Sensitivity of high-resolution three-dimensional magnetic resonance angiography and three-dimensional spoiled-gradient recalled imaging in the prediction of neurovascular compression in patients with hemifacial spasm

Clinical article

Ahmed M. Raslan, M.D.,1 Reynaldo De Jesus, M.D.,1,3 Caglar Berk, M.D.,1 Andrew Zacest, M.B.B.S.,1,4 Jim C. Anderson, M.D.,2 and Kim J. Burchiel, M.D.1

Departments of 1Neurological Surgery and 2Radiology, Oregon Health & Science University, Portland, Oregon; 3Hospital San Lucas, Ponce, Puerto Rico; and 4Department of Neurosurgery, Royal Adelaide Hospital, Adelaide, South Australia

Object. Hemifacial spasm is a clinical syndrome caused by vascular compression of the facial nerve in the cerebellopontine angle, which can be relieved by surgical intervention. Advances in medical imaging technology allow for direct visualization of the offending blood vessels in hemifacial spasm and similar conditions (such as trigeminal neuralgia). The utility of high resolution 3D MR angiography and 3D spoiled-gradient recalled (SPGR) imaging sequences for surgical decision-making in hemifacial spasm, as measured by sensitivity, specificity, and positive and negative predictive values, has not been previously determined.

Methods. A retrospective review was undertaken of 23 patients with hemifacial spasm who underwent operations between January 2001 and December 2006 at Oregon Health & Science University. All patients underwent preoperative high-resolution 3D MR angiography and 3D SPGR imaging. The sensitivity of the SPGR imaging/MR angiography interpretation of neurovascular compression (NVC) by both a neurosurgeon and 2 neuroradiologists was determined in relation to the presence of actual NVC during surgery.

Results. All patients were found to have NVC at surgery. After review by a neurosurgeon and 2 neuroradiologists, imaging data from 19 of the 23 patients were evaluated. The neurosurgeon’s interpretation had a sensitivity of 79% and a positive predictive value (PPV) of 100%. The first neuroradiologist’s interpretation had a sensitivity of 21% with a PPV of 100%. Further interpretation by a blinded second neuroradiologist with expertise in MR imaging of hemifacial spasm and trigeminal neuralgia was conducted, and sensitivity was 59% and PPV was 100%. Specificity was not determined because there were no true negative cases. The negative predictive value was 0% for both the neurosurgeon’s and neuroradiologists’ evaluations.

Conclusions. Although high-resolution 3D MR angiography and 3D SPGR imaging was helpful in providing information about the anatomical relationship of cranial nerve VII and surrounding blood vessels, the authors determined that in the case of hemifacial spasm these types of imaging did not influence preoperative surgical decision-making. (DOI: 10.3171/2009.3.JNS08393)

Key Words • hemifacial spasm • cranial nerve • cerebellopontine angle • magnetic resonance angiography • spoiled-gradient recalled imaging

Primary hemifacial spasm is a neurological syndrome secondary to vascular impingement of CN VII in the cerebellopontine angle1,3,16 and may be cured surgically if definitive microsurgical decompression is performed.2,9,11 Although surgical decision-making has traditionally been clinically driven, recently the role of improved neuroimaging studies such as 3-T MR imaging sequences to guide or assist the surgical candidacy decision has been questioned.3 Currently, many imaging techniques are used to demonstrate NVC before surgery. High-resolution 3D MR angiography and 3D SPGR imaging are 2 of the standard acquisition sequences used for this purpose.12,14 However, to date the sensitivity and specificity of high-resolution 3D MR angiography and 3D SPGR imaging in predicting the presence of NVC in hemifacial spasm has not been accurately determined. Therefore, we conducted this study to: 1) determine the sensitivity, PPV, and NPV of high-resolution 3D MR an-
giography and 3D SPGR imaging to demonstrate NVC in patients with hemifacial spasm; and 2) determine whether high-resolution 3D MR angiography and 3D SPGR imaging evaluations actually contribute to surgical decision-making.

Methods

Study Population and Data Collection

The aim of the study was to determine the sensitivity and specificity of high-resolution 3D MR angiography and 3D SPGR imaging in predicting NVC in a retrospective cohort of patients with hemifacial spasm who underwent operations by the same neurosurgeon (K.J.B.) at Oregon Health & Science University from January 2001 to December 2006. The study was approved by the Oregon Health & Science University Institutional Review Board.

All patients were identified who underwent a surgical procedure performed by the neurosurgeon (K.J.B.) for a diagnosis of hemifacial spasm in the time span indicated. A retrospective review of patient medical charts was undertaken. Patient data that were collected and evaluated included demographics, clinical history, imaging obtained, and preoperative imaging evaluation. The preoperative imaging evaluation included evaluations conducted by the neurosurgeon who was aware of the clinical condition of the patient at the time of evaluation, and by a neuroradiologist who was aware of the clinical diagnosis but unaware of the patients’ specific clinical history, including the side of hemifacial spasm or the intraoperative findings. All patients had undergone high-resolution 3D MR angiography and 3D SPGR imaging before surgery. Imaging evaluations performed by the neurosurgeon and the first neuroradiologist were undertaken prior to surgery. A post hoc independent evaluation was also obtained from a blinded neuroradiologist (the second neuroradiologist) with a particular expertise in MR images of TN and hemifacial spasm. Postoperative information was not collected because the aim of the study was not related to surgical outcome. Both the neurosurgeon and the neuroradiologists determined the presence or absence of artery or vein compression. Neurovascular compression was defined as definite contact between the vessel and the nerve or its root entry zone with indentation, angulation, or displacement of the nerve. Imaging evaluation included dichotomous variables regarding NVC (yes/no), side of NVC (left/right), and type of NVC (arterial/venous) if it was present.

Data Analysis

A standard 2 × 2 table was created for the test (3D MR angiography and 3D SPGR imaging) and the disease (hemifacial spasm). The variable “true disease” was defined as the presence of NVC as determined intraoperatively by the neurosurgeon, and the variable “negative disease” was defined as the absence of NVC as determined intraoperatively by the neurosurgeon. A positive test was defined as the categorical variable “yes” in the same side of the disease and a negative test was defined as the categorical variable “no” or the categorical variable “yes” on the opposite side of the disease. Sensitivity and specificity were calculated from the standard 2 × 2 table. Standard parametric statistical descriptions of patient data were created using the Statistical Package for the Social Sciences (SPSS) version 15.0 for Windows (SPSS, Inc.).

Imaging Technique

The MR imaging technique used was 3D TOF MR angiography (1.5-T Signa, General Electric Medical Systems) centered on the pons. Sequence parameters included: TR 33 msec, TE 2.4 msec, 512 × 512 matrix, and voxel size 0.5 mm × 1 mm². In 4 patients multiple 3D TOF sequences were performed with varying flip angles to optimize the contrast of the TOF enhancement and CN VII with respect to cisternal CSF. On the basis of these experiments, a flip angle of 25° was used for all 3D TOF angiography sequences. An axial, 3D, high-resolution (1 mm³), T2 fast spin echo sequence (TR 3000 msec, TE 118 msec, echo time 32 msec) was also performed to visualize fine anatomical details and rule out demyelinating or other lesions. After intravenous Gd-diethylenetriamine pentaacetic acid (0.2 mmol/kg) injection, a 3D SPGR Gd sequence was run (TR 11.5 msec, TE 2.2 msec, flip angle 45°, voxel size 1 mm³). Arteries and nerves were distinguished by comparison of 3D TOF MR angiography and 3D SPGR Gd source images. Identification of the vessel was made by tracing the nerve branches visualized by 3D SPGR imaging back to the parent vessel and comparing them with the structures identified by MR angiography. Vessels visualized by 3D TOF MR angiography were identified as arteries. Those that could be identified on 3D SPGR Gd images but not on 3D TOF MR angiography were identified as veins.

Results

Final study analysis included 19 patients, 8 male (42%) and 11 female (58%). The mean age of the patients was 51.5 years (range 34–80 years) with a median age of 47 years. Five patients (26%) showed right-sided hemifacial spasm, and 14 (74%) showed left-sided hemifacial spasm. Mean disease duration (since first diagnosis) was 6.8 years (range 6 months–20 years; Table 1). The neurosurgeon’s interpretation of MR imaging was positive (presence of NVC) in 15 of 19 patients; all NVCs were interpreted as arterial (Table 2). The first neuroradiologist’s interpretation of MR imaging was positive in 4 of 19 cases, and again all NVCs were interpreted as arterial (Table 2). The second neuroradiologist’s interpretation of MR imaging was positive in 11 of 19 cases. All cases interpreted as positive by the first neuroradiologist were also interpreted as positive by the neurosurgeon, but only 2 of these 4 cases were interpreted as positive by the second neuroradiologist. All cases that were interpreted as negative by the neurosurgeon were, surprisingly, interpreted as positive by the second neuroradiologist. Intraoperatively, all cases had either arterial compression (15 of 19 cases), venous compression (2 of 19 cases), or a combination of arterial and venous compression (2 of 19 cases; Table 2).

The sensitivity of MR angiography when interpreted
Predicting neurovascular compression in hemifacial spasm

TABLE 1: Patient demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>sex (no. of patients)</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>8</td>
</tr>
<tr>
<td>F</td>
<td>11</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>51.5</td>
</tr>
<tr>
<td>side of hemifacial spasm</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>3 rt, 5 lt</td>
</tr>
<tr>
<td>F</td>
<td>2 rt, 9 lt</td>
</tr>
<tr>
<td>mean duration of hemifacial spasm (yrs)</td>
<td>6.8*</td>
</tr>
</tbody>
</table>

* As reported by 15 of 19 patients in whom duration data was available.

by a neurosurgeon was 79%. The sensitivity of MR angiography when interpreted by the first neuroradiologist was 21%, and 59% when interpreted by the second neuroradiologist. The PPV was 100% and the NPV was 0% for both the neurosurgeon and neuroradiologists’ evaluations (Table 2). There were no true negative cases, thus ruling out a calculation of specificity.

Discussion

Since the first modern description of hemifacial spasm by Gowers7 in 1884, an expounding growth in the medical literature has detailed the pathophysiology and management of this syndrome. Although many authors had theorized about the condition’s origin, it was not until 1947 that Campbell and Keedy4 formally proposed that vascular abnormalities in the posterior fossa were the cause and triggering factor for hemifacial spasm. In 1962, Gardner and Sava5 emphasized the importance of the cause and triggering factor for hemifacial spasm. In that vascular abnormalities in the posterior fossa were determined how management of this syndrome. Although many authors had theorized about the condition’s origin, it was not until 1947 that Campbell and Keedy4 formally proposed that vascular abnormalities in the posterior fossa were the cause and triggering factor for hemifacial spasm. In 1962, Gardner and Sava5 emphasized the importance of the cause and triggering factor for hemifacial spasm.

The study we describe in this paper was designed to ask the question: “Is MR imaging/angiography sensitive and specific enough to influence the decision to offer surgery based on imaging findings alone?” We compared the sensitivity and specificity of high-resolution 3D MR angiography and 3D SPGR imaging for demonstrating NVC in patients with hemifacial spasm, and determined how the retrospective interpretation of this imaging by an experienced neurosurgeon and 2 different neuroradiologists compared with operative findings (as determined by the same neurosurgeon). The sensitivity of the MR angiography interpretation by the neurosurgeon was 79% with indeterminable specificity; the sensitivity of the first neuroradiologist’s interpretation—in which a preoperative report produced by multiple radiologists was considered—was only 21%, again with an indeterminable specificity. The same sensitivity rose to 59% when a second (blinded) neuroradiologist with an expertise in the field of TN and hemifacial spasm imaging interpreted the images. The PPV of all interpretations was 100% with a NPV of 0%. Therefore high-resolution 3D MR angiography and 3D SPGR imaging is useful when NVC is positive, but of no use when NVC is negative.

Other imaging techniques that are used in visualization of NVC in the posterior fossa are not routinely used at our institution. Girard et al.6 in 1997 described 3D Fourier transformation MR imaging with a constructive interference in steady state sequence to be 97% sensitive in detecting hemifacial spasm NVC, however, they interpreted compression of the pons by the vertebral artery or any other vessel as a positive finding. In the study we present, only compression of the facial nerve itself or the facial nerve exit point from the pons (the root entry zone) were interpreted as positive. This methodological distinction may explain the difference in sensitivity detected between the 2 studies. Interestingly, Girard et al. noted a sensitivity of 73% if they accounted for compression of the nerve only, a result that is very similar to the sensitivity of the neurosurgical interpretation in the present study.

A commonly used imaging sequence is FIESTA. To the best of our knowledge, the sensitivity, specificity, PPV, and NPV of FIESTA has not been determined in cases of hemifacial spasm. However, Benes and colleagues1 reached a similar conclusion to our conclusion in this study regarding FIESTA imaging in predicting NVC in TN and they recommended careful use of this type of imaging for the purpose of identifying patients for surgery. The sensitivity of high-resolution 3D MR angiography and 3D SPGR imaging in predicting NVC in hemifacial spasm is low when compared with TN. This disparity can be explained by the anatomical difference between the facial and trigeminal nerves and the relative insensitivity of MR imaging in detecting smaller arterial branches.

Our study has a number of limitations. Even though the first neuroradiologist was unaware of the side of the hemifacial spasm, and the second neuroradiologist was blinded to the side and whether the patients had TN or hemifacial spasms, the neurosurgeon was aware of these variables. The variable “true disease” (true NVC) was determined by the neurosurgeon’s evaluation of intraop-

J Neurosurg / Volume 111 / October 2009

TABLE 2: Neurovascular compression evaluation summary

<table>
<thead>
<tr>
<th>Physician/Evaluation</th>
<th>NVC</th>
<th>No NVC</th>
<th>Sensitivity† (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>neurosurgeon/MRA</td>
<td>15 (arterial)</td>
<td>4</td>
<td>79</td>
</tr>
<tr>
<td>first neuroradiologist/MRA</td>
<td>4 (arterial)</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>second neuroradiologist/MRA</td>
<td>11</td>
<td>8</td>
<td>59</td>
</tr>
<tr>
<td>neurosurgeon/intraoperative</td>
<td>arterial</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>venous</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>arterial + venous</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

† PPV = 100% and NPV = 0% in all MRA evaluations.

MRA = MR angiography.
Refractive findings and not by a later blinded evaluation of the recorded surgical procedure by another surgeon (recorded intraoperative procedures were unavailable for a substantial number of patients).

The marked sensitivity interpretation differences between the neurosurgeon and the neuroradiologists might be explained by the neurosurgeon’s bias due to knowledge of the individual patient’s condition and/or surgical experience that allowed for correlation of the degree of NVC observed on the MR images with actual NVC observed intraoperatively. Sensitivity differences between the first neuroradiologist (21%) and the second neuroradiologist (59%) could be related to the second neuroradiologist’s experience with MR imaging interpretation of TN and hemifacial spasm. The interobserver sensitivity variability of MR imaging interpretation in this case eliminates its usefulness for surgical decision-making.

There remains the argument that if the neurosurgeon can successfully clinically predict NVC with 100% specificity, why even perform MR imaging? However, MR imaging in this case is not performed as a diagnostic tool but instead as a confirmatory tool that provides detailed anatomical information relative to the precise relationship between CN VII and the surrounding structures including vessels.

The study results that we present clearly indicate that high-resolution 3D MR angiography and 3D SPGR imaging is not sensitive or specific enough to constitute a diagnostic tool for identifying patients with hemifacial spasm as surgical candidates. Until further advancements prove useful, caution should be exercised when interpreting high-resolution 3D MR angiography and 3D SPGR imaging data. While helpful in surgical planning, the data does not yet suffice in determining surgical candidacy.

Conclusions

High-resolution 3D MR angiography and 3D SPGR imaging is currently not sufficient to identify patients with hemifacial spasm who require surgical intervention. When interpreted by an experienced neurosurgeon with a particular interest in imaging techniques, sensitivity was only 79%. Therefore, the inability to detect NVC in preoperative imaging studies should not deter a surgeon from exploring the possibility of surgery in a patient with typical hemifacial spasm. The surgical decision-making process of whether to perform microvascular decompression at our institution at this time is clinically based. Given the data we present here, we see no reason to alter that rationale.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Address correspondence to: Kim J. Burchiel, M.D., Department of Neurological Surgery, CHSN, Oregon Health & Science University, 3303 SW Bond Avenue, Portland, Oregon 97239. email: burchiek@ohsu.edu.