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Positron Emission Tomography in Imaging Spinal Cord Tumors

Jo M. Wilmshurst, MRCP; Sally F. Barrington, MRCP; Dylan Pritchard, BSc (Hons); Tim Cox, FRCR; Peter Bullock, FRCS; Michael Maisey, MD; Richard O. Robinson, FRCPC

ABSTRACT

The ability of positron emission tomography (PET) to detect spinal cord tumors was studied prospectively in 14 patients presenting over a 5-year period. Abnormal uptake by [¹⁸F]-fluorodeoxyglucose (FDG) or ¹¹C-methionine was detected in all except one. These data were assessed in relation to magnetic resonance imaging (MRI) findings with regard to tumor type and extent preoperatively, findings at operation, and subsequent clinical course. The group consisted of six astrocytomas, five ependymomas, one mixed ependymoma and astrocytoma, one schwannoma, and one ganglioglioma, all confirmed histologically. This is the largest study comparing spinal PET to MRI. Accurate preoperative correlation between PET and MRI was found in all eight patients scanned at first presentation. The PET uptake was in keeping with the low-grade histology of the tumors. Postoperatively, PET and MRI findings were in agreement in nine patients. In eight of these the findings were in keeping with the subsequent clinical course. In three patients, however, the PET findings were at variance with the clinical course and MRI findings. In one, persistent FDG uptake after radiotherapy was seen where there was subsequent tumor resolution. In two patients with low-grade astrocytomas, scanned with FDG and ¹¹C-methionine, respectively, tracer was not taken up by residual tumor. In this small group of patients, PET did not provide additional useful information. This could be because all tumors studied were low grade and the limited spatial resolution of PET does not lend itself to imaging small spinal cord tumors. The prospective study of larger numbers of patients with a wider range of tumor types is required, but this might be difficult to achieve given the rarity of spinal cord tumors. (*J Child Neurol* 2000;15:465-472).

The most common intramedullary spinal tumors are astrocytomas and ependymomas.¹ Astrocytomas are more often cervicothoracic and tend to infiltrate and therefore are difficult to resect. Ependymomas are more often in the conus, can be exophytic, are more easily totally removed, and are more vascular.

Positron emission tomography (PET) has been used increasingly as an adjunct in oncology management.^{2,3} It is a whole-body imaging technique that uses positron-emitting isotopes of biologic elements, such as carbon, oxygen, nitrogen, and fluorine, for the functional assessment of metabolism. Tracers used in oncology include the glucose analog [¹⁸F]-fluorodeoxyglucose (FDG) and ¹¹C-labeled methionine. Increased uptake of these tracers can be seen in tumor cells compared with normal tissue by virtue of their increased glucose cell membrane transfer, glycolysis, and increased amino acid transport and metabolism.⁴⁻⁶ Tumor histology and behavior has been shown to correlate well with FDG uptake in brain tumors.^{7,8} Uptake of FDG in some low-grade tumors can be of similar or lower intensity to that of normal brain, which can make detection of some low-grade tumors or tumor recurrence difficult. This has led to the additional use of ¹¹C-methionine in these circumstances as it has very low uptake into normal brain and permits greater contrast between normal tissue and some low-grade gliomas than does FDG. It has not been shown to provide the same

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prognostic information as FDG and therefore many regard these tracers as complementary.

Since neither tracer is taken up in areas of fibrosis, PET has been used to distinguish between residual viable tumor and tumor necrosis post treatment,^{9,10} although uptake of FDG sometimes can occur in inflammatory cells after treatment¹¹ and low-grade ¹¹C-methionine has been demonstrated in intracerebral hematoma, presumably as a result of disruption of the blood-brain barrier.¹²

Tracer uptake within tumors can be measured with PET. Absolute quantification involves arterial sampling, and is invasive, time consuming, and not widely used in clinical studies. A semiquantitative measure, the standardized uptake value, is used; this is obtained by placing a region of interest over the maximal uptake of the tumor and correcting for the injected activity and the body weight. In general, the higher the standardized uptake value, the higher the tumor grade and the greater the likelihood of residual tumor being present after treatment.

Magnetic resonance imaging (MRI) demonstrates tumor anatomy well, but correlates poorly with tumor grade,¹³ although the lower-grade gliomas tend not to enhance with gadolinium on MRI.¹ Residual tumor is not always easily distinguished from postsurgical change or radionecrosis and thus PET could add useful information in both the initial assessment of brain tumors and in the assessment of residual disease post treatment.¹⁴

The use of PET in primary and recurrent brain tumors has been extensive. However, information on its use in spinal cord tumors is limited. Case reports have suggested that PET could have a role in addition to anatomic imaging. Four previous studies report PET findings in five patients with spinal cord tumors. Two patients imaged with FDG showed high uptake in high-grade tumors, enabling recurrent disease to be differentiated from fibrosis in one where anatomic imaging had been unhelpful.^{15,16} Another patient imaged with FDG had uptake in a ganglioneuroma, which failed to enhance on CT preoperatively.¹⁶ Two patients had uptake of ¹¹C-methionine in ependymomas studied preoperatively.^{17,18}

We present 14 patients with a range of spinal tumors in whom pre- and post-therapy PET and MRI were performed. Results were reviewed to assess what additional information was gained by the PET studies.

METHOD

All patients admitted over a 5-year period with spinal tumor were included in this study. Patients were assessed according to age at presentation; tumor type, grading, and site; imaging findings on PET and MRI; and treatment regimen.

All MRI scans were performed on a 1.5-Tesla Phillips Gyroscan ACS with 10 mT gradients. The images were acquired using a quadrature birdcage head coil. A combination of T₁- and T₂-weighted images with contrast were performed. PET was performed using a Siemens 951 ECAT scanner. Images were obtained after a 6-hour fast. Patients who were imaged with FDG were injected with

250 MBq for local views or 350 MBq for half-body images and scanned at 50 minutes post injection. Patients imaged with ¹¹C-methionine were injected with 370 MBq and scanned at 15 minutes. (The dose of tracer was scaled down according to body weight for children.) Half-body FDG images were obtained by acquiring 10 consecutive 5-minute images from the base of the brain to the pelvis. Local emission views were acquired over 15 minutes over an axial field of view of 10.8 cm with corresponding transmission images acquired using rotating Ge68 rod sources to enable attenuation correction to be performed during image reconstruction. The complete set of image planes was reconstructed to obtain a single dataset with coronal, axial, and sagittal views. The spatial resolution of the local reconstructed images was 13 mm and the half-body images was 10 mm.

Standardized uptake values were obtained by placing 8 mm circular regions of interest over sites of maximal uptake of tracer within tumor on attenuation correction images. The average activity per milliliter in the region of interest was obtained by applying a calibration factor derived from scanning a uniform 20-cm cylinder containing a known activity concentration. The uptake in these regions was then corrected for injected activity and patient weight with a partial volume correction applied where the tumor was smaller than 2 cm in diameter.¹⁹ The partial volume correction factors were obtained in a series of phantom experiments by scanning cylinders ranging in diameter from 8 to 40 mm.

PET and MR images were reviewed with specialists from both neuroradiology and nuclear medicine. The appearances of the tumors on PET and MRI were compared and the visual uptake and standardized uptake value on PET compared to the level of enhancement seen on MRI. The scan results were correlated with the surgical outcome, including histology, and the subsequent clinical course.

RESULTS

Fourteen patients admitted over a 5-year period were studied. The group consisted of nine male and five female patients. Ages ranged from 1 to 58 years (pediatric group; *n* = 10; median age, 7 years; adult group, *n* = 4; median age, 39½ years). Median follow-up was 4 years (range, 3 to 6 years), excluding the two patients who died 1 year and 2 years after diagnosis. The tumors comprised six astrocytomas, five ependymomas, one mixed astrocytoma and ependymoma, one ganglioglioma, and one schwannoma (Figure 1A and B).

Histologic grading was low grade (grade 1 or 2, World Health Organization classification) in all. One ependymoma, one astrocytoma, and one mixed ependymoma and astrocytoma were cervical; one ependymoma and one astrocytoma were cervicothoracic; two ependymomas and three astrocytomas were thoracic; one astrocytoma and one ganglioglioma were thoracolumbar; and one ependymoma and one schwannoma were lumbar. Patient data presented in Table 1 include age at diagnosis, histologic type, grading, level of tumor, and clinical outcome.

Eight PET studies were preoperative. Twelve postoperative combined MRI and PET studies were performed,

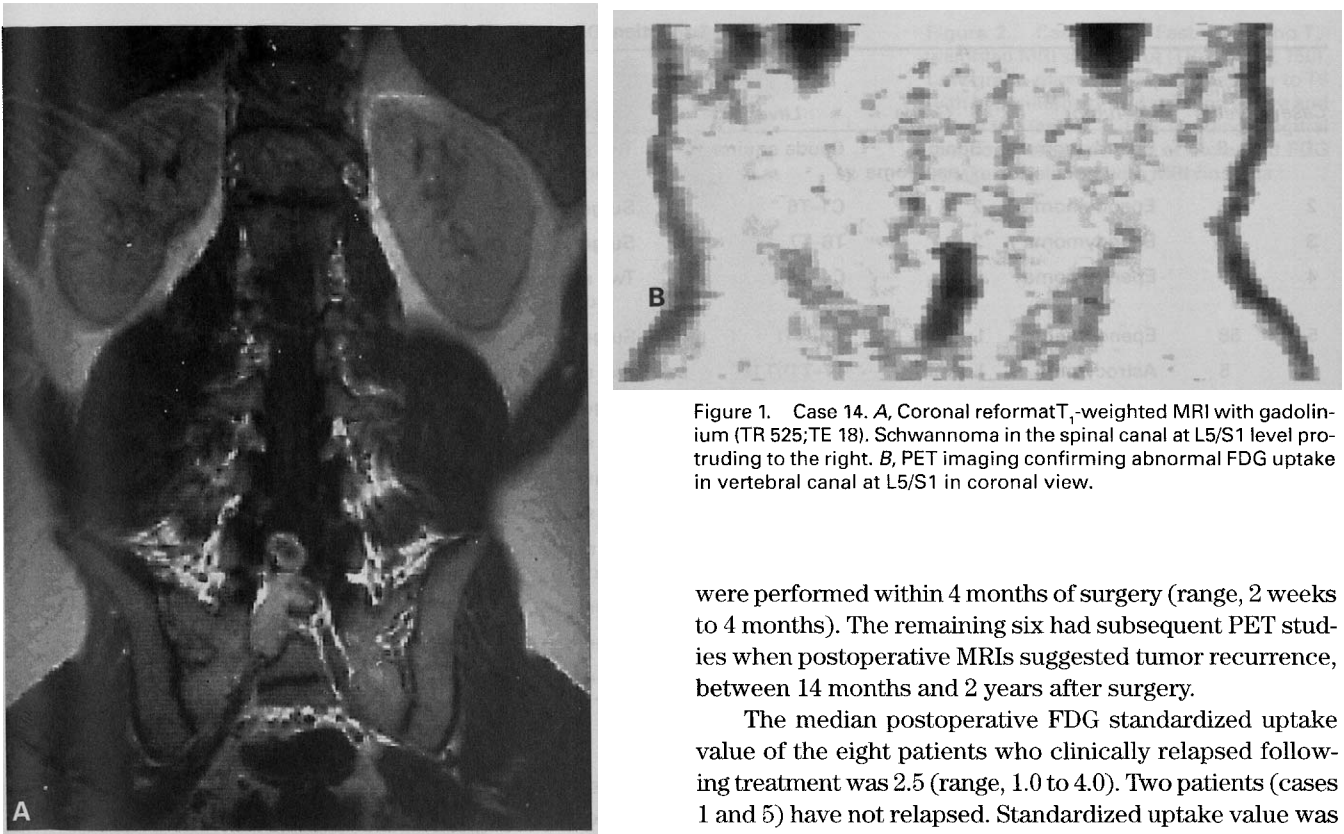


Figure 1. Case 14. A, Coronal reformat T₁-weighted MRI with gadolinium (TR 525; TE 18). Schwannoma in the spinal canal at L5/S1 level protruding to the right. B, PET imaging confirming abnormal FDG uptake in vertebral canal at L5/S1 in coronal view.

relapse having occurred in eight of these patients. Data on the patients imaged preoperatively with PET are given in Table 2. There was good correlation between MRI and PET in all eight. Median FDG standardized uptake value was 2.4 (range, 1.6 to 4.1; $n = 6$), suggesting increased metabolic activity consistent with the grade 1 to 2 histology. Two patients did not have FDG standardized uptake value assessment. One had a ¹¹C-methionine study (case 12) and the other did not have attenuation-corrected images (case 5). The low-grade glioma (case 13; Figure 2A and B) had, surprisingly, a standardized uptake value of 4.1, with MRI demonstrating marked hyperintensity in the same anatomic distribution. However, despite these appearances the child has followed a benign course with gradual resolution of the tumor following surgery. The abnormalities seen on PET were sometimes less extensive than the abnormalities seen on MRI, with the PET likely to demonstrate the most metabolically active part of the tumor. This was suggested in cases 7 and 13, where the abnormality seen on PET corresponded to the site of tumor enhancement seen on MRI. Preoperative standardized uptake values of the two cases who subsequently relapsed were 2.6 and 3.2. Median preoperative standardized uptake value of nonrelapse patients was 2.2 (range, 1.6 to 4.1; $n = 4$). Overall, no additional information was gained from the preoperative studies.

Table 3 describes the postoperative MRI and PET studies. In all cases MRI and PET were performed within a few weeks of each other, except in case 12, in whom there was a 5-month interval. Six of the 12 postoperative PET studies

were performed within 4 months of surgery (range, 2 weeks to 4 months). The remaining six had subsequent PET studies when postoperative MRIs suggested tumor recurrence, between 14 months and 2 years after surgery.

The median postoperative FDG standardized uptake value of the eight patients who clinically relapsed following treatment was 2.5 (range, 1.0 to 4.0). Two patients (cases 1 and 5) have not relapsed. Standardized uptake value was available in case 1 and is discussed below. Case 5 did not have a standardized uptake value calculated as an attenuation-corrected scan was not performed. However, a definite reduction in FDG uptake was evident visually following surgery.

In five cases (cases 2, 4, 5, 11, and 12) the PET and MRI findings correlated well in relation to the size of the tumor, MRI enhancement with maximal metabolic activity seen on PET, and the subsequent clinical course, including surgical findings. In these cases, while PET was helpful in confirming the likely disease status, it did not alter management in individual patients. In three cases (cases 1, 6, and 8) the PET findings were at variance with those of the MRI. The MRI findings were more in keeping with the subsequent clinical course than were the PET findings.

The MRI in case 1, an 8-year-old boy with a benign papillary ependymoma, demonstrated tumor at S1; the FDG PET detected increased uptake also at S1. The ¹¹C-methionine scan failed to detect any abnormal tumor uptake. At reoperation tumor removed from the S1 region showed unchanged histology. Four months after surgery, and 2 months after radiotherapy, FDG PET confirmed increased uptake at S1. The standardized uptake value at this site of 5.2 suggested significant metabolic activity, at variance with tumor grade, 2 months after radiotherapy. The PET was not repeated. Follow-up MRIs have shown gradual resolution in the tumor. The child remains well 3 years later.

Case 6, a 5-year-old boy with a low-grade astrocytoma from T7–T11/T12, demonstrated a relatively low standardized uptake value of 1.0 on FDG PET 2 weeks after surgery. MRI 4 weeks following surgery prompted further debulking

Table 1. Patient Data

Case	Age at Diagnosis, years	Tumor	Grade	Level	Management	Outcome
1	8	Ependymoma	Benign papilloma	Cauda equina	Two surgical procedures, radiotherapy	Relapsed once, now in remission
2	11	Ependymoma	2	C1–T6	Surgery, radiotherapy	Died 2 years after treatment
3	26	Ependymoma	2	T6–T7	Surgery	Relapsed once, now in remission
4	49	Ependymoma	Low	C4–C5	Two surgical procedures, radiotherapy	Relapsed once, now in remission
5	58	Ependymoma	Low	T10/T11	Surgery, radiotherapy	Remission
6	5	Astrocytoma	Low	T7–T11/T12	Two surgical procedures	Relapsed once, now in remission
7	6 ⁸ / ₁₂	Astrocytoma	Pilocytic	T10–L1	Surgery	Remission
8	7 ⁴ / ₁₂	Astrocytoma	2	T9–T12	Two surgical procedures	Relapsed once, now in remission
9	11	Astrocytoma	2	Medulla–C7	Surgery, radiotherapy	Died 1 year after treatment
10	8	Astrocytoma	1	T6–T8	Two surgical procedures	Relapsed once, now in remission
11	3 ⁹ / ₁₂	Astrocytoma, ependymoma	2	Medulla, cervical	Two surgical procedures, radiotherapy	In relapse—outlook poor
12	1	Ganglioglioma	1	T5–L3	Surgery	Outlook poor
13	5	Astrocytoma	1	C3–T5	Surgery	Remission
14	30	Schwannoma	Benign	L5–R	Surgery	Remission

with confirmation that active tumor was still present. In this case the PET was not able to determine the presence of residual tumor, possibly because the tumor was not metabolically very active.

Case 8, a 7-year-old boy with a grade 2 astrocytoma at T9–T12, demonstrated good anatomic correlation initially with FDG PET 1 year after surgery. At relapse 1 year later

the subsequent PET study using ¹¹C-methionine failed to detect any evidence of tumor. No FDG scan was performed. At reoperation the histology was unchanged. Case 8 also demonstrated marked disparity between standardized uptake value and enhancement on MRI. FDG PET demonstrated two areas of increased uptake corresponding with enhancement with gadolinium on MRI. However, the prox-

Table 2. Preoperative Features

Case	Level	MRI Findings	PET Findings	PET Tracer	SUV	Correlation
9	Medullocervical	Tumor from foramen magnum to T1/T2	Moderate FDG uptake from medulla to C7	FDG	3.2	Good
11	Medullocervical	Expanded cord lesion in cervicomedullary region with mixed components and two enhancing areas	Low-grade FDG uptake in cervical cord and medulla	FDG	1.8–2.6	Good
13	C3–T5	Lesion medulla to T6 with enhancing component and swelling above and below	Area of increased FDG uptake correlating with enhancing MRI region	FDG	4.1	Good
3	T6–T7	T6/T7 expanded lesion on T ₂ -weighted images	Abnormal FDG uptake at T6	FDG	2.2	Good
5	T10/T11	Intrinsic tumor T10–T12 with extensive syrinx	Increased FDG uptake mid to lower thoracic spine	FDG	—	Good
7	T10–L1	Marked expansion of conus with multiloculated cystic region with enhancing solid compartment	Focus of increased FDG uptake at approximately T12, including but not extending beyond area of MRI enhancement	FDG	2.2	Good
12	T5–L3	Large intrinsic lesion T5–L3 with syrinx above	Low-grade uptake of ¹¹ C-methionine at T7–L1	¹¹ C-methionine	1.7	Good
14	L5/R	Multilobulated intradermal tumor with large extradural component to right L5/S1 level	Abnormal FDG uptake in vertebral canal at L5/S1	FDG	1.6	Good

MRI = magnetic resonance imaging; PET = positron emission tomography; SUV = standardized uptake value on PET imaging at maximum uptake point; FDG = [¹⁸F]-fluorodeoxyglucose.

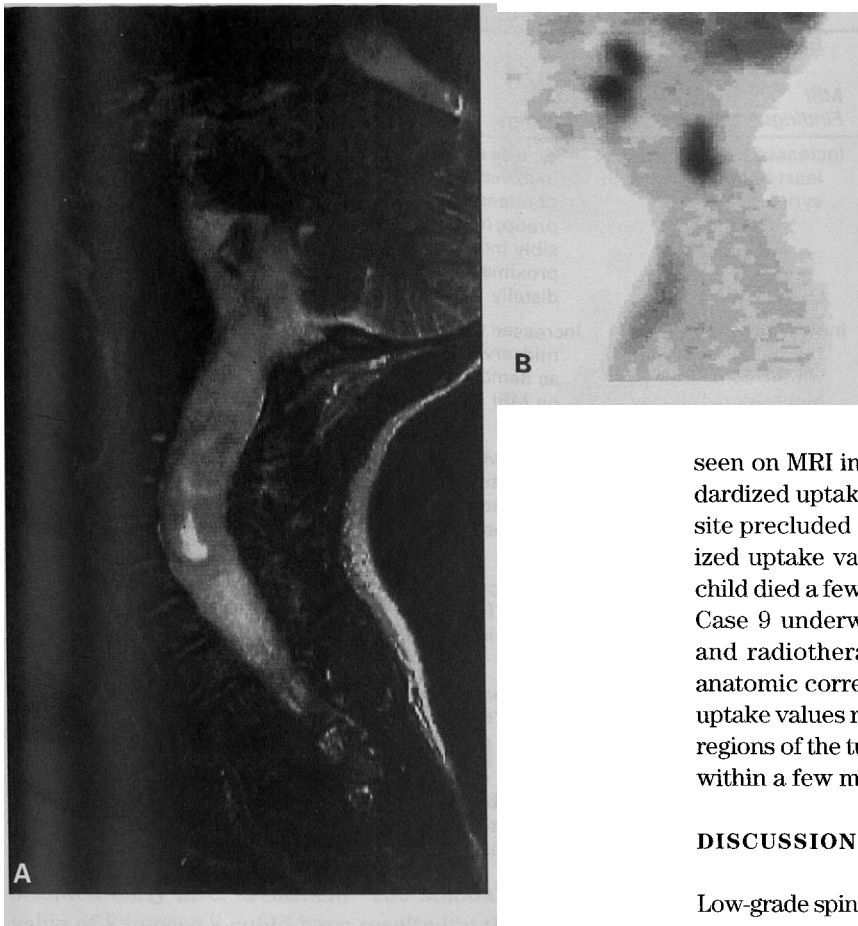


Figure 2. Case 13. *A*, Fast spin echo T₂-weighted MRI sagittal cut (TR 2200; TE 150). Low-grade glioma from the medulla to T6 with hyperintensity and swelling above and below the lesion. *B*, PET imaging (sagittal cut) confirming an area of increased FDG uptake correlating with MRI findings.

imal lesion seen on FDG PET had a standardized uptake value of 8, while the distal lesion's value was 2, whereas the lesions seen on MRI enhanced more distally than proximally. MRI 1 year later at clinical relapse suggested that the distal lesion had enhanced further and the child proceeded to a second debulking procedure. Tumor had identical histology at both sites.

In these three studies the PET findings were not borne out by subsequent clinical progress and while the results did not alter the children's management, the PET results could have been misleading if acted upon in isolation.

In one case (case 10) neither PET nor MRI correlated well with the clinical course. PET and MRI both indicated residual disease in an 8-year-old girl with a grade 1 astrocytoma, which was confirmed at operation. Subsequent scanning 1 month later again suggested residual disease, with PET additionally indicating a new abnormal focus. The child was then conservatively treated and followed a benign clinical course, with no evidence of disease relapse at 6 months follow-up.

In one study the PET contributed usefully (case 5), confirming a reduction in FDG visually following surgery and radiotherapy, in keeping with the clinical progress.

Two patients died (case 2 and 9). They presented with tumors that were extensive and bulky, located in the medullocervical and cervicothoracic areas. The preoperative site

seen on MRI in case 2 was confirmed by PET with a standardized uptake value of 3.2 (Figure 3A and B). The tumor site precluded complete resection. The elevated standardized uptake value implied future tumor progression. The child died a few months following surgery and radiotherapy. Case 9 underwent FDG PET and MRI following surgery and radiotherapy to an ependymoma. There was good anatomic correlation between MRI and PET. Standardized uptake values ranged between 2.6 and 4.1 in the most active regions of the tumor. The tumor progressed and the boy died within a few months.

DISCUSSION

Low-grade spinal cord tumors were reliably identified by PET preoperatively in our study at sites correlating with MRI. The low metabolic activity within the tumors studied by PET agreed with the tumor histology of grade 1 to 2. Cases where the abnormalities seen on PET were less extensive than the MRI findings might be explained by assuming that only the areas of highest functional activity were detected by PET. This is suggested by the two cases in which PET uptake corresponded to the sites of MRI enhancement, and more specifically in case 7, where there was absent FDG uptake within multiloculated cystic areas above the solid area of tumor, which accumulated FDG. This would appear to be borne out by other case reports in the literature in which abnormalities seen on PET corresponded to sites of active tumor. In three patients with ependymomas imaged previously, two were scanned with methionine before surgery at presentation and methionine differentiated solid regions of tumor from cystic components.^{17,18} PET was thought to be a useful adjunct to direct biopsy and surgery. In another patient increased uptake of FDG was reported in a ganglioneuroma preoperatively, which did not enhance on CT.¹⁶

The abnormalities seen on PET thus helped to pinpoint metabolically active tumor in the above case reports, but in the patients we studied, PET merely confirmed MRI findings and did not provide sufficient additional information to affect patient management preoperatively. Further study is needed to determine whether the sites of increased tracer uptake we observed on PET correspond to more metabol-

Table 3. Postoperative Features

Case	Site	Time Between Surgery and Scan*	Time Between Radiotherapy and Scan*	MRI Findings	PET Findings	PET Tracer	SUV	Correlation
11 [†]	Medullocervical	5 months	2 weeks	Increased enhancement at least to level of C7 with syrinx below	FDG: less extensive involvement; level of intensity as for preop; meth: possibly more uptake proximally than distally	¹¹ C-methionine FDG;	2.5	Good
4 [†]	C4–C5	4 years	—	Increased tumor mass; more disease signal within; some of the higher-signal spaces possibly cystic	Increased uptake in the midcervical region, as demonstrated on MRI	FDG	3.3	Good
2 [†]	C1–T6	4 months	1 month	Significant tumor left; more enhancement above and below suggesting tumor progression	Low-grade uptake brain stem to conus; some postsurgical changes	FDG	2.6–4.0	Good
10 [†]	T6–T8	1 month	—	Abnormal signal T2–T9	Two foci of increased uptake T6 and T8; uptake in between less	FDG	2.3	Good
10	T6–T8	1 month	—	Cord lesion C7–T10; enhancement T6–T8, especially posteriorly	Two abnormal uptake areas; T6–T8 and T12–L2 posteriorly	FDG	T7–T9 2.1 T12–L2 3.8	Good
5	T10/T11	2 years	1 year	Fusiform swelling T10–T12; enhancement T10/T11	Increased uptake as before but fainter; suggestive of reduced tumor activity	FDG	—	Good
6 [†]	T7–T11/T12	PET: 2 weeks MRI: 4 weeks	—	Tumor enhancing in lower dorsal region	Uptake as in MRI, T7–L1	FDG	1.0	Good
8	T9–T12	1 year	—	Expansion T9–T12; two areas enhance at T11 and T12 (brightest)	Increased uptake in two regions T11 (brightest) and T12	FDG	T11–8 T12–2	Good
8 [†]	T9–T12	2 years	—	Residual tumor unchanged; enhancing areas within; distal area more conspicuous	Meth: normal	¹¹ C-methionine	—	Poor
12 [†]	T5–L3	MRI: 2½ years PET: 2 years	—	Still extensive tumor bulk extending distally T10–L2	FDG: T10 enhanced, imaging did not extend distal to this	FDG	2.6	Good
1 [†]	Cauda equina	14 months	—	Enhancing lesion lower border of S2 on gadolinium scan	Meth: normal; FDG: Hot spot S1	¹¹ C-methionine FDG	2.0 2.4	Poor
1	Cauda equina	4 months	2 months	Little more tissue at S2	Uptake right of midline of S1	FDG	5.2	Mod

*PET and MRI performed at the same time except where noted.

[†]Patient relapsed.

MRI = magnetic resonance imaging; PET = positron emission tomography; SUV = standardized uptake value on PET imaging at maximum uptake point; FDG = [¹⁸F]-fluorodeoxyglucose; meth = ¹¹C-methionine.

ically active areas of tumor and could be used to direct biopsy.

In the patients studied postoperatively for surveillance purposes or where disease recurrence was suspected, several (cases 1, 6, and 8) demonstrated significant discrepancy between standardized uptake value, histology, and subse-

quent outcome. The subsequent clinical course of these patients was more accurately predicted by MRI. No further tumor progression occurred in case 1 despite the raised standardized uptake value of 5.2. The high standardized uptake value might have been due in part to postradiation changes—a recognized problem with PET when various tumors are

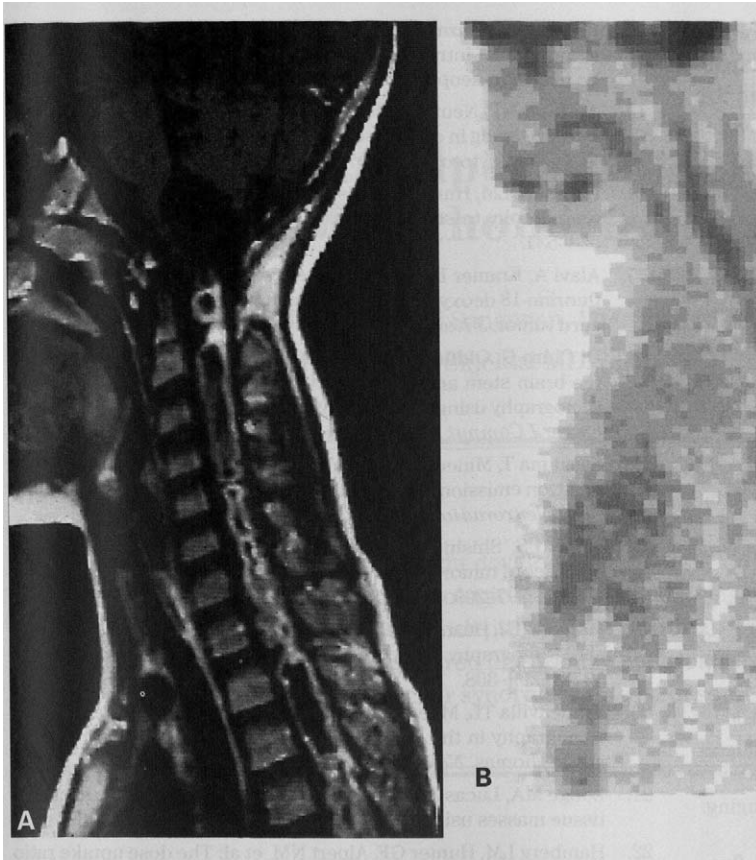


Figure 3. Case 2. A, Sagittal cut of T₁-weighted MRI with gadolinium (TR 450; TE 25). Postoperative appearances of a grade 2 ependymoma with significant tumor remaining extending from C1 to T6. B, PET imaging (sagittal cut) confirming increased FDG uptake from the brain stem to the conus with some additional postsurgical changes.

scanned early after treatment. The standardized uptake value of 8 in case 8 could have resulted in the wrong area being biopsied. The unusually low standardized uptake value of case 6 could have given false reassurance when in fact active tumor was still present. Had the patient undergone preoperative PET, tumor might have confirmed the same uptake as the rest of the spinal cord, leading to the conclusion that postoperative PET might be uninformative. The need for serial images to monitor the individual behavior of low-grade cerebral gliomas has been noted previously, to allow for potential variability in individual tumor uptake resulting from location, vascularity, and blood supply.²⁰ This principle also could be applied to spinal cord tumors.

The standardized uptake value measurement is highly dependent on the timing between injection of the tracer and imaging. Tracer uptake reaches a maximum following which it plateaus. Imaging must be performed during this plateau period. In our study, standardized uptake values were measured at 75 minutes after injection of FDG and 25 minutes after injection of ¹¹C-methionine. It is possible, though, that this plateau period could vary for different tumor types and if imaged prior to the plateau phase, the standardized uptake value might not be such a good discriminator between benign and malignant tissue.^{21,22} Also the metabolic activity of normal brain stem and spinal cord is lower than that of the cerebral hemispheres such that the implications of spinal cord standardized uptake values might not be strictly comparable to cerebral standardized uptake values.¹⁶ Accu-

racy in imaging cerebral tumors has been enhanced by comparison of uptake with the unaffected hemisphere^{13,23} This approach is not as useful with spinal cord tumors because the cord is small and comparison between sides is usually not practical.²⁴

FDG can accumulate in benign lesions where there is increased glucose metabolism. Increased FDG uptake can occur with infection, inflammation, seizure activity, radiation necrosis, edema, and infarction,²³ resulting in significant numbers of false-positive results being reported at low standardized uptake values.²⁵ Inflammatory effects of radiation necrosis can last up to 6 months.²⁶ The limited spatial resolution of PET associated with shrinkage of tumor mass following treatment can result in inaccuracies if not corrected for.

CONCLUSION

All our patients demonstrated raised standardized uptake values preoperatively, as would be expected in tumors, but no information in addition to that provided by MRI was obtained that altered management. Numbers are too small to allow valid comparison of preoperative standardized uptake values between patients who subsequently relapsed and those who did not. The same can be said for the postoperative comparisons as we have not felt justified in routinely carrying out PET studies in patients who do not relapse. Other studies have suggested that PET reliably assesses tumor viability but demonstrates less correlation

with tumor proliferation.^{13,16} In our study neither histology, MRI appearance, nor PET reliably predicted tumor relapse.

It is possible that useful lessons could emerge from the prospective study of larger numbers of patients with a wider range of tumor types using serial PET imaging. This will, however, be difficult to achieve given the scarcity of PET resources and the rarity of spinal cord tumors. Development of further ligands could increase the clinical value of PET in imaging spinal cord tumor. ¹¹C-methionine might be superior to FDG in delineating tumor margins and in distinguishing tumor recurrence from radiation necrosis.²⁷ A marker that correlates better with subsequent tumor behavior would be of considerable value.

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