ALASKAN MR CENTER EMPLOYS
MR SPECTROSCOPY IN ROUTINE CLINICAL PRACTICE

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Decades of R&D have been put into realizing the potential of proton MR spectroscopy as a noninvasive tool for determining the presence – or absence – of cancer. Thousands of patients around the world have been assessed effectively. Yet, despite its proven value, proton spectroscopy is rarely applied in routine clinical practice. A case performed at the Wasilla office of Alaska Open Imaging Centers on a Hitachi Echelon 1.5T scanner demonstrates the value of this tool for speedy evaluation and efficient patient management.

Introduction

Magnetic resonance spectroscopy dates back 30 years. Its most common form, called proton MR spectroscopy (1H-MRS), is so named because it relies on single-proton hydrogen atoms to determine the in vivo concentration of metabolites.

Lack of anatomical motion, and minimal fat content make the brain especially well suited to this modality. Peer reviewed research has documented its potential for the differential diagnosis and management of patients with brain cancer. (1) Biochemical signatures of cancer are commonly found in the spectral peaks of choline, creatine and N-acetyl aspartate, and their ratios to each other. Abnormal ratios, for example of choline versus creatine, are often obvious, when compared to the ratios of these metabolites in nearby healthy tissue. The detection of metabolites, such as lactate (2), may have prognostic value, as well.

Making these measurements is much easier today thanks in large part to recent advances in MR technology. When 1H-MRS was first developed decades ago, acquisitions were tedious and data took hours to process and match to images. Improved electronics, pulse sequences, processing algorithms and computing hardware have solved many of the early problems.

Modern MR scanners can be easily configured with the advanced electronics, protocols, advanced processing, and computing platforms to support spectroscopy. One such scanner, the Hitachi Echelon 1.5T, can be equipped to perform high performance MR spectroscopy. The high-order active shim, needed for MR spectroscopy, is available as standard equipment. Automated acquisition and processing have increased ease of use and improved workflow.

In some instances, we have used 1H-MRS to help choose the best place within lesions to obtain a biopsy sample. In others, we have used spectroscopy in place of surgery to confirm cancer, particularly when patients due to poor operative status were not candidates for biopsy. In such cases, MR spectroscopy offers advantages in speed and efficiency, as well as an obvious advantage in its noninvasiveness.

1H-MRS can immediately provide information about whether a lesion is cancerous. (3) We have found that such use of spectroscopy can collapse the time for differential diagnosis, thereby allowing prompt and appropriate care of the patient. The conventional alternative is to follow patients suspected of brain cancer, performing periodic MRI scans to determine whether the lesions are growing and, if so, how quickly. Rapid growth indicates malignancy. Waiting for progression to indicate cancer, however, is antithetical to the efficient management of cancer patients, as “progression” is one word oncologists don’t like to hear.
Our Wasilla office of the Alaska Open Imaging Centers performs MR spectroscopy as part of our mission to provide Alaskans a wide range of diagnostic possibilities. We serve our state from several other locations in Anchorage, Soldotna and Fairbanks, providing ultrasound, nuclear medicine, x-ray, CT and MR. Although these are small outpatient facilities, we have been progressive in our outlook on providing patient care.

We were the first in the state to offer PET in 2003. We were also the first in Alaska to provide 1H-MRS, installing a spectroscopy-capable scanner at our Fairbanks facility in January 2006. We added the single-voxel 1H-MRS equipped Echelon 1.5T short bore at our Wasilla office in November 2009.

The spectroscopy process requires the presence of the radiologist at the console to guide the technologist in sampling suspicious lesions and healthy contra lateral tissue. Contra lateral samples provide baseline data for comparison. Data acquisition on the Hitachi system is quick, as the spectroscopy sequences typically are complete within six minutes each for the lesion and the corresponding contra lateral tissue.

Interpretation is often straightforward. Malignancy indicators often reach optimal thresholds of 2 to 1 for ratios of choline versus creatine or choline versus NAA, although occasionally these numbers enter a gray zone of lesser certainty. The key considerations, however, are the peaks and ratios taken as a whole and in comparison with contra lateral normals. Critical indicators of cancer are elevated choline/creatine peak and a diminished NAA. In one particularly exemplary case, staff at Alaska Open Imaging Centers used 1H-MRS on the Hitachi Echelon 1.5T to diagnose lesions in the brain of a glioma patient that appeared on MRI after biopsy of the primary tumor. The lesions clearly did not represent a common spread of cancer or recurrence of the primary tumor. Instead, they appeared on the track followed by the biopsy needle from the Burr hole to the glioma, raising the question of whether they were due to infection from the outside in or the seeding of cancer cells from the inside out.

1H-MRS was performed after neither MRI or PET could determine the involvement of either cancer or infection. The only other alternative was to perform needle biopsy on the patient who, due to the previous intervention, was not a good surgical candidate. Assessment of the relative levels of metabolites, particularly choline and creatine, proved conclusive in drawing the differential diagnosis and quickly beginning appropriate therapy.

Case study

At the end of November 2009, a 20-year-old Native Alaskan male presented with diplopia and right-sided ptosis, while complaining of mild numbness in the left hand. A brain MRI on December 10, 2009, demonstrated a right mid-brain lesion. Glioma was the most likely consideration. A CT scan of the chest, abdomen, and pelvis December 11, 2009, showed no abnormalities.

On December 30, a repeat MRI of the brain showed a slight interval enlargement of the mid-brain mass. This lesion, measuring 2.3 cm x 2.4 cm x 2.4 cm and localized in the right pontine-cerebral peduncle, showed some central enhancement. T-2 weighted images demonstrated an area of edema measuring as much as 3 cm cranial-caudal. The aqueduct of Sylvius showed some displacement towards the left. There was expansion of the pons, but no hydrocephalus.

Stereotactic brain biopsy and an MRI were performed on January 6, 2010 at Swedish Hospital in Seattle. Frozen section pathology showed high-grade glioma. Images obtained with a CT simulator were fused with T-2 images from the Swedish Hospital MRI to create a radiation therapy plan. Six weeks of radiation treatments began January 12. A brain MRI was performed two weeks after radiation therapy was completed. A 12-month regimen of chemotherapy was then begun. MRIs were performed periodically every two to three months thereafter.

Five months after completing radiation treatment, the patient reported occasional numbness and tingling in the left hand, persistent headaches, and nausea with vomiting. A brain MRI performed August 23, 2010, revealed three new lesions. One was in the right parietal. The two others, combined and forming a dumbbell-shaped process on coronal imaging, appeared in the posterior medial aspect of the right basal ganglia.

Alignment of the three lesions suggested seeding along the biopsy track. Etiology was either infection from the outside, or cancer cells from the biopsied glioma.
A follow-up MRI performed October 4, 2010 (Fig. 1), showed significant increase in the size of the right parietal and two basal ganglia lesions. Over the six-week period between the two most recent MRIs, the diameter of the three lesions approximately doubled in diameter and its volume increased eight-fold.

On October 7, 2010, a PET scan showed strikingly intense uptake of the radiotracer fluorine-18 FDG by each of the three lesions (Fig. 1D). The hypermetabolic appearance of the three lesions indicated either infection due to an atypical bacterium or fungus or highly aggressive malignant lesions. We recommended MR spectroscopy as a non-invasive step toward differential diagnosis.

1H-MRS was performed October 8 using the Hitachi Echelon 1.5T short-bore MR scanner (Fig. 2). Single-voxel spectroscopy sampled sites inside each of the three suspect lesions and at three contra lateral sites representing healthy brain tissue.

Choline/creatine ratios were substantially elevated for each of the three suspicious lesions. The most superior of the right-sided lesions had a choline/creatine ratio of 1.47 compared with a ratio of 0.55 for the contra lateral control. The superior of the confluent lesions in the basal ganglia showed a ratio of 2.06 compared with 0.4 for the contra lateral. We also obtained spectral data on the primary tumor located in the right cerebral peduncle-pontine area, finding a choline/creatine ratio of 0.89 compared with a ratio of 0.26 on the contra lateral side.

We concluded on the basis of the MR spectra that the three prominent lesions located along the stereotactic track were due to seeding of the glioma into the track during withdrawal of the biopsy needle and not infection. This conclusion was consistent with the hypermetabolic rates seen on the PET scan and rapid volumetric growth seen on MRI. We further concluded, based on PET and 1H-MRS data, that residual malignancy persisted in the primary site of the right pontine-cerebral peduncle area.

By showing definitively that this was a malignancy and not infection, the radiation oncology could confidently irradiate those areas, sparing the patient a trip to a tertiary care center for surgical biopsy.

Radiation treatment of the three lesions began October 19 and extended through November 16. Over those 28 calendar days, 20 radiation treatments were administered along with chemotherapy.
Conclusion

Recent advances in MR technology have put MR spectroscopy within the grasp of routine practitioners, as exemplified by the Hitachi Echelon 1.5T in its spectroscopy-ready configuration. In concert with others, including MRI and PET, 1H-MRS can provide the information needed to effectively manage patients. This may be an especially important alternative for patients who are not good candidates for biopsy. Consequently, applying MR spectroscopy to objectively quantify the presence, or absence, of cancer can be an important adjunct when determining the most appropriate treatment of patients.

Citations
