Int J Clin Oncol (1999) 4:327–330

ORIGINAL ARTICLE

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An anatomical study of the arteries for intraarterial chemotherapy of head and neck cancer

Received: February 12, 1999 / Accepted: July 28, 1999

Abstract
Background. The intraarterial approach is one of the most important routes for the administration of anticancer drugs for head and neck cancer. A profound knowledge of the anatomical characteristics and variations of the carotid artery, such as its branching pattern, length, and inner diameter, is essential to avoid complications with catheter insertion.
Methods. We conducted a morphometric investigation of head and neck arteries in 29 Japanese cadavers (58 sites).
Results. The branching pattern of the external carotid artery showed variations. In 65.5% of the cadavers, the lingual, facial, and superior thyroid arteries arose separately. However, in 31.0% of the cadavers, the lingual artery formed a common trunk with the facial artery, and in 3.5%, the lingual artery formed a common trunk with the superior thyroid artery. The transverse facial artery arose from the superficial temporal artery in 53.4% of the specimens, from the maxillary artery in 27.6%, and from a site central to the maxillary artery in 19.0%. The posterior auricular artery arose from the external carotid artery at the same level as the maxillary artery in 37.9% of specimens, and from a site central to the maxillary artery in 62.1%. The occipital artery arose from the external carotid artery at the same level as the maxillary artery in 55.2% of specimens, and from a site peripheral to the facial artery in 44.8%. The lengths from the auricular point to the origins of the upper branches of the external carotid artery were: 2.8mm to the transverse facial artery, 3.2cm to the maxillary artery, 3.8cm to the posterior auricular artery, 6.6cm to the occipital artery, 7.4cm to the facial artery, 8.8cm to the lingual artery, and 10.4cm to the superior thyroid artery.
Conclusions. These results, have led to some clarification of the clinicoanatomical basis for intraarterial infusion. These data should be helpful for assessing the approximate level of the catheter tip and for evaluating whether the catheter is placed appropriately, by transient staining of the infused area.

Key words Intraarterial chemotherapy · Head and neck cancer · Anatomical study

Introduction

Anticancer agents have been used, along with radiation therapy, to increase tumor-cell killing and for the palliative treatment of advanced head and neck cancers. Intraarterial chemotherapy for head and neck cancer has been used since 1950.[1] This procedure for head and neck cancer appears to allow high concentrations of antitumor agents, enhancing local disease regression with minimal systemic toxicity.[2–5] The side effects of arterial infusion including bleeding, arterial embolism, and thrombosis, were sometimes associated with catheter malposition,[4–7] and catheter malposition reduced the effects of the anticancer drug and could be responsible for an undesirable outcome. Catheter position has been checked by the injection of several milliliters of either 5% sodium fluorescein or 5% Evans-blue to produce transient staining of the infused area. Recently, subtraction angiography has been used, as it can reveal the exact position of the catheter tip.[8] Despite the usefulness of subtraction angiography, however, this method has been limited to certain institutions, because it needs particular techniques and equipment. Therefore, blind catheterization is still the most common approach. The purpose of the present study was to establish the clinicoanatomical basis of the carotid artery by morphological and morphometric examination of Japanese cadavers.

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Materials and methods

We examined the carotid vessels in 58 sites of 29 Japanese cadavers. The subjects had been aged between 38 and 93 years. The following anatomical features were examined: variation in the branching patterns of the carotid artery and distances among the branches of the external carotid artery, as well as the inner diameter of these branches. The distances from the auricular point to the points where each branche arose (transverse facial, maxillary, posterior auricular, occipital, facial, lingual, and superior thyroid arteries) were measured. The inner diameters of the vessels were measured with a digital caliper (Mitsutoyo, Tokyo, Japan) at points 1,2, and 3 cm from the division of each branch. Segments of vessels, 2- to 3-mm in length, were removed from each measured site and cut open lengthwise with micro-scissors. The circumference was measured, from which the inner diameter was calculated (inner diameter = circumference/π) and the mean value was obtained. Measurements were made with a stereoscopic microscope (SMZ-10; Nikon, Tokyo, Japan) and a digital measuring system (D-10S; linear gauge and 5S counter, Ozaki, Tokyo, Japan) to calculate the mean. Differences between the inner diameters of vessels at the measured sites were tested using the Wilcoxon single-rank test. Differences between the right and left sides were tested by Mann-Whitney *U*-tests. The significance level was set at 5% for each analysis.

Results

Variations in the branching patterns of the external carotid artery are shown in Fig. 1 and the distances from the auricular point to each branching point are shown in Fig. 2. Table 1 shows the inner diameter of each examined vessel. The lingual, facial, and superior thyroid arteries arose separately from the external carotid artery in 65.5% of the specimens. A faciolingual trunk was observed in 31.0% of specimens, and a thyrolingual trunk was observed in 3.5%. Thyrolinguofacial and faciomaxillary trunks were not observed in this study. While the transverse facial artery arose from the superficial temporal artery in half of the specimens, in other specimens this artery arose together with the maxillary artery, and in others, it arose from a site central to the maxillary artery. The posterior auricular artery arose posteriorly from the external carotid at the same level as the maxillary artery in 37.9% of specimens, and in the other specimens arose from the external carotid artery at a site central to the maxillary artery. The occipital artery arose from the external carotid artery at the same level as the maxillary artery in 55.2% of specimens, and in the remainder it arose from a site peripheral to the facial artery.

Figure 2 shows the average length from the auricular point to each arterial division. There were no significant differences in length between the right and left side arteries of each cadaver. There were also no significant differences between the inner diameters of the arteries of the right and

Table 1. Inner diameter of head and neck arteries

	Inner diameter (mm)	
	Right (mean ± SD)	Left (mean ± SD)
Superficial temporal artery	1.7 ± 0.4	1.7 ± 0.5
Maxillary artery	2.3 ± 0.3	2.3 ± 0.4
Facial artery	1.9 ± 0.4	2.2 ± 0.5
Lingual artery	1.6 ± 0.4	1.8 ± 0.4
Superior thyroid artery	1.4 ± 0.3	1.7 ± 0.4

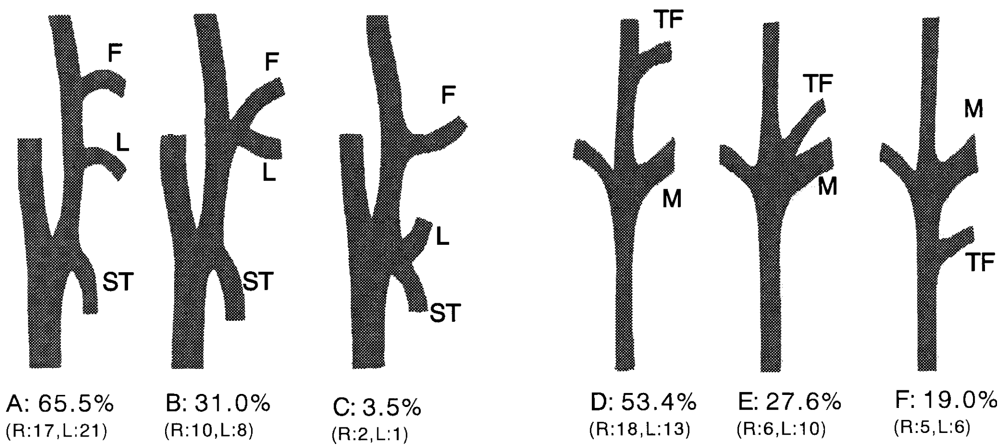

Fig. 1A–F. Branching patterns of the external carotid artery. **A**, **B**, and **C** illustrate the branching patterns of the facial (*F*), lingual (*L*), and superior thyroid (*ST*) arteries. **D**, **E**, and **F** illustrate the branching patterns of the transverse facial (*TF*) and maxillary (*M*) arteries. **A** Common branching pattern (facial, lingual, and superior thyroid arteries arising separately) was observed in 65.5% of specimens (17 of 29 on the right side [*R*] and 21 of 29 on the left side [*L*]). **B** Faciolingual trunks were observed in 31.0% of specimens (R, 10; L, 8). **C** Thyrolingual trunks were observed in 3.5% of specimens (R, 2; L, 1). **D** Transverse facial artery arising peripherally on the same side as the maxillary artery was observed in 53.4% of specimens (R, 18; L, 13). **E** Transverse facial artery arising with the maxillary artery was observed in 27.6% of specimens (R, 6; L, 10). **F** Transverse facial artery arising central to the maxillary artery was observed in 19.0% of specimens (R, 5; L, 6)

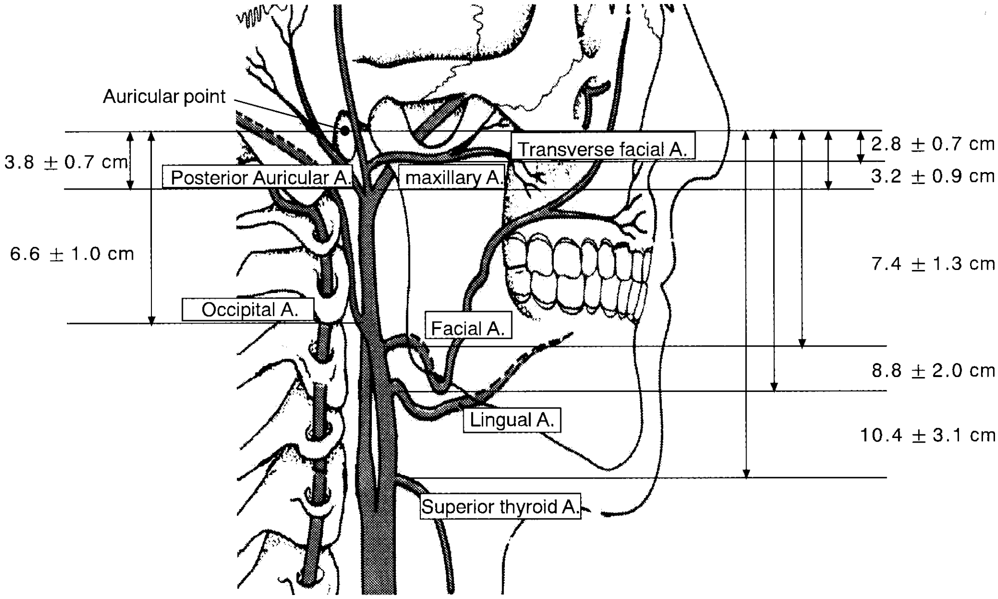

Fig. 2. Distance (mean ± SD) from auricular point to each branch of the external carotid artery. The mean distances from the auricular point were: 2.8 ± 0.7 cm to the transverse facial artery (*A*). (Right side [R], 2.6 ± 0.7; left side [L], 3.0 ± 0.7 cm); 3.2 ± 0.9 cm to the maxillary A (R, 3.0 ± 0.7; L, 3.5 ± 1.0 cm); 3.8 ± 0.7 cm to the posterior auricular A (R, 3.7 ± 0.6; L, 3.9 ± 0.8 cm); 6.6 ± 1.0 cm to the occipital A (R, 6.3 ± 1.2; L, 6.9 ± 0.8 cm); 7.4 ± 1.3 cm to the facial A (R, 7.5 ± 1.2; L, 7.2 ± 1.3); 8.8 ± 2.0 cm to the lingual A (R, 8.2 ± 2.1; L, 9.0 ± 1.8 cm); 10.4 ± 3.1 cm to the superior thyroid A (R, 10.2 ± 3.2; L, 10.5 ± 3.0 cm). There was no significant difference between the distances on the right and left sides

left sides (Table 1). The inner diameters of the superficial temporal, facial, lingual, and superior thyroid branches of the external carotid artery were very similar, while that of the maxillary artery was significantly greater ($P < 0.05$) (Table 1).

Discussion

It is generally acknowledged that intraarterial chemotherapy produces higher regional concentrations of cytotoxic agents. Despite equivalent or higher concentration in the tumor, systemic toxicity may be less pronounced when a drug is delivered intraarterially than when is administrated systemically.[9] Many reports have shown the advantage of the intraarterial method for head and neck cancer.[3–5,7] However, intraarterial chemotherapy for head and neck cancer has a high incidence of catheter-related complications.[6] The most common complications, besides infection and bleeding at the catheter site, were catheter-embolism and malposition of the catheter tip.[6,7] These complications were related to variations in the branching, length, and inner diameters of the vessels.[6,7]

Some authors have described the risk of complications with catheter malposition.[4–7] Freckman[4] reported that catheter displacement occurred in 5.9% of 169 patients. Recently, digital subtraction angiography has been used to reveal the exact position of the catheter tip, avoiding some of the potential complications of intraarterial chemotherapy.[8] This method is excellent for determining the proper positioning of the catheter; however, the techniques and equipment, such as digital fluorography X-ray, are still limited to certain institutions. Therefore, in many institutions, intraarterial catheterization is usually done blindly. The position of the tip of the catheter can be assessed by injecting several milliliters of either 5% sodium fluorescein or 5% Evans-blue through the catheter to produce transient staining of the infused area.[2–6] Even when we use transient staining for defermination of the infused area, it is important to know the anatomical variations of the external carotid artery, because clinicoanatomical information, (such as variations in the branches, their length, and their inner diameter) is useful to determine the approximate position for catheter insertion, and to evaluate whether the catheter is placed properly, as shown by the transiently stained area.

In this study, the facial, lingual, and superior thyroid arteries presented two variations different from the regular branching pattern. There were faciolingual trunks in 31.0% of the specimens and a thyrolingual trunk in 3.5%. Our observations in Japanese cadavers showed a higher frequency of anatomical variations of the faciolingual and thyrolingual trunks compared with the observations made by Ronald.[10] He reported that a faciolingual trunk was present in only 10% to 20% of subjects and that a thyrolingual trunk was very unusual.[10] There has been no detailed report about the variations of the superficial temporal artery and the transverse facial artery. Ronald[10] reported only that the transverse facial branch may arise from the superficial temporal artery, and that there were sometimes two branches. In the present study, in 53.4% of the specimens, the transverse facial arteries originated from the superficial temporal artery, but in 27.6% of the specimens this artery arose with the maxillary artery, while in 19.0% of the specimens, it originated from a site central to the maxillary artery. We also studied variations of the posterior auricular artery, and in 37.9% of the specimens, this artery arose from the external carotid artery at the same level as the maxillary artery, and in the remainder it arose from a site central to the maxillary artery. In general, it has been noted that the transverse facial artery arose from a site peripheral to the maxillary artery, and the posterior auricular artery arose at the same level as the maxillary artery.[11,12] The relationships between the facial artery and the occipital artery were also varied. Some authors reported that the occipital artery arose from a site central to the facial artery.[11,12] In our study, in 45% of the specimens this artery arose from a site peripheral to the facial artery. These findings of the branching patterns provide useful information for the proper positioning of the catheter tip determined by transient staining of the area.

We found that the mean length from the auricular point of the external carotid artery to the branching of the arteries was 2.8 mm to the transverse facial artery, 3.2 cm to the maxillary artery, 3.8 cm to the posterior auricular artery, 6.6 cm to the occipital artery, 7.4 cm to the facial artery, 8.8 cm to the lingual artery, and 10.4 cm to the superior thyroid artery. These data can be clinically applied to assess the approximate level of the catheter tip, and to evaluate whether the catheter tip is placed properly, by transient staining of the infused area. Satou et al.[13] described a method for intraarterial chemotherapy and established some measurements, using the tragus of the ear as a landmark. According to their observations, the mean distances from the tragus were: 5 cm to the maxillary artery, 9 cm to the facial artery, and 10 cm to the lingual artery. Our findings in the cadavers were similar to their clinical measurements. We found that the inner diameter of the external carotid branches mean value for right and left sides was 1.7 mm for the superficial temporal artery, 2.3 mm for the maxillary artery, 2.0 mm for the facial artery, 1.7 mm for the lingual artery, and 1.5 mm for the superior thyroid artery. Although there may be differences in the diameters of the corresponding vessels in a living person, these data appear to be of great value for determining catheter selection and placement.

In conclusion, from these results, some of the clinicoanatomical basis for intraarterial infusion has been clarified. These pieces of anatomic information should be considered as important guidelines for catheterization in the intraarterial chemotherapy of head and neck cancer.

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