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EDITORIAL

Misalignment Between PET Transmission and Emission Scans: Effect on Myocardial Imaging

The paper by McCord et al. is an interesting and useful investigation which draws attention to a too often overlooked source of artifacts in PET examinations of the myocardium. It is probably obvious that a misalignment between transmission measurements of the thorax utilized in correcting emission images of the myocardium would yield artifacts in the corrected images. The merit of this article is that it describes these artifacts with reference to the type of misalignment (left to right, cephalad to caudal, various degrees of rotation, etc.) quantitates the effects thus observed, and particularly shows that these effects are different in different sectors of the myocardium. It is now important to take the next step and consider, and eventually apply, means for overcoming this difficulty.

Since the problem is created by a misalignment between transmission and emission measurements, one could remove the problem by doing away with the attenuation measurement altogether. This, as we all know, would severely distort the images obtained due to the variability of the attenuation experienced by the annihilation photons as they encounter different absorbers and would impair the usefulness of any study relying on static images. On the other hand, this approach would, in many instances, not affect measurements based on the variation as a function of time of the activity in different segments of the myocardial, such as wash in or wash out studies, this with the additional advantage of doing away with the noise contribution of the attenuation measurement. Parenthetically, misalignment between transmission and emission measurements would not affect a wash out study.

Another intriguing approach to the solution of this problem is the simultaneous acquisition of emission and transmission measurements, as proposed and demonstrated by Thompson et al. (*1*) in PET imaging of the brain. One of the weaknesses of this otherwise ingenious approach is that PET detectors, under simultaneous measurements, are subjected to the need of acquiring data for two measurements with a concomitant contribution of various sources of noise randoms, and of dead time from both measurements. So far, with present equipment, this approach does not seem to be practical for myocardial imaging, but deserves further investigation.

Another possible solution would be to verify the proper alignment of the transmission and emission measurements through the use of some frame of reference common to both measurements. In cases of misalignment, the transmission sinograms could be suitably displaced by a method similar to the one described in the paper under discussion. At this time, a convenient common frame of reference does not come to mind, but could probably be developed.

Perhaps the easiest way, at least at this time, to overcome the problem is to minimize, as much as possible, any displacement of the patient between the transmission and emission measurements. This can be achieved by the combination of several approaches. In the first place, the patient will be less inclined to move if he or she is in a comfortable position during the examinations. This can be easily achieved in many of the existing PET imaging systems which put, perhaps, less strain on the patient than mentioned in the McCord et al. article (. . . tending to draw the patient into the gantry . . .). Another easy approach towards minimizing patient motion is use of a plastic foam restraining device molded to the patient's anatomy (this approach has been used at Washington University). A crucial factor in minimizing patient motion is to reduce the length of the examination. While this is obviously either difficult or perhaps impossible for emission measurements, there is no reason why the transmission measurement cannot be carried out with a sufficient amount of activity in the attenuation source to collect statistically adequate data in a short period of time. The rotation of the patient can be considerably minimized by supporting the patient's arms in comfortable arm-

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For reprints contact: M.M. Ter-Pogossian, PhD, Professor of Radiation Sciences, Mallinckrodt Institute of Radiology, 510 S. Kingshighway, St. Louis, MO 63110.

rests. These relatively simple measures usually, but not always, maintain the patient probably within a centimeter and/or a few degrees between the transmission and emission measurements. This has been verified at our institution in a number of cases by carrying our two blood-pool imaging procedures before and after measurements to verify the correct position of the patient. This approach offers the added advantage of keeping the patient relatively stationary during transmission and emission measurements, in addition to maintaining alignment between emission and transmission images.

It is very useful to know the magnitude of the effect produced by misalignment as a function of patient translations and/or rotations. With proper care, these motions can be kept to a minimum, under which circumstances the described effect introduces a, so far, unavoidable but often tolerable source of error.

M.M. Ter-Pogossian
Washington University
St. Louis, Missouri

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(continued from page 1182)

SELF-STUDY TEST ANSWERS

baseline rates in the general population would not apply. For instance, an organ transplant patient may be at a much greater risk, as much as 30 times higher in some cases, for cancer during his or her lifetime compared with a typical member of the population.

Because of the established variation in incidence for spontaneous and radiation-induced cancer, PC tables must take into account both age and sex. Because tobacco smoking (particularly cigarette smoking) is the single most important external risk factor for human cancer, estimated to cause 25%–40% of all cancer deaths in the U.S., it is also taken into account.

The weight of radiobiological evidence favors a linear-quadratic dose response to low-LET radiation for most cancers. Thyroid cancer and female breast cancer are exceptions in that the epidemiologic data for these cancers strongly favor a linear dose response.

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ITEMS 11–15: Risks of ^{131}I Therapy for Thyroid Carcinoma

ANSWERS: 11, T; 12, T; 13, F; 14, F; 15, F

Edmonds and Smith have reported the follow-up of 258 patients treated with high doses of ^{131}I for thyroid cancer. They observed a small but significant excess of deaths from cancer of the bladder and from leukemia. Despite the high levels of irradiation of the salivary glands, no malignancies and only one adenoma were found. No evidence of reduced fertility or of overt genetic damage has been reported in individuals (and their offspring) treated with ^{131}I for thyroid cancer

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ITEMS 16–20: Adverse Effects of ^{131}I Therapy for Thyroid Carcinoma

ANSWERS: 16, F; 17, T; 18, F; 19, T; 20, F

Undesirable side-effects of radiation therapy with internal emitters are much less prominent than those encountered with external beam radiation therapy or chemotherapy. The parathyroid gland is rarely clinically impaired by even the highest dose procedures to the thyroid with ^{131}I; only isolated cases of hypoparathyroidism have been reported. The limiting tissue dose is that to the bone marrow, which receives approximately 0.5 rad/mCi of ^{131}I administered to the patient with thyroid cancer. Radiation nephritis is not a reported complication of ^{131}I therapy (or of other nuclear medicine therapy). Mild nausea may occur, but vomiting is a rare complication (<1%). Cytogenetic changes in circulating lymphocytes occur after internal irradiation as they do after external radiation exposure. Their frequency is correlated with the exposure to blood.

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ITEMS 21–23: Adverse Effects of ^{32}P Therapy of Polycythemia Vera

ANSWERS: 21, F; 22, T; 23, T

Phosphorus-32 administered as the phosphate in high doses to treat polycythemia vera has the desired effect of decreasing the number of circulating platelets and erythrocytes. Leukopenia, predominantly lymphopenia, is noted as with any other high whole-body radiation exposure. Leukemia does occur in increased frequency in these patients, although it is not certain whether this is due to the radiation exposure per se or to the longer lifespan of ^{32}P-treated patients, giving more time for the natural evolution to leukemia that occurs in this diease. No elevated incidence of thyroid cancer has been reported in patients with polycythemia vera treated with ^{32}P.

ITEMS 24–27: Therapy with Radiolabeled Monoclonal Antibodies

ANSWERS: 24, F; 25, F; 26, F; 27, F

Radiolabeled monoclonal antibodies show great promise for use in diagnosis. However, the tumor-to-background ratios achieved with radiolabeled monoclonal antibodies generally have been too low to permit use of these agents as the sole means of treatment of tumor metastases. The radiosensitivity of the bone marrow usually limits the ability to obtain a full therapeutic effect. Nonuniform dose distribution is due in part to regional blood flow variations, which along with antigenic heterogeneity, nonspecificity of tumor-associated antigens, and changing antigenic composition of tumors, limit the current utility of monoclonal antibody therapy. Because it is difficult to ensure that antibodies will bind to each cell of the tumor, the use of radionuclides emitting short-range, high-LET radiations (e.g., alpha particles) is not optimal. Beta emission is more likely to result in a more uniform dose distribution within the tumor.

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ITEMS 28–32: Dose-Equivalent Concept with Bone Marrow Exposure

ANSWERS: 28, T; 29, T; 30, F; 31, F; 32, F

There is controversy regarding the comparability of risk coefficients based on partial-body radiation exposure with those based on whole-body exposure. For the purposes of radiation protection, it has been assumed that a dose to a portion of the bone marrow could be "averaged" over the entire marrow (i.e., as in the example in the question, a dose of 800 rads to 40% of the marrow would be equivalent to a dose of 320 rads to the whole marrow).

(continued on page 1242)