Supraclavicular Flap: Reconstructive Strategy for Massive Facial Arteriovenous Malformations

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Abstract: Arteriovenous malformations (AVMs) are uncommon errors of vascular morphogenesis. Hemodynamically, they are high-flow lesions. Approximately 50% of AVMs are located in the craniofacial region. The successful treatment of vascular anomalies depends on the profound knowledge of the biologic behavior of vascular lesions and their correct classification. Vascular malformations that persist lifelong require treatment in most cases, especially when clinical symptoms occur. On the basis of individual parameters such as the diameter, location, or growth behavior, different therapeutic options such as cryotherapy, corticosteroids, laser therapy, sclerotherapy, surgical intervention, and/or embolization can be performed successfully. Subtotal excision or proximal ligation of the feeding vessel frequently results in rapid progression of the AVMs. Hence, the correct treatment consists of highly selective embolization (superselective) followed by complete resection 24 to 48 hours later. Reconstructive procedures in the head and neck region use a wide range of flaps for defect closure. The methods range from local, mostly fasciocutaneous flaps and skin grafts, to free microsurgical flaps. To ensure a satisfactory functional and aesthetic result, good texture and color of the flap are always essential. Moreover, the donor-site defect needs to be reduced, with no resulting functional or aesthetic impairment. The supraclavicular flap has been used successfully for difficult facial reconstruction cases, providing acceptable results without using microsurgical techniques. We treated 2 patients with facial AVM by this method. Both of the lesions were located within the cheek and lip. There were no procedure-related complications, and the cosmetic results were excellent.

Key Words: Arteriovenous malformation, superselective embolization, face and neck, supraclavicular flap

Arteriovenous malformations (AVMs) are the result of errors of vascular development between the fourth and sixth weeks of gestation. Failure to prune unwanted primitive communications between the arterial and venous systems may result in a malformation. Most of these lesions are obvious at birth, whereas some are obvious during adolescence or adulthood. It is believed that the enlargement is the result of changes in pressure and flow, ectasia, shunting, and collateral proliferation rather than cellular proliferation. Arteriovenous malformations have a tendency to grow with the child. Then, after the individual has attained full growth, AVMs remain stable through lifetime. Some enlargements may occur in response to trauma or hormonal disturbances during puberty or pregnancy. Treatment of AVMs can be difficult because frequently, after an apparently successful extirpation, there is regrowth of the tumor to a size larger than its original size, often with supply by surgically inaccessible vessels. Furthermore, the high flow rates and hypervascularity of these lesions can lead to life-threatening complications, such as hemorrhage and/or cardiovascular instability.

An AVM of the face is an abnormal fistulous connection between the feeding arteries and draining veins, without an intervening capillary bed within the subcutaneous layer. The draining veins are grossly dilated and tortuous and may show varicical dilatation. The dilatation of vascular channels often results in deformity of the face that is usually not life threatening but can cause substantial aesthetic and social disturbances.

In the past, treatment of AVM of the face was primarily reliant on surgical excision or ligation of the feeding arteries. Excision often was associated with extensive blood loss, and there was the need for skin reconstruction procedures. Ligation of feeding arteries has been particularly troublesome because of the recruitment of a collateral vessel supply and the loss of access to the fistula for further embolization. With the advent of endovascular treatment techniques and new embolic agents, embolization has become the treatment of choice for these lesions. Transarterial and transvenous embolization of the face AVM has been used as an adjunct to surgery or as definitive therapy.

Today, the treatment of AVM of the face has evolved from the primary use of surgery as the sole treatment to surgery as an adjunct to embolization therapy. In treating these types of AVM, surgical excision has been the most common method of obliteration. These procedures were necessarily extensive, and for a complete cure, the entire fistula had to be removed; otherwise, an AVM was likely to recur, together with recruitment of a collateral blood supply. Because of the complex vascular anatomy and risk of massive intraoperative hemorrhage, however, complete surgical removal often is difficult. Before surgery, occlusion of the feeding arteries may be necessary; in addition, transarterial embolization with the lodging of embolic material in proximal feeding vessels decreases the blood supply, and it has been a helpful adjunct to surgery.

The visibility of the head and neck during social contact and the fact that these regions have high movement make reconstructive procedures in this area a challenge. In the face, surgical reconstruction has to take account of the aesthetic units and provide a thin flap to enable mimic function. Again, the texture of the transferred skin has to be considered. Head and neck soft tissue tumoral resections often result in complex reconstructive problems that require a dependable local, regional, or free flap to restore both

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form and function. Nowadays, with the recent advances in micro-surgical free tissue transfers, the reconstructive bar has been elevated. Significant donor-site morbidity is neither acceptable nor necessary.

As a basic concept, first formulated by Gillies\textsuperscript{21} in 1920, the more adjacent the donor site is, the better the skin will match the recipient site.\textsuperscript{22,23} To achieve these goals, a thin reliable flap, harvested close to the face/neck region with good skin texture match and a smooth hairless skin surface—one that provides sensitivity—is needed. Everyday clothing should conceal the donor site. For resurfacing of defects in the head and neck, fasciocutaneous flaps should be used. In 1842, Mutter\textsuperscript{24} was the first to describe a random patterned flap of the supraclavicular region extending toward the shoulder. In 1949, the first clinical application of a flap from the shoulder ("charreter") or acromial flap was performed by Kazanjian and Converse.\textsuperscript{25} Charretera, in Spanish, means the shoulder area where honors are bestowed on military personnel. After further modification,\textsuperscript{26} and closer examination of the vascularization, the flap was described as the supraclavicular axial patterned flap.\textsuperscript{27}

Anatomically, the neck/shoulder flap was based on the supraclavicular artery. We reduced the donor-site defect by limiting preparation to the size of the flap actually required. Surgical resection of the vascular tumor should be performed with a skin-sparing incision to avoid disfigurement. Excision should be followed by primary closure whenever possible. Superficial tissue losses can be covered with a split thickness skin graft. Local tissue flaps (skin rotation flap for cheek) and Estlander flap for the upper lip will give

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\includegraphics[width=\textwidth]{figure1.png}
\caption{Patient’s facial appearance on admission and her angiographies.}
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\begin{figure}[h]
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\includegraphics[width=\textwidth]{figure2.png}
\caption{A and B, The patient after the first operation. C to F, The patient 2 years after the first operation.}
\end{figure}
better cosmetic results. We think that one of the best options for reconstruction of deep and large facial AVM is supraclavicular flap in the form of island or pedicular. There may be a need for free tissue transfer in the reconstruction of more complex defects. With the advent of superselective angiography and new embolic agents, embolization has become an integral part of treatment. The preoperative embolization diminishes blood loss and facilitates complete surgical extirpation.

CLINICAL REPORT

This clinical report is about superselective embolization, followed by surgical resection in 2 cases of massive facial AVMs. The first one was reconstructed with expanded pedicled supraclavicular flap and the second by pedicled supraclavicular flap without expansion.

Patient 1

The first case is a 21-year-old young woman who had massive facial AVM. She referred to our center in 2007 for the first time. She was a candidate for lesion excision and facial reconstruction with supraclavicular flap. In this sense, she was first chosen for superselective angiography before complete facial excision of the lesion. Her lesion and its angiographies are illustrated in Figure 1. Intraoperatively, after 48 hours of superselective angiography and embolization, we wanted to excise her lesion completely. However, we were not able to control its massive bleeding during excision of the AVM, so we only debulked her lesion partially.

After this, her lesion grew larger than the original (Fig. 2). Two years later, another surgery was planned to be performed by expanded supraclavicular flap. Hence, a tissue expander was inserted in her right shoulder. Again, 4 months later, a superselective angiography and embolization was conducted. Afterward, the lesion was excised completely, and pedicled expanded supraclavicular flap was used for facial reconstruction (Figs. 3 and 4A–D). After 3 weeks, the pedicle was cut. Finally, after 6 months, she was very satisfied with the result (Figs. 4E–H).

Patient 2

The second case is a 24-year-old man who had massive facial AVM. He was referred to our center in 2006 for the first time. He...
had been in another center previously, in which he had been planned to be operated on. However, he became problematic because of full-thickness and massive necrosis after highly selective angiography and embolization.

After being referred to us, he was under full observation to determine the extent of necrosis. Then wound care and multiple debridements were done for him. Afterward, the patient was planned for folded supraclavicular flap for both facial reconstruction and lining. Also, a pedicular type was used for future reconstruction of the lip after a pedicular cut (Figs. 5A–D). Then intraoperatively, we excised full-thickness necrosis and the entire lesion. The folded flap was then used for simultaneous reconstruction of the lining and face (Figs. 5E–H). Three weeks later, the pedicle was cut completely from the base and used for the reconstruction of the full thickness of the lip (Figs. 6A, B). In 6 months after this operation, the first revision was made near the left paranasal (Figs. 6C, D). Two years later, the patient refused performing scar revision because he was very satisfied of his current result (Figs. 6E–H).


FIGURE 6. A and B, Three weeks later, the pedicle was cut completely from the base and used for the reconstruction of the full thickness of the lip. C and D, Six months after the operation, the first revision was made near the left paranasal. E to H, Patient’s appearance 2 years after the operation.
DISCUSSION

Arteriovenous malformations are the result of a failure of regression of the arteriovenous channels in the primitive retiform plexus. They are composed of a central nidus with anomalous congenital shunts between the arterial and venous systems. These abnormal vascular channels may not cannulate or conduct blood flow for many years. This enlargement is the result of dilatation of the adjacent arteries and veins (collateralization and recruitment) rather than endothelial proliferation. Clinically, AVMs accompany pain, hyperemia, thrill, trophic changes, ulceration, and bleeding. Puberty and pregnancy affect the onset and progression of these lesions. Arteriovenous malformations can be diagnosed with pulsed Doppler, which documents the arterial output, and can be used to follow the progression of an AVM. Magnetic resonance imaging best demonstrates the extent of the malformation, and angiography is unnecessary until the intervention is contemplated. Arteriovenous malformations present a therapeutic challenge because of their hemodynamic characteristics and their modality of growth. Surgical resection is often associated with extensive blood loss, and an incomplete resection frequently leads to regrowth of the tumor to a size that is often larger than its original. Proximal ligation of the parent vessel should be avoided because it is ineffective and may aggravate the problem, making future endovascular therapy difficult or impossible.

In an effort to circumvent these problems, preoperative embolization of the feeding arteries has been shown to reduce the hypervascularity and, therefore, to aid surgical resection of these lesions. Recent developments in the design of microcatheters and distal navigation techniques have facilitated catheterization of feeding arteries close to the nidus.

Complications from embolization are infrequently seen. However, necrosis of adjacent tissues may occur, as it was evident in our second patient. Hence, patients must be adequately treated with broad-spectrum antibiotics. The most serious complication is the backflow of the embolus into the internal carotid or vertebral arteries as a result of circulatory sluggishness. A distal placement of the micro catheter close to the nidus will avoid this complication.

Highly selective embolization as a single-treatment modality is rarely successful with high-flow lesions because of the later development of new vascular pathways. However, it leads to a significant reduction in the blood flow within the vascular tumor, which decreases operative blood loss and permits complete resection of the tumor.

Experience has shown that the 24- to 48-hour period after embolization is the ideal time for surgical intervention. The aim is complete resection, unlike staged resection that is applicable to slow-flow vascular malformations to minimize the chances of recurrence. The pattern of bleeding from the wound edges is the best way to determine whether the resection is adequate. A more-than-normal bleeding indicates presence of residual malformed tissue. Combined embolization and resection is most successful for well-localized stage 1 or 2 AVMs. Consequently, superselective embolization followed by a complete surgical resection is the correct treatment of AVMs on the facial region. After this combined modality of embolization, followed by resection, the patient must be followed up for years by clinical examination, ultrasonography, and/or magnetic resonance imaging.

During the past 30 years, our growing knowledge of skin vascular anatomy and physiology has led to significant advancements in skin flap–harvesting techniques and technical refinements, making “forgotten” flaps more reliable and predictable. The supraclavicular artery island flap has been rediscovered by several groups after an extended period of absence from the literature.

Also, tissue expansion has become a major reconstructive modality in the past 3 decades. However, one must be prepared for complications when using tissue expanders because complications are inherent in the process of expanding skin using repeated filling of implanted foreign bodies. Outcomes are dependent on thorough planning, meticulous technique, close follow-up, and patient compliance. Tissue expansion has very much revolutionized plastic surgery. In addition, it has permitted the plastic surgeon to achieve the goals of reconstruction with tissue of similar color, texture, and thickness, with minimal donor-site morbidity. Preservation of sensation in a durable flap has allowed the surgeon to achieve acceptable functional as well as aesthetic goals simultaneously. Reconstructive procedures in the head and neck region have to take into account anatomic, aesthetic, and functional aspects. First, normal contours have to be achieved; in the neck, the cervicomandibular angle has to be reformed. Second, the aesthetic units have to be taken into account. Third, the functional outcome has to ensure full range of movement, both of the lower face and of the neck. Finally, additional scarring of the upper chest should be avoided. To cover defects of the inner and outer neck flaps with good color and texture match should be used. The best color and texture match is achieved with local and regional flaps. Usability of the local flaps may be restricted because of radiation or destruction of vascularization. Severe defects can also be reconstructed by free flaps, especially the free para- or scapular flap. Microsurgical transplantation of free flaps enables coverage by vascularized tissue to fill larger defects. The preferred free flaps are the radial forearm flap and the latissimus dorsi and scapular flaps. The level of complications with free tissue transfer ranges between 5% and 10%. In addition to technical problems, the aesthetic outcome largely depends on the donor site. The use of regional flaps in reconstructive surgery gives high reliability when covering large defects and reduces the risk of complications to a level lower than found for free flaps. Aesthetic restoration of the head and neck is restricted by limited availability of local tissue. The shoulder is a region much easier to conceal and should therefore be used in reconstruction procedures if fasciocutaneous regional flaps are needed. High-risk patients (those with advanced age, advanced tumors, poor nutrition, or multiple medical issues) are not always acceptable surgical candidates for potentially prolonged microsurgery; therefore, regional flaps remain the preferred technique in these more difficult cases. The supraclavicular flap, a thin flap of good texture, is an excellent and highly reliable flap for covering defects of the head and neck. The indication for double folding the supraclavicular island flap in reconstruction of the inner and outer lining is possible and merits future consideration, although there is a need for further clinical experience.

The supraclavicular flap is our flap of choice for most of the middle and lower third defects of the face and neck. Flaps have been harvested successfully in patients with various comorbidities, including obesity, poor nutrition, diabetes, and smoking history. Contraindications have been limited to patients who have had previous neck dissections and/or radiated necks. The surgeon must adapt his or her choice of therapy to the patient. If thin flexible fasciocutaneous flaps are needed, the shoulder provides an easy-to-conceal donor site, which can be closed primarily. As experience with the supraclavicular artery flap in head and neck reconstructive surgery expands, proper patient selection and improved technical refinements will continue to be paramount. Maybe in the future, flap variations could include composite flaps using both the supraclavicular skin, subcutaneous, fascia for soft tissue reconstruction and an osteomusculoscutaneous trapezius flap for selected head and neck defects. We specially recommend using expanded folded pedicle-type supraclavicular flap for the best coverage of the whole defect after extirpation of massive or complicated AVMs. In this way, we can add the pedicle reserve for more reconstruction.
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