area (compared with white matter), or shows a change in repeat studies from a low to a high uptake. This documentation of metabolic change in the neoplasm, often accompanied by clinical deterioration, represents another indication of the exquisite sensitivity of the PET-FDG method, and its ability to characterize the essential tumor features. In the late 20th century, the PET metabolic studies of tumors should be considered at least on a par with, if not more important than, "static" histologic findings.

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REPLY: We thank Drs. DiChiro and Brooks for their comments on our recent results (*1*) and would like to respond.

Differences in the interpretation of results for local cerebral metabolic rate of glucose (LCMRGl) in untreated gliomas exist between our centers. We reported variable, but low values of glucose metabolism in tumors, irrespective of tumor grade (*1*), compared to the gray matter LCMRGl. DiChiro et al. (*2*) reported a "correlation between the rate of glycolysis and malignancy in primary cerebral tumors"; this statement was made on the basis of 28 studies in 23 patients. Of these, 14 were preoperative PET scans, and in only seven of these cases was a histologic diagnosis of tumor grade available. In these seven cases with biopsy specimens, high-grade tumor metabolism ranged from 16 to 57 μmol/100 g/min, and low-grade tumor metabolism ranged from 15 to 35 μmol/100 g/min; indicating a considerable degree of overlap between the two groups. In their letter, Drs. DiChiro and Brooks state that "in all three (high-grade) cases . . . a visually distinct "hot" area was identified within the tumor . .". Since one of these patients was reported as having a peak LCMRG1 of 16 μmol/100 g/min, this demonstrates the discrepancy that may arise from relying on "visual" interpretation of scans as compared to quantitative analysis.

Further individual points mentioned by Drs. DiChiro and Brooks which might lead to differences in the interpretation of results between our centers may be addressed.

1. *Tissue of comparison.* We indeed used normal gray matter LCMRG1 values as a reference to distinguish between high and low tumor metabolism. The actual LCMRG1 values were given however, and even if white matter were used as a reference, over 70% of high grade tumors had metabolic rates equal to or below normal control white matter values in this laboratory (25 ± 4 μmol/100 g/min). Thus comparison with white matter would not alter our main finding that glucose metabolism in our untreated high-grade gliomas was variable, but low overall. In our opinion, it is not appropriate to compare tumor metabolic rate of glucose with that of white matter because the calculated rate constants for those tumors reported in our paper were significantly different from those for white matter (*3,4*). All of our values were calculated by using regionally measured rate constants.

2. *Localization of region.* We reported not only the average LCMRG1 values of the tumor regions, but also the range of values, due to the known heterogeneity of tumor areas, while DiChiro et al. (*5*) selected "the hottest region within the tumor area". We felt that since the heterogeneity of the tumor occurred both at the macroscopic and microscopic levels, below our scanner resolution, an average of LCMRG1 values would give more information on the overall metabolic state of the tumor. In addition, given the greater noise associated with the selection of smaller regions of interest (ROIs) when analyzing positron emission tomography (PET) data, the strategy of "peak-picking" seeks to trade increased noise for homogeneity of underlying structure. Bearing in mind that, because of image resolution limitations, any small ROI value will represent the weighted average of a substantial volume of surrounding tissue and will, of course, be much lower than the true metabolic rate at that point, there is no overwhelming reason to adopt that strategy over that of using larger ROIs. Furthermore, since tumor structure may be quite convoluted within the field-of-view of the imaging plane, the peak-picking approach is more vulnerable to artifactual local increases in apparent metabolic rate caused by differential partial volume effects through the body of the tumor. This issue demonstrates the difficulties in the use of PET to evaluate heterogeneous tissues; several different analysis techniques may be employed, depending on the physiologic information desired from the study.

3. *Scanning technique.* Again, increased scanner resolution would be expected to provide increased accuracy in quantitation. In our cases, we obtained three simultaneous slices at each of two scan positions, covering an axial distance of 54 to 72 mm. Nontumor areas were included in at least one slice above and below the tumor mass. Thus, given the number of slices available simultaneously and the resolution of our scanner, we feel that the tumors were surveyed in sufficient detail to detect hypermetabolic areas. The ability of our scanner (resolution = 12 mm transverse and axial) to detect such areas was obviously greater than that of the ECAT II (resolution = 17 mm transverse, 19.5 mm axial). Also, since the rims of some cystic tumors demonstrated high LCMRG1 values while others showed low values, we do not believe that partial volume mixing was a predominant factor in artificially lowering the results.

4. *"Numerical" diagnosis.* While the visual appearance of the scans may serve as a guide in the placement of ROI, we believe that it is preferable to utilize anatomic information from CT or MRI in the analysis of functional PET images.

We did not attempt to apply arbitrary "numerical diagnoses" to our tumor cases, since all had histologic confirmation of tumor grade. We have elected to quantitate physiologic parameters as accurately as possible, rather than relying on visual interpretation.

We agree with Drs. DiChiro and Brooks that our two cases of Grade II tumors are too few for us to derive conclusions about Grade II tumors as a group. We included them in our report because, before biopsy, their clinical presentation and CT findings suggested the presence of a high grade glioma. The histology of these two cases has been reviewed, and they remain classified as Grade II; however, metabolically, they may represent a point on the spectrum of malignancy that is closer to a higher grade. It was interesting to note that the rates of oxygen metabolism seem to differ markedly between the high grade and low grade tumors, but again this is difficult to interpret when based on only two cases. This finding may, however, highlight the need to measure multiple metabolic parameters in tumors, not LCMRG1 alone.

In conclusion, we agree with Drs. DiChiro and Brooks (*5*) that PET provides an exciting opportunity to evaluate the hemodynamic and metabolic characteristics of tumors. Such data, combined with histologic studies and anatomic information from magnetic resonance imaging, will no doubt greatly increase our clinical understanding of intracerebral malignancies. Certainly this is the reason that we are heavily committed to the metabolic study of tumors. Cerebral gliomas are *very* heterogeneous pathologically and, as PET studies now indicate, metabolically. Continuing research in this field is much needed, with higher resolution instrumentation in PET and with standardized PET data analysis techniques, including direct matching with MR imaging and correlation with MR spectroscopy (*6*).

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Xenon-133 Splenoportography in Budd-Chiari Syndrome

TO THE EDITOR: The paper by M. Picard et al. (*1*) on the Budd-Chiari syndrome was of great interest to us. We agree with the authors that the diagnosis of hepatic venous occlusion still remains difficult because of the nonspecificity of the symptomatology. We wish to present a case of this syndrome in which xenon-133 (^{133}Xe) splenoportography was used to supplement information obtained from [^{99m}Tc]colloid liver scan, by demonstrating obstruction to hepatic blood flow.

The patient, a 16-yr-old girl, presented with nonspecific symptoms: hepatomegaly, ascites, and abdominal pain. A liver scan with ^{99m}Tc-colloid demonstrated hepatomegaly and slight splenomegaly with the typical scintigraphic pattern of a hypertrophic caudate (left) lobe and decreased uptake in the right lobe (Fig. 1A). After puncture of the spleen with a thin needle, we injected ^{133}Xe directly into the parenchyma and recorded the distribution of ^{133}Xe in the upper abdominal region by means of an Anger camera and an on-line computer system following the method of Kashiwagi et al. (*3*). The splenic and portal veins were clearly seen on initial image (Fig. 1B). On later dynamic imaging, cephalad collaterals were clearly visible, as well as small caudad collaterals (Fig. 1C). Wash-out curves to estimate the hepatic blood flow demonstrated a very sharp decline in the left liver lobe activity caused by the massive collaterals and a nearly horizontal wash-out curve over the right lobe. The patient died 2 mo following establishment of the diagnosis although we tried to improve the hemodynamics of the liver by surgical shunt operation. In the postmortem findings the diagnosis of occlusion of the main liver veins (Budd-Chiari syndrome) could be verified. The delayed ^{133}Xe wash-out from the right lobe could only be explained by occlusion of the liver veins, since the histologic findings revealed no fat in the liver cells, and the cirrhotic transformation was not so significant as to account for this considerable delay of ^{133}Xe wash-out.

The ^{133}Xe procedure described above appears to be a suitable method for confirming a diagnosis of Budd-Chiari syndrome provided there is a sizable posthepatic block which prevents outflow of ^{133}Xe.

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