Spectral Changes Affect Intrinsic Count Rate Tests

TO THE EDITOR: Measurement of intrinsic count rate performance is an important acceptance and reference test for scintillation cameras. A method of measuring intrinsic count rate performance is given both by the National Electronic Manufacturers Association (NEMA) (*1*) and by the International Atomic Energy Agency (IAEA)(*2*). Although this test is primarily an acceptance test, we perform it annually to monitor camera performance. During recent measurements in our department, we found results that merited further investigation.

The procedure that both NEMA and IAEA recommend for measuring intrinsic count rate performance uses a source of ~ 300 MBq of technetium-99m (^{99m}Tc) placed in a thick lead pot at a distance of five camera diameters from the uncollimated camera face. Several copper plates (2–3 mm thick) of known attenuation factor are placed over the source, and counts are recorded for 100 sec. As each plate is removed, counts are recorded for 20 sec. All counts are corrected for background. The input count rate is calculated by dividing the count rate from the 100-sec count by the product of the attenuation factors of the plates that have been removed.

The IAEA document suggests measuring the attenuation factor of each plate individually by placing a source of approximately 10 MBq of ^{99m}Tc in a thick lead pot at a distance of five camera diameters in front of the uncollimated camera. Counts are recorded for 100 sec with a single plate over the source. This plate stays over the source throughout the entire experiment. Then, plates are put over the source one at a time, and again counts are recorded for 100 sec. After correcting for source decay and background, the attenuation factor for each plate is easily calculated.

During the actual measurement of the camera's intrinsic count rate performance, the input count rates are calculated by dividing the count rate measured during the 100 sec count by the product of the attenuation factors of the plates that have been removed. This, however, does not take into account the broad-beam conditions of the experiment. The broad-beam attenuation factors can be measured directly by a method similar to that used to measure the attenuation factors of the individual plates. Figure 1 shows that the product of the attenuation factors of several plates is not equal to the measured attenuation factors of those same plates.

This discrepancy causes errors in the count rate response curve for high count rates. Since the attenuation factor appears in the denominator of the expression for the input count rate, the input count rate is underestimated if the broad-beam attenuation factors are not used. This changes the shape of the count rate curve, and alters the value of the count rate corresponding to a 20% loss. Figure 2 shows curves obtained with the multiplied attenuation factors and with the broad-beam attenuation factors. In this case, the 20% loss count rate changes from 155,000 cps for the standard method, to 135,000 cps for the broad-beam method.

It can also be observed from Figure 2 that the count rate response curve shows extra counts at low count rates while the output count rate exceeds the input count rate. Throughout the experiment, scatter was reduced by using a thick lead pot, and changes in background were eliminated by ensuring that no other sources of activity were near the camera room. Spectra were analyzed for several thicknesses of copper by connecting a multi-channel analyzer to the z-output of the camera. Count rates were kept in the linear range of the camera's response so that only changes in the source spectrum, and not the changes in the camera's performance, would be detected. As Figure 3 shows, changes in the thickness of copper cause changes in the amount of scatter that is within the 20% window. It is these changes that are responsible for the extra counts at low count rates.

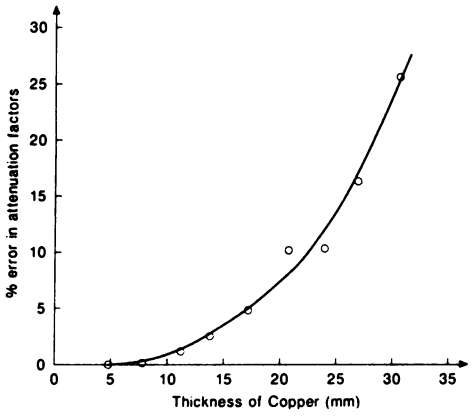

FIGURE 1
Error of attenuation factor calculation as a function of thickness of copper. The percent error is defined as the multiplied attenuation factor less the broad-beam attenuation factor, divided by the broad-beam attenuation factor.

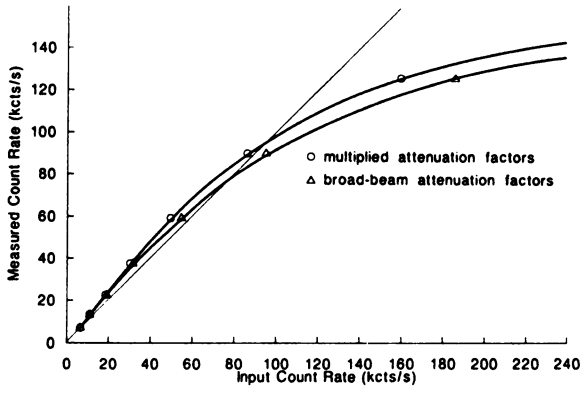

FIGURE 2
Comparison of curves calculated with standard method and with broad-beam attenuation coefficient. Data are for a Searle LFOV camera.

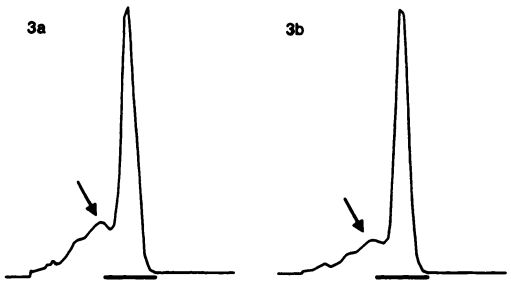

FIGURE 3
Spectrum of photon fluence, (A) 30 mm of copper (B)11 mm of copper. Bar on abscissa indicates position of 20% acceptance window. The arrows indicate the increased contribution due to scatter in (A).

In summary, the IAEA method of measuring the intrinsic count rate performance does not take into account the broad-beam conditions of the experiment. This can be easily corrected by measuring the attenuation factor of several plates rather than by measuring each plate's attenuation factor individually. The shape of the count rate curve is changed, and there is a change in the important parameter of count rate corresponding to a 20% loss.

The extra counts at low count rates are due to changes in the spectrum of the photon fluence caused by changes in the thickness of the copper. This anomaly causes slight changes in the count rate corresponding to a 20% loss. This error can be eliminated by using a decaying source to change the photon fluence; however, this procedure is time-consuming. The test recommended by NEMA and IAEA is still a useful test, as long as one is mindful of its inherent errors.

REFERENCES

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2. Intrinsic count rate performance. In: *Quality control of nuclear medicine instruments. TECDOC-317.* Vienna: International Atomic Energy Agency; 1984; 174–183.

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Determination of Brain Death with Technetium-99m-HMPAO

TO THE EDITOR: Recently, Laurin et al. published their excellent results on "Cerebral Perfusion Imaging with Technetium-99m-HMPAO in Brain Death and Severe Central Nervous System Injury" (*1*). The use of ^{99m}Tc-HMPAO in the diagnosis of cerebral death has been established in our clinic for a couple of years (*2,3*) (Fig. 1). The method has shown to

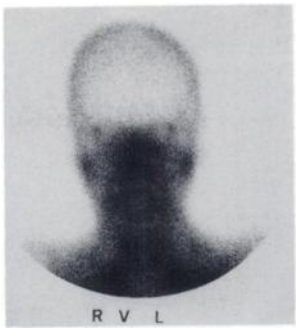

FIGURE 1
Completely absent intracranial uptake (15 min p.i.) of the flow tracer ^{99m}Tc-HMPAO in a patient with brain death after trauma.

be useful, noninvasive, and without additional risks for the patient in comparison to other methods, especially angiography (*4*). Nevertheless, caution is requested because problems from the "instability" of lipophilic ^{99m}Tc-HMPAO may occur. Technetium-99m-HMPAO is one of the most "labile" technetium complexes used in nuclear medicine. Not only the rather fast degradation of the initial lipophilic complex to a number of hydrophilic compounds but also the extremely low content of stannous chloride (7.6 μg) may be responsible for these problems. In our opinion, this low concentration of reductant especially might have caused a number of pitfalls in ^{99m}Tc-HMPAO scintigraphy that we observed within the last three years. Figure 2 shows the scintiphoto of a ^{99m}Tc-HMPAO-study in which we used the "first eluate" of a ^{99m}Tc-generator (three patients). Obviously there is no ^{99m}Tc-HMPAO, but there is a reasonable amount of pertechnetate. This might be explained by the presence of oxidants in the generator eluate or by the addition of air-oxygen during the preparation. In a second case (eight patients), one single lot of sodium chloride used for the reconstitution of the kit has been identified to be responsible for the extremely low labeling yield.

In regard to these observations, we recommend that in the diagnosis of cerebral death the integrity of lipophilic ^{99m}Tc-HMPAO has to be carefully examined prior to application. In our departments, we use the procedure described by the manufacturer (chromatography on ITLC-SG strips with saline and 2-butanone, respectively). The quantification can be done with a TLC-scanner, by a scintiphoto of the developed TLC-plates, or by cutting the TLC-support and counting in a well-type counter. Alternatively, a rapid HPLC-method (*5*) can be used to determine the exact labeling yield of each preparation. By using these methods, quality control of ^{99m}Tc-HMPAO can be done before injection within 10 to 15 min.

Complementary to the in-vitro quality control, we recommend an "in vivo" control by taking two additional scintiphotos. A negative scintigram of the thyroid gland will prove the

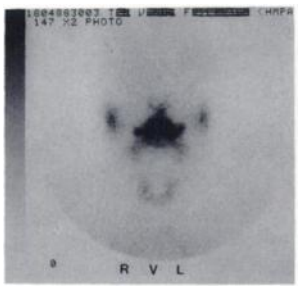

FIGURE 2
Absence of uptake in the brain (1 hr p.i.) of a patient with unknown headaches due to the low labeling yield of the flow marker ^{99m}Tc-HMPAO. Uptake in the thyroid and salivary glands indicates the presence of pertechnetate.