

Use of Real-Time Magnetic Resonance Guidance to Assist Bone Biopsy in Pediatric Malignancy

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ABSTRACT. Magnetic resonance (MR) imaging (MRI) has the advantage of demonstrating lesions not visualized by other radiologic modalities. We present a case involving pediatric malignancy where MR-guided bone biopsy confirmed correct histologic diagnosis and was used to plan additional treatment. A 2-year, 9-month-old boy had a history of spontaneous regression of stage 4S neuroblastoma. ¹²³I-metaiodobenzylguanidine scintigraphy showed a hot spot at his right lower leg; however, neither plain radiograph ^{99m}Tc diphosphonate bone scan was positive. Only MRI depicted a lesion at the distal third of his right tibia, and a subsequent MR-guided bone biopsy was diagnostic of bone marrow metastasis. After 6 courses of intensive chemotherapy, he has been in complete remission. MR-guided biopsy technique is likely to be particularly useful for the resection of invisible metastatic lesions, especially those that are only visible using MRI. *Pediatrics* 2002;109(1). URL: <http://www.pediatrics.org/cgi/content/full/109/1/e18>; *magnetic resonance imaging, biopsy, neoplasm.*

ABBREVIATIONS. MR, magnetic resonance; MRI, magnetic resonance imaging; VMA, vanillylmandelic acid; HVA, homovanillic acid; MIBG, metaiodobenzylguanidine.

Magnetic resonance (MR) imaging (MRI) has the advantage of demonstrating lesions not visualized on computed tomography or other conventional imaging methods.¹ Moreover, it is extremely sensitive in detecting abnormalities of bone marrow.² When an abnormality can be seen on MRI only, or can be seen significantly better on MR images, MR-guided interventional surgery may be required for diagnosis and therapy. In this report, we present a case of pediatric malignancy where bone biopsy under real-time MR guidance was diagnostic of metastasis.

CASE REPORT

A 2-year, 9-month-old boy had a history of spontaneous regression of stage 4S neuroblastoma. He was found to have bilateral adrenal tumors and multiple liver masses on the abdominal ultrasound at his regular 1-month-old infant health checkup. Blood neuron specific enolase was high (72 ng/mL), and urinary vanillylmandelic acid (VMA) and homovanillic acid (HVA) were

elevated, 435 mg/g creatinine, 153 mg/g creatinine, respectively. Bone marrow aspiration did not show pathology. The diagnosis of stage 4S neuroblastoma was confirmed by a biopsy of skin metastasis. N-myc was not amplified, with a weak Trk-A expression. There was no 1p deletion. With all these favorable biological features except for a diploid DNA content, a wait-and-see strategy was initiated. By the age of 1 year 4 months, spontaneous regression of all the tumor was detected by graphic studies including ultrasound, computed tomography scan, MRI, and ¹²³I-MIBG (metaiodobenzylguanidine) scan. Although decreasing, urinary VMA and HVA excretions remained in higher levels, 26 mg/g creatinine and 56 mg/g creatinine, respectively. Now, at the age of 2 years and 9 months, a repeat MIBG scan showed a hot spot at his lower extremity (Fig 1). Neither plain radiographs nor ^{99m}Tc diphosphate bone scan showed any abnormalities. Only MRI showed abnormal shadow at the distal third of his right tibia (Fig 2). Using the 3-dimensional navigation system EasyGuide Neuro (Philips Medical Systems, DA BEST, The Netherlands; Fig 3), bone biopsy was performed after obtaining informed consent for the procedure. The biopsy was diagnostic of metastatic neuroblastoma and he received 6 courses of intensive chemotherapy (Regimen A₁)³ of the Study Group of Japan, which included cisplatin, cyclophosphamide, vincristine, and doxorubicin. Now he is 4 years, 8 months old and has been well without evidence of disease. The urinary VMA, HVA excretions are 13, and 45 mg/g creatinine, respectively, and serum neuron specific enolase level is 9 ng/mL.

DISCUSSION

At diagnosis, the majority of neuroblastomas have metastasized to distant sites, most commonly the bone marrow. In recent years, MIBG scintigraphy has been increasingly used to identify a neuroblastoma lesion. It is used in the diagnosis, staging, and reassessment of patients with neuroblastoma, and has been shown to be highly sensitive and specific in this condition.⁴ Meanwhile, MRI is extremely sensitive in detecting abnormalities of bone marrow. Bone marrow involvement (with or without bony involvement) is seen as areas of decreased signal intensity on T₁-weighted images because of the replacement of the fat tissue normally seen with high signal intensity by tumor cells.⁵ In our case, MIBG scan showed a suspected area of positive isotope uptake in the right lower leg, which was not visible on plain radiographs. Only MRI depicted the small lesion at the distal third of right tibia. Concerned that lack of confirmation of the exact location of the tissue sampled might cause an inconclusive biopsy, we performed MR-guided open bone biopsy using 3-dimensional navigation system, a light-emitting-diode based computer system for frameless stereotactic navigation,⁶ which consists of 3 main components: a mobile workstation, a position digitizer (camera array), and a pointing device.

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Fig 1. ^{123}I -MIBG scintigram showing abnormal isotope uptake in the right lower leg.

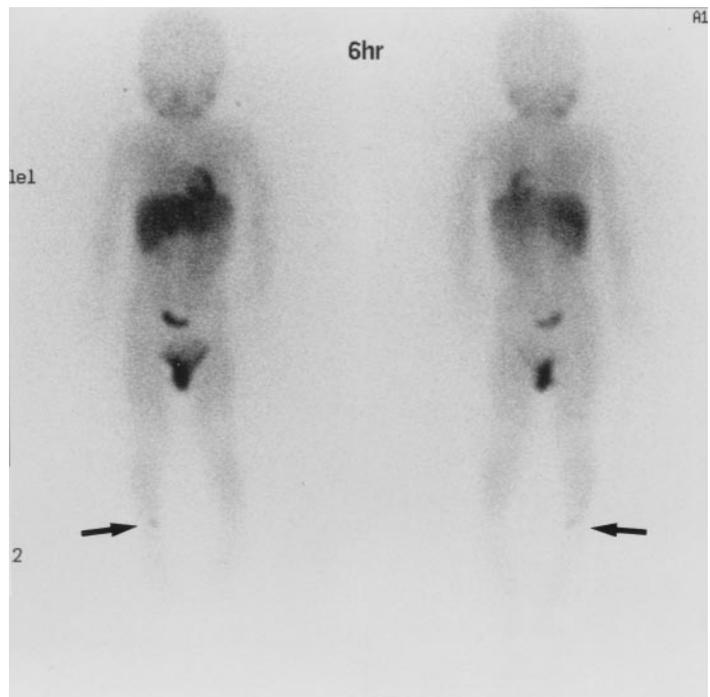


Fig 2. The T_1 -weighted coronal MRI showing an abnormal area of low marrow signal corresponding to the area of high-MIBG isotope uptake.

Preoperatively, MRI study is performed with several skin fiducials placed around the point of interest. At the operating theater, their positions were digitized and registered as anatomic reference points by touching the pointer to each of the conical markers. The computer calculates the position, direction, and rotation of the tip of the pointer in space, and this space information is registered to the preoperative images loaded into the workstation. In open biopsy,

this navigation system allows the surgeon to study preplanned regions of interest because the tip of the pointer is demonstrated on the monitor to tell where you are and the precise biopsy site can be assured by pointing it.

In case of neuroblastoma, it has been reported that in the presence of complete normalization of the MIBG scan after chemotherapy, the persistence of a hypointense signal on bone marrow on T_1 -weighted



Fig 3. Operating room setup. Three components of the imaging system are camera array, pointing device, and a computer workstation with image screen.

image does not necessarily indicate persistence of disease, but may be attributable to delayed normalization.⁷

Our case seems to indicate that MRI is extraordinarily sensitive modality for the detection of bone marrow abnormalities and that MR-guided biopsy should have virtually 100% specificity to avoid the potentially disastrous misdiagnosis of a malignant tumor as being a benign lesion. Moreover, without using radiation this technique would be advantageous when treating children or pregnant women. In this case, excisional biopsy was diagnostic; however, needle or core biopsy under MR guidance should be equally specific and less invasive.

CONCLUSION

MRI provides excellent tissue discrimination, and its capability for tissue targeting and localization will be extremely useful for the guidance of biopsy in pediatric malignancy.

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DOI: 10.1542/peds.109.1.e18

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