PICTORIAL REVIEW

Vascular supply with angio-CT for superselective intra-arterial chemotherapy in advanced maxillary sinus cancer

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ABSTRACT. Recently popularised, the combined angiography and CT (angio-CT) system is useful for correctly identifying the feeding arteries and their perfusion in various organs. We applied this system for advanced maxillary cancer to expose its feeding arteries and their supplying territories. In addition to the maxillary artery, extramaxillary feeding arteries were usually observed, including the ophthalmic, accessory meningeal, facial, transverse facial and ascending palatine arteries. These extramaxillary feeding arteries exhibited uniform tendencies, depending on the site of extramaxillary tumour extension.

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Combined therapy with radiotherapy and superselective intra-arterial chemotherapy for advanced maxillary sinus carcinoma has recently been attempted at many institutions to preserve the organ and improve prognosis [1–3]. Although the maxillary artery is the usual main feeder, we frequently encounter extramaxillary supplying arteries when tumours grow exophytically or invade adjacent organs. Therefore, interventional radiologists should be familiar with the imaging findings of the supplying arteries associated with maxillary cancer. In this pictorial review, we illustrate the feeding arteries (and their supplying territories) of advanced maxillary cancer using a combined angiography and CT (angio-CT) system, which provides more accurate vascular anatomy than digital subtraction angiography (DSA).

Patients and techniques

From January 2006 to July 2008, 56 sessions of superselective transarterial chemotherapy were performed in 14 patients with advanced maxillary cancer at our institutions. The patients comprised 10 men and 4 women, ranging in age from 42 to 80 years (mean, 60 years). The clinical T factors for these patients were T3 ($n=4$) and T4 ($n=10$).

All catheterisations were performed via a transfemoral approach, and systemic heparinisation was accomplished by intravenous administration of 3000 IU of heparin. Catheterisation of the external or internal carotid artery was performed using a 5-French standard headhunter

catheter. Superselective catheterisation of external carotid branches was performed with a coaxial catheter system using a 5-French catheter and 2.2-French microcatheter (SIRABE Piolax, Yokohama, Japan). DSA and angio-CT were performed using CT with a DSA system (Infinix VC; Toshiba, Tokyo, Japan). For DSA of internal or external carotid arteries, 6 ml of non-ionic contrast material (Iopamiron300, <300 mg iodine per mm; Bayer-Schering Pharma, Osaka, Japan) was injected at a rate of 4 ml s⁻¹. For the branches of the external carotid artery, 2–4 ml of non-ionic contrast material was injected at a rate of 0.7–1.5 ml s⁻¹. For the angio-CT study of the external or internal carotid arteries, 30 ml of Iopamiron-150 (<150 mg iodine per mm) was injected at a rate of 3 ml s⁻¹. For the external carotid branches, a total 10–20 ml of contrast medium was injected at a rate of 0.8–1.5 ml s⁻¹.

Feeding arteries

The feeding arteries are summarised in Figure 1. For all of the tumours, the maxillary artery was the main feeder. Five tumours were supplied by the ophthalmic artery, which is a branch of the internal carotid artery. All other extramaxillary feeding arteries were branches of the external carotid artery; three tumours were supplied by the accessory meningeal artery, six by the facial artery, four by the transverse facial artery and four by the ascending palatine artery.

Supplying territories of the feeding arteries

The internal maxillary artery supplied the tumours in the maxillary sinus and nasal cavity and the tumours' posterior

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Figure 1. Lateral view of the external carotid angiogram. A, artery.

extension to the retromaxillary fat pad and pterygopalatine fossa. Other arteries usually supplied tumour that extended to the extra maxillary sinus as follows:

- The ophthalmic artery supplied the tumour with upward extension to the orbit and ethmoid sinus.
- The accessory meningeal artery supplied the tumour with posterior extension to the pterygoid muscle.
- The facial artery supplied the tumour with medial frontal extension to the subcutaneous tissue and downward extension to the gingival.
- The transverse facial artery supplied the tumour with lateral frontal extension to the subcutaneous tissue.
- The ascending palatine artery supplied the tumour's downward extension to the palate.

Maxillary artery

The maxillary artery (Figure 2) is divided into three major portions based on its relationship to the external pterygoid muscle [4]. Usually, this artery is the main feeding artery of the maxillary cancer, supplying the tumours in the maxillary sinus and the tumours' posterior extension to the pterygopalatine fossa and retromaxillary fat pad (Figure 3a–d).

The first section of the maxillary artery courses along the lower border of the external pterygoid muscle, giving rise to two major branches: the middle meningeal artery and the inferior alveolar artery. The second section runs obliquely forward and upward, as well as medially, through the infratemporal fossa, usually superficial (although occasionally deep) to the external pterygoid muscle. The branches of this section are entirely muscular branches. The third section of the internal maxillary artery enters the pterygopalatine fossa and terminates by dividing into several branches.

To avoid drug infusion to the middle meningeal artery, which supplies the cavernous sinus region, or to

Figure 2. Selective angiogram of the maxillary artery. The white arrow indicates the middle meningeal artery; the arrowhead indicates the accessory meningeal artery; and the black arrow indicates the inferior alveolar artery.

the inferior alveolar artery, which supplies the inferior alveolar nerve, we recommend that the tip of the microcatheter should be advanced distally to the first section of the maxillary artery.

Accessory meningeal artery

The accessory meningeal artery is identified in 78% of cases by classical angiography; 75% of these arise from the middle meningeal artery and 25% arise from the maxillary artery [5]. When the tumour extends beyond the pterygopalatine fossa and invades the pterygoid muscle, the accessory meningeal artery is implicated in feeding the tumour (Figure 3e,f).

Ophthalmic artery

The ophthalmic artery acts as a frequent extramaxillary supplying vessel. The ophthalmic artery supplies the tumour's upward extension to the orbit and ethmoid sinus (Figure 4). Ethmoidal branches of the ophthalmic artery anastomose with the nasal branches of the maxillary artery, which indicates that the ophthalmic artery becomes the feeder for the tumour in the nasal cavity and maxillary sinus when the maxillary artery is hypoplastic or occluded [6].

Facial artery

The facial artery is the most common extramaxillary feeding vessel supplying maxillary cancer. When the tumour medial/frontal extends to the subcutaneous tissue (Figure 5a–c) or extends downward to the gingiva, the facial artery is implicated in feeding the tumour. The facial

Figure 3. A 42-year-old man with T4 right maxillary cancer. (a) An MR T_2 weighted image shows the tumour occupying the maxillary sinus and extending into the retromaxillary fat pad (black arrowheads) and pterygopalatine fossa (short white arrow). In addition, the tumour shows further extension to the medial pterygoid muscle (long white arrow). (b) Digital subtraction angiography (DSA) of the main trunk of the external carotid artery. (c) DSA of the second portion of the maxillary artery shows tumour staining. (d) In an angio-CT of the second section of the maxillary artery, almost all of the tumour (in the maxillary sinus, retromaxillary fat pad and pterygopalatine fossa) is enhanced. The tumour extending to the medial pterygoid muscle is not enhanced (arrowhead). (e) DSA of the middle meningeal artery depicts enhancement of the pterygoid muscle. The arrow indicates the middle meningeal artery, and the arrowhead the accessory meningeal artery. (f) Angio-CT of the middle meningeal artery shows definite enhancement of the tumour extending to the medial pterygoid muscle (arrowhead). MMA, middle meningeal artery; STA, superficial temporal artery.

and maxillary arteries have abundant anastomotic points, including buccal, masseteric and infraorbital anastomoses [7], which indicates that the facial artery acts as the main collateral pathway when the main maxillary trunk is occluded (Figure 6).

Transverse facial artery

The transverse facial artery usually arises near the origin of the superficial temporal artery. The usual supplying territory includes tumours with lateral frontal extension to the subcutaneous tissue (Figure 5d,e).

Ascending palatine artery

The ascending palatine artery arises close to the origin of the facial artery or directly from the external

carotid artery, and usually supplies the soft palate, tonsils and auditory tube. Importantly, this artery often forms an anastomosis with the ascending pharyngeal artery, which supplies the lower cranial nerves. When the tumour medial/downward extends to the palate, this artery is implicated in feeding the tumour (Figure 7).

Conclusions

An angio-CT system can clearly demonstrate the feeding arteries and their supplying territories in advanced maxillary cancer, and these arteries are fairly uniform. However, by using an angio-CT system, additional radiation dose, time to perform the procedure, volume of contrast material and cost are required compared with using DSA alone [2]. Knowledge of the

(a)

(b)

(c)

(d)

Figure 4. A 49-year-old man with T3 left maxillary cancer. (a) An MR T_2 weighed image shows the tumour extending to the ethmoid sinus. (b) Internal carotid angiogram of the arterial phase shows the dilated branches of the ophthalmic artery. The arrow indicates the posterior ethmoidal artery; the arrowheads indicate the nasal branches. (c) Internal carotid angiogram of the venous phase shows tumour staining (arrows). (d) Angio-CT of the internal carotid artery shows enhancement of the tumour extension to the ethmoid sinus.

Figure 5. A 73-year-old woman with T3 right maxillary cancer. (a) An MR T_2 weighted image shows the tumour extending into the subcutaneous tissue. (b) On digital subtraction angiography (DSA) of the facial artery, tumour staining in the subcutaneous tissue is suspected, although this finding is unclear. (c) Angio-CT of the facial artery clearly depicts enhancement of the tumour extension into the medial subcutaneous tissue. (d) DSA of the transverse facial artery does not depict any tumour staining. (e) Angio-CT of the transverse facial artery clearly depicts enhancement of the tumour extending into the lateral subcutaneous tissue.

(a)

(b)

(c)

Figure 6. A 60-year-old-man with recurrent maxillary cancer who had received combined therapy with radiotherapy and superselective intra-arterial chemotherapy 15 months earlier. (a) An MR T_2 weighed image shows the recurrent mass in the infratemporal fossa (arrowheads). The external carotid angiogram (not shown) revealed complete occlusion of the maxillary artery; digital subtraction angiography of the facial artery (b) showed abundant collateral vessels leading to the area of the internal maxillary artery (arrows). (c) Angio-CT of the facial artery shows enhancement of the recurrent tumour.

(a)

(b)

(c)

Figure 7. A 70-year-old woman with T4 right maxillary cancer. (a) The ascending palatine artery arises directly from the external carotid artery (arrow). (b) Digital subtraction angiography of the ascending palatine artery shows enhancement of the soft palate (arrow) and pharyngeal wall (arrowhead), but the presence of tumour staining is unclear. (c) Angio-CT of the ascending palatine artery shows enhancement of the tumour extending into the palate.

patterns of the feeding arteries and their supplying territories in advanced maxillary cancer can counteract the disadvantages of using an angio-CT system.

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