Cost-effectiveness of MRS in the Management of Recurrent Brain Tumors

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Introduction
The clinical utility and efficacy of proton magnetic resonance spectroscopy (MRS) has been well established in a number of large studies that compare the sensitivity and specificity of MRS to stereotactic biopsy, the current gold standard of diagnosing brain tumors [1-4]. However, despite overwhelming evidence of its importance as a non-invasive diagnostic test, MRS is still considered to be an “experimental”, “investigational”, or “research” tool [5]. Although having FDA approval and a CPT code does not guarantee the acceptance of MRS as a clinical test, several papers call for the determination of cost-effectiveness of MRS [5-7] which has never been published. This type of evidence could convince insurance companies that the benefits of MRS lie beyond its non-invasive nature but as cost-effective measure in the management of brain tumors.

Methods
In a study previously published determining the efficacy of MRS in clinical decision making for patients with suspected brain tumors [8], ten patients with biopsy-proven tumors had full clinical work-ups including contrast enhanced MRI. Five additional patients with either non-diagnostic or no previous biopsy due to high-risk lesion areas (brainstem or basal ganglia) were also examined. At this point, the clinician mapped a diagnostic and treatment plan. Single voxel short-echo proton MRS was then conducted in all 15 patients and tumor diagnosis made upon those results. The MRS results were then reported to the clinician and were then factored into the clinical decision-making and a final diagnostic and treatment plan was formulated.

The diagnostic costs of the initial treatment plan were determined using CPT codes of the recommended procedures (stereotactic biopsy: CPT 61750, surgical pathology: CPT 88307, anesthesia: CPT 01902, repeat MRI: CPT 70552, open craniotomy: CPT 61510). Hospital costs were determined by using average medical fees in the 50th percentile for those codes [9]. Due to variations in average costs for items such as anesthesia (ie. local vs total dependent upon region of interest), appropriate inpatient costs and length of stay (LOS) costs were estimated by a billing specialist. These estimates assume no complications due to the procedures and are weighted in the 50th percentile of hospital costs. Cost savings due to MRS were determined by changes in the treatment plan which led to more cost-effective means of treatment minus the cost of a single MRS exam per patient. Morbidity/mortality rates of each of the procedures are not included in the calculation but are discussed per procedure.

Results
In the initial treatment plan, stereotactic biopsy was recommended in eight cases, repeat MRI every 6 weeks in three cases, resection in the another three cases, and proceed to chemotherapy in the final case. This would have come to a total cost of $90,026 as shown in Table 1. In the final treatment plan, stereotactic biopsy was avoided in seven of eight cases. This alone was a cost savings of $40,768. In addition, the morbidity/mortality rate of stereotactic biopsy is approximately 3-4%[10] compared to 0% chance of injury/death in a non-invasive test such as MRS.

Instead of repeat MRI, the MRS results prompted the clinician to begin direct treatment in two cases and patient observation only in the third case. Repeat MRI with contrast enhancement determines growth rate in brain tumors and therefore several scans may have been required before moving to treatment [11]. This is not only a cost savings of at least $5,094 (Table 1, subtracted MRS costs), but the use of MRS initiated faster decision making allowing for the chance of greater treatment success. Morbidity due to complications of gadolinium injections was not examined.

In two of the three resections decisions and the chemotherapy decision, MRS confirmed recurrent tumor and the original treatment plan was executed. In the third resection case, MRS showed radiation necrosis and resection was decided against. This resulted in a cost-savings of $3,590 due to the unnecessary resection after MRS cost. There is an obvious morbidity/mortality rate for the resections. Loss of function in certain regions of the brain due to resection could have resulted in the unnecessary operation.

All patients were then monitored or had resections analyzed and in 94% of the cases MRS accurately predicted brain tumor. Had serial MRS exams been utilized, the one case that became tumor could have received early, possibly effective treatment. In the one case where MRS did not deter biopsy, the physician was convinced that the region was a tumor despite negative MRS results. The resulting pathology revealed that indeed there was not tumor and surgery could have been avoided. The specificity of MRS in this study is easily comparable to the current gold standard of stereotactic biopsy which has a reported 88-92% accuracy due to sampling error and non-diagnostic histologies [12].

Conclusion
The total cost savings of MRS in the clinical management of just these 15 patients was $49,452, an average of $3,296.80 per patient. Considering that there are over 17,000 new cases of brain tumor diagnosed each year [13], the cost savings of spectroscopy could be at least $56.1 million a year. Although we are not advocating that MRS replace biopsy (histology can not be determined accurately with MRS), we certainly feel it has a strong place as an excellent tool in the management of patients with the possibility of recurrence. Not only is it cost-effective, but it carries no chance of any injury to the patient and can help expedite the treatment of patient by early prediction. Similar cost-benefit calculations are essential before widespread acceptance of other MRS diagnostic tests (eg. Alzheimer's disease, stroke, etc).

References
12. Sosa TM et al Stereotact Funct Neurosurg 64:183-196

<table>
<thead>
<tr>
<th>Table 1. Costs of Diagnostic &amp; Treatment Plans</th>
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<tbody>
<tr>
<td>CT-Guided Stereotactic Biopsy</td>
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<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>Physician professional fee</td>
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<tr>
<td>LOS costs</td>
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<td>Operating room use and surgical supplies</td>
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<td>Guided CT</td>
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<td>Surgical pathology</td>
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Total cost per procedure: $7,024 $8,380 $2,898 (min 2x)

# of Proc in Orig Plan: x8 x3 x3

Total Cost of Orig Plan: $90,026