doses and state-of-the-art nuclear cameras combined with the skill of necessarily well trained technologists and physicians.

It would be a shame if the dogma of the 20-mCi dose would discourage a part of our community from utilizing simultaneous function and perfusion assessment, a unique approach of imaging coronary artery disease by nuclear medicine.

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Jean-Paul Esquerré
Florent J. Coca
University Hospital Purpan
Toulouse, France

REPLY: Esquerré and Coca raise several significant issues in their comments regarding first-pass radionuclide angiography (FPRNA) using single-crystal gamma cameras. Foremost of their concerns is the issue of the appropriate dose of ^{99m}Tc. Both our group (*1*) and Nichols et al. (*2*) have suggested that a 20-mCi (740 Mbq) dose is necessary to provide consistently reliable count rates during FPRNA on a single-crystal system. We also adhere to that recommendation even when using the multicrystal camera to avoid suboptimal clinical results. Esquerré and Coca are concerned that such a recommendation will inhibit the application of FPRNA during same-day sestamibi protocols where one dose must be 10 mCi (370 MBq). They suggest that, in their experience, FPRNA can be reliably performed with 10-mCi injections and average count rates of approximately half those reported by Gal et al. (*1*) and Nichols et al. (*2*) in previous studies using single-crystal systems.

The appropriate dose for a first-pass study depends on several factors, including the sensitivity of the camera-computer system, the collimation, the acquisition matrix, the body habitus of the subject, the number of sinus beats available for analysis during the left ventricular phase, the range of statistical reliability that the operator is willing to accept and the objective of the study. Esquerré and Coca do not provide enough information in their letter for us to assess those variables in their data. They report an average of 2.7–1.3 kcts at end-diastole in the representative cycle. The statistical error in the measurement of left ventricular ejection fraction (LVEF) increases as both the counts and the LVEF decrease. At 2.7 kcts, the error in an LVEF that is 0.50 is ±0.05, whereas the error in an LVEF of 0.30 is ±0.10 (*3*). When the LVEF is in the normal range, the exact identification of the end-diastolic peaks and end-systolic troughs becomes less critical and the count rate is much more forgiving. When the LVEF is low, small errors in the calculation of end-diastolic and end-systolic counts make much larger differences in the calculated LVEF. Fortunately, at low LVEFs, the chambers are usually large and there are frequently more beats for analysis, so there are usually adequate count statistics. Clinically, however, it is the measurement of intermediate range LVEFs that is so critical prognostically, because survival is fairly stable at LVEFs above 0.50 and consistently poor at LVEFs less than 0.30. Prognosis varies dramatically, however, when the LVEF is in the range of 0.35–0.50 (*4*). One of the examples given by Esquerré and Coca of a patient with an intermediate range LVEF and only 1.53 kcts at end-diastole is important since it points out how very low count rates can occur despite the best intentions of the operator. The error in the calculated LVEF of 0.38 was 0.06 LVEF units. In other words, the true LVEF could have been 0.32–0.44, which is clinically unacceptable. The prognosis of a 0.32 LVEF is much different than that of a 0.44 LVEF.

The objective of the study is also important in determining the necessary count rate and dose. When performed adjunctively with perfusion imaging, some clinicians are only interested in obtaining the prognostic information contained in the LVEF. For that purpose, it may not be mandatory to get the absolutely highest count rates possible. For diagnostic quality, however, in regional wall motion assessment, the count rate requirement is higher than that for the measurement of LVEF alone. We routinely use collimation that provides an acceptable compromise between count rate and spatial resolution so that we may analyze regional wall motion confidently. Parametric image analysis is also highly dependent upon the count density of the data.

The count density is also lower when the acquisition matrix is 64 × 64 as is so typical of FPRNA on many single-crystal systems. Unfortunately, at the average count rate of 2.7 kcts recorded by Esquerré and Coca on a 64 × 64 matrix, one should expect suboptimal and occasionally uninterpretable end-systolic images due to the low count densities per pixel. That problem has been our experience and our main concern with low-dose FPRNA on both single- and multicrystal systems and we never use a matrix larger than 32 × 32.

In making recommendations for the general application of FPRNA, we have always believed that if it is important enough to do the study, it is equally important to ensure adequate statistics. We have no doubt that the 10-mCi study will frequently be technically acceptable when all conditions (patient size, camera, collimator, acquisition matrix, bolus and number of beats) are favorable. Unfortunately, there are too many instances where those conditions are not met and the data become marginal at best and frequently unacceptable. The higher dose study can accommodate a larger patient, fewer available beats, a delayed bolus and even somewhat higher resolution collimation.

I would certainly not dissuade Esquerré and Coca from pursuing low-dose FPRNA in their laboratory, but the onus is on them to prove to the imaging community that the low-dose, first-pass study, especially when acquired on a single-crystal system, is consistently clinically reliable both at rest and during exercise. Those of us interested in first-pass studies would welcome a manuscript from Esquerré and Coca that documents their experience.

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Steven Port
Sinai Samaritan Medical Center
Milwaukee, Wisconsin

Ken Nichols
St. Lukes-Roosevelt Hospital Center
New York, New York

Dosimetric Models and S Factors for Radiation Doses to the Bladder Wall in Children Receiving Therapeutic Iodine-131-MIBG

TO THE EDITOR: With the introduction of [^{131}I]metaiodobenzylguanidine (MIBG) therapy for the treatment of neuroblastoma, there is a need for accurate estimation of radiation dose to the urinary bladder in children. Bladder dosimetry is of particular importance when MIBG therapy is part of a combined modality treatment, either in combination with total body external beam irradiation (*1*) or chemotherapy agents (*2*) where additive damage to the bladder could become clinically significant. Published information on bladder doses from [^{131}I]MIBG is relatively scarce (*3*), but there are at least two publications which focus on bladder dosimetry in children (*4,5*), each using a different calculation method. We evaluated these publications in view of our initial experience with the new MIRD urodynamic model since the original publications had errors (*6,7*). The exercise raises doubts about the certainty of S factors previously used in children.

In the United Kingdom Children's Cancer Study Group (UKCCSG) publication (*4*), data on urinary output of radionuclides were collected by measuring whole-body radioactivity before and after voiding in five noncatheterized patients who had received therapeutic [^{131}I]MIBG. All five patients had been hydrated (3 liter/m^2 for at least 24 hr) and had voided frequently (every 1–5 hr). No patients exceeded 10.4 yr of age. Cumulative activity in the bladder was taken to be the sum of the products of the activity in each void and the mean residence time, the latter being one-half the time between voids.

Dose to the bladder wall was then determined from the product of cumulated activity and the appropriate S factor (dose per unit cumulated activity from bladder contents to surface of bladder wall) at each age; the S factor was obtained from Report 73 of the National Council on Radiation Protection and Measurements (*8*). The estimated radiation doses to the bladder wall per unit administered activity of ^{131}I ranged from 2.2–5.3 mGy/MBq.

The approach used by a Task Group of the International Commission on Radiological Protection (ICRP) (*5*) was different in that cumulated activity in the bladder was derived from a mathematical model in which the rate of renal excretion of MIBG is determined from the whole-body retention curve, which is described by a series of exponential functions. The interval between voids is taken to be constant (3.5 hr) and the same for all ages. A fixed average bladder content is used, i.e., the model does not allow for bladder filling, but allowance is made for variation of bladder contents with age: 200 ml for adults and 152, 97, 61 and 31 ml for 15-, 10-, 5- and 1-yr-old children, respectively. The Task Group derived S factors for final dose calculations and estimated doses to the bladder wall ranged from 0.73 mGy/MBq at age 15 yr to 3.3 mGy/MBq at age 1 yr.

Although the UKCCSG patients were hydrated, there appeared to be reasonable correspondence between these two sets of dose estimates, considering the differences in methodology. We have been investigating the application of the new MIRD urodynamic model (corrected version) (*6,7*) in children. This model allows for bladder expansion, permits choice of urine flow, void time and initial bladder contents. Our work has brought to light substantial discrepancies between the S factors employed by the NCRP (*8*) and ICRP (*5*). Although the factors in the latter report are not explicitly calculated, it is possible for them to be determined through back calculation by dividing the estimated dose per unit activity (mGy/MBq) by the cumulated activity in the bladder (MBq-hr), an expression for which is given in the report. The calculation requires whole-body clearance to be expressed as a sum of exponential components. Two components of whole-body clearance of MIBG are identified in the ICRP report and apply to all age groups, namely, 36% with a biological half-period of 3 hr and 63% with a biological half-period of 33.6 hr. All MIBG excretion is taken to occur by the renal route. Our mean retention curve in seven children was similar. The two components were 57.5% with a half-period of 9 hr and 42.5% with a half-period of 51.1 hr.

ICRP S factors derived in this way for different ages are compared with those tabulated in the NCRP report (*8*) (Table 1). Our own S factors for the nonpenetrating component of ^{131}I radiation calculated by standard methods (*9*) and using the ICRP values for average bladder contents at different ages are also included. These comparisons show the NCRP S factors to be greater than the others. In the NCRP report, no information is given for bladder content volume at different ages, but they would need to be much

TABLE 1
Comparison of S Factors

Age (yr)	mGy/MBq-hr		
	ICRP	NCRP	Bolster et al.*
Newborn	—	21.05	—
1	1.94	4.81	1.80
5	1.00	3.22	0.92
10	0.65	—	0.58
15	0.43	—	0.37
Adult†	0.35	—	0.28

*Nonpenetrating component only.
†S values for adults in this table are similar to the values in *MIRD Pamphlet No. 10.*

TABLE 2
Bladder Wall Dose (mGy/MBq) at Different Ages

Age (yr)	ICRP model	New MIRD model	Daytime urine flow (ml/min)
1	3.30	2.33	0.44*
5	1.70	1.99	0.52
10	1.10	1.33	0.79
15	0.73	1.21	0.87
Adult	0.59	0.96	1.11

*At half this value, the estimated dose is approximately doubled; at twice this value, the dose is halved.