Measurement of Total-Body Cobalt-57 Vitamin B_{12} Absorption with a Gamma Camera

John A. Cardarelli, D. Ward Slingerland, Belton A. Burrows, and Aaron Miller

Nuclear Medicine and Medical Services, V.A. Medical Center, Boston, Massachusetts

Previously described techniques for the measurement of the absorption of [^{57}Co]vitamin B_{12} by total-body counting have required an iron room equipped with scanning or multiple detectors. The present study uses simplifying modifications which make the technique more available and include the use of static geometry, the measurement of body thickness to correct for attenuation, a simple formula to convert the capsule-in-air count to a 100% absorption count, and finally the use of an adequately shielded gamma camera obviating the need of an iron room.

J Nucl Med 26:941–943, 1985

A recent study (*1*) described the modifications of total-body counting techniques necessary to measure accurately the retention of cobalt-57 (^{57}Co) vitamin B_{12} in the assessment of low B_{12} serum levels (*2*). These modifications included the use of a liver phantom to represent the distribution of absorbed B_{12}. The patient was counted 7–14 days after ingestion of [^{57}Co]vitamin B_{12}, and the data obtained from the phantom was used to correct the patient count for attenuation, calculate the 100% absorption value and, in turn, the retention of labeled B_{12}. The study was done using equipment not widely available, an iron room with two scanning detectors.

The present study was designed to modify the technique so that a lightly shielded gamma camera might be used as a fixed detector.

MATERIALS AND METHODS

Measurements were made in the previously described (*1*) total-body iron room using two 8 in. × 4 in. NaI(Tl) scanning crystals above and below the patient and compared to those obtained by using a static standard field camera* ($\frac{1}{2}$ in. crystal of $12\frac{7}{8}$ in. diam) placed 15 cm from the supine and prone patient. The window width, 20%, was that used for imaging. Data from the two scanning crystals had indicated that counts approached background levels as the detectors reached the upper sternal and lower pelvic regions. The uncollimated camera subtends approximately the active area noted by the scanning detectors. Initially room background and natural body radioactivity were measured. A ^{57}Co Vitamin B_{12} capsule was counted in air at 15 cm from the detector and given orally with 50–100 ml of water. The patient was counted 7–14 days after ingestion of the capsule. His supine body thickness was measured just caudal to the costal margin.

As previously described (*1*) a [^{57}Co]vitamin B_{12} capsule was dissolved and injected into a 1,000 ml water filled plastic bag. The latter was suspended in a water tank with its long axis in a plane parallel to the surface at various depths between and including the surface and the bottom of the tank to simulate the patient's counting geometry when most of the absorbed B_{12} is in the liver. The phantom was counted with the camera 15 cm above the surface and then 15 cm below the bottom of the tank to obtain an upper/lower ratio. The curve of ratio-to-total count values measured at a phantom tank depth similar to the patient's measured thickness was used to correct the capsule count for 100% absorption (*1*) (Fig. 1).

A somewhat similar procedure was used with a mobile (LEM) ($\frac{3}{8}$ in. crystal of $10\frac{7}{8}$ in. diameter) in a scanning room not lined with lead. To reduce background a double layer of lead aprons was hung to form a cone from camera to patient and more were placed on a scanning bed. It is possible to construct a thin lead cone to simulate the lead aprons and make the procedure effective, simple and available. Even with the apron shield, the room background was several times that of the iron room. The net body activity, presumably largely ^{40}K, was also higher than that determined in the iron room. The explanation for this is not established but may be related to differences in camera sensitivity. Background counts must be measured before and after patient counts using carefully duplicated shielding and positioning for body background

Received Nov. 1, 1984; revision accepted Apr. 15, 1985.

For reprints contact: John A. Cardarelli, MS, Nuclear Medicine Service, V.A. Medical Center, 150 So. Huntington Ave., Boston, MA 02130.

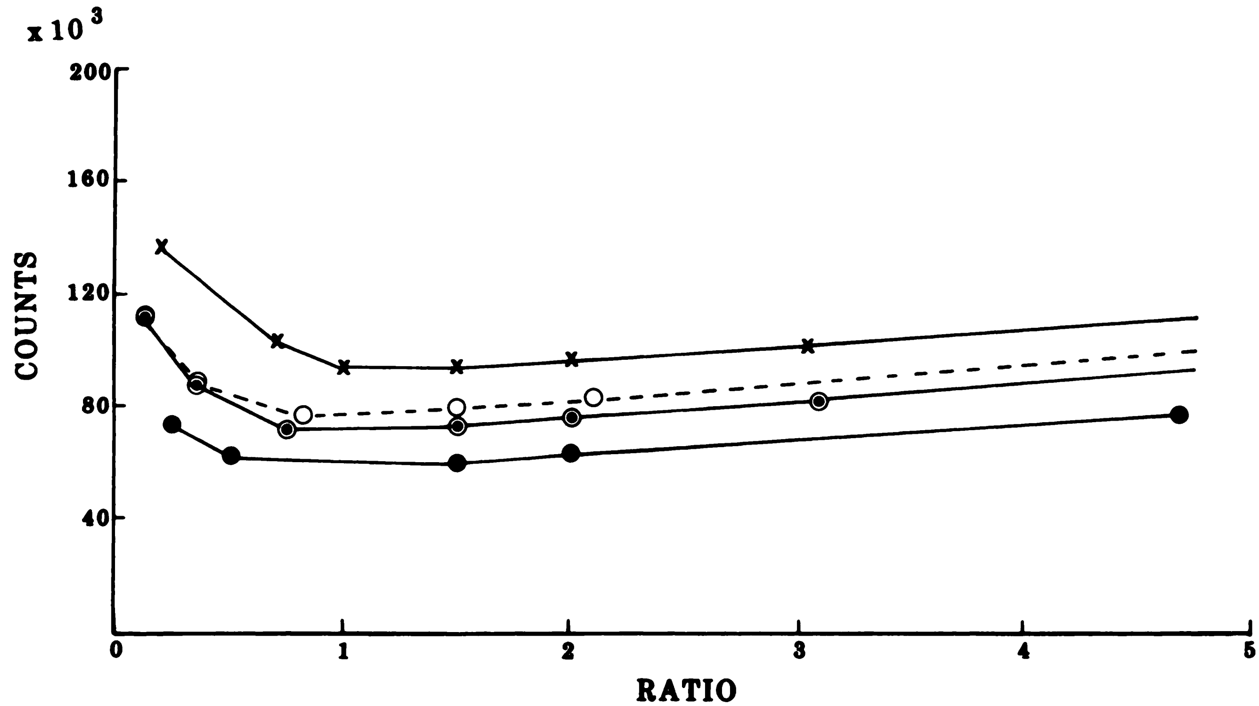

FIGURE 1
Relationship between ratio of counts and total counts detected by cameras placed 15 cm above and below water tank containing liver phantom ([^{57}Co]vitamin B_{12} in 1,000 ml plastic bag) set at various levels from surface to bottom of tank of depths (*) 20, (-⊙-) 25, and (-●-) 30 cm. (Searle –O– 25 cm)

and final counts. The procedure should not be carried out in the presence of patients who have been injected for imaging or when radioactivity sources for camera calibration are in the area. The counting times needed for a 5% error in patients with very low absorptions of [^{57}Co]vitamin B_{12} vary from 5 min for the camera in the iron room to a maximum of 25 min for the camera in the scanning room.

RESULTS

With the liver phantom at various depths in the water tank counts were first determined in the iron room with the upper and lower detectors and then with the standard field camera. The slopes derived by plotting total counts versus the ratio of upper to lower counts for the camera were similar to those published (*1*) for the upper and lower detectors. Next, the same procedure was used outside the iron room with the mobile camera. The slopes for the mobile camera were, in turn, similar to those for the standard field camera (Fig. 1). In 88 patients (Table 1) the ratio of counts from the upper and lower detectors averaged 1.46 (range 1.05–2.42) and in 35 patients in the prone and supine positions the ratio of counts using the standard field camera in the iron room averaged 1.44 (range 1.05–2.12) and in seven patients using the mobile camera averaged 1.46 (range 1.02–1.81). In 13 patients, including normals and those with pernicious anemia, the final uptakes of [^{57}Co]vitamin B_{12} measured by the standard field camera in the iron room were not significantly different than paired measurements by the detectors in the room (Table 2). In seven patients (Table 2) the final uptakes of [^{57}Co]vitamin B_{12} measured by the mobile camera with lead apron coning were not significantly different than those determined by the standard field camera in the iron room.

TABLE 1
Ratio of Upper/Lower Detector Counts and Prone/Supine Counts

Patients	Ratio
88	Upper/lower 1.46 (1.05–2.42)
35*	Prone/supine 1.44 (1.05–2.12)
7†	Prone/supine 1.46 (1.02–1.81)

* Standard field camera—iron room.
† Mobile (LEM) camera—scanning room.

TABLE 2
Total-Body B_{12} Absorptions: Iron Room Upper/Lower Detector: Standard Field Camera Compared with Mobile Camera

Item	B_{12} Absorption (%)		
	Range	Mean	s.e.m.
Two detectors	1–74	41.5	8.0
Iron room camera (n = 13)	1–84	43.3	8.3
Iron room camera	2–95	33	14.0
Shielded camera (n = 7)	3–75	29	11.5

DISCUSSION

A recent study (*1*) described modifications of total body counting to measure accurately the absorption of [^{57}Co]vitamin B_{12}. Previous studies used an early count to determine 100% absorption (*3–6*). Such counts vary greatly as attenuation changes during the first hours after ingestion of vitamin B_{12} and during its absorption. With the use of a liver phantom in a water tank to simulate the later distribution of vitamin B_{12} a more accurate initial 100% absorption can be calculated and vitamin B_{12} absorptions easily determined. However, the equipment necessary for the technique described (*1*) is not easily available.

The use of a gamma camera as the detector would make the technique more available. With the collimator removed and the wide crystal of a camera subtending a large solid angle low energy ^{57}Co can be efficiently detected. The results obtained with a gamma camera compared to those from scanning detectors in a side by side iron room were superimposable. A gamma camera outside the iron room shielded by six lead aprons with careful background measurements, shielding, and positioning gave similar results to those in the iron room. It is, therefore, clear that a facility available to most hospitals is adequate to do total-body B_{12} absorption measurements.

Two further modifications make less stringent the need for the patient to turn over when he is too sick to do so, and the need to set up a phantom. The difference in total counts between those patients with a ratio of 1.0 and those with a ratio of 2.0 is only 10% (Fig. 1). A mean ratio of 1.5 may therefore be applied to all patients with little error. The variations in thickness amongst patients, however, do cause such differences in attentuation that the capsule-in-air count must be corrected to 25% for a 20 cm patient, 18% for a 25 cm patient, and 13% for a 30 cm patient. These corrections may be used to calculate the appropriate 100% absorption count. Given that it is difficult to turn the patient over and to construct a phantom, the ratio of 1.5 and these corrections for attenuation may be used in lieu of actual measurements.

The use of these corrective assumptions in calculations when actual determinations are too difficult and the demonstrated effectiveness of a gamma counter as the detector add to the advantages of total-body counting over urine collection (*6*) in measuring vitamin B_{12} absorption.

FOOTNOTE

* Siemens Medical Systems Inc., Iselin, NY.

REFERENCES

1. Cardarelli JA, Burrows BA, Miller A, et al: Correction of attenuation in whole-body determination of Co-57 B_{12} absorption. *J Nucl Med* 24:949–951, 1983
2. Slingerland DW, Cardarelli JA, Burrows BA, et al: The utility of serum gastrin levels in assessing the significance of low serum B_{12} levels. *Arch Intern Med* 144:1167–1168, 1984
3. Haversten Y, Liden K, Stahlberg KG, et al: The study of ^{57}Co-vitamin B_{12}-absorption using a whole-body counter. *Phys Med Biol* 14:441–453, 1969
4. Boddy K, Will G, Holmes BM: An evaluation of ^{57}Co-labelled vitamin B_{12} in a double tracer test of absorption using a whole-body monitor. *Phys Med Biol* 14:455–462, 1969
5. Tait CW, Hesp R: Measurement of ^{57}Co-vitamin B_{12} uptake using a static wholebody counter. *Br J Radiol* 49:948–950, 1976
6. Fairbanks VF, Wahner HW, Phyliky RL: Tests for pernicious anemia: The "Schilling Test." *Mayo Clin Proc* 58:541–544, 1983