3. GARSÓN OL, PALOOS MC, RADICELLA R: A technetium-99m labeled colloid. *Int J Appl Radiat Isot* 16: 613, 1965

4. HAWKINS LA, MCALISTER JM: The use of ^{99m}Tc antimony sulphide colloid for liver scanning: its preparation and some clinical and experimental observations. *Br J Radiol* 42: 657–661, 1969

5. BRUUN P: Standardized sterile kits for preparation of ^{99m}Tc-labelled albumin, macroalbumin, iron ascorbic acid complex, and antimony sulphide colloid. *Scand J Clin Lab Invest* 28: 313–323, 1971

THE AUTHOR'S REPLY

I share Mr. Bruun's concern that flocculation of ^{99m}Tc-sulfur colloid (TcSC) might cause lung uptake on liver–spleen studies. When only one patient is studied with a day's preparation of TcSC, it is difficult to be sure that flocculation has not occurred either before or after injection. In addition, particle stability in vitro does not preclude flocculation or binding to circulating macroaggregates in vivo.

There have been five clinical studies of lung uptake of TcSC (*1–5*). Three of them (*2–4*) state that in all cases the same preparation of TcSC which was used in the patient who showed lung uptake was also used in other patients who did not show lung uptake. In addition, several of the patients in two of these studies (*2,3*) showed lung uptake of TcSC on repeated liver–spleen studies. The study by Steinbach (*1*) included one instance in which the same preparation of TcSC was used to study three patients and only the second patient showed lung uptake. In another instance a patient showed lung uptake on studies done with both TcSC and ^{198}Au-colloid. These points tend to exclude flocculation of TcSC before injection as a cause of lung uptake in these patients. In the prospective study of the incidence of lung uptake in patients with liver transplants as detected by anterior chest scintigram, patient controls were not available (*5*). In the relatively large experience with liver transplant patients at the University of Colorado Medical Center, however, lung uptake has been seen frequently whereas lung uptake on liver-spleen studies in general has been seen very infrequently (*6–8*).

Three studies have investigated the possibility of flocculation of TcSC after injection as a cause of lung uptake. Steinbach mixed the serum and plasma of a patient who showed lung uptake with TcSC and found no microscopic evidence of flocculation or change in particle size (*1*). Klingensmith and Ryerson used lung and heart time–activity curves to show that the uptake of TcSC by the lung occurs gradually and is more consistent with a phagocytic mechanism than with flocculation (*2*). Quinones noted marked lung uptake of TcSC after intraperitoneal injection of endotoxin in rats. Autoradiography of the lungs showed that the radioactivity was distributed over individual cells and not in clumps (*9*).

Evidence has accumulated which shows that under most conditions macrophages originate in the bone marrow, circulate in the blood with a half-time of 22 hr, and then become fixed in the liver, spleen, and lung (alveolar macrophages) or enter serous cavities such as the peritoneum (*10*). Conditions such as inflammation result in an elevated number of circulating macrophages (blood monocytes) secondary to an increased rate of formation and release from the bone marrow (*10*). As experiments have shown that circulating macrophages are temporarily trapped in the lung capillary bed with a half-time of 1–3 hr (*11*), the amount of lung uptake of TcSC may be an index of the number of circulating macrophages as long as the blood clearance is in the normal range. In addition, by this reasoning one would expect to have a small amount of lung uptake normally as is the case experimentally (*12*) and clinically.

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REFERENCES

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

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

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

4. 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

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. GROTH CG, BROWN DW, CLEAVELAND JD, et al: Radioisotope scanning in experimental and clinical orthotopic liver transplantation. *Surg Gynecol Obstet* 127: 808–816, 1968

7. BROWN DW, STARZL TE: Radionuclides in the postoperative management of orthotopic human organ transplantation. *Radiology* 92: 373–376, 1969

8. STARZL TE: *Experience in Hepatic Transplantation.* Philadelphia, WB Saunders, 1969, p 321

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

10. VAN FURTH R: Origin and kinetics of monocytes and macrophages. *Semin Hematol* 7: 125–141, 1970

11. ROSER B: The migration of macrophages in vivo. In *Mononuclear Phagocytes,* Van Furth R, ed, Oxford, Blackwell Scientific Publications, 1970, pp 166–174

12. STERN HS, MCAFEE JG, SUBRAMANIAN G: Preparation and utilization of technetium-99m-sulfur colloid. *J Nucl Med* 7: 665–675, 1966

THE AUTHOR'S REPLY

In relation to the comments on our recent publication, we should like to record the following observations.

The comments on the size of sulfur colloid particles and general observations about colloids are well recognized.

The possibility of flocculation during or after injection for reasons based on the instability of particle size does not seem a likely explanation as this phenomenon is observed so infrequently and other patients injected from the same batch of colloid fail to exhibit lung uptake. The available evidence would suggest that this phenomenon is related to the condition of the patient rather than of the colloid.

We agree that kits for the production of antimony sulfide colloids provide a simple method of obtaining a satisfactory liver scanning agent; however, in defense of those who produce their own sulfur colloid I would point out that the three simple chemicals required, namely, hydrochloric acid, sodium thiosulfate, and phosphate buffer are readily available at minimal cost in most hospitals.

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DEADTIME LOSSES

This letter is written in reference to the Concise Communication—"Unexpected Deadtime Losses in a Modified Rectilinear Scanner System" by Philip Cooper, et al (*1*). The authors have presented data and calculated deadtime correction factors that appear to deviate from a theoretical calculation of correction factor versus observed counting rate. No attempt was made to explain the wide deviation, and a set of empirical equations are derived to represent the correction factors thus found. These equations have, however, no physical basis. If the data are analyzed to obtain the system deadtime using the familiar equation:

$$R_{true} = \frac{R_{obs}}{1 - R_{obs}\tau}$$

where R_{true} is the true counting rate, R_{obs} is the observed counting rate, and τ is the system deadtime, then one finds that the data can be fit essentially with a deadtime of approximately 170 μsec. This sets a saturation counting rate at approximately 360K cpm and gives a curve with the shape of that given for the experimental data. If the deadtime of the multichannel analyzer is 32 μsec as stated, then the rest of the system must be the limiting factor with an inherent deadtime of about 170 μsec.

The actual operation of the analyzer in the reported study is somewhat difficult to ascertain from the paper. A few comments on the possible ways of using an analyzer for such studies is in order and from this an insight into the reported use may be gained. Modern multichannel analyzers (MCAs) operate in two modes, analog (PHA) and multiscale (MCS), and both modes can be used to some degree to obtain quantitative data from instruments such as scanners.

In the PHA mode an analog voltage from a position-sensitive potentiometer can be fed to the analog input and a signal from the scanner SCAs can be fed into the coincidence/sample input. The analog input is sampled on command by the signal from the SCA. A count is then added in the memory channel that corresponds to the position of the scanner at the time of the valid SCA pulse output. In this manner a histogram is obtained of counts versus scanner position. Readout of the memory must be performed at the end of every pass and a composite image reconstructed at a later time. Using a nuclear ADC in this