The authors do not seem to consider that the positive predictive value (PPV) and the negative predictive value (NPV), [and, hence, the accuracy (ACC)] are a function of the prevalence (PREV). Indeed, if we use the sensitivity and specificity values reported in their paper on populations with prevalences of 0.25, 0.28, and 0.50, we can derive the following values from Bayes' theorem:

PREV	Three-phase			Four-phase		
	PPV	NPV	ACC	PPV	NPV	ACC
0.25	0.55	1.00	0.80	0.67	0.93	0.85
0.28	0.58	1.00	0.80	0.70	0.92	0.85
0.50	0.78	0.99	0.88	0.86	0.82	0.84

It appears, therefore, that in a population with a 50% prevalence, the three-phase method would have yielded the higher accuracy.

In fact, the authors can be faulted on two levels: first, even in low prevalence populations one would prefer a negative three phase study, yielding a 1.00 NPV, or a positive four phase study yielding a PPV of 0.67 or 0.70. The relative value of each study is therefore a function of the outcome (positive or negative) rather than of the accuracy. This applies particularly in a case where one procedure is part of another (every four-phase includes a three phase).

Second, accuracy is, as demonstrated here, a function of the population, and poorly reflects the value of the test. Indeed, a test which would *never* be positive, would, in a population with a prevalence of 0.05 yield an accuracy of 95%, but would it be the better test?

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REPLY: We thank Dr. Goris for his interesting remarks on our report, "Value of a 24-Hour Image (Four-Phase Bone Scan) in Assessing Osteomyelitis in Patients with Peripheral Vascular Disease," published in the July, 1985 issue of the Journal. It is encouraging and stimulating to know that articles are being read with attention to detail and thought about what is not included in the article, as well as what is included.

The study presents data comparing three-phase and four-phase bone scans performed in 21 studies on 17 patients. All data for three- and four-phase studies are derived from the same population. Thus, Dr. Goris' statement in Paragraph 2 of his letter that there were two populations which were not identical is incorrect.

The paper did not address positive predictive value and negative predictive value. In the hypothetical situation of a

50% prevalence of osteomyelitis, Dr. Goris points out that the three-phase method would have yielded higher accuracy. The population studied was actually a population in which the risk for osteomyelitis is probably as high as imaginable in any population. These were adult patients with lower extremity ulcers, underlying diabetes mellitus, and/or peripheral vascular disease, who were referred for bone scans because of suspected osteomyelitis. The prevalence of osteomyelitis was 5/20 scans (one scan was not included in calculations of sensitivity, specificity, or accuracy, because clinical pathology, as well as three- and four-phase results were indeterminate). While the accuracy for three-phase calculates to 80% and the accuracy for four-phase to 85%, sensitivity, as reported in this paper, is higher for three-phase studies, while specificity, is higher for four-phase studies. Since the most difficult interpretation of the three- or four-phase bone scan occurs in patients who have degenerative bone disease (degenerative disease is a cause of false-positive three- or four-phase bone imaging for osteomyelitis), the increased specificity in adult populations at risk for osteomyelitis who are likely also to have degenerative disease, makes the increase in specificity of four-phase imaging extremely important. Thus, although we must agree with Dr. Goris' statement that the value of the test is a function of the population to be studied, we would take issue with his statement that the accuracy poorly reflects the value of the test. Dr. Goris uses the hypothetical situation where a test would never be positive to support his statement that accuracy does not reflect the value of the test. In real life, as described in the study which we did to address assessment of osteomyelitis in patients with peripheral vascular disease, we feel that the more favorable specificity of the four-phase bone scan is an important advantage in assessing osteomyelitis, particularly in patients likely to have degenerative disease.

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Estimation of Bladder Wall Absorbed Dose

TO THE EDITOR: To assess the radiation risk to both volunteers and patients, correct dosimetry calculations are necessary. The bladder remains one organ where errors are often encountered in absorbed dose estimations.

The recent article by Harvey et al. (*1*) concluded that the human bladder wall received the highest absorbed dose, by a factor of ten over any other organ, after an i.v. administration of 6-[^{18}F]fluoro-L-dopa. Others have taken the same general approach to calculate radiation dose to the bladder. We suggest an alternative approach.

In general, the mean absorbed dose to a target organ from a source of radiation in another organ is determined by the product of the cumulated activity in the source organ, the inverse of the mass of the target organ and an S factor (*2*). The S factor, which is unique for a given radionuclide, contains information about the fraction of each emitted particle's energy, that is deposited, on the average, in the target organ. The numerical value of S is dependent upon the amount and composition of the absorbing medium between the source of

radiation and the target organ, on the energy and type of particle emitted and on the size, shape and composition of the target and source organ. All of these parameters affect the value of S and consequently the absorbed dose. In the case of irradiation of the bladder (wall), changing the volume of the bladder contents, results in a change in the absorbed dose received from radioactivity within the bladder content. For bladder wall dose estimation, it is necessary to estimate the change in bladder content volume over time since the S factors also change.

Tabulations of the S factors, as well as specific absorbed fractions are available (e.g., 2-5). Harvey et al. (1) utilized those in ICRP-23 (3) for photons and ICRP-30 (6) for the beta particles. Unfortunately, ICRP-23 lists specific absorbed fractions for the bladder wall only for a fixed bladder content volume of 200 ml. Harvey et al. used the same 200-ml volume for estimating the beta dose by means of the ICRP-30 GI-tract model.

Those who originally performed the specific absorbed fraction calculations listed in ICRP-23 emphasized (2,4,5) that the dose to the bladder wall, for a given cumulated activity in the bladder can vary by as much as a factor of ten depending upon assumptions about initial bladder volume, urinary output, frequency of micturition, etc. Assuming a fixed bladder content of 200 ml is often misleading. Harvey et al. (1) assume that one-half of the injected 6-[^{18}F]fluoro-L-dopa accumulates initially in the 200-ml bladder contents. A significantly higher absorbed dose from the betas and the photons would result with smaller bladder contents. Furthermore, sampling every 2-4 hr does not permit accurate estimation of the time of arrival of the activity into the bladder. Chen (7) has described a situation in which early micturition could contribute to increasing the total absorbed dose if radioactivity continued to be excreted by the kidneys after micturition.

How can the required data be obtained to accurately assess bladder dose? Among the methods are: (a) the use of a well-collimated external probe over the bladder, (b) PET measurements of the bladder, (c) bladder catheterization, or (d) animal studies. Such methods can yield valid time-activity information. From these data, specific absorbed fractions for the gammas can then be calculated, for example, by using the empirical formulas of Snyder (5).

A more detailed knowledge of the arrival of the activity in the bladder would also allow for an optimal choice of the micturition after tracer injection. In addition, as noted by Harvey et al. (1), the bladder dose could be minimized further by insuring the patient is well hydrated (and the bladder contains urine) prior to the administration of the radiopharmaceutical.

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Single Moderate-Sized Segmental V/Q Mismatch: Moderate Probability for Pulmonary Embolus

TO THE EDITOR: In a previous publication (1) we discussed the impact that different perfusion and ventilation perfusion patterns have in estimating the probability of pulmonary embolism. However, our data on single segmental defects were derived from only five patients: one with pulmonary embolism and four without. Since then, Cheely et al. found that one of three patients with a single segmental V/Q mismatch had pulmonary embolism (2). In looking at moderate-sized defects (e.g., an entire segment or 25-75% of a lung segment) associated with normal ventilation, Biello et al. showed that one of three patients with this pattern had pulmonary embolism (3).

In order to expand the number of patients in this category, we have subsequently reviewed the scans of eight patients who had single segmental defects, negative chest radiographs, and pulmonary angiography. With these criteria it took 5 yr to collect the above patient data. The scans were all performed with technetium-99m macroaggregated albumin and with xenon-133 as the ventilatory agent. Of the eight patients, four (50%) had evidence of pulmonary embolism by pulmonary angiography.

Thus, we conclude that single defects can occur with pulmonary embolism but that other manifestations are more frequent. Moreover, once this type of pattern is found, the chance of pulmonary embolism is in an intermediate range.

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