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Case Report

Usefulness of arterial spin labeling MR angiography as preprocedural mapping for the intra-arterial chemotherapy in patients with maxillary sinus cancer: A case report ☆

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ABSTRACT

Arterial spin labeling (ASL) magnetic resonance angiography (MRA) (ASL-MRA) is a newly developed method that can visualize small arteries, particularly those running tortuously and inferiorly at slow flow rates. It provides excellent visualization of the external carotid artery system, with superior performance in visualizing the middle meningeal artery (MMA) compared to that of computed tomography angiography (CTA). Here, we report a case of maxillary sinus carcinoma in which ASL-MRA revealed an ipsilateral ophthalmic artery originating from the MMA that was not visualized on CTA. Volume rendering or maximum intensity projection images of CTA may fail to depict small arteries that run close to bony structures, including anomalies of the MMA originating from the external carotid artery system. In such cases, ASL-MRA may serve as a useful tool to easily visualize the arteries.

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Introduction

Head and neck cancers are the seventh most common cancer globally [1–3]. Intra-arterial chemotherapy combined with radiotherapy (IACRT) is one of the important treatment options for these cancers [4]. Understanding the anatomy of the external carotid artery (ECA) is essential for performing this procedure effectively and safely, given the potential anastomoses between the ECA and cerebral arteries. For instance, branches of the internal maxillary artery (IMA) can anastomoses with the ophthalmic artery (OphthA) and petrocavernous internal carotid artery (ICA), while the ascending pharyngeal artery is connected to the vertebral arteries [5]. Computed tomography angiography (CTA) is commonly performed before procedures, often generating volume rendering (VR) or maximum intensity projection (MIP) images through bone subtraction using a workstation for preprocedural mapping [6,7].

Arterial spin labeling (ASL) magnetic resonance angiography (MRA) (ASL-MRA) is a newly developed method, which can visualize small intracranial arteries that flow slowly and inferiorly, particularly in conditions such as Moyamoya disease and dural arteriovenous fistulas [8–10]. ASL-MRA is also useful for visualizing the ECA system, demonstrating superior visualization of the middle meningeal artery (MMA) compared to that of CTA on MIP images [11].

In this report, we present a maxillary sinus carcinoma case, where the ipsilateral ophthalmic artery originated from the MMA, which was not visualized on either VR or MIP images of CTA but was well captured on MIP image of ASL-MRA.

Case presentation

A 43-year-old male with no significant medical or family history was referred to our hospital with pain and swelling in the left cheek. The patient had a 25-year history of smoking (30 cigarettes per day) and alcohol consumption (2 cans of beer per day). Blood examination revealed an elevated squamous cell carcinoma antigen level of 7.1 ng/mL (normal range <1.5 ng/mL), whereas the soluble interleukin-2 receptor level was within normal range.

CT and magnetic resonance imaging (MRI) revealed a heterogeneously contrast-enhanced, bulky tumor measuring 5×5×3.5 cm in the right maxillary sinus (Fig. 1A). Diffusion-weighted imaging showed heterogeneously restricted diffusion, reflecting a high cellular density. The tumor extended to the ipsilateral ethmoid and sphenoid sinuses, nasal aperture, and hard palate. There was also a contralateral level II lymph node metastasis, with a diameter of 3.5 cm, demonstrating extranodal invasion (Fig. 1B). Positron Emission Tomography demonstrated extensive fluorine-18-fluorodeoxyglucose uptake in the right maxillary tumor and left level II lymph node metastasis, with mean standard uptake values of 17.4 and 18.6, respectively. Endoscopic examination revealed bilateral nasopharyngeal masses in the nasal cavity. An oral pharyngeal examination revealed no abnormalities in the nasopharynx.

A biopsy of the tumor was performed, and histological examination confirmed squamous cell carcinoma. Based on these findings, the patient was diagnosed with right maxillary sinus carcinoma, T4aN3bM0, stage IVB. After a multidisciplinary conference with head and neck surgeons, IACRT was planned. The patient underwent preprocedural CTA, and VR image for mapping was generated as a clinical routine (Fig. 1C). The right IMA and angular artery were identified as tumor feeders. We also found that the right OphthA did not branch from the right ICA, whereas the contralateral OphthA originated from left ICA. Upon careful review of the original axial CTA images, it was determined that the right OphthA originated from the right MMA. The origin of the right MMA was visualized on the VR or MIP images, but not at the level of the spinous foramen.

We performed pseudo-continuous ASL-MRA [11] to confirm the entire vascular structure of the right MMA and OphthA. MR examination was performed using a 3T scanner (Ingenia Elition; Philips Healthcare, Best, Netherlands). We used three-dimensional T1 turbo field echo acquisition, set the labeling plane 30 mm inferior to the carotid artery bifurcation, with a labeling duration and post labeling delay of 2000 ms and 50 ms, respectively, according to previously reported settings [11]. ASL-MRA visualized the right MMA, including part of the spinous foramen, and OphthA, originating from the MMA at the level of the orbit on the MIP image (Figs. 2A–E). We planned to perform the selective infusion therapy with docetaxel and nedaplatin, distal to the origin of the MMA in the IMA to avoid orbital complications.

Prior to the infusion, we performed digital subtraction angiography and found that the right OphthA originated from the right MMA (Fig. 2F), where the whole vasculature structure was almost identical to the MIP image of ASL-MRA (Figs. 2A and F). As initially planned, selective infusion therapy was administered distal to the origin of the MMA in the right IMA, careful monitoring to prevent drug reflux into the MMA. The patient retained full ipsilateral vision. The maxillary sinus carcinoma responded well to IACRT, and no recurrent tumors were observed.

Discussion

ASL-MRA can visualize small and meandering cerebral arteries with slow flow rate better than time-of-flight MRA [8–10,12,13]. It is particularly useful for visualizing the whole vasculature in conditions such as Moyamoya disease or arteriovenous fistulas [8–10]. We previously reported the effectiveness of ASL-MRA in visualizing the ECA system, which is also a small and meandering artery with a slow flow rate compared with the cerebral arteries [11]. ASL-MRA can visualize the superior thyroid artery, lingual artery, facial artery, submental artery, transverse facial artery, and IMA better than TOF-MRA, and it can visualize many ECA branches as well as CTA. Furthermore, it is superior to CTA for visualizing the periphery of the IMA and MMA on MIP images [11]. Therefore, ASL-MRA is valuable for imaging the ipsilateral MMA and OphthA originating from the MMA, contributing to achieving safe IACRT.

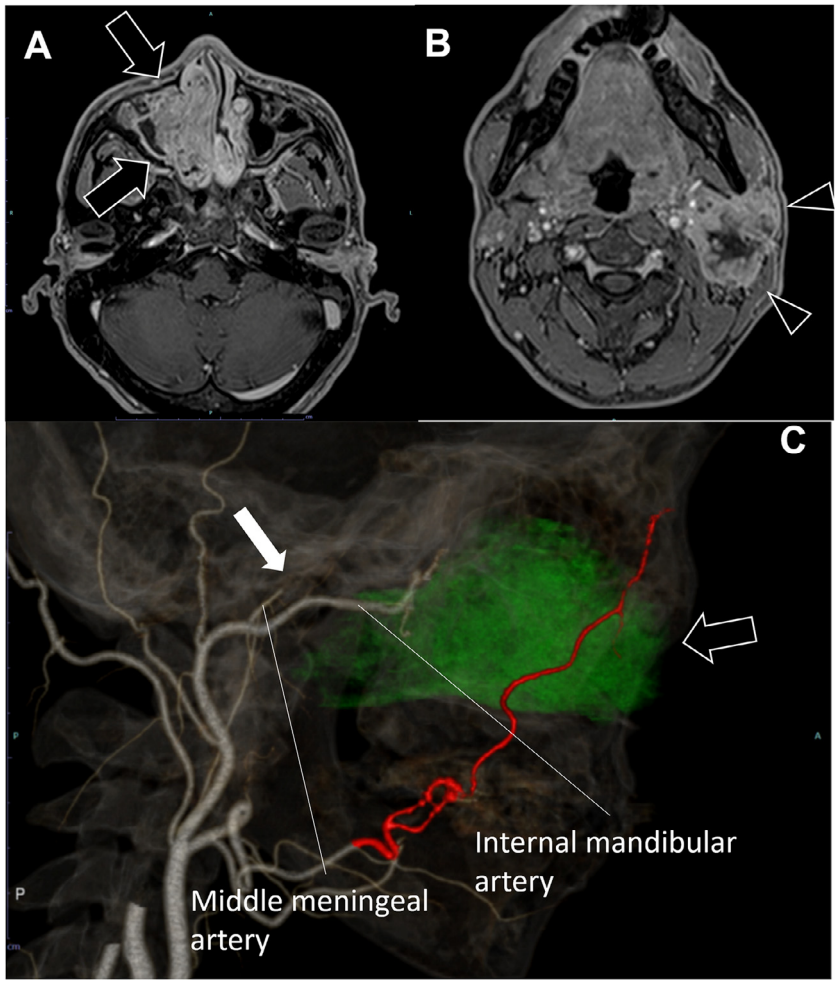

Fig. 1 – (A) Contrast-enhanced T1 weighted image demonstrates a heterogeneously contrast-enhanced bulky tumor in the right maxillary sinus, extending to the ipsilateral ethmoid and sphenoid sinuses and the nasal aperture (black arrows). (B) The same sequence reveals a contralateral level II lymph node metastasis, with a diameter of 3.5 cm, demonstrating extranodal invasion (black arrowheads). (C) Volume rendering (VR) image derived from computed tomography angiography (CTA) displays the right maxillary sinus cancer colored green and the right facial artery colored red, demonstrating only the proximal part of the right middle meningeal artery (MMA). We could not evaluate the periphery of the MMA or the ipsilateral ophthalmic artery originating from the MMA.

It is supposed that the distal parts of the MMA and OphthA, originating from the MMA, were obscured by the bone subtraction process, along with the surrounding cranial bones forming the spinous foramen, during the generation of VR or MIP images on CT. The spinous foramen opens at the greater wing of the sphenoidal bone of the skull, through which the MMA and the meningeal branch of the mandibular trigeminal nerve pass. The diameter of the foramen ranges from 1.7 to 4.7 mm (with a mean of 2.5 mm on the right side and 2.9 mm on the left), and its length ranges from 5.3 mm to 14.8 mm (with a mean of 7.7 mm on the right side and 9.1 mm on the left) [14]. In addition, the mean diameter of the MMA is 1.3 mm, with a 95% confidence interval ranging from 1.3 to 1.4 mm [15]. The diameters of the spinous foramen and MMA are similar; therefore, the bone subtraction software cannot distinguish the MMA from the surrounding bony structures on CTA. It is possible to manually trace the MMA within the spinous foramen to generate VR or MIP images, this process requires extensive anatomical knowledge and is dependent on the creator. In contrast, ASL-MRA is unaffected by surrounding bony structures and can visualize the entire vascular structure of the ECA system. ASL-MRA may be useful for detecting anomalies in the ECA branches, which are small, meandering, and run through narrow spaces surrounded by bones, especially in cases of anastomosis with the ICA system.

OphthA can have an anomalous origin and an aberrant course, depending on the complex embryology. It typically arises from the proximal intradural segment of the ICA. The most common anomalous origin is the MMA, followed by the cavernous segment of the ICA. Other reported origins are the anterior cerebral artery, basilar artery, or posterior communicating artery [16,17]. It is essential for interventional radiologists to understand the variations in vascular anatomy before

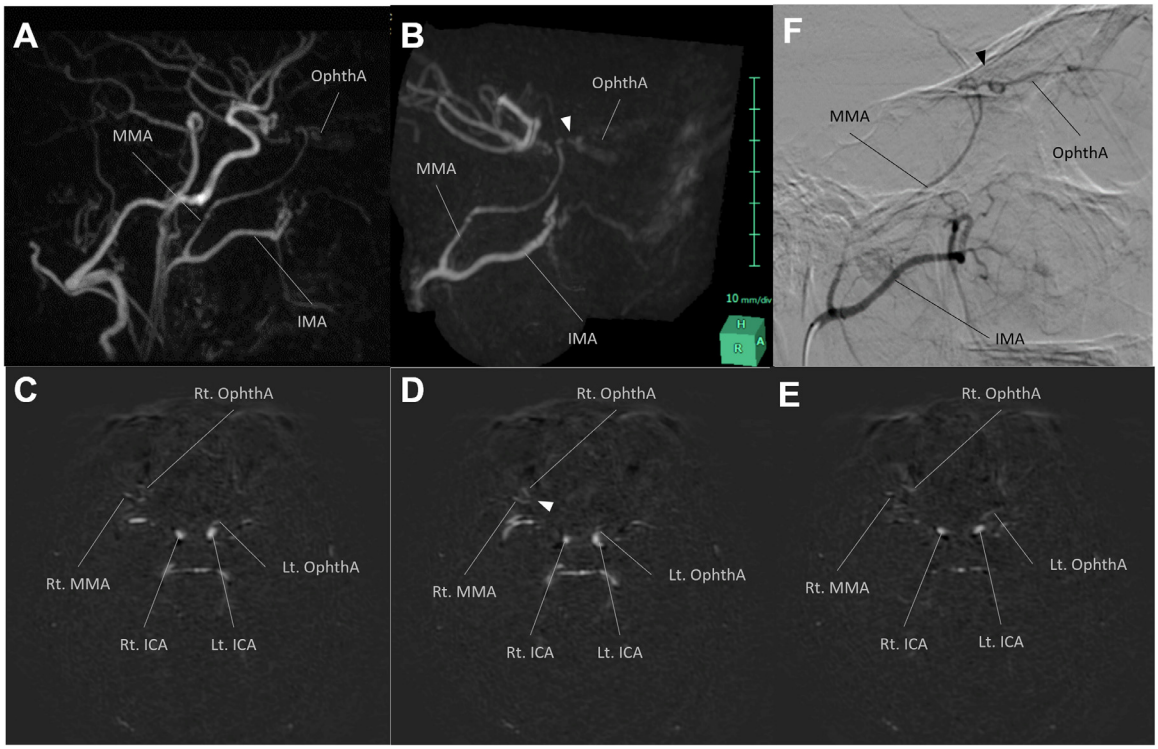

Fig. 2 – (A and B) Maximum intensity projection (MIP) image of arterial spin labeling (ASL) MR angiography (MRA) (ASL-MRA) and (C–E) the original axial images demonstrate the right middle meningeal artery (MMA) and the ipsilateral ophthalmic artery (OphthA). The MMA runs the right sphenoid bone and turns anteriorly into the orbit at the inferior orbital fissure (white arrowheads). (F) Angiography of the right internal maxillary artery (IMA) demonstrates the right OphthA originating from the MMA and bending anteriorly (black arrowhead), as demonstrated by the MIP images of ASL-MRA. Abbreviations: ICA, internal carotid artery; IMA, internal maxillary artery; Lt., left; MMA, middle meningeal artery; OphthA, ophthalmic artery; Rt., right.

the procedure to avoid the severe complications [16,18,19]. In patients with OphthA arising from the MMA, performing anticancer drugs proximal to the MMA origin during infusion can result in catastrophic ipsilateral vision loss if they are delivered to the OphthA [16]. CTA is commonly the first choice for preprocedural mapping. However, ASL-MRA may compensate for CTA by visualizing small arteries close to the bony structures. Further studies are needed to demonstrate the usefulness of ASL-MRA in preprocedural mapping in patients with head and neck cancer.

Conclusion

Here, we present a case in which ASL-MRA successfully visualized OphthA originating from the MMA well, which was not clearly depicted on CTA-VR/MIP images. We used both CTA and ASL-MRA for mapping and performed IACRT effectively without complications. CTA is the first choice for preprocedural mapping, but it may not adequately visualize small arteries located near bony structures, including anomalies of the MMA originating from the ECA system. In such cases, ASL-MRA may be a useful tool for easily visualizing these arteries.

Patient consent

Informed consent was obtained from the patient featured in this case report.

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