Nasal Arterial Vasculature

Medical and Surgical Applications

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Objectives: To analyze the nasal superficial arterial vasculature and to compare these anatomic findings with the results of ultrasonography Doppler investigations to evaluate nasal blood flow in physiological and pathologic conditions.

Methods: We performed 40 ultrasonography Doppler investigations in patient volunteers, 20 facial anatomic dissections in fresh cadavers, and a review of the literature on nasal blood supply. In cadavers, facial arteries were dissected to analyze nasal arterial supply.

Results: When the facial artery, the ophthalmic artery, or both were compressed on 1 side in volunteers, blood flow inversion was proved by ultrasonography Doppler investigation at the level of the nasal area. These results confirm anatomic findings that demonstrate a polygonal system.

Conclusions: A schema of nasal blood supply as a polygonal system connecting the external and internal carotid systems is proposed. This facilitates our understanding of anatomic variations, physiological and pathologic modifications of blood flow, and nasal reconstructions with local flaps and medical rhinoplasties using filler injections.

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HE NASAL SUPERFICIAL ARTERIAL vasculature is well known from classic anatomic investigations. More recent studies1,2 have been performed to clarify the vasculature of the nasal tip to show the safety of the external rhinoplasty approach using a transcolumellar incision.

Videos available online at www.archfacial.com

Based on experience in the field of facial anatomic dissections, investigators have described the nasal structures.3,4 The objectives of the present study were (1) to analyze the nasal superficial arterial vasculature and (2) to compare these anatomic findings with the results of ultrasonography (US) Doppler investigations to evaluate nasal blood flow in physiological and pathologic conditions.

Not only is this topic relevant from the rhinoplasty viewpoint, but such knowledge will also facilitate our performance of cancer resections, nasal reconstructions with local flaps, and rhinoplasties using filler injections. A precise knowledge of the nasal arterial vasculature is helpful to facial plastic surgeons and aesthetic practice.

ANATOMIC INVESTIGATIONS

The nasal superficial arterial blood supply was studied at the Laboratoire d’Anatomie de la Faculté de Médecine de Nice Sophia Antipolis, Nice, France. Bilateral facial anatomic dissections were performed in 20 fresh cadavers.

Four cadavers were injected in the common carotid arteries to show the external and internal carotid systems and, particularly, the ophthalmic artery and its nasal branches; 2 were injected with red methylmethacrylate and 2 with gray latex. Four cadavers were injected with red latex in the external carotid arteries. Twelve cadavers were injected with red latex in the facial artery where it crosses the inferior border of the mandible anterior to the masseter muscle insertion.

Sharp facial dissection was then performed on both sides, following the facial arteries to the nasal artery and ophthalmic artery intraorbitally to allow complete exposition of the arterial vasculature of the nose. The main branches were identified and dissected, including the submental artery, inferior labial artery, and superior labial artery and then the lat-
eral nasal artery and the distal branch of the facial artery (angular artery) (Figure 1). To analyze the complete superficial arterial blood supply of the nasal pyramid, we focused on all the vessels that were present below the dermis layer. At the level of the alae, the dissection was performed down to the marginal border of the nostrils to not miss the small vessels that are there.

Photographs were taken at each step of the dissection. A digital camera was used.

US DOPPLER INVESTIGATIONS

Informed consent was obtained from 40 patient volunteers for US Doppler investigations. Ultrasonography Doppler tracking of the nasal area arteries was performed bilaterally using a 10-MHz transducer (Figure 2).

After locating the arterial flow lateral to alar-facial groove, selective compression of the homolateral facial artery was performed at the level of the mandible to assess if blood flow inversion could occur. Then, simultaneous compression of the ipsilateral facial artery and the nasal ophthalmic artery was performed to analyze blood flow direction. Finally, the compression was released to observe what happened to the blood flow (video; http://www.archfacial.com).

RESULTS

ANATOMIC INVESTIGATIONS

At the main trunks, the facial artery and the ophthalmic artery were identified in all 40 cases. Variations in the facial artery were noted based on the location, direction, and branches of the artery. In 32 cases (80%), the facial artery ran directly toward the oral commissure and then in the upper lip medially to the nasolabial fold until the alar-facial groove and divided into terminal branches; we considered this a typical (type 1) facial artery (Figure 3). In 6 cases (15%), the facial artery ran into the cheek lateral to the nasolabial fold and divided into the lateral nasal and angular arteries; we considered this a long (type 2) facial artery (Figure 4). In 2 of the cases with a long facial artery, an ipsilateral type 1 facial artery was present simultaneously; we considered this a double facial artery. In 2 cases (5%), the facial artery ended in the parasymphyseal area; we considered this a short (type 3) facial artery (Figure 5). In the cases of a short type 3 facial artery, a contralateral type 1 facial artery was present, which assumed the vascularization of both sides of the face (Figure 3 and Figure 5). No variation in the ophthalmic artery was observed in our study.

At the main branches of the facial artery, we observed 4 constant vessels (Figure 6).

First, the subnasal artery ran horizontally in the upper lip from the alar-facial groove to the lower portion of the columella and formed a vertical branch (columellar artery) at the level of the columella upward to the nasal tip (Figure 7). The subnasal artery anastomoses with the philtral artery, a vertical branch of the superior labial artery, forming the base of the so-called nostril circle. Second, the lateral nasal artery ran obliquely over the cephalic margin of the lower lateral cartilage (LLC) lateral crus and formed small branches. Third, the angular artery ran longitudinally toward the medial canthus. In the dissection shown in Figure 6, the angular artery is present but atrophic and is not clearly visible. Fourth, the dorsal nasal artery ran vertically over the nasal dorsum.

We identified 3 additional nasal arteries. First, in 33 cases (83%) a marginal alar artery (Figure 8) branched (1) from the facial artery or before and more caudally than the lateral nasal artery (23 cases) or (2) from the lateral nasal artery itself (10 cases); in 6 cases, the marginal alar artery was larger than the lateral nasal artery. The marginal alar artery courses horizontally following the LLC caudal bor-
der toward the nasal tip area. Many vertical anastomoses were noted over the LLC lateral crus between the marginal alar artery and the lateral nasal artery. When a marginal alar artery was absent, the vertical vessels from the lateral nasal artery formed a superficial lateral nostril arterial network. Second, in 8 cases (20%) a rim artery running along the nostril margin was noted; the rim artery was concomitant with the marginal alar artery in 5 cases, while the marginal alar artery was missing in 3 cases. Note that subcutaneous tissue in the nostril margin area is not easily dissected because the skin is tightly attached to the underlying dilator naris muscle (Figure 1). Third, in 7 cases (18%) an intermediate longitudinal artery (Figure 6) ran longitudinally over the lateral nasal wall from the lateral nasal artery to the radix artery.

At the branches of the ophthalmic artery, the radix artery ran transversely at the level of the radix of the nose in all cases. The radix artery branched from the angular artery or from the nasal artery. It usually culminated in the dorsal nasal artery.

All vessels running transversely met either the contralateral homologous artery over the midline or into a branched opposite vertical artery (Figure 8). These branched to form various anastomoses mainly over the nasal tip.

**US DOPPLER INVESTIGATIONS**

In all the patient volunteers who underwent US Doppler investigation of nasal arterial vasculature, nasal blood flow was performed, and US tracked the presence of blood flow in all the patients from the facial artery and from the ophthalmic artery. When the facial artery was compressed, US tracked the presence of blood flow in 20% of patients (n=8) from the contralateral facial artery and in 80% of patients (n=32) from the ipsilateral ophthalmic artery. When both the ipsilateral facial artery and ophthalmic artery were compressed, US tracked the presence of blood flow in 30% of patients (n=12) from the contralateral facial artery and in 20% of patients (n=8) from the contralateral ophthalmic artery.

Preliminary results confirmed that the intercarotid anastomosis is always present. The transfacial anastomosis was more difficult to demonstrate.

In 80% of patients (n=32), the intercarotid anastomosis showed instantaneous blood flow inversion between the ipsilateral facial artery and ophthalmic artery, as registered by the transducer; in 20% of patients (n=8), the peak was positive but lower because the flow was from the contralateral facial artery (Figure 9). The transfacial anastomosis was observed but is harder to evaluate because of the less intense signal owing to the smaller
size of the anastomotic vessels. When both the facial artery and the ophthalmic artery were compressed on 1 side, US tracked the presence of blood flow in 50% of patients, with 20% from the contralateral ophthalmic artery (negative peaks) and 30% from the contralateral facial artery.

Our study shows that the superficial blood supply of the nose can be described as a multidirectional arterial anastomotic system (Figure 10) that is formed by branches of the external and internal carotid arteries. One can consider the longitudinal arteries as forming the intercarotid anastomosis and the transverse arteries as forming the transfacial anastomosis (Figure 11).

Therefore, we propose a schema of nasal blood supply composed of longitudinal and transverse vessels whose anastomoses form a polygonal system. We propose the following 4 transfacial arcades: (1) marginal alar arcade, formed by the junction between the 2 marginal alar arteries and their branches; (2) alar valve arcade, formed by the junction of the 2 lateral nasal arteries; (3) radix arcade, formed by the junction of the 2 radix arteries; and (4) nostril circles, which join the marginal alar arcade to the subnasal and columellar arteries.

These transfacial arcades are connected by the longitudinal anastomotic intercarotid vessels, which create a mesh pattern–like polygonal system. Branching from the polygonal system, perforating arteries form the subdermal plexus and reach the skin. At the level of the nasal tip, an arteriole-capillary network is always present, forming the top of this connecting system and protecting the nasal tip from frost ischemia.

CLINICAL AND SURGICAL APPLICATIONS

In our polygonal system, major blood flow is provided simultaneously by the external and internal carotid arteries. Variability exists in patient anatomy (with some vessels absent), as well as in physical features (with higher blood pressure in the external vs internal carotid artery so that the blood can run from the nasal tip to the radix, from the radix to the face, and vice versa).

This system explains the physiological blood supply to the nose and the possible inversion of that flow depending on the respective blood pressure in the external and internal carotid arteries. It also explains the different types of nasal vasculature described by Jung et al,3 which are related to the provenance of the major blood supply.
Our results confirm previous findings. The external rhinoplasty approach with dissections below the nasal superficial musculoaponeurotic system (SMAS) is absolutely safe because the blood supply to the nasal tip is extremely rich and even closure of a major vessel does not cause necrosis.

The polygonal system is relevant in reconstructive procedures. It allows the use of local flaps with longitudinal or transverse pedicles to reconstruct nasal defects that respect the nasal subunits described by Burget and Menick.

When performing medical primary rhinoplasties using fillers, injections should be performed in the avascular deep plane below the nasal SMAS, where the main vessels lie. If injections are performed intravascularly, the presence of many anastomoses may cause (1) a risk of anterograde arterial embolism, which in most cases does not cause skin necrosis owing to blood supply from other vessels, and (2) a risk of retrograde arteriolar microembolism into the ophthalmic artery via the nasal artery, which can lead to temporary or permanent visual loss.

The position of the needle or cannula tip should be checked by aspiration. Also, compression of the ophthalmic artery is recommended when injecting fillers in the nasal area, and care should be taken to avoid the application of high pressure on the syringe.

Before filler injection in revision rhinoplasties, it is important (especially in the nasal tip area) to evaluate the presence of certain structures. First, the presence of any adherence between the dermis and the bony or cartilaginous structure should be assessed. In a previous rhinoplasty, the nasal SMAS layer may not have been respected, in which case ensuing scar tissue may have caused a direct adhesion between the dermis and the deeper nasal structures. Second, the presence of subcutaneous grafts...
the columellar arteries over the domal area to form the rim. These small vessels reach the nasal tip and meet branches that pass over the lateral crura toward the nos-

lateral crura of the lower lateral cartilage, forming small lateral nasal artery runs along the cephalic margin of the 4% of cases analyzed). Toriumi et al13 reported that the lateral nasal artery branched from the facial artery (in 96% of cases analyzed), in type 2 from the ipsilateral dorsal nasal artery (in 15.7%), in type 3 from the contralateral lateral nasal artery (in 15.7%), and in type 4 from the contralateral dorsal nasal artery (in 5.9%). In most cases, the lateral nasal artery is the main blood supply to the nasal tip, followed by the dorsal nasal artery, and variable contributions come from the columellar arteries.

When the blood supply to the nasal tip is compromised, filler injections performed in this area may further compress preexisting vessels or new vessels from postoperative neoangiogenesis. This may occur even if the filler injections are performed correctly.

**REVIEW OF THE LITERATURE ON NASAL BLOOD SUPPLY**

Classic anatomic investigations focused on the facial artery and its branches.11 Small distal branches of the lateral nasal artery form several anastomoses with the contralateral branches and with the columellar arteries. The terminal branch of the facial artery is generally considered the angular artery, which runs over the medial canthal area to meet the nasal artery.

A 2002 study12 of nasal blood supply showed that the lateral nasal artery branched from the facial artery (in 96% of cases analyzed) or from the superior labial artery (in 4% of cases analyzed). Toriumi et al13 reported that the lateral nasal artery runs along the cephalic margin of the lateral crura of the lower lateral cartilage, forming small branches that pass over the lateral crura toward the nostril rim. These small vessels reach the nasal tip and meet the columellar arteries over the domal area to form the alar arcade that runs over the alar lobule. Other blood supply to the nasal area comes from the dorsal nasal artery, which at its origin at the radix may be considered a terminal branch of the ophthalmic artery (branch of the internal carotid artery).14

Jung et al15 classified the distribution of arteries that form the main blood supply of the nasal tip in Asians into 4 types depending on the origin of the vasculature. In type 1, the vessels to the nasal tip originate from the ipsilateral lateral nasal artery (observed in 62.7% of cases analyzed), in type 2 from the ipsilateral dorsal nasal artery (in 15.7%), in type 3 from the contralateral lateral nasal artery (in 15.7%), and in type 4 from the contralateral dorsal nasal artery (in 5.9%). In most cases, the lateral nasal artery is the main blood supply to the nasal tip, followed by the dorsal nasal artery, and variable contributions come from the columellar artery.

The marginal alar artery (Figures 3, 6, and 7), which follows the LLC caudal border, is not mentioned in these studies; however, the marginal alar artery was observed in 33 of 40 cases (80%) in our anatomic investigations, and it was larger than the lateral nasal artery in 6 of 33 cases (18%). The dissection of subcutaneous tissue in the area caudal to the caudal border of the LLC is difficult, and this is probably the main reason why the presence of a marginal alar artery has not usually been reported in literature, although it was reported in work by Salmon.15

In a 1973 study, Mitz et al16 stated that the blood supply to the whole face is always preserved by the presence of many anastomoses. They confirmed that the main arteries run in or below the SMAS layer, dividing into perforating branches that run to the dermis to form the subdermal plexus (superficial anastomosis). This vascular structure is present also at the level of the nasal area, where the superficial anastomoses are mainly at the level of the radix and the nasal tip. Mitz et al called these anastomoses the superior nasal arcade and the inferior nasal arcade. We observed the same anatomic disposition as Mitz et al, but the inferior nasal arcade seems to be placed at...
the nostril margin level, where we noted marginal and rim arteries forming caudal arcades, which is lower than the location to which they referred. Relationships between these arcades and the LLC lateral crura are shown in Figure 6.

LIMITATIONS OF THE ANATOMIC AND US DOPPLER METHODS IN THE STUDY

Physiological blood flow is not completely and precisely visible in anatomic cadaver dissection. A technique that allows analysis of blood flow and tissue vascularization is the evaluation of facial and nasal angiosomes\(^{17}\) (Figure 12). However, arterial injections with liquid dyes can show anatomic situations whose technical interpretation may not correspond to the vascular status for several reasons. First, vessel obstructions in cadavers (such as preexisting clots or air bubbles) may block the injected liquid dye. Second, the force of injection can modify the vessel diameter, showing a smaller or larger arterial volume than actually exists. Third, the thickness of the liquid dye can alter the findings. These technical situations likely explain why cadaver dissections performed by surgeons and anatomists may demonstrate differences in anatomic patterns other than those that exist because of natural physiological variation.

With US Doppler investigations, the device size and the nasal morphologic structure do not allow full 360° orientation. Nevertheless, the tip of the transducer was applied herein at the level of the pyriform aperture, where only 2 branches of facial artery lie, the angular and lateral nasal arteries. Therefore, it was possible to analyze arterial blood flow from the facial artery or from the ophthalmic artery (ie, anastomoses of the vessels).

The primary aim of the US Doppler investigations herein was to show the direction of arterial blood flow in the nasal area and its possible inversion when compressing the facial artery, the ophthalmic artery, or both. Therefore, the role of arterial anastomoses could be objectified and magnified. To our knowledge, this study is the first to show and register this phenomenon (video).

The main artery providing vascularization to the nasal pyramid is the facial artery, while the ophthalmic artery may be of relevance in some physiological or pathologic situations (eg, when the facial artery is missing or ligated, the ophthalmic artery prevents the face and mainly the nose from ischemia). Further studies will be performed to evaluate the various statistical physiological situations.

CONCLUSIONS

We describe herein a nasal arterial polygonal system based on the findings of anatomic and US Doppler investigations, whose results confirm each other. This study demonstrates the existence of an anastomotic system, situated in the SMAS plane, that connects the external and internal carotid systems and the transfacial nasal vascular supply, which gives rise to the subdermal plexus. The major blood supply to the nasal area may come from each of these arteries depending on physiological and pathologic modifications of blood flow. The blood supply is optimized by the presence of 3 arterial anastomotic arcades. This network explains why many different pedicles can be safely used for local flaps in nasal reconstructions and why they all work. Furthermore, after skin tumor resections, the presence of these anastomotic vessels enables a major vessel ligature without skin necrosis. However, the presence of so many anastomotic vessels in the nasal area, whose blood flow can be easily inverted during injections, creates a risk of embolism or microembolism, especially in medical rhinoplasties using fillers.

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