postmenopausal year have a relatively larger deficit of trabecular bone. A precise measurement of their spinal bone mass can hardly be achieved with the present DPA technique, and for the diagnosis of crush fracture it is easier to take an x-ray. The interesting question is, however, how to diagnose mild osteoporosis, and this was the aim of our study. As described in detail our 28 unselected patients had mild osteoporosis and in these patients DPA measurement of the lumbar spine had no advantages over SPA measurement of the distal forearm.

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Quantifying Intracranial CSF Volume Using MRI

TO THE EDITOR: Chawluk et al. (*1*) described a method of correcting for the presence of cerebrospinal fluid (CSF) in positron emission tomography (PET) estimations of cerebral metabolism per unit mass of brain tissue. They did so using a series of x-ray (XCT) computed tomography images with areas of CSF in sulci and ventricles being identified subjectively using a data tablet operating on a high resolution display. This use of XCT images follows the similar approach taken by Herscovitch et al. (*2*).

We would like to point out that a more accurate correction technique exists that does not involve ionizing radiation. While using magnetic resonance (MR) images, it does not do so in the way suggested by Chawluk et al. (*1*), namely, simply as a substitute for the XCT slices with CSF spaces again being identified subjectively. Rather, it takes a radically different approach by utilizing the significant differences between the relaxation times of CSF ($T_1 > 3{,}000$ ms, $T_2 > 2{,}000$ ms) and those of gray matter (513 ms, 118 ms) and white matter (242 ms, 86 ms) (*3*). Using an IRCP5000/300/400 ($T_R/T_I/T_E$) image contrasts between a unit volume of CSF and a unit volume of brain tissue of > 200:1 are obtained in practice. In other words, images are effectively obtained that show only CSF with the signal from each pixel being proportional to the amount of CSF contained in the corresponding volume element. A reference vial containing a known volume of water that has very similar relaxation times to CSF (*4*), is used to translate this into absolute volume. Slices can be obtained in any orientation and thickness and thus can be accurately matched to the actual PET images to be corrected and estimates of absolute CSF volume (ventricular and extra-ventricular) can be obtained. The method is not subject to the beam hardening effects of XCT, does not suffer from significant partial volume effects (*3*) and does not require either a threshold algorithm (*2*) or subjective observer choice (*1*) to define regions of CSF. Its noninvasive nature and lack of ionizing radiation means that it may be used to establish normal values in volunteers as well as being applied serially to patients with greater frequency than would be possible with XCT. The fact that each pixel in the MR image represents the absolute volume of CSF in the corresponding volume element means that it may also be possible to correct the PET images on a voxel by voxel basis as opposed to the present global correction as described by Chawluk et al. (*1*).

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REPLY: We appreciate the interest demonstrated by Condon and colleagues in the issue of quantifying CSF spaces in vivo. Their method is the most promising we have encountered to date, and provides the potential for greater accuracy and ease of implementation than the more subjective and operator-intensive XCT technique which we have employed for the past several years (*1–3*).

The method of quantifying intracranial CSF volume described by Condon et al. (*4*) uses an MR pulse sequence designed to produce a maximal signal from CSF, minimizing the signal from other tissues (gray and white matter). As currently presented, a potential disadvantage of this technique in studies of aging and dementia is the length of time required to obtain a single slice (almost 5 ½ min with a 64 × 64 matrix). The magnitude of this disadvantage is partially counteracted by the use of thicker slices, permissible given the very high signal contrast between CSF and brain.

Data from phantom studies and reproducibility data using this method are quite good (*4*). Several factors limit an uncritical implementation of this method, however, including image nonuniformity, unavoidable residual partial volume averaging effects, and motion during scanning (patient motion as well as CSF bulk flow). Another limitation of this "thick-slice" approach is that measurements of regional atrophy are

limited to larger volumes defined in one dimension by the slice thickness. Reducing the slice thickness would greatly increase the time needed to completely study the intracranial contents. A three-dimensional data acquisition routine could conceivably overcome this disadvantage. PET scanners with high resolution three-dimensional data collection are currently being built (*5*). With appropriate scaling and registering of images, PET data could be corrected for atrophy based upon MR data, on a voxel-by-voxel basis, as proposed by Condon et al.

Future efforts to quantify cerebral atrophy for whatever purposes will require proton-MR data. The careful and original work of Condon and associates has provided a valuable starting point for these endeavors.

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Caution in the Use of Volume Expansion Diuretic Renal Scan

TO THE EDITOR: In the article "Volume Expansion Diuretic Renal Scan in Urinary Tract Obstruction" (*J Nucl Med* 1987; 28:824–828) Howman-Giles et al. suggest a protocol for volume expansion that includes "An i.v. infusion of 0.9% sodium chloride at a rate of 360 ml/m^2 over 30 min prior to the scan." Although the described hydration protocol appears at first glance to be relatively benign, I believe some potential problems exist.

The study population contained only one adult yet they endorsed the protocol by stating: "No complications, in particular, cardiac failure or hypertension, were observed from the intravenous fluid load during the study". In a 70-kg, 6-ft adult, the body surface area would be ~1.9 m^2. The intravascular volume of such a patient would be ~3.5 liters (Total body water = 60% body weight; Extra cellular fluid volume = ⅓ TBW; Plasma volume = ¼ ECF) (*1*). The recommended saline load by the protocol proposed by Howman-Giles would be 684 ml, or ~20% of the intravascular volume. In an elderly patient who may already have other problems related to his renal failure, such as organic heart disease, a rapid increase of the intravascular volume by 20% may be disastrous. Although they fared well with the one adult patient, with a set hydration protocol it would only be a matter of time before a patient with a diathesis for congestive heart failure would be encountered and volume overloaded.

They also state "To obtain optimal conditions for interpretation, the study should be performed in a standardized manner. The variables, both anatomic and physiologic, need to be reduced". A set protocol for hydration, however, could only over-hydrate the normovolemic patients and may not even return severely dehydrated patients to a normovolemic state. Each patient undergoing diuretic renography should be evaluated individually, preferably by the primary care provider. The nuclear medicine consultant and the primary clinician can then coordinate any hydration orders and tailor those orders for the particular needs of the individual patient. A hydration protocol may lead to carelessness in the handling of individual patients, resulting in potentially harmful orders from a consultant who may not know the details of a particular patient's fluid status.

My last concern is the mention of "routine bladder drainage with an indwelling catheter in all patients undergoing a diuretic stress". Bladder catheterization is not a benign procedure (*2*), particularly in patients with evidence of urinary stasis and incomplete bladder emptying. A more individualized analysis of the risk/benefit ratio for each patient needs to be made before catheterization is ordered.

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REPLY: The letter from Dr. Donahue makes the important point that patients should be clinically assessed prior to the administration of intravenous saline as described in our protocol (*1*). We omitted this point in our article for the simple reason that in Australia where nuclear medicine is practiced exclusively by nuclear medicine consultant physicians trained initially in internal medicine, it is routine and prerequisite to all nuclear medicine studies that the patient be clinically assessed prior to the administration of any radiopharmaceutical. We certainly agree that this protocol should not be applied to patients with hypertension or potential cardiac failure. By far the majority of patients requiring this extension of the normal diuretic renal scan are in the pediatric group, though since first performing these scans almost 3 yrs ago, we have performed the test on now a total of six adults and 70 children and can continue to report no complications with the intravenous hydration procedure. If the protocol is to be applied in an environment where the patients are not routinely clinically assessed by the nuclear medicine physician then we would certainly recommend that a clinical assessment by the