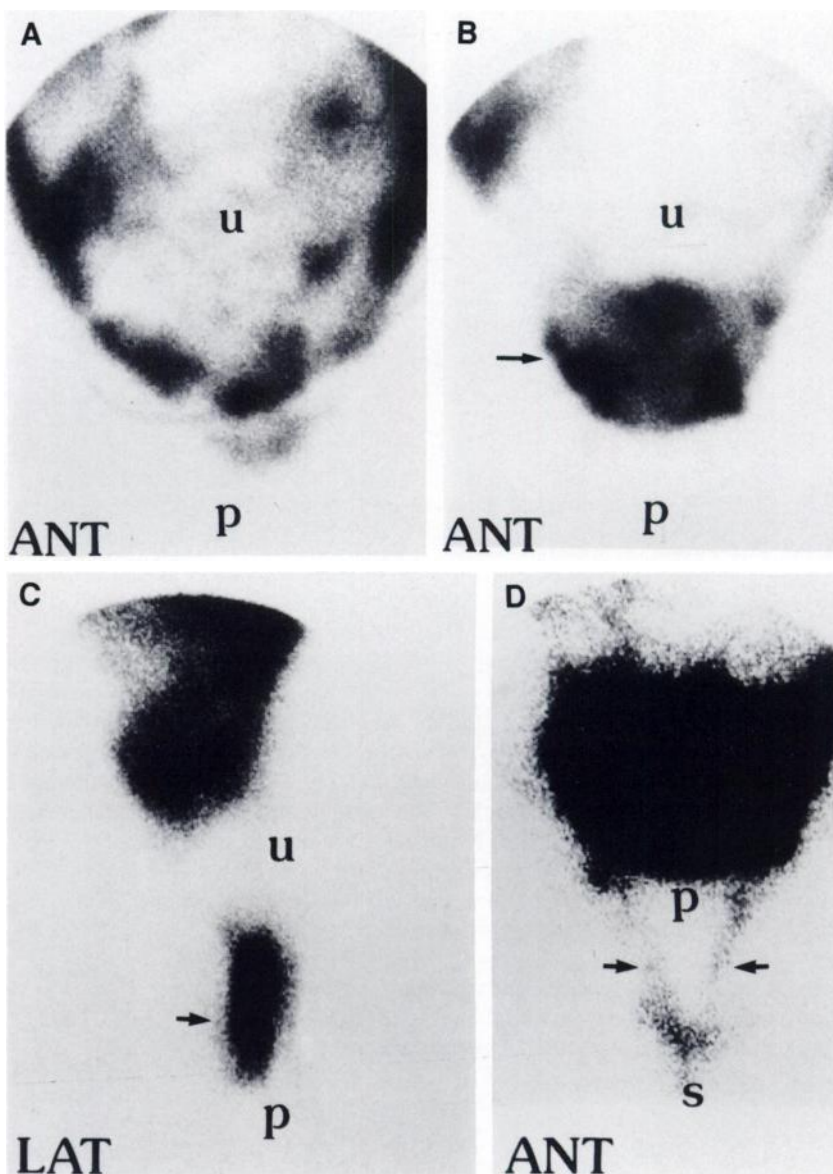


FIGURE 2

Case 2. Abdominal/pelvic scintigraphy postintraperitoneal [^{99m}Tc]albumin colloid. At 15 min (A) activity is within the peritoneal cavity. At 2 hr (B&C) leakage of the dialysate into the mid lower anterior abdominal wall is noted (arrows). A high intensity scintiphoto at 2 hr (D) demonstrates a small fraction of the leakage in the scrotum (arrows). Pubis(p), scrotum(s).

and right pleuritic chest pain. On physical examination she had dullness in the right thorax and chest roentgenogram demonstrated a right pleural effusion. Lung perfusion and lung ventilation imaging demonstrated a large matching ventilation/perfusion defect in the right lower lung field corresponding to the right pleural effusion. Thoracentesis revealed serosanguineous fluid with 200 nucleated cells/mm³, 60% of which were monocytes and mesothelial cells, glucose of 173 mg/dl and total protein of 0.49 g/dl. Cytologic examination of the fluid was unremarkable and culture revealed no bacteria.

CAPD was continued and the right pleural effusion recurred. Methylene blue instilled along with a 2-l dialysate exchange did not appear in the pleural fluid on repeat thoracentesis.

Multiview camera scintigraphy of the abdomen and thorax was performed at 30 min, 4 hr, and 20 hr postintraperitoneal instillation of 1 mCi [^{99m}Tc]macroaggregated albumin (MAA)

and 2 l of dialysate via the Tenckhoff catheter (Fig. 4). Imaging at 30 min showed no thoracic activity. Imaging at 4 hr showed focal accumulation of activity at the level of the diaphragm over the dome of the right hepatic lobe as well as focal uptake of activity just above the level of the right diaphragm medially. A dialysate exchange was then performed and repeat imaging was performed at 20 hr. At that time further nodular localization of activity was noted in the medial inferior aspect of the right thorax and a very slight degree of diffuse activity was noted over the right hemithorax with the patient in a supine position.

Several days later multiview scintigraphy of the abdomen and thorax was performed at 15 min and 2 hr postintraperitoneal instillation of 5 mCi [^{99m}Tc]albumin colloid and 2 l of dialysate via the Tenckhoff catheter (Fig. 5). At 15 min slight uptake of activity was noted in the right hemithorax. At 2 hr definite diffuse uptake was noted in the right thorax documenting the transdiaphragmatic leak.

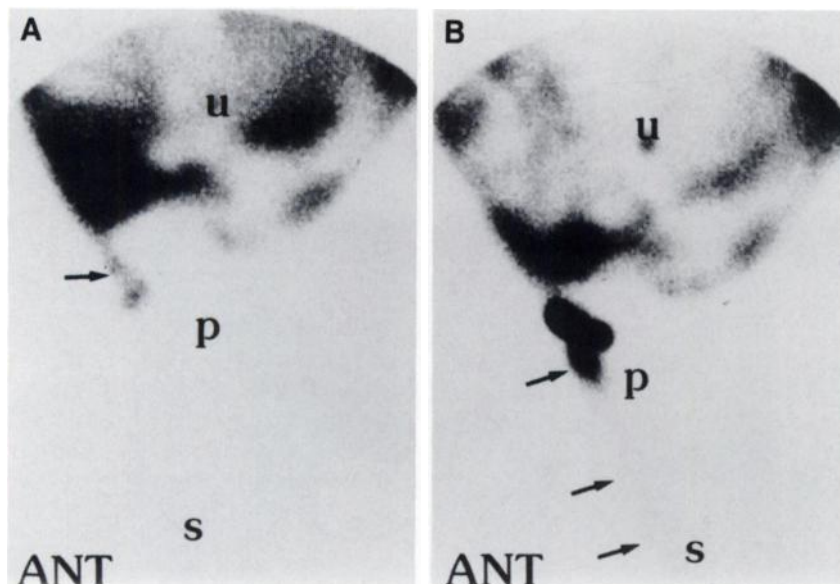


FIGURE 3

Case 3. Abdominal/pelvic scintigraphy post intraperitoneal [^{99m}Tc]albumin colloid. At 15 min (A) extension of the labeled fluid is noted in the proximal right inguinal canal (arrow). At 2 hr (B) there is considerable accumulation of activity proximally and passage of fluid via a patent processus vaginalis into the right hemiscrotum (arrows). Umbilicus(u), pubis(p) and scrotum(s).

DISCUSSION

Patients on CAPD have a number of pathophysiologic factors that may contribute to the formation of hernias and leaks from the peritoneal cavity. Foremost among these factors is the 1 to 2 l of dialysate induced chronic elevation in intra-abdominal pressure, resulting in increased stress on the abdominal wall and diaphragm (8,10). Contributing systemic conditions include uremia, obesity, transperitoneal protein loss, and

anemia (8). Local predisposing factors include prior abdominal surgery including hernia repair, parity of three or greater (9), and complete or partially opened processus vaginalis (8,11-14).

Both ventral and inguinal hernias are commonly associated with CAPD. The overall incidence of CAPD induced hernia ranges from 2.7%-25% (3,4,8,9,15,16). Extraperitoneal leakage of dialysate may occur at the catheter site as well as from tears in the peritoneum within a hernia sac (17,18). Also an amount of fluid

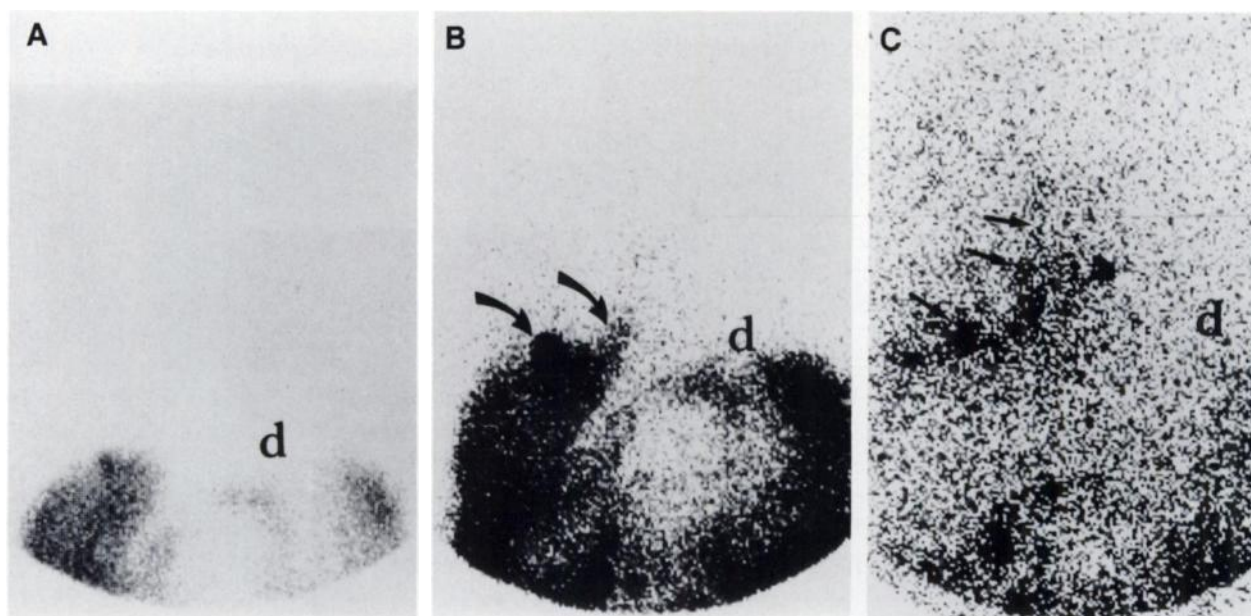


FIGURE 4

Case 4. Abdominal/thoracic scintigraphy post intraperitoneal [^{99m}Tc]MAA. At 30 min (A) no thoracic activity is noted. At 4 hr (B) there is focal accumulation of activity at the level of dome of the right diaphragm as well as a less intense focus just above the level of the right diaphragm medially (arrows). Imaging at 20 hr (C) post dialysate exchange reveals further focal accumulation of activity medially just above the right diaphragm as well as a slight degree of diffuse activity on the right hemithorax (arrows). Diaphragm(d).

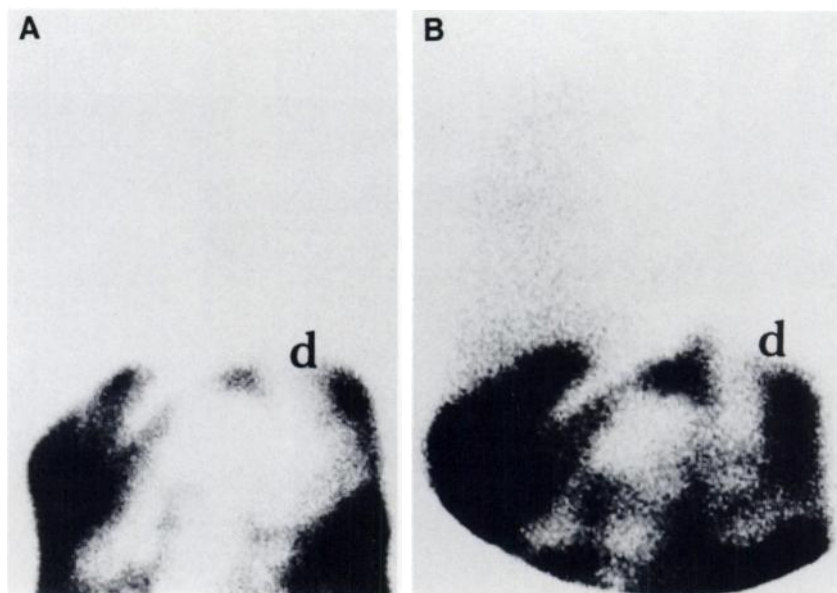


FIGURE 5
Case 4. Abdominal/thoracic scintigraphy postintra-peritoneal [^{99m}Tc]albumin colloid. At 15 min (A) a very slight degree of activity is noted in the right hemithorax. By 2 hr (B) a significant degree of leakage into the right hemithorax has occurred.

sufficient to cause scrotal and penile edema can be resorbed from a patent processus vaginalis with an intact peritoneal lining with or without clinical findings of hernia (11,12,19).

The clinical features of these different situations noted above can be quite similar, consisting of one or more of the following: scrotal edema, penile edema, edema of the abdominal wall, flanks, buttocks and thighs, the presence of an obvious hernia, and a history of poor dialysate return. Such a spectrum of findings are well illustrated by Cases 1, 2, and 3.

A number of different diagnostic procedures have been employed to determine the exact nature of the abnormality and guide the surgical approach to correction, if necessary. These procedures include the intra-peritoneal instillation of methylene blue dye, contrast catheterogram and peritoneography (17), contrast enhanced computerized tomography (20,21), and abdominal pelvic scintigraphy after intra-peritoneal instillation of [^{99m}Tc]colloid (8,11,12). Methylene blue can be quite irritating (22), and requires surgical exploration for any degree of accuracy. The contrast catheterogram and peritoneogram may be useful in detecting problems of obstruction to free flow of the dialysate and massive leaks. However, as in Case 2 of this study, it may be a relatively insensitive method of detecting leak sites and their causes. The accuracy of contrast enhanced computerized tomography is still undefined as this procedure has been applied to very few patients. A number of groups have found abdominal pelvic scintigraphy after intra-peritoneal administration of the [^{99m}Tc]colloid a very useful diagnostic tool in CAPD patients with suspected peritoneal leaks (8,11,12,18). It is accurate, readily available, easy to perform and without any discomfort or morbidity. The ability to simultaneously examine the entire area of interest in a repetitive man-

ner coupled with a high degree of sensitivity in detecting relatively small volumes of leakage accounts for the excellent diagnostic accuracy of this procedure.

Patients with a patent processus vaginalis may demonstrate movement of tracer activity beginning early and in the lateral inguinal region and extending in a definite tract-like fashion into the ipsilateral scrotum as is illustrated in Case 3 (Fig. 3). This pattern has been noted in CAPD patients with scrotal edema, with or without clinical findings of inguinal hernia, who were found to have a patent processus vaginalis (8,11,12,18,19).

A second pattern exhibiting progressive medial or paramedial accumulation of activity around the site of peritoneal insertion of the catheter, as seen in Case 1, is indicative of a pericatheter intra-abdominal wall leak (Fig. 1). A variant of this pattern was noted on Case 2. In this patient a more diffuse accumulation of activity was noted within the suprapubic intra-abdominal wall (Fig. 2). At 2 hr high intensity scintiphotos show faint bilateral tracts of activity extending from the suprapubic accumulation into the scrotum. This finding demonstrates dissection of fluid between the layers of the superficial abdominal fascia around the spermatic cords into the scrotum thus explaining this patient's marked scrotal edema.

While CAPD induced abdominal wall hernia and leaks are not uncommon, transdiaphragmatic leaks of dialysate are relatively rare. While it may be clinically difficult to determine the cause of pleural effusion in patients on CAPD one should suspect direct peritoneal pleural communication when the effusion is massive, unilateral, right sided, reaccumulates rapidly, and is similar in composition to the peritoneal fluid. Also these patients usually have no evidence of heart failure or pulmonary disease (23).

Because of the effects of the hydrothorax and the associated poor dialysate return, transdiaphragmatic leaks must be corrected to allow the patient to continue on CAPD. A number of different techniques have been used to attempt to demonstrate peritoneal pleural communication in patients on CAPD and in patients with ascites.

These procedures have included the use of methylene blue (24), chemical analysis of pleural and peritoneal fluid, pneumoperitoneum and the use of radionuclide tagged tracers with and without imaging (23,25-30). The use of methylene blue as well as the comparative chemical analysis of pleural and peritoneal fluid requires a thoracentesis. While methylene blue can usually detect a large opening it may fail to detect very small transdiaphragmatic communications as was noted in Case 4. One explanation of this phenomenon is that the methylene blue dye is preferentially taken up by diaphragmatic lymphatics and shunted into the general lymphatic system (31). Another explanation may relate to the rate of the transdiaphragmatic leak, the volume of dilution by the existing hydrothorax, and the ability to visually detect low concentrations of the dye. Pneumoperitoneum is time consuming and requires the patient to be sitting for 24 hr.

Scintigraphy of the thorax and abdomen after intraperitoneal instillation of ^{99m}Tc -labeled particulate radiopharmaceuticals has been found to be an accurate, safe, simple, and relatively rapid means of detecting diaphragmatic leaks in patients on CAPD (23,27-30). While most of these studies have reported the successful use of ^{99m}Tc -labeled colloid, Spardaro et al. advocated the use of [^{99m}Tc]MAA (27). The rationale for this use of [^{99m}Tc]MAA was based on the fact that the albumin macroaggregates are larger (10-90 μ in diameter) than the normal diaphragmatic mesothelial pores (4-12 μ in diameter) which communicate with lymphatic vessels (32), thus preventing the lymphatic uptake of the MAA as had been postulated for methylene blue. In this study we had the opportunity to investigate the same patient, Case 4, with both [^{99m}Tc]MAA and [^{99m}Tc]albumin colloid. In each case the tracer was administered intraperitoneally along with 2 l of dialysate. While the study with [^{99m}Tc]MAA revealed no thoracic activity at 4 hr and very faint activity at 20 hr (Fig. 4), the use of the labeled colloid showed slight thoracic activity at 15 min with evidence of progressive transdiaphragmatic leakage by 2 hr (Fig. 5). These findings suggest that the size of the abnormal transdiaphragmatic communications in this patient were quite small, probably in the range of 1 to 10 μ . It is of interest to speculate that the nodular accumulation of activity noted just above the level of the right diaphragm in the [^{99m}Tc]MAA study (Fig. 4) may have been due to nodal trapping of some of the smaller [^{99m}Tc]MAA particles that crossed the diaphragm by some other route.

From these findings, as well as the results obtained by others, it appears that [^{99m}Tc]colloid is the tracer of choice for the detection of diaphragmatic leaks. The features of the procedure used to obtain optimal results are similar to those for the detection of abdominal wall leaks with the exception that the thoracic area is included in the scintiphotography.

In summary, the chronic increase in intra-abdominal pressure coupled with a variety of systemic and local factors predispose patients on CAPD to develop peritoneal leaks from the abdominal wall and diaphragm. In some patients with suspected peritoneal leakage the diagnosis of the specific mechanism may be difficult. In such patients abdominal-pelvic or abdominal-thoracic scintigraphy after intraperitoneal instillation of [^{99m}Tc]colloid along with dialysate affords a safe, simple, rapid and accurate means of providing a diagnosis, and the requisite information that is required for therapy.

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