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The arterial supply of the clavicle

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Summary. This report based on delineation of the arterial system with 3 component plastic material on 10 human cadavers describes the arterial supply to the clavicle. The study was performed in 2 parts. One part, which showed the total arterial supply to the clavicle and one part with selective injections of the relevant arteries, with the intention of finding a central nutrient arterial supply to the clavicle. Three arteries were found to supply the clavicle: the suprascapular a.; the thoracoacromial a.; and the internal thoracic (mammary) a. The main supply was primarily periosteal. No nutrient artery was found.

La vascularisation artérielle de la clavicule

Résumé. Ce travail, basé sur l'injection du système artériel avec 3 composants plastiques sur 10 cadavres humains, décrit la vascularisation artérielle de la clavicule. L'étude a été faite en 2 parties, la première montre la vascularisation artérielle dans son ensemble et la seconde comporte des injections sélectives des artères concernées, dans le but de rechercher un apport artériel central de la clavicule. Trois artères ont été mises en évidence : l'a. suprascapulaire; l'a. thoracoabdominale; l'a. thoracique interne. L'apport artériel principal est périosté. Aucune artère nourricière n'a été trouvée.

Key words : Arteries — Clavicle — Microsurgery — Technology

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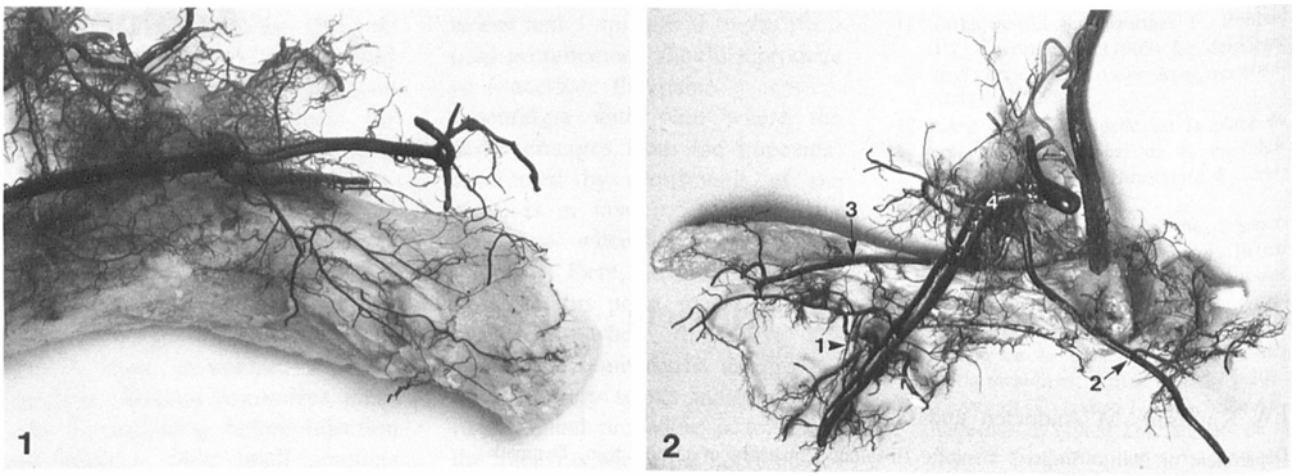
As the vascular anatomy of the clavicle has not been fully investigated with respect to the different parts of the bone, the present investigation was undertaken to study the macroscopic arterial supply to the clavicle, with the intention of examining the possible donor vessels for a free vascularised bone graft.

Technique and material

To delineate the arteries injection of "Batson's No. 17 plastic kit" (Polysciences Inc, Warrington PA 18976, 2590) was used. Ten fresh cadavers, 9 with a median age of 69 (range 52-82), and one 22 years of age were examined unilaterally. In the first series of 5 preparations the subclavian a. was injected to show the total arterial supply to the clavicle. Medially the vertebral a. and the subclavian a. were ligated, the latter at its origin from aorta. The internal thoracic a. was ligated between the third and fourth ribs. Injection of the subclavian a. was done after ligation of the axillary a. between the subscapular and the lateral thoracic a., the latter of which also was ligated.

In the second series of 5 preparations, selective injections into 3 arteries : the suprascapular a. (SSA), the internal thoracic a. (ITA) and the thoracoacromial a. (TAA), were undertaken to get a better visualisation of the distal vascular tree, in an attempt to find one or more nutrient arteries. To show if there was a vascular connection to the clavicle through the sternocleidomastoid m., the sternocleidomastoid a. and the superior thyroid a. were injected selectively. Only 2 arteries in each preparation were injected with different colours (blue and red). In this way 2 preparations of each artery were produced. The SSA was injected in front of scalenus anterior, the TAA, where it arises from the second part of the axillary a. and the ITA between the third and fourth ribs after ligation, where it arises from the subclavian a. The



Figs. 1, 2
1 The fine periosteal network delineated with plastic, at the acromial end of the clavicle (selective injection of SSA) **2** The total arterial supply of the clavicle delineated with plastic. *1* TAA (thoracoacromial a.) *2* ITA (internal thoraco a.) *3* SSA (suprascapular a.) *4* SCA (subclavian a.). The common carotid a. and the superior thyroid a. are also shown in this preparation

1 Les fins réseaux périostiques injectés au plastique, à l'extrémité acromiale de la clavicule (injection sélective de l'ASS) **2** La vascularisation artérielle totale de la clavicule injectée au plastique. *1* ATA (a. thoraco-acromiale) *2* ATI (a. thoracique interne) *3* ASS (a. suprascapulaire) *4* ASC (a. subclavière). L'a. carotide commune et l'a. thyroïdienne supérieure sont aussi visibles

sternocleidomastoid a. was injected near the muscle, and the muscular branch of the superior thyroid a. was also injected near the muscle. After injection of the vessels, the tissue block was dissected before the hardening process (which took about 15-20 min) was completed, in order not to break the plastic material when manipulated. The block was dissected free with adjacent muscles (min. 5 cm), manubrium sterni including the sternoclavicular joint and the medial part of the first rib, and placed in water.

Maceration was undertaken in a 30% KOH bath at room temperature. After 8-12 h in KOH the tissue block was placed in water for 8 h. This alternation between KOH and water was repeated for shorter periods until all connective tissue had been removed. This technique of maceration preserved the attachment of the periosteal vessels and avoided maceration of the bone.

Results

As the plastic had a low viscosity which gave it the ability to show the finest vascular network (Fig. 1), the study was technically satisfactory. However a branch which might be expected to have a medullary (nutrient) supply was not demonstrated. In this investigation of the entire arterial supply of the clavicle, only a periosteal supply was demonstrated based on 3 arteries (Fig. 2).

The suprascapular a. (SSA)

It showed a constant supply of the entire clavicle except for 1/5 of the sternal end. In its course its relation to the clavicle was posteroinferior, and it passed the place described as nutrient foramina, just medial to the conoid tubercle. The nutrient branch was either missing of indistinguishable from the periosteal branches to the Volkmann canals in the cortex along the bone. A variation of the SAA was found. In 3 out of 5 blocks it branched from the ITA and in the other two from the base of thyrocervical trunk. In 1 block it arose a 1/2 cm below, and in 2 blocks it arose 3 cm below the origin of the ITA (Fig. 3).

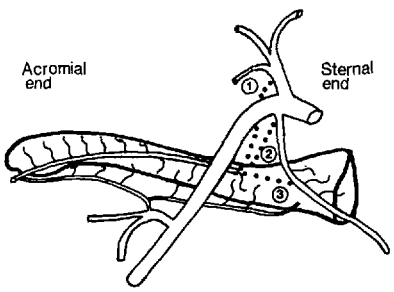


Fig. 3
The variations (marked 1, 2 and 3) in the origin of the SSA is shown

Les variations (indiquées 1, 2, 3) de l'origine de l'ASS sont visibles

The thoracoacromial a. (TAA)

It was found to arise from the axillary a. It was of considerable size and was a constant trunk. It showed a constant supply of the lateral 4/5 of the clavicle with an inferoanterior relation to the clavicle, by the clavicular and acromial branches. A variation of the branching of the trunk was noticed, but the supply to the clavicle was constant. The acromial branch anastomosed with the suprascapular a. at the acromial end of the clavicle.

The internal thoracic a.

It constantly arose in all blocks from the subclavian a. opposite the thyrocervical trunk, and has a constant considerable size. It supplied 1/5 of the sternal end of the clavicle, the sternoclavicular joint and the sternum with small periosteal branches.

The sternocleidomastoid a. (ITA)

This artery and the muscular branch of the superior thyroid a. were shown to supply the sternocleidomastoid m. through a fine arterial network within the muscle, but it did not pass on to the periosteum of the clavicle (2 preparations).

Discussion

The clavicle is a membranous bone and has a mixed type of ossification. Two primary centers develop between the medial 2/3 and lateral 1/3 of the condensed mesenchymal band in the 18 mm embryo. This intramembranous ossification is followed, after fusion of the two centers, by cartilage formation towards the sternal and acromial ends around the inner layer. In this phase periosteal vessel invasion through the chondral layer to the central mesenchymal bone matrix is seen. The mesenchymal bone matrix is soon dissolved and disappears in the 32 mm embryo. A secondary ossification center for the sternal end appears in the late teens. A rudimentary centre sometimes develops at the acromial end [2, 3, 5].

In the attempt to find the best artery for a free vascularised bone graft, a donor vessel with branches both to the periosteum and endosteum was sought. The authors' hypothesis with respect to the development of the blood supply to the clavicle was that there could be nutrient a. to the two primary fetal centers and to the late secondary center at the sternal end of the clavicle: this study did not support this theory. A well developed nutrient a. was not demonstrated. The dominant blood supply to the clavicle was found to be periosteal through numerous canals of Volkmann into the cortex (cf the last phase of the embryonic development of the bone). The nutrient foramen might possibly be explained as the site of major venous drainage. The lack of an important nutrient a. can be explained by the fact that the clavicle, unlike most other long bones, does not possess a medullary cavity [5], and is therefore not dependent on a central vascular supply. The injection of a young (22-year-old) cadaver showed a similar pattern supply of the bone, even to the medial part near the secondary ossification center. The present study has revealed that the main arterial supply to the clavicle derives from:

- *the suprascapular a. (SSA)* which supplies the lateral 4/5 of the clavicle with a posteroinferior relation to the bone. The study has revealed an unusual anatomical variation in the origin of that artery. In 1882, Quain [7] described the SSA as "rarely arising from the internal mammary a." and Adachi [1] described it as arising from the ITA in 9 out of 544 (1,7%) cadaver dissections in Europeans and 6 out of 138 (4,3%) in Japanese. In the present study the SSA arose from the ITA in 3 out of 5 injections. Compared to the results of Quain and Adachi this variation may be explained by the difference between conventional cadaver dissections and the plastic injection technique used in the present study which furthermore has demonstrated a rich periosteal supply to the lateral 4/5 of the clavicle, not previously described in the anatomical literature [5, 6, 7];

- *the thoracoacromial a. (TAA)* which supplies the lateral 4/5 of the clavicle through its clavicular and acromial branches, with an inferoanterior relation to the bone. These 2 branches were always present and of considerable size even though there was a variation in the branching from the trunk. We found that this trunk arose constantly from the axillary a. and had a considerable size as described by Quain [7]. The variations in branching were found to correspond well with those described by Reid [8];

- *the internal thoracic a. (ITA)* which supplies the sternal 1/5 of the clavicle and the sternoclavicular joint. The ITA arose constantly from the first part of the subclavian a. and had a considerable size.

The vascular connection from the muscular attachment of sternocleidomastoid to the clavicle described by Siemssen [10], who used the muscle as a pedicle to a clavicular bone graft, could not be demonstrated in the present study. The success of this pedicled bone flap therefore must be explained by a good "take" of the periosteum-covered graft in a well vascularised recipient bed.

The results from this investigation show that if the clavicle is used for microvascular reconstruction, it should be pedicled either on the SSA or TAA. The variable start of the SSA, and its posteroinferior relation to the bone, makes the

dissection difficult; therefore the TAA is more suitable as a possible donor vessel. It has a constant origin, a considerable size, and is easily dissected. The TAA has been used as a donor vessel for a free vascularised bone graft [9]. Both whole bone graft and split bone graft can be used. For cosmetic, and to a lesser degree functional reasons [4, 11], the split bone graft is preferable, as it also protects the subclavian vessels and the brachial plexus. When splitting the clavicle this should be done with regard to the relation to the donor artery — eg the anteroinferior aspect, when the TAA is used. The ITA may be the choice if the sternoclavicular joint is needed for reconstruction, eg of the temporomandibular joint.

Conclusion

The main arterial supply to the clavicle is primarily periosteal, and not based on a nutritive artery. Three arteries, the thoracoacromial a., the suprascapular a. and the internal thoracic a. supply the clavicle. If the clavicle is used as a free vascularised bone graft, the thoracoacromial vessels are the donor vessels of choice.

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