jnm/CASE REPORT

LUNG UPTAKE OF ^{99m}Tc-SULFUR COLLOID IN PATIENT EXHIBITING PRESENCE OF Al^{3+} IN PLASMA

Darrell D. Bobinet, Roger Sevrin, Mary T. Zurbriggen, Leonard Spolter, and Marvin B. Cohen

Veterans Administration Hospital, Sepulveda, California

Moderate lung uptake of ^{99m}Tc-sulfur colloid was observed in a patient on hourly antacids who was found to have an elevated plasma aluminum level. A repeat scan 5 days after discontinuing antacids when the patient had only a slight increase in plasma aluminum level revealed minimal uptake in the lungs.

Lung uptake of ^{99m}Tc-sulfur colloid, observed by several groups, has generally been attributed to altered RES function or clumping and embolization (*1–7*). Another cause of this phenomenon is suggested by experience with a patient whose lungs were visualized after the patient received a ^{99m}Tc-sulfur colloid injection for a liver scan. Analysis of this patient's plasma indicated the presence of elevated plasma aluminum ion which may have caused formation of macroaggregates in vivo.

CASE REPORT

A 65-year-old white man was admitted to the Veterans Administration Hospital in Sepulveda, because of partial small-bowel obstruction. The patient had had a partial gastrectomy with Billroth II anastomosis 16 years before for ulcer disease and a radical prostatectomy for carcinoma of the prostate, Stage C, 8 months before. Following the radical prostatectomy, the patient had been admitted twice for small-bowel obstruction which resolved with conservative treatment. The patient had no history of alcoholism or of liver disease. Except for slight abdominal distension and mild tenderness in the midepigastrium and around the umbilicus, the physical examination was normal.

Management consisted of decompression with nasogastric and intestinal tubes and suction, intravenous fluids, cephalothin, and gentamicin. After signs of improvement, the intestinal tube was removed on the fourth day, the nasogastric tube was removed on the sixth day, and oral feeding was resumed progressively. Subsequently, the patient did well until the 14th hospital day when he had another episode of small-bowel obstruction, which was again relieved by intestinal decompression for 5 days. After oral intake was resumed, the patient's medication included notably Mylanta (200 mg $Al(OH)_3$/5 ml) 30 ml Q 1 hr.

X-ray film of the chest, bone scan, SGOT, BUN, alkaline phosphatase, bilirubin, serum proteins, and acid phosphatase were normal. The initial liver scan was performed on the 30th hospital day after injection of 3 mCi of ^{99m}Tc-sulfur colloid prepared by a previously described method (*8*). This scan revealed moderate uptake of colloid in the lungs with no discernible radioactivity in the bone marrow, stomach, or cardiac blood pool.

On the day of the original liver scan, a sample of the patient's plasma was obtained following the observation of increased lung deposition of the sulfur colloid. An 0.5-cc aliquot of the plasma was added to 1 cc of ^{99m}Tc-sulfur colloid. A white flocculant precipitate was observed visually and microscopically (Fig. 1). A flocculant precipitate of this nature was described as capable of lodging in the pulmonary circulation (*9–11*). The technetium sulful colloid used was found to contain less than 1 ppm aluminum ion as determined colorimetrically. A colorimetric determination for aluminum ion in the patient's plasma revealed about 35 ppm (normal is less than 4 ppm). A sample was not available to

Received May 1, 1974; revision accepted July 23, 1974.

For reprints contact: Darrell D. Bobinet, Nuclear Medicine Service, Veterans Administration Hospital, 16111 Plummer St., Sepulveda, Calif. 91343.

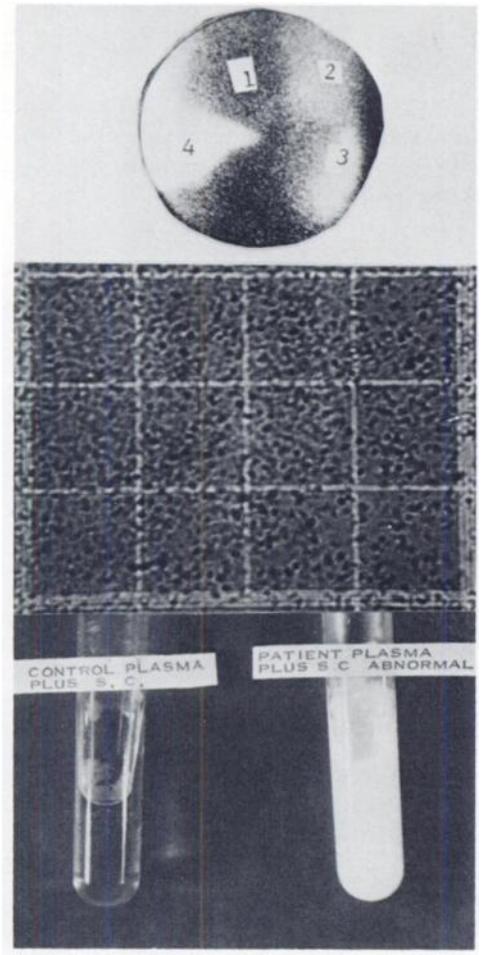

FIG. 1. (Top) Abnormal scintigraph with marked lung uptake of ^{99m}Tc-sulfur colloid. 1, Heart pool; 2, lung; 3, spleen; 4, liver. (Cf. Fig. 2.) Plasma Al^{3+} level at this time was 35 ppm. (Middle) Microscopic observation (each square = 50 μm) of flocculant precipitate formed when 0.5 cc of patient plasma at time of abnormal scintigraph above was added to 1 cc of ^{99m}Tc-sulfur colloid. (Cf. Fig. 2.) (Bottom) Visual observation of flocculant precipitate which formed when 0.5 cc of patient plasma at time of abnormal scintigraph above was added to 1 cc of ^{99m}Tc-sulfur colloid as compared with control. (Cf. Fig. 2.)

check by atomic flame-absorption spectrophotometry. The colorimetric determination for aluminum ion was also run on a number of control plasmas and no abnormal amounts of aluminum were observed in these control plasmas. None of the control plasmas exhibited precipitation when added to sulfur colloid as was observed with the abnormal patient.

Seven days after the first scan when the patient had no evidence of bowel obstruction and had taken no antacids for 5 days, the liver scan was repeated and only minimal lung uptake was observed (Fig. 2). The orientation of the spleen in Fig. 1 is different from the orientation of the spleen in Fig. 2. Splenic displacement has been reported by Landgarten, et al who hypothesized that it may have been caused by displacement of intra-abdominal organs (*12*). However, in this case, no abdominal films were available for the days the scans were performed to substantiate that there was a displacement of intra-abdominal organs at the time of the scan in either Fig. 1 or Fig. 2. A sample of the patient's plasma was obtained after the repeat scan, and the test for precipitation of the colloid was run. No precipitate was formed (Fig. 2). A colorimetric determination for aluminum ion revealed at this time that aluminum was present in a concentration of 10 ppm (atomic flame-absorption spectrophotometry indicated a plasma level of 20 ppm).

Five months later lysis of intestinal adhesions and segmental small-bowel resection were performed because of recurrence of small-bowel obstruction and the patient died of postoperative complications. Autopsy revealed no cirrhosis of the liver and no local recurrence or metastases of the prostatic carcinoma.

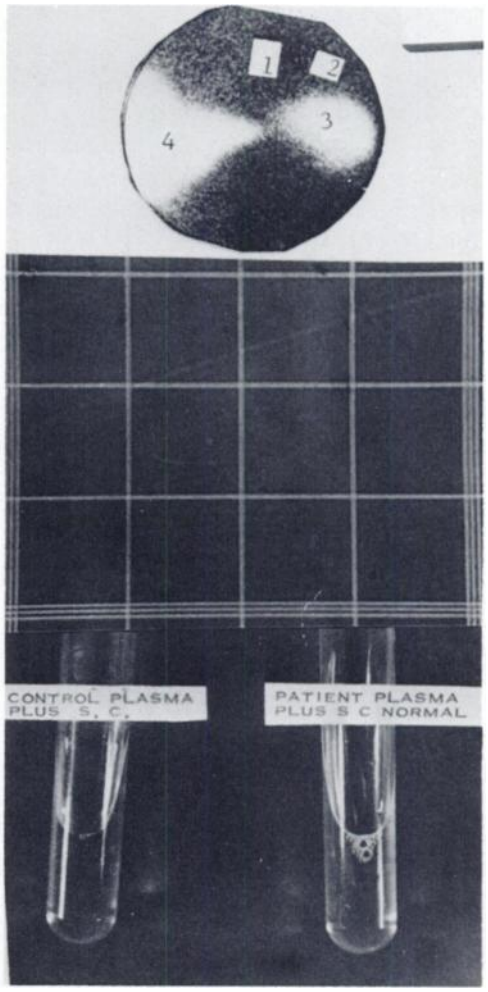

FIG. 2. (Top) Repeat scintigraph in same patient as Fig. 1. Only minimal lung uptake of ^{99m}Tc-sulfur colloid is observed (1, heart pool; 2, lung; 3, spleen; 4, liver). Plasma Al^{3+} level at this time was 10–20 ppm. (Middle) microscopic observation when 0.5 cc of plasma was added to 1 cc of sulfur colloid. Note absence of visible particle formation. (Bottom) Visual observation of absence of particle formation when 0.5 cc of plasma was added to 1 cc of sulfur colloid. Note that precipitate did not form.

DISCUSSION

The following "quality criteria" of Keyes, et al (*1*) were used to evaluate the intrinsic characteristics of the colloid: "There had been at least one other scan dose done with the same batch of colloid which did not show lung uptake (control scan). No more than one scan from the batch of colloid showed lung uptake".

References have been made previously in the literature to uptake of sulfur colloid in the lungs primarily in patients with malignancy and cirrhosis but also in other patients undergoing liver scans (*1–7*). One patient with a spleen and bone marrow transplant exhibited lung uptake. The increased lung uptake was attributed to increased reticuloendothelial (RE) activity of the lungs (*4*). In a group of 22 patients who exhibited lung uptake from sulfur colloid preparations out of a total of 1,205 patients reviewed (an incidence of 1.6%), increased activity of RES elements in the lung as well as intravascular clumping with pulmonary microembolization were considered, but the authors stated: "There is insufficient evidence at the present time to determine the role of either altered RES function or clumping and embolization in the etiology of lung accumulation of radiocolloid" (*1*). Gillespie, et al suggested the possibility of the presence of aluminum ion but ruled it out because of "an outstanding lack of absorption from the alimentary tract" (*2*). No reference was made in any of the cases as to whether the patient's blood was checked for the presence of aluminum ion.

It is generally believed that aluminum is essentially not absorbed from the alimentary tract and is present in blood in a concentration below 4 ppm by colorimetric determination (*13,14*). However, aluminum intoxication has been demonstrated in uremic and nonuremic rats after modest doses of oral aluminum (*15*). Plasma–aluminum levels were found to be raised in one out of every three people with advanced renal failure taking aluminum hydroxide (*16*). Plasma–aluminum levels reached as high as 110 ppm. In normal man absorbed aluminum is readily excreted by the intact kidney and the amount absorbed from the intestine is unknown. It was determined that aluminum was indeed present in this patient's blood in a concentration of about 35 ppm on the day of the abnormal scintigraph. This would suggest that some factors intrinsic to this patient, possibly related to the transient bowel obstruction, caused aluminum ion to be adsorbed and present in the blood in a high enough concentration to cause macroaggregates to form in vivo. Such macroaggregates could be capable of blocking pulmonary microcirculation and giving abnormal uptake of ^{99m}Tc-sulfur colloid in the lung. It appears that the 10 ppm of aluminum in this patient's plasma was barely sufficient to cause the lung uptake of sulfur colloid observed when the patient's aluminum plasma level was 35 ppm.

Increased RE activity of the lungs may be one mechanism causing pulmonary uptake of sulfur colloid. Other mechanisms such as abnormal carrier protein in the blood may also exist. Our observations suggest that aluminum absorption from the intestine may be a factor in pulmonary uptake of sulfur colloid in some patients.

REFERENCES

1. KEYES JW JR, WILSON GA, QUINONES JD: An evaluation of lung uptake of colloid during liver imaging. *J Nucl Med* 14: 687–691, 1973

2. GILLESPIE PJ, ALEXANDER JL, EDELSTYN GA: High concentration of ^{99m}Tc-sulfur colloid found during routine liver scan in lungs of patient with advanced breast cancer. *J Nucl Med* 14: 711–712, 1973

3. KLINGENSMITH WC, RYERSON TW: Lung uptake of ^{99m}Tc-sulfur colloid. *J Nucl Med* 14: 201–204, 1973

4. QUINONES JD: Localization of technetium-sulfur colloid after RES stimulation. *J Nucl Med* 14: 443–444, 1973

5. KLINGENSMITH WC, RYERSON TW, CORMAN JL: Lung uptake of ^{99m}Tc-sulfur colloid in organ transplantation. *J Nucl Med* 14: 757–759, 1973

6. STEINBACH HL: Pulmonary accumulation of ^{99m}Tc-sulfur colloid during liver scanning. *Tex Med* 68: 137–138, 1972

7. TURNER JW, SYED IB, HANC RP: Lung uptake of ^{99m}Tc-sulfur colloid during liver scanning. *J Nucl Med* 15: 460–462, 1974

8. PATTON DD, GARCIA EN, WEBBER MM: Simplified preparation of technetium-99m sulfide colloid for liver scanning. *Am J Roentgenol Radium Ther Nucl Med* 97: 880–885, 1966

9. STAUM MM: Incompatibility of phosphate buffer in ^{99m}Tc-sulfur colloid containing aluminum ion. *J Nucl Med* 13: 386–387, 1972

10. WEINSTEIN MB, SMOAK W: Author's Reply. *J Nucl Med* 11: 767–768, 1970

11. CUNNINGHAM RE: *Aluminum flocculation in ^{99m}Tc labelled sulfur colloid preparation.* Communication from AEC to Licensees July 7, 1970

12. LANDGARTEN S, SPENCER RP: Splenic displacement due to gastric dilatation. *J Nucl Med* 13: 223, 1972

13. STOKINGER HE: The metals (excluding lead). In *Industrial Hygiene and Toxicology*, vol 2, Patty FA, ed, New York, Interscience Publications, 1964, pp 987–1194

14. SOLLMAN T: *Pharmacology*, 7th ed, Philadelphia and London, WB Saunders Co, 1948, pp 938–939

15. BERLYNE GM, YAGIL R, ARI JB, et al: Aluminum toxicity in rats. *Lancet* 1: 564–568, 1972

16. BERLYNE GM, ARI JB, PEST D: Hyperaluminemia from aluminum resins in renal failure. *Lancet* 2: 494–496, 1970