4. NATRELLA MG: *Experimental Statistics*, National Bureau of Standards Handbook 91. Washington, U.S. Govt Printing Office, 1963

Reply

Dr. Collé is, of course, correct in his explanation of the measurement theorist's definition of the terms *accuracy* and *precision;* I was taught these many years ago by Dr. Eisenhart at the National Bureau of Standards. But I also realize that all definitions are arbitrary; e.g., most dictionaries use "precise" as a synonym for "accurate".

I used these same words to draw a distinction, often ignored by researchers, that *precision* relates to variability whereas *accuracy* is associated with lack of bias. The problem with using the definitions advocated by NBS and others is that because of the interrelationship between the two words, a technically accurate explanation tends to obscure rather than clarify precisely the distinction that I wanted to draw.

SHELDON G. LEVIN
Armed Forces Radiobiology Research Institute
Bethesda, Maryland

Editor's Comment

(In the minds of many people, including those who edit dictionaries, the words "accurate" and "precise" are nearly alike. Since most of us who work with statistics are not 'purists,' perhaps a simple remedy would be the use of words that are more descriptive. Possibly "repeatability"would be an improvement over "precision," and certainly the difference between "repeatability" and "accuracy" is appreciably more obvious. Editor).

Re: Scintigraphic, Electrocardiographic, and Enzymatic Diagnosis of Perioperative Myocardial Infarction in Patients Undergoing Myocardial Vascularization

I read with interest the study by Burdine and coworkers in the July issue of the *Journal of Nuclear Medicine* (*1*), in which they conclude that Tc-99m pyrophosphate myocardial imaging (TcPPi) is "probably the most valuable means of diagnosing perioperative myocardial infarction."

However, the study design is handicapped because of the lack of external determination of the end point. The authors use combinations of the predictor variables to determine the outcome "myocardial infarction."

Further, the particular combinations of predictor variables to define the outcome event appears to bias the study against the possibility that enzyme elevation is the most valuable variable. By requiring both enzyme elevation and TcPPi to be positive for "definite myocardial infarction," "positive" cases cannot be classified by enzyme elevation alone. To qualify as "probable myocardial infarction," the authors require that enzyme elevation must be accompanied by persistent electrocardiographic changes—usually the least sensitive factor in myocardial infarction.

To illustrate the concerns, I have prepared a hypothetical table of data wherein the "truth" is known. Test A represents the least sensitive test and Test B the most sensitive, with Test C intermediate in sensitivity.

Using the "truth," the sensitivity of Tests A, B, and C are 0.621, 0.947 and 0.800, respectively. The specificity of the three tests are 0.989, 0.994, and 0.994. The predictive value of the three tests when positive (PVP) are 0.855, 0.947, and 0.938. The predictive value of the negative tests (PVN) are 0.961, 0.994, and 0.979, respectively. Thus, B is the most sensitive test; B and C are equally specific. B has the highest predictive values for both positive and negative tests.

TABLE

Group	n	"Truth"	Test results A	B	C	A or (B + C) positive
1	895	−	−	−	−	−
2	5	−	+	−	−	+
3	5	−	+	−	+	+
4	17	+	−	+	−	−
5	3	+	−	−	+	−
6	2	+	+	−	+	+
7	2	+	+	+	−	+
8	16	+	−	+	+	+
9	55	+	+	+	+	+

In contrast, when the criteria A or (B + C) are used, the following figures result. Sensitivity for Tests A, B, and C: 0.812, 0.859, and 0.918. Specificity with these criteria are 1.00, 0.981, and 0.997, respectively. The predictive value of a positive test for the three tests are 1.00, 0.811, and 0.963. Predictive value of negative tests are 0.983, 0.987, and 0.992. Using this analysis, C appears to be preferable to B by each measure of test utility.

The numbers in this example were quickly assembled to illustrate the point that predictor variables should not be used to define the outcome measure. I did attempt to make the incidence of events comparable to those of perioperative myocardial infarction, to make Test A resemble electrocardiographic diagnosis in being the least sensitive of the three methods, and to have Test B with a slight advantage over Test C. The example is not intended to prove that enzyme elevation is the most valuable means of diagnosing perioperative myocardial infarction, although this may be true. Rather, it is to illustrate that, given the approach used by the authors, I cannot conclude that they have demonstrated that TcPPi myocardial imaging is the most valuable means of diagnosing perioperative myocardial infarction.

DENNIS M. DAVIDSON
Stanford University School of Medicine
Stanford, California

REFERENCE

1. BURDINE JA, DEPUEY EG, ORZAN F, et al: Scintigraphic, electrocardiographic, and enzymatic diagnosis of perioperative myocardial infarction in patients undergoing myocardial revascularization. *J Nucl Med* 20: 711-714, 1979

Reply

We agree with Dr. Davidson that the use of predictor variables to determine outcome is less than optimal, but we emphasize that there is no definitive procedure short of necropsy to diagnose perioperative myocardial infarction (POMI). Postoperative assessment of regional wall motion adds valuable information, but is still less than definitive, particularly when damage is confined to the subendocardium. This problem of a lack of a satisfactory "gold standard" hampers all such comparative studies.

While we therefore agree with Dr. Davidson's concerns, we nevertheless believe that he is incorrect in his conclusions. In view

of the well-documented incidence of false-positive enzyme studies in the postaortocoronary bypass setting (presumably due to surgical trauma, hemolysis, renal insufficiency, etc.), bias against using enzyme levels as the sole criterion for POMI is in our opinion justified. Dr. Davidson does not point out that we also place equal bias against the use of a positive pyrophosphate scan as the sole criterion of POMI. Considering the demonstrated lack of sensitivity of the ECG and the nonspecificity of enzyme levels, we contend that our conclusion is valid and that of these three testing modalities, the pyrophosphate scan is the most valuable method to diagnose POMI.

JOHN A. BURDINE
E. GORDON DEPUEY
Baylor College of Medicine, St. Luke's Episcopal Hospital, and Clayton Foundation for Research
Houston, Texas

Cardiopulmonary Flow Studies Show Venous Return From Upper Half of Body Passing Directly to Left Atrium

Cardiopulmonary blood flow studies with labeled microspheres may show intracardiac shunts between right and left cavities (*1*) when lungs and other organs dependent on the systemic circulation are visualized simultaneously. We had the opportunity to use such a dynamic sequence to detect an abnormal return of venous blood without any visualization of the lungs.

A 14-year-old boy was admitted to the Lyon Cardiovascular Hospital with a history of polycythemia and hypoxia. Three years before, he sustained successively two cerebral abscesses that required neurosurgery.

The pulmonary ventilation scintigram (Xe-133) was normal. After right antecubital intravenous administration of Tc-99m-labeled microspheres, serial scintiphotos of the thorax, recorded every 5 sec, revealed that all of the radioactivity seen first in the right "subclavian" vein was then found first in the left atrium, then in the left ventricle, and finally in the aorta. The lungs and the right cardiac cavities were never seen during this examination.

Subsequent scintiphotos centered first on the thorax, then on the abdomen, were performed. A thoracic picture realized at 1 min, only showed the thyroid gland. An abdominal picture taken at 2 min displayed radioactivity in the spleen, in the right kidney, and in a large diffuse left abdominal area (Fig. 1).

FIG. 1. Anterior view showing Tc-99m-labeled microspheres in spleen, right kidney, and in a large diffuse left abdominal area. Tracer was injected in right arm.

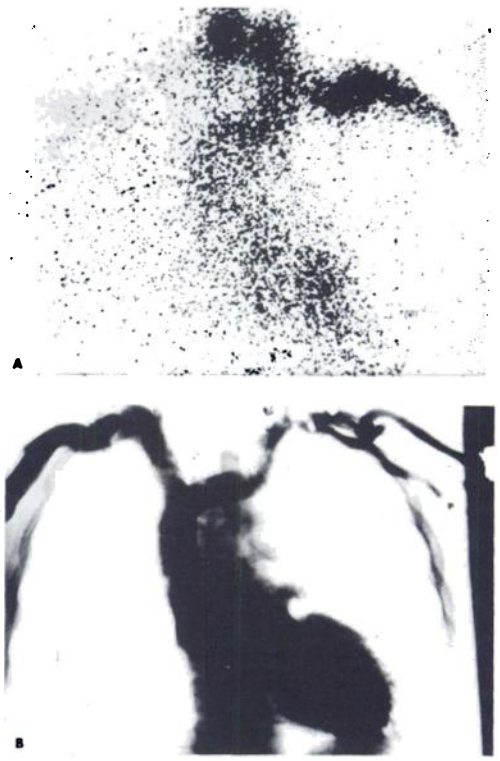

FIG. 2. (A) Scintigram after injection of tracer in left antecubital vein. Pattern of radioactivity is same as that observed after injection in right antecubital vein. (B) Contrast angiogram shows ending of superior vena cava in left atrium.

Next Tc-99m-labeled microspheres were injected i.v. in the left arm (Fig. 2A). The same results were observed.

The tracer was finally injected in a right foot vein. A normal lung scintigram was obtained.

This comprehensive scintigraphic study demonstrated that the venous return from the upper half of the body ended directly in the left atrium. Subsequent contrast angiography corroborated this malformation—that is to say, the ending of the superior vena cava in the left atrium (Fig. 2B). Three pulmonary veins ended in the left atrium, and the right superior pulmonary vein ended in the superior vena cava. The size of the right atrium was normal. Renal arteriography showed two normal kidneys.

The two scintigraphic images obtained after injection of microspheres, first in a right-arm vein, then in a left, clearly demonstrated, in a nontraumatic way, the return of venous blood from the upper half of the body directly to the left atrium. The lung image obtained after injection of the microspheres into a foot vein demonstrated that the inferior vena cava ended normally in the right atrium. The picture of the abdominal distribution of radioactivity after injection into an arm vein is more difficult to understand. We can eliminate the hypothesis of a situs inversus, since the abdominal aortic angiography performed before surgery displayed normal positions of liver and spleen. We thought that the microspheres were distributed according to the differential flow between the branches of the celiac trunk. The hepatic artery, being the smallest branch, received too few microspheres to visualize the liver. The large diffuse abdominal shadow was probably due to the flow of microspheres into the superior mesenteric artery. It remains