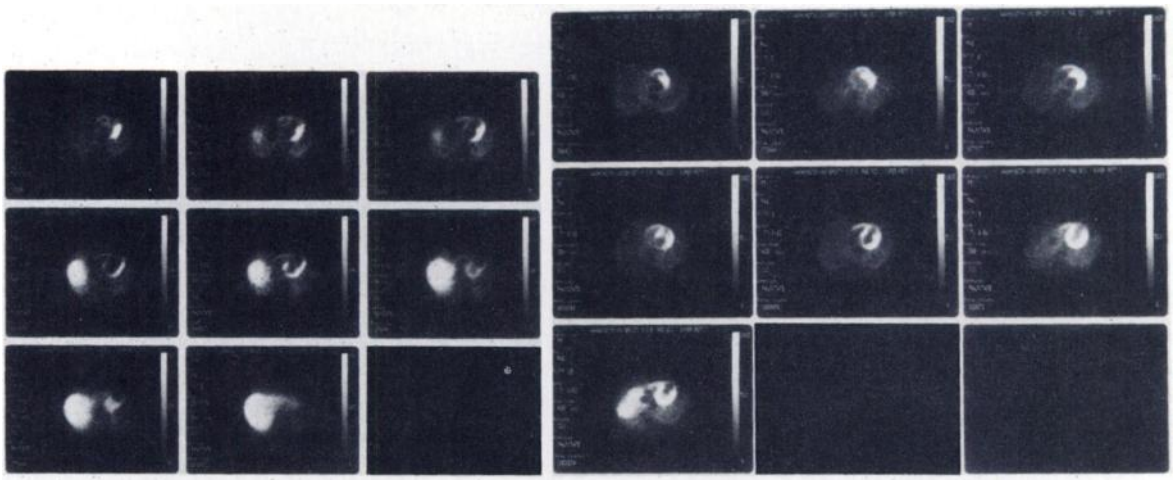

FIG. 1. Transverse tomographic PET images obtained in chest of two human subjects following intravenous injection of C-11-labeled palmitate for assessment of myocardial metabolism. Note high concentration of C-11 activity in liver slices co-planar with some images of the heart. These images were obtained by means of time-of-flight positron-emission tomograph Super PETT I.

palmitate and ammonia) used for the imaging of the myocardium. Other radiopharmaceuticals that have been used with success in the imaging of the heart (such as Rb-82) also exhibit an often high concentration of activity in organs other than the heart (including the liver, lungs, and spleen), which may be transversally co-planar to this organ. This situation is worsened if the tomographic section is selected in the attempt to image the heart in tomographic planes approximately perpendicular to the heart's long axis. It is our experience, from clinical studies carried out for the past 10 mo, that the utilization of time-of-flight has been *particularly favorable* for the imaging of the human heart with C-11 palmitate and Rb-82.

In the editorial the statement is made that "another problem of TOFPET systems at present is the lack of small phototubes required for achieving a spatial resolution competitive with conventional PET." This statement is puzzling. Indeed, one of the smallest photomultiplier tubes currently available for *either* TOFPET or PET applications (Hamamatsu R1635) has a diameter of ⅜th of an inch. However, if one wishes to incorporate smaller crystals into the design of a PET device (with or without TOF) it is possible to couple optically more than one crystal to the photocathode of a photomultiplier tube and use a coding scheme to identify individual crystals. Schemes of that sort are currently being incorporated by several groups (including our own) into the design of conventional and TOFPET systems. To our knowledge, spatial resolution in TOFPET is not limited by the size of photomultiplier tubes and it is competitive with conventional PET.

The above comments are meant only to improve an otherwise perceptive and potentially useful analysis of time-of-flight in PET by clarifying some factors that could lead to misconceptions about this modality.

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Reply

I agree with the clarification of the error in the index of refraction problem. A few years ago I expressed my concerns with respect to the tradeoff between achieving the optimum in time of flight with limited depth crystals and at the same time maintaining high efficiency.

With regard to the efficiency issue, I would like to make the following observations, which might lead to some clarification.

1. The detection efficiency of 0.74 from Vacher et al. is a theoretical efficiency with no description or justification (*1*). I suspect that this is a gross detection efficiency and includes multiple-crystal interactions that are normally rejected electronically. I think we have discussed a similar difference for the single-photon compared with positron issue.

2. I believe that N. Mullani's measurements (Ref. 14) support the conclusions of Table I in the tutorial article. First, he made measurements on 2 × 2 × 3 cm BGO compared with 2 × 2 × 7 cm cesium fluoride. Even with this important difference in the depth of crystals, the coincident efficiency ratio was still $(0.4/0.52)^2 = 0.59$. The conclusion from Table 1 in my article is 0.48 for 1.5 × 3 × 3 cm crystals. Based on these arguments, I believe that CsF and BGO do not compete well. Clearly, as one uses deeper crystals, the efficiency will improve, but then that is at some cost; this was the main point I endeavored to make in the discussion of index of refraction.

Whereas the liver does protrude into the field when examining the apex of the heart, particularly in a nontilt mode, the overwhelming majority of human subjects have this contamination in only one section. The major sections we have usually examined in our rubidium studies do not have liver contamination. Of course, to examine the posterior wall and inferior wall of the heart well, one should tilt the system, and this will lead to a larger effective number of resolution elements. Whereas light piping is always a solution, it comes at some cost.

Overall, I think that the main thrust of my attempt to clarify the situation—exemplified by the article of Huang and Texas colleagues for the general reader—cannot be interpreted as a negative view of time-of-flight positron tomography. It is an attempt to clarify the issues having to do with time-of-flight without offending those who have claimed in the past or who now claim that it will improve resolution, or who claim that time-of-flight positron-emission tomography is the *sine qua non* of nuclear medicine.

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