CT and MR Findings of Cavernous Sinus Lesions

Mee Young Cho, M.D., Seon Hee Park, M.D., Sang Hum Yoon, M.D., Jong Deok Kim, M.D.

PURPOSE: To classify the cavernous sinus lesions, to describe their radiological findings, and to assess the usefulness of MR compared to CT.

MATERIALS AND METHODS: Forty-five patients with lesions involving the cavernous sinus proved by histological and/or clinical and imaging methods were studied retrospectively and classified into neoplastic, vascular, and inflammatory lesions. CT and MR findings were compared in 21 patients evaluated by both modalities simultaneously according to these 4 categories.

RESULTS: Pituitary macroadenoma was the most common cavernous sinus lesion (42%). Diffuse convex bulging of the lateral wall of cavernous sinus was the most frequent radiological finding (84%), and the others were encasement of the cavernous carotid artery (49%), remodelling of the surrounding bones (44%), and complete obliteration of Meckel’s cave (38%), in descending order of frequency. Bulging of the lateral wall of cavernous sinus was equally well demonstrated on both modalities, but encasement or displacement of the cavernous carotid artery and complete or partial obliteration of Meckel’s cave were much better delineated on MR than on CT with the ratio of 3.8:1 and 4.6:1, respectively. Only bone changes were much better demonstrated on CT than on MR with the ratio of 3.8:1.

CONCLUSION: MR is superior to CT in demonstrating the cavernous carotid artery encasement and obliteration of Meckel’s cave, but CT is much better than MR in demonstrating bone changes.

Index Words: Cavernous sinus
Cavernous carotid artery
Cavernous sinus lesion, CT and MR.
Pituitary macroadenoma.

INTRODUCTION

High-resolution CT (HRCT) enables direct visualization of the cavernous sinus and its neurovascular contents. The changes in size, density, and configuration of the cavernous sinus are useful signs in detecting cavernous sinus diseases (1-2). MR superbly depicts cranial nerves, internal carotid arteries, and other anatomical structures. The sensitivity of MR in the detection of cavernous or pericavernous lesions exceeds that of CT. Coronal sections are the most informative in the evaluation of cavernous sinus and cranial nerves because their long axis lies in the axial plane (3-4).

The purposes of this study are to classify the cavernous sinus lesions, to describe their radiological findings, and to assess the usefulness of MR compared with that of CT.

MATERIALS AND METHODS

We reviewed the findings of CT, MR and angio-
The radiological findings by these 3 imaging techniques were classified into 4 categories: bulging of the lateral wall of cavernous sinus (convex or straight), invasion of the cavernous carotid artery (encasement or displacement), obliteration of Meckel’s cave (complete or partial), and change of the surrounding bones (remodelling, destruction, or hyperostosis). Both CT and MR findings were compared in 21 patients according to these 4 categories.

CT was performed at a TCT-80A or TCT-300S (Toshiba, Japan) in 39 patients. Iodinated contrast material was administrated by intravenous drip infusion. Axial and coronal CT images of brain were obtained with a 10-mm thickness and the cavernous sinus was scanned with a 3-5-mm thickness. Twenty-seven patients were scanned at a 0.5T MRI-50A superconducting scanner (Toshiba, Japan), and axial and coronal short TR/TE images were obtained with the parameters of 400/15/2 (TR/TE/excitations) and double echo long TR coronal or axial scans were performed with the parameters of 2500–3000/30, 120–1–2. The slice thickness was 3–5mm, the field of view was 25cm, and the matrix number was 256x256. Used contrast material was 0.1mmol/kg of Gd-DTPA.

**RESULTS**

The diseases involving the cavernous sinus consisted of benign tumor (60%, pituitary macroadenoma, meningioma, trigeminal neuroma, chordoma, neurofibromatosis), malignant tumors (13%, nasopharyngeal carcinoma, palate liposarcoma, metastatic hematoma), vascular lesions (18%, CCF, giant aneurysm of cavernous carotid artery), and inflammatory lesions (9%, septic cavernous sinus thrombophlebitis, Tolosa-Hunt syndrome, sphenoid sinus mucocele). Among these, pituitary macroadenoma was the most common disease representing 42% of all cavernous sinus lesions (Table 1).

Of the radiological findings, diffuse convex bulging of the lateral wall of the cavernous sinus (Fig. 1, 4) was the most common radiological finding (64%) and the others were encasement of the cavernous carotid artery (49%) (Fig. 1, 3, 5), remodelling of the surrounding bones (44%) (Fig. 1, 4), and complete obliteration of Meckel’s cave (38%) (Fig. 3, 4). Ninety-five percent of all cases showed diffuse bulging of the lateral wall of the cavernous sinus when straight bulging (Fig. 3) was included. One of 4 meningiomas showed localized lateral bulging of the lateral wall of cavernous sinus (Fig. 2). The lesion extended from the palatal liposarcoma showed localized, irregular convex bulging. Sixty-three percent of the benign tumors, 50% of the malignant tumors, and 50% of the inflammatory lesions revealed the cavernous carotid artery encasement, which was diagnosed by MR and/or angiography. The cavernous carotid artery was surrounded and displaced by lesions in 4 of 33 tumors without changing its luminal diameter (Fig. 2). It was classified as 'displacement' rather than 'encasement' in our study (Table 2).

When the findings of CT were compared with those of MR in 21 patients, bulging of the lateral wall of cavernous sinus was equally well demonstrated on both modalities (20:21) (Fig. 1, 3, 4, 5), but encasement (Fig. 1, 3, 4, 5) or displacement of the cavernous carotid artery and complete or partial obliteration of Meckel’s cave (Fig. 1) were much better delineated on MR than on CT with the ratios of 3.8:1 and 4.6:1, respectively. Only bone changes such as remodelling, destruction, and hyperostosis were much better demonstrated on CT than on MR with the ratio of 3.8:1 (Fig. 1, 4) (Table 3).

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**Table 1. Classification of Cavernous Sinus Lesions (n=45)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A. Tumors (33)(73%)</td>
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<tr>
<td>1. Benign (27)</td>
<td>(1) Pituitary macroadenoma</td>
<td>19(42%)</td>
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<td></td>
<td>(2) Meningioma</td>
<td>4(9%)</td>
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<td></td>
<td>(3) Trigeminal neuroma</td>
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<td></td>
<td>(4) Chondrochordoma</td>
<td>1</td>
<td></td>
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<td></td>
<td>(5) NF2</td>
<td>1</td>
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<tr>
<td>2. Malignant (6)</td>
<td>(1) Nasopharyngeal Ca.</td>
<td>4(9%)</td>
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<td></td>
<td>(2) Palate liposarcoma</td>
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<td></td>
<td>(3) Metastasis from hepatoma</td>
<td>1</td>
<td></td>
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<tr>
<td>B. Vascular Lesions (8)(18%)</td>
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<td>(1) C. C. F.</td>
<td>5(11%)</td>
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<td>(2) Intracavernous ICA giant aneurysm</td>
<td>3</td>
<td></td>
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<tr>
<td>C. Inflammatory Lesions (4)(9%)</td>
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<tr>
<td>(1) Cavernous sinus thrombophlebitis</td>
<td>2</td>
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<tr>
<td>(2) Tolosa-Hunt syndrome</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>(3) Sphenoid sinus mucocele</td>
<td>1</td>
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<tr>
<td><strong>Total</strong></td>
<td>45(100%)</td>
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NF2: neurofibromatosis type II.
C. C. F.: carotid-cavernous fistula
ICA: internal carotid artery
Ca.: carcinoma
DISCUSSION

MR could demonstrate the dural lateral borders and the contents of the cavernous sinuses more effectively than CT could. The anatomic landmarks in MR studies, including cranial nerves III, V1, and V2, the venous space between V1 and V2, and the carotid artery, can be used in the detection of the masses encroaching the cavernous sinuses. It is important to demonstrate the vascular encasement, that is, whether a blood vessel is surrounded by a lesion or not because it can alter the management plan. But, in the definition of bone erosion and destruction, or hyperostosis, MR is inferior to CT. However, when surgical intervention is considered, angiography still provides valuable anatomic informations, such as, the vascularity of a tumor, the morphologic characteristics of aneurysm, and the nature of a carotid-cavernous fistula (CCF) (5-9).

The diseases involving cavernous sinus can be classified into inflammatory (e.g., cavernous sinus thrombophlebitis, Tolosa-Hunt syndrome), vascular (e.g., aneurysm, CCF), and neoplastic (e.g., neuroma, meningioma, metastatic tumor) lesions (1, 11). Tolosa-Hunt syndrome is the most frequently encountered inflammatory disorder (11). Of the malignant cavernous sinus lesions, the majority is the lesions extended from nasopharyngeal carcinomas. As a result of our study, most of the cavernous sinus lesions were neoplastic (73%), followed by vascular (18%) and inflammatory.

Fig. 1. Pituitary macroadenoma. Post-contrast coronal CT(a) shows diffuse convex bulging of the right cavernous sinus by a large mixed-density mass in the pituitary fossa with extension into all directions and remodelling of the sellar floor. On Gd-DTPA-enhanced coronal T1WI(b), obliteration of the cavernous ICA and Meckel's cave and the relationship between the mass and optic chiasm and infundibulum, which are not demonstrated on CT, are well seen. ICA encasement in addition to opening of the carotid siphon on sagittal T1WI(c) corresponds to the angiographic findings(d).
Table 2. Radiological Findings of Cavernous Sinus Lesion (n=45)

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<td>Tumor(33)</td>
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<td>Benign(27)</td>
<td>22</td>
<td>3</td>
<td>17</td>
<td>3</td>
<td>10</td>
<td>3</td>
<td>16</td>
<td>5</td>
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<tr>
<td>Malig. (6)</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
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<tr>
<td>Vascular(8)</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Inflamm. (4)</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Total(45)(%)</td>
<td>38(84)</td>
<td>5</td>
<td>22(49)</td>
<td>7</td>
<td>17(38)</td>
<td>3</td>
<td>20(44)</td>
<td>9</td>
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Fig. 2. Meningioma. Axial T1WI(a) reveals a lobular, isointense mass arising from the right cavernous sinus with localized convex bulging and medial displacement of the cavernous ICA. Low signal intensities within the mass represent calcifications. On Gd-DTPA-enhanced axial(b) and coronal(c) T1WIs, the mass is intensely and homogenously enhanced and displacement of the ICA by the mass is well seen.

lesions (9%). Pituitary macroadenoma (Fig. 1) was the most common disease representing 42% of all cavernous sinus lesions, followed by CCF (11%), meningioma (9%) (Fig. 2) and nasopharyngeal carcinoma (9%) (Fig. 3). Nasopharyngeal carcinoma was the most common malignant tumor (4/6).

According to Kline et al. (2) who evaluated over 255 patients with sellar and parasellar lesions, CT criteria suggesting an abnormal cavernous sinus are: (a) asymmetry of size, (b) asymmetry of shape, particularly the lateral wall, (c) focal areas of abnormal density within the sinus. Ahmadi et al. (4) reported that CT findings of cavernous sinus invasion by pituitary adenoma were the expansion of cavernous sinus and visible encasement of cavernous carotid artery. Among these, bulging of the lateral wall is the most sensitive indicator of pathologic involvement because, no matter what the cause is, it leads to volume expansion of the involved cavernous sinus on CT (10).

Daniels et al. (3-4) reported MR signs of cavernous sinus lesions including obliteration of cavernous carotid artery, bulging of the lateral wall of the cavernous sinus, and obscuration of cranial nerves on coronal images. Scotti et al. (7) reported that the most sensitive MR sign of cavernous sinus invasion was an asymmetry in signal intensity between the two sides, and the most specific sign was carotid artery encasement, which, although not often present, was seen only in those patients with cavernous sinus invasion. Young et al. (6) observed the lateral displacement of the carotid artery may occur before encasement. They also reported that MR was superior to angiography when the tumor surrounded the carotid artery without changing the diameter of its lumen, whereas, MR was equal
to angiography in the cases with luminal narrowing of the artery after reviewing 11 patients with parasellar masses. Coronal scanning appears to be the best plane of MR imaging for the evaluation of encasement and well correlated with the anteroposterior angiogram. CT is ineffective in demonstrating the displacement or encasement of the carotid artery because of the concomitant enhancement of the carotid artery, the cavernous sinus, and the mass itself(3, 6). In the evaluation of the neighboring cranial nerves, we simply

Fig. 3. Nasopharyngeal carcinoma with intracranial extension. Postcontrast axial CT(a) reveals diffuse straight bulging of the right cavernous sinus. On axial(b) and coronal(c) Gd-DTPA-enhanced T1 WIs diffuse encasement of the cavernous ICA and intracranial extension from the nasopharyngeal carcinoma are well demonstrated.

Fig. 4. Giant aneurysm of cavernous ICA. Postcontrast axial CT(a) shows a uniformly enhancing mass in the right cavernous sinus with remodelling of the sphenoid sinus. On axial T1WI(b), the mass shows an area of signal void containing hyperintense interior and periphery, associated with phase-encoding artifacts. Follow-up axial T1WI(c) reveals hyperintense aneurysm suggestive of thrombosis in it after ligation of the cervical ICA.
Analysed whether the Meckel's cave, which contains the cranial nerve V1 and sometimes V2, was obliterated or not instead of differentiating each cranial nerve (III, IV, VI) encroachment. The reasons why the gasserian ganglion/V1-V2 complex is consistently demonstrated on both CT and MR as a relatively symmetric, oblong, intracavernous structure was not always possible to identify the cranial nerves in our series due to the effacement by the adjacent lesions. Complete obliteration of the Meckel's cave was observed in the benign and malignant tumors (Fig. 3), giant aneurysms (Fig. 4) and CCFs. Remodelling of the surrounding bones was demonstrated in 60% of the benign tumors (Fig. 1) and in all giant aneurysms of cavernous carotid artery (Fig. 4), but destruction was seen in 67% of the malignant tumors and 21% of the pituitary macroadenomas. Hyperostosis was demonstrated only in one of 4 meningiomas (Table 2).

Giant aneurysms show uniform enhancement on CT and are indistinguishable from neoplasms such as meningiomas or nerve sheath tumors. In giant aneurysms, there may be a sizable thrombus, which can be demonstrated by CT or MR. Therefore, the true size of a giant aneurysm can usually be better assessed by CT or MR than by angiography. Angiogram may underestimate the true size of a partially thrombosed giant aneurysm. With MR, the lumen of a giant aneurysm may appear as an area of signal void, or hypointense, or heterogeneous signal intensities, depending on the velocity and turbulence of the blood flow or the presence of thrombus. It is often associated with phase-encoding artifacts. Meningiomas are isointense relative to brain parenchyme on T1- and T2-weighted images and show homogeneous enhancement on Gd-DTPA T1-weighted images. Pituitary adenomas tend to have signal characteristics that are similar to those of normal pituitary gland itself, but many are partially cystic or hemorrhagic. Parasellar neoplasms other than meningiomas and pituitary adenomas are hypointense on T1- and hyperintense on T2-weighted images (2, 5, 12-14). In our cases, there was no difficulty in differentiating the giant aneurysms from meningiomas and neuromas because of the signal intensities of the former on MR, although all were
homogeneous enhancing lesions on CT. According to Yousem et al. (15) the MR features of Tolosa-Hunt syndrome are abnormal signals and/or mass lesions in the cavernous sinus, enlarged cavernous sinus with or without convex outer margin and extension into the orbital apex. In our case, diffuse convex bulging of the lateral wall of cavernous sinus and encasement of the cavernous carotid artery without orbital extension were seen on the initial MR, which were improved in accordance with clinical symptom on the follow-up MR one month after steroid therapy. Reported CT findings of septic cavernous sinus thrombosis are multiple irregular filling defects in the enhancing cavernous sinus, inflammatory changes in the orbital soft tissue, and enlargement of ophthalmic vein due to the extension of thrombophlebitis, which seem to be specific although there are many causes that show filling defects within enhancing cavernous sinus(10, 16). Additionally, air in the cavernous sinus can be a sign of septic cavernous sinus thrombosis(17), but was not seen in our cases. In one of 2 cases with septic cavernous sinus thrombophlebitis(Fig. 5), MR showed additionally brain abscesses and meningeal thickening in the ipsilateral temporal lobe, which were improved rapidly on follow-up MR after treatment with antibiotics. A CCF may result from trauma or surgery, or may occur spontaneously. On CT, all of our cases showed homogenously intense enhancement of the bulged cavernous sinus with complete obliteration of Meckel’s cave and orbital changes including proptosis, enlargement of the ophthalmic vein, and thickening of the extraocular muscles.

In summary, pituitary macroadenoma was the most common cavernous sinus lesion in our 45 cases(42%). Of the radiological findings, diffuse convex bulging of the lateral wall of cavernous sinus was the most frequent finding(84%), and the others were encasement of the cavernous carotid artery(49%), remodelling of the surrounding bones(44%), and complete obliteration of Meckel’s cave(38%). Although the number of the cases was small, we might conclude MR was superior to CT in demonstrating the cavernous carotid artery encasement and obliteration of Meckel’s cave.

REFERENCES

10. 정진욱, 장기련, 한문희등 "언정맥동질환에서의 전산화단층촬영술" 대한방사선의학회지 1988; 24(2): 201-212
해면정맥동 병변의 뇌 전산화단층촬영과 뇌 자기공명영상 소견
조미영·박선희·윤상홍·김종덕
인제대학교 의과대학 진단방사선과학교실

목 적: 해면정맥동 병변의 종류와 반도를 알아보고 이들의 방사선학적소견을 분석하여 CT와 MR의 유용성을 비교하고자 하였다.

대상 및 방법: 조직병리학적 또는 임상적 소견으로 확진된 해면정맥동 병변 45예를 후향적으로 분석하여 질환별로 분류하고, 이 중 CT와 MR을 동시에 시행한 21예에서 방사선학적 소견들을 각각 서로 비교하여 이 두 영상의 유용성을 비교하였다.

결 과: 해면정맥동 측벽의 미만성 볼록팽창이 가장 흔한 질환이었고(42%), 방사선학적 소견으로는 해면정맥동 측벽의 미만성 물록팽창(84%), 해면정맥동부위 내경동맥의 미만성 협착(49%), 주위골의 재형성(44%) 및 Meckel동 폐색(38%)의 순이었다. 해면정맥동 측벽의 미만성 물록팽창은 CT와 MR 둘다에서 같은 정도로 잘 볼 수 있었지만 내경동맥의 협착이나 전위, 그리고 Meckel동 폐색은 MR에서 CT보다 각각 3.8:1과 4.6:1의 비율로 더 잘 보였다. 그러나 주위 골변화의 발견은 CT가 훨씬 더 좋았다(3.8:1).

결 론: 해면정맥동 병변에서 내경동맥의 협착과 Meckel동 폐색의 관찰에는 MR이 CT보다 좋으나, 주위 골변화를 보는 데에는 CT가 MR보다 좋다.