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Whole Body Pediatric Neuroblastoma Imaging: 123I-mIBG and Beyond

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Abstract

Pediatric cancer imaging stands to benefit from higher tumor detection sensitivity without ionizing radiation exposure. A prospective protocol compared diagnostic 123I-mIBG with whole-body diffusion-weighted MRI (DWI) to validate adjunctive methods of identifying small volume oligometastatic neuroblastoma tumor deposits. Dual modality imaging (123I-mIBG & DWI) was obtained within a 3 and 25 day window at baseline and again at one year in the first enrolled patient. MRI was able to define the full extent of metastatic disease foci with improved resolution. These findings may provide critical information for definitive loco-regional surgery and radiotherapy for high-risk neuroblastoma treatment.

Keywords

pediatric; diffusion-weighted MRI; 123I-meta-iodobenzylguanidine; neuroblastoma

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1A & B.

A three year-old female presented in mid-2011 with International Neuroblastoma Staging System Stage 4 neuroblastoma with *MYCN* amplification and right adrenal primary disease. She was enrolled on a prospective Phase II study assessing pattern of failure and functional imaging comparison of ^{123}I -mIBG against DWI-MRI for surveillance of oligometastatic disease progression [1]. She received induction chemotherapy (cyclophosphamide, doxorubicin, etoposide; alternating with cisplatin, etoposide) followed by surgical resection (gross total) and autologous stem cell rescue. She then received focal radiotherapy to the tumor bed, draining lymphatics and dorsal sympathetic ganglia on the ipsilateral side [2, 3]. Anterior (**A**) and posterior (**B**) whole body planar images obtained 24 hours after injection of ^{123}I -mIBG at the completion of definitive therapy. The distribution of tracer is normal.

1C & D: Coronal Short Inversion Time Recovery (STIR) sequence (**C**) of the abdomen and pelvis demonstrates no iliac adenopathy. Note the decreased STIR signal in the liver indicating iron overload. (**D**) Coronal reconstruction generated from axial diffusion

weighted imaging (DWI) (400 b value) reveals no area of restricted diffusion in the left iliac chain.

2A & B.

Within three months of completing maintenance immunotherapy she developed the first evidence of distant progressive disease, noted in the retroperitoneum, lower pelvis, and left femur. Serial prospective multi-modality imaging with DWI-MRI to assess oligometastatic disease demonstrated excellent tumor detection with very sharply definable anatomic borders. (A) Eleven months later, coronal (left), sagittal (middle), and transverse SPECT images of the pelvis and proximal lower extremities. Abnormal uptake is present on the left side of the pelvis (black arrows), corresponding with the pelvic mass on MRI, and the left distal femur (black arrowheads). (B) SPECT CT fusion images showing CT bone window indicating pelvic (white arrows) and femoral disease (white arrowhead) with the same orientation as (A).

2C & D: Eleven months later, coronal STIR sequence (C) of the abdomen and a portion of the pelvis demonstrates interval development of extensive left iliac lymphadenopathy. These pathologic lymph nodes are increased in signal on the STIR sequences (white arrows). Note

again the decreased signal of the liver, indicating iron overload. **(D)** Coronal reconstruction generated from axial DWI images (400 b value) demonstrates restricted diffusion of pathologic lymph nodes (white arrows). Note also the restricted diffusion associated with a large metastatic deposit in the distal left femur (white arrowhead). Atelectasis is noted in the dependent portions of the lungs. Research suggests that DWI-MRI may be both a sensitive and specific method for detection of small tumor volumes, and may accurately distinguish between neuroblastoma, ganglioneuroblastoma, and ganglioneuroma [4, 5]. Furthermore, DWI does not require contrast agent, nor ionizing radiation dose to acquire information, which may be helpful in very young children, particularly when treated with nephrotoxic regimens [6, 7]. We suggest that DWI-MRI may be a valuable adjunctive tool in the recently validated imaging-based Curie or International Society of Paediatric Oncology Europe Neuroblastoma (SIOPEN) staging systems for high-risk neuroblastoma [8, 9].