Clinical Anatomy in the Neck Region – The Position of External and Internal Carotid Arteries May be Reversed –

By

Hideshi ITO, Izumi MATAGA, *Ikuo KAGEYAMA and *Kan KOBAYASHI

The Nippon Dental University, School of Dentistry at Niigata, Department of Oral and Maxillofacial Surgery II, *Department of Anatomy

– Received for Publication, April 26, 2005 –

Key Words: Neck dissection, Common carotid artery, Hypoglossal nerve, External jugular vein, Cervical ansa, Vessel measurement

Summary: Knowledge of clinical anatomy in the neck region is useful for the diagnosis of primary tumors and metastatic lymph nodes. Arteries and nerves in the neck region of forty Japanese cadavers (80 cases), 18 males (36 cases) and 22 females (44 sides) were studied by dissection. We obtained the following results. Reverse of the location of the external and internal carotid arteries was found in 5 cases (6.3%). The course of the hypoglossal nerve made an acute curve and ran anterior-inferior in the neck region. In regard to the height of bifurcation of the common carotid artery (CC), high bifurcation was seen in 25 (31.2%), standard bifurcation in 46 (57.5%), and low bifurcation in 9 (11.3%) in a total of 80 cases. Furthermore, the facial artery had the largest inner diameter among the branches of the external carotid artery. Based on these findings, the facial artery will be one of the most beneficial arteries for transplantation as a recipient artery.

Knowledge of clinical anatomy in the neck region is useful for the diagnosis of primary tumors and metastatic lymph nodes\(^1\). Fundamental procedures of neck dissections are classified by the method of preservation of the internal jugular vein, the sternocleidomastoid muscle and the accessory nerve. The dissected region will be decided on an anatomical basis for the trapezius and omohyoid muscles. Many variations regarding arteries and nerves in the neck area have been observed. Knowledge of the possible pattern of origin, course, and distribution of the vessels and nerves is necessary to obtain safe dissection of the neck. Although we need more precise information regarding the structure in the neck, we still have limited knowledge due to the many morphological variations for each individual. Therefore, we tried to clarify the limited anatomical knowledge regarding vessels and nerves in the neck.

Materials and Methods

1. Materials
Forty cadavers (80 cases), 18 males (36 cases) and 22 females (44 sides) were studied by dissection in the Nippon Dental University School of Dentistry at Niigata. The age of the cadavers ranged from 44 to 102-years-old. The average age of the cadavers was 75.7 ± 13.0 years (Table 1). In all the cadavers, 10 of the following solution was injected into the femoral arteries: alcohol, 70%; formalin, 5%; phenols, 5%; and glycerin, 5%. After the 1\(^{st}\) fixation, the cadavers were preserved in a tank for acute fixation.

2. Methods
After reflection of the skin toward the lateral side in the neck portion, we dissected the platysma carefully and made markers for fine nerves and

Corresponding Author: Hideshi Ito, D.D.S. Ph.D., Department of Oral and Maxillofacial Surgery II, The Nippon Dental University School of Dentistry at Niigata, 1-8 Hamaura-cho, Niigata-city, 951-8580 Japan. e-mail: hidesan@ngt.ndu.ac.jp
vessels on the muscle with brightly colored threads. Then we reflected the platysma upwards to reveal the sternocleidomastoid muscle. We cut the sternal and clavicle parts of the muscle near the origin, then reflected the muscle toward the lateral side. After reflection, we carefully dissected the fine twigs of the vessels and arteries in the deep layer, and in particular we removed the connective tissue of the carotid sheath to dissect the common carotid artery, the internal jugular vein and the vagus nerve. Furthermore, we studied the relationship between the cervical ansa and the infrahyoid muscles, namely, the sternohyoid, sternothyroid, thyrohyoid and omohyoid muscles, the course of the nerve to the thyrohyoid, the branch of the hypoglossal nerve and the distribution pattern of the arteries and veins in the neck region. Photographs we’re taken and anatomical sketches made at each step. We recorded the data and discussed our findings.

### Observation Items

1. Location of the external and internal carotid arteries
2. Height of bifurcation of the common carotid artery (CC)
3. Confluent part of the external jugular vein
4. Course of the hypoglossal nerve
5. Course of the cervical ansa
6. Measurements of the inner diameters of the main arteries

#### 1. Location of the external and internal carotid arteries

We classified the location of the external and internal carotid arteries into two types. In the standard type, the external carotid artery was located anterior to the internal carotid artery. In the reversed type, the position of the external and internal carotid arteries was reversed, namely the internal carotid artery was located anterior to the external carotid artery (Fig. 1).

#### 2. Height of bifurcation of the common carotid artery

After dissection of the CC, the external and the internal arteries, the height of CC bifurcation was classified into three types with the level of the transverse process of the cervical vertebrae. High bifurcation included division of the CC between the level of the second and third cervical vertebrae or above the second vertebra. Standard bifurcation was when the CC divided at the level of fourth vertebra, and low bifurcation meant that the CC divided between the fourth and fifth vertebrae or below the fifth vertebra (Fig. 2). Furthermore, the origin and course of the superior thyroid, lingual and facial arteries were observed.

#### 3. Confluent part of the external jugular vein

We observed the confluent part of the external jugular to the other veins. We classified it into three types. Type 1, in which the external jugular vein emptied directly into the subclavian vein; Type 2,

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>40~49 years old</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>50~59 years old</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>60~69 years old</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>70~79 years old</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>80~89 years old</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>90~99 years old</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>over 100 years old</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>22</strong></td>
<td><strong>40</strong></td>
</tr>
</tbody>
</table>
in which the vein emptied into the venous angle (the influence between the internal jugular and subclavian veins); and Type 3, in which the vein emptied into the internal jugular vein (Fig. 3).

4. Course of the hypoglossal nerve
The relationship between the course of the hypoglossal nerve and the bifurcation of the CC was studied (Fig. 4).

5. Course of the cervical ansa
According to Kikuchi’s classification, basically two types were observed. In the lateral type, the superior root and the inferior root made the cervical ansa superficial to the internal jugular vein. In the medial type, the two roots made the cervical ansa deep to the internal jugular vein (Fig. 5).

6. Measurements of the inner diameter of the main arteries
Fifty-six sides were measured using a suitably equipped stereomicroscope, because we had difficulties in measurement due to prior damage caused by a student dissection course. We chose four main arteries; the external carotid, superior thyroid, lingual, and facial arteries (Fig. 6). We followed Shimai’s method, which measured the inner diameter of arteries under the comparison between Japanese and German specimens.
Method of Measurements

In the superior thyroid, lingual and facial arteries, the arteries were cut lengthwise at 1 and 3 cm distal to their origin. In the external carotid artery, the artery was cut lengthwise at 1 and 2 cm. All specimens were placed on a black corkboard. Each circumference was measured, and the internal diameter was calculated (Fig. 7). Measurements were made with a stereoscopic microscope (STEREO PHOTO SMZ-10) and digital caliper (DIGIMATIC CALIPER 500-110). To calculate the average for each site, all samples were mea-
sured three times. Differences in the internal diameter were tested by the Wilcoxon signed ranks test \((p < 0.05)\). Differences between the right and left sides were also tested by the Wilcoxon signed sum test \((p < 0.05)\).

**Results**

1. **Location of the external and internal carotid arteries**
   Reversal of the location of the external and internal carotid arteries was found in 5 cases (6.3%). In all cases, the superior thyroid, lingual and facial arteries arose from the posterior margin of the external carotid artery, then ran forward superior to the internal carotid artery (Fig. 8).

2. **Height of bifurcation of the common carotid artery**
   In regard to the height of bifurcation of the CC, high bifurcation was seen in 25 (31.2%), standard bifurcation in 46 (57.5%), and low bifurcation in 9 (11.3%) of a total of 80 cases (36 males, 44 females). In males, high bifurcation was seen in 14 (38.9%), standard and low bifurcation in 20 (55.6%) and 2 (5.5%) respectively. In females, high bifurcation was seen in 11 (25.0%), standard and low bifurcations in 26 (59.0%) and 7 (16.0%) respectively. The height of bifurcation tended to be lower in males than in females (Table 2). Regarding side differences, a different bifurcation level in both sides was seen in 15 cases (37.5%). There was only one case which had a high bifurcation on the left side and a low bifurcation on the right side (Fig. 9). Frequent common stems in the superior thyroid artery, lingual, and facial arteries was observed in 18 cases (22.5%). A common stem between the facial and lingual arteries was found in 14 cases (17.5%), and between the lingual and the superior thyroid arteries in 4 cases (5.0%). Although common stems were found in 8 cases (44.4%) in the high bifurcation group and 10 cases (55.6%) in the standard bifurcation group, no common stem was observed in the low bifurcation group.

Fig. 10 shows a typical case of a high bifurcation in the left neck and Fig. 11 indicates a typical case of a low bifurcation.

3. **Confluent part of the external jugular vein**
   In Type 1 the external jugular vein emptied directly into the subclavian vein, Type 2 into the venous angle and Type 3 into the internal jugular vein. Forty cases (50.0%) were observed of Type 1, 30 cases (37.5%) of Type 2, and 8 cases (10.0%) of Type 3. Observation was impossible in 2 cases due to previous damage in this area from a student dissection course.

4. **Course of the hypoglossal nerve**
   Although no relationship between the course of the hypoglossal nerve and the bifurcation of the CC was observed, the hypoglossal nerve made a gentle curve in which the hypoglossal nerve crossed the sternocleidomastoid branch or a branch of the occipital artery.

5. **Course of the cervical ansa**
   The lateral type was seen in 39 cases (48.8%), the medial type in 35 cases (43.7%), and 6 cases were impossible to determine due to previous damage.

6. **Measurements of the inner diameter of main arteries**
   The inner diameter of the superior thyroid artery at 1 cm distal to the origin (point A) was 1.8 mm (max), 0.6 mm (min), and 1.1 \(\pm 0.3\) mm (mean). The inner diameter of the artery at 3 cm distal to the origin (point A') was 1.7 mm (max), 0.6 mm (min), and 1.0 \(\pm 0.8\) mm (mean). The inner diameter of the lingual artery at 1 cm distal to the origin (point B) was 2.8 mm (max), 0.7 mm (min), and 1.3 \(\pm 0.4\) mm (mean). The inner diameter of the artery at 3 cm distal to the origin (point B') was 2.2 mm (max), 0.6 mm (min), and 1.2 \(\pm 0.3\) mm (mean). The inner diameter of the facial artery at 1 cm distal to the origin (point C) was 2.2 mm (max), 0.7 mm (min), and 1.5 \(\pm 0.4\) mm (mean). The inner diameter of the artery at 3 cm distal to the origin (point C') was 2.2 mm (max), 0.7 mm (min), and 1.4 \(\pm 0.3\) mm (mean). The inner diameter of the external carotid artery at 1 cm distal to the common carotid artery (point D) was 5.0 mm (max), 2.0 mm (min), and 3.5 \(\pm 0.7\) mm (mean). The inner diameter of the artery at 2 cm distal to the origin (point D') was 4.8 mm (max); 1.2 mm (min), and 2.7 \(\pm 0.8\) mm (mean) (Table 3).

**Discussion**

The margins of the standard radical neck dissection are decided as follows. The upper margin is the inferior margin of the mandible, the lower is the supraclavicle, the posterior is the trapezius muscle, and the deep are the obliques muscles. Fat tissue, fascia, interfascial lymph nodes and vessels and lymph nodes surrounding vessels were removed as well as the internal jugular vein, sternocleidomastoid muscle, and accessory nerve. According to Matsuura\(^3\) and Kamata\(^4\), a modified neck dissec-
Fig. 8. The positions of reversed external and internal arteries.

Upper left: Right side neck distant view, photographic findings.
Upper right: Right side neck close-up view, photographic findings.
Lower left: Right side neck distant view, anatomical sketch.
Lower right: Right side neck close-up view, anatomical sketch.

tion is recommended due to the preservation of function and morphology after an operation. This method will preserve one of the following, namely, the internal jugular vein, sternocleidomastoid muscle, and accessory nerve. To these have also been added the supraomohyoid neck dissection in which anatomical structures are removed above the omohyoid muscle. These procedures are quite similar to international classification\(^5,6\).

On the other hand, some structures must be preserved due to post-operative function such like the common carotid artery, vagus, especially the recurrent laryngeal nerve, hypoglossal and phrenic nerves. We need more precise knowledge regarding these vessels and nerves.

The external and internal carotid arteries commonly arise from the common carotid artery, whereinafter, the external carotid artery is locate anteriorly to the internal carotid artery. Reversal of the location of the external and internal carotid arteries was found in 5 cases (6.3%). In all of the cases, the superior thyroid, lingual and facial arteries arose from the external carotid artery, then ran forward superiorly to the internal carotid artery. The occipital artery arose from the anterior margin of the external carotid artery, then ran deeply to the external carotid artery and was distributed to the occipital region. According to Jazuta\(^7\), the percentage of reversal of the location between the external and internal carotid arteries was 4.5% in adults. Our present data showed a similar result. Although the reason why this reversal of the location of the two arteries is still not clear, operations should proceed carefully in the case of the neck dissection and in the case of an emergency ligature of the external carotid artery to stop bleeding.

According to Adachi\(^8\), in 171 cases (80%) out of 214 cases, the height of bifurcation of the CC was located between the transverse process of the third and fourth cervical vertebrae. According to Toyota\(^9\), the height of bifurcation of the CC was at the level of the third vertebra in 240 arteries (147 Japanese subjects) using cephaloangiography. In our results, high bifurcation occurred in 25 (31.2%), standard bifurcation in 46 (57.5%), and low bifur-

<table>
<thead>
<tr>
<th></th>
<th>High bifurcation type (%)</th>
<th>Standard bifurcation type (%)</th>
<th>Low bifurcation type (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>14 (38.9)</td>
<td>20 (55.6)</td>
<td>2 (5.5)</td>
</tr>
<tr>
<td>Female</td>
<td>11 (25.0)</td>
<td>26 (59.0)</td>
<td>7 (16.0)</td>
</tr>
<tr>
<td>Total</td>
<td>25 (31.2)</td>
<td>46 (57.5)</td>
<td>9 (11.3)</td>
</tr>
</tbody>
</table>

Fig. 9. Difference of the bifurcation in the same individual.
*: Bifurcation of the common carotid artery, CC: Common carotid artery.
Fig. 10. A typical case of high bifurcation in the left neck.

Fig. 11. A typical case of low bifurcation in the right neck.
According to Adachi et al., cases (55.6%) in the standard bifurcation group, no cases (44.4%) in the high bifurcation group and 10 (5.0%). Although the common stem was found 8 lingual and facial arteries in 4 cases was found in 14 cases (17.5%), and between the served in 18 cases out of 80 cases (22.5%). A common stem between the lingual and facial arteries was observed in 13 cases (21.7%) and the stem between the superior thyroid and lingual arteries was observed in one case (1.7%), namely in 14 cases out of 60 cases common stems were observed using German cadavers. The result of our present study was very similar to the result of the German study. Frequency of a common stem between the lingual and facial arteries was greater than that of the lingual and superior arteries.

Furthermore, the superior thyroid artery tends to be an independent branch in comparison with the lingual and facial arteries. According to Adachi, in 28 cases (13.3%) out of 214, the superior thyroid artery arose from the common carotid artery and in 58 cases (27.3%), the superior thyroid artery originated from near a bifurcation of the common carotid arteries. The reasons why there are less common stem cases in the superior thyroid artery is enough space exists for the origin of the superior thyroid artery, because the superior thyroid artery is the first branch of the external carotid artery after the bifurcation of the CC. However, according to Sato et al., the suggested reason was that each artery has a different course. Namely, the course of the lingual and facial arteries run superiorly from the hyoid bone, and the course of the superior thyroid runs artery inferiorly from the hyoid bone.

According to Mochizuki, the percentages of the external jugular vein which emptied directly into the subclavian vein (Type 1) was 49.9%, into the venous angle (Type 2) was 36.6%, and into the internal jugular vein (Type 3) was 12.5%, respectively. In our present study, we obtained a similar result, forty cases (50.0%) were observed of Type 1, 30 cases (37.5%) of Type 2, and 8 cases (10.0%) of Type 3. Two cases were difficult to observe due to previous damage caused to the region by a student dissection course. On the base of the results, if a ligation of the internal jugular vein is made at the upper clavicle margin, the blood stream of the external carotid artery might be blocked.

The hypoglossal nerve is an important nerve for movement of the tongue. Although the inter-relationship between the course of the hypoglossal

<table>
<thead>
<tr>
<th>Blood vessel diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior thyroid artery</td>
</tr>
<tr>
<td>Lingual artery</td>
</tr>
<tr>
<td>Facial artery</td>
</tr>
<tr>
<td>External carotid artery</td>
</tr>
</tbody>
</table>

Table 3.

cation in 9 (11.3%) in a total of 80 cases. The percentage of the standard type in our study is a little smaller than that of previous data.

A difference in bifurcation of the CC between the right and left was not found, however, the left side was little higher than the right. The height of bifurcation tended to be lower in males than in females. Regarding the side differences, a different bifurcation at each side was seen in 15 cases (37.5%). There was only one case which had a high bifurcation on the left side and a low bifurcation on the right. We suggest that a cause of these results is a morphogenetic difference between the external and internal carotid arteries. According to Sadler, embryologically, the external carotid artery arises from the third aortic arch and unites parts of the first and second aortic arches. A part of origin of the internal carotid artery arises from the third aortic arch and the remainders of the artery arise from the cranial part of the dorsal aorta. The level of the bifurcation of the CC might be decided depending on how the internal carotid artery takes in the segment of the third aortic arch. In our present study, high bifurcation was when the common carotid artery divided between the level of the second and third cervical vertebrae or above the hyoid bone, and low bifurcation was when the CC divided between the fourth and fifth vertebrae or near the thyroid cartilage.

Frequency of a common stem in the superior thyroid artery, lingual, and facial arteries was observed in 18 cases out of 80 cases (22.5%). A common stem between the facial and lingual arteries was found in 14 cases (17.5%), and between the lingual and the superior thyroid arteries in 4 cases (5.0%). Although the common stem was found 8 cases (44.4%) in the high bifurcation group and 10 cases (55.6%) in the standard bifurcation group, no common stem was observed in the low bifurcation group. According to Adachi, frequency of the common stem of superior thyroid, lingual and facial arteries increased in the high bifurcation group. We obtained a similar result in our present study. In the case of high bifurcation, branches of the external carotid artery tended to be a common stem due to the limited space of the external artery, however, in the case of low bifurcation, the branches of the external carotid artery which are the superior thyroid, lingual and facial arteries tended to be independent arteries because the external carotid artery has more space.

According to Shima et al., a common stem between the lingual and facial arteries was observed in 13 cases (21.7%) and the stem between the superior thyroid and lingual arteries was observed in one case (1.7%), namely in 14 cases out of 60 cases common stems were observed using German cadavers. The result of our present study was very similar to the result of the German study. Frequency of a common stem between the lingual and facial arteries was greater than that of the lingual and superior arteries.
nerve and the level of bifurcation of the CC was not observed clearly, the nerve tended to take a gentle curve in the neck region and at the low bifurcation of the CC. The nerve looped round the inferior sternocleidomastoid branch of the occipital artery and having crossed the internal and external carotid arteries, it crossed the loop of the lingual artery a little above the tip of the greater cornu of the hyoid bone, being itself crossed by the facial vein. The superior and inferior branches of the occipital artery ran to the sternocleidomastoid muscle. We speculated that the inferior branch might have an influence on the curved course of the hypoglossal nerve. According to Sato et al., the location of the occipital artery presumably decided the course of the hypoglossal nerve. Namely, the course of the occipital artery ran along the inferior margin of the posterior belly of the digastric muscle, and reached medial to the mastoid process. The artery then pierced the propria dorsalis and trapezius muscles, and was distributed to the sternocleidomastoid and the propria dorsalis muscles.

The lateral type was found in 39 cases (48.8%), the medial type in 35 cases (43.7%), and in 6 cases the type was impossible to determine due to previous damage. The cervical ansa is the nerve of the suprahyoid muscles, and usually consists of the superior and inferior roots. The superior root consists of the 1st, 2nd cervical and hypoglossal nerves, while the inferior root consists of the 2nd, 3rd and 4th cervical nerves. There are two types: the medial and lateral types. In the lateral type, the superior and inferior roots make a typical ansa superficial to the internal jugular vein and in the medial type, the superior and inferior roots make an incomplete ansa deep to the internal jugular vein. According to Kazama and Kikuchi, the percentages of the lateral type were 35.5%, 40.6% respectively. In this study, our result indicated the percentage of the lateral type were 35.5%, 40.6% respectively. In this reason, the facial artery had the largest inner diameter among the branches of the external carotid artery. The reason why the distal diameter was larger than the mesial was because there are many anastomosis in the distal part of the superior thyroid artery. The facial artery had the largest inner diameter among the branches of the external carotid artery. From this reason, the facial artery will be one of the most beneficial arteries for transplantation as a recipient artery.

Conclusions

Arteries and nerves in the neck region of forty cadavers (80 cases), 18 males (36 cases) and 22 females (44 sides) were studied by dissection. After precise dissection using a well-equipped stereomicroscope, photography and anatomical sketching was performed at each step. We obtained the following results.

1. Reversal of the location of the external and internal carotid arteries was found in 5 cases (6.3%).
2. In regard to the height of bifurcation of the CC, high bifurcation was seen in 25 (31.2%), standard bifurcation in 46 (57.5%), and low bifurcation in 9 (11.3%) of totally 80 cases (36 males, 44 females).
A frequency of a common stem in the superior thyroid artery, lingual, and facial arteries was observed in 18 cases out of 80 cases (22.5%).

3. Type 1 was where the external jugular vein directly emptied into the subclavian vein, Type 2 into the venous angle and Type 3 into the internal jugular vein. Forty cases (50.0%) were observed in Type 1, 30 cases (37.5%) in Type 2, and 8 cases (10.0%) in Type 3.

4. The course of the hypoglossal nerve made an acute curve and ran anterior-inferior in the neck region in the case of no branches to the sternocleidomastoid muscle, however, the nerve made a gentle curve when branches to the sternocleidomastoid muscle existed.

5. The lateral type of the cervical ansa was seen in 39 cases (48.8%), while medial type was seen in 35 cases (43.7%).

6. The inner diameters of the superior thyroid artery at 1 cm and 3 cm distal to the origin were 1.1 ± 0.3 mm and 1.0 ± 0.8 mm, respectively. The inner diameters of the lingual artery at 1 cm and 3 cm distal to the origin were 1.3 ± 0.4 mm and 1.2 ± 0.3 mm and the inner diameters of the facial artery at 1 cm and 3 cm distal to the origin were 1.5 ± 0.4 mm and 1.4 ± 0.3 mm. The inner diameters of external carotid artery at 1 cm and 2 cm distal to the origin were 3.5 ± 0.7 mm and 2.7 ± 0.8 mm, respectively.

Acknowledgement

We acknowledge with thanks the assistance of all staff of the Department of Maxillofacial Surgery II and the Department of Anatomy, the Nippon Dental University School of Dentistry at Niigata.

References