An Easy, Cost-Effective and Time-Conserving Method of Studying the Vascular Anatomy of the Base of the Skull

Abstract—In this work we present a simple, rapid, cost-effective and time-conserving method of studying the vascular anatomy of the base of the skull. This method is based on the injection of the arteries and veins with an appropriate coloring solution that possesses the property of rapid solidification. This technique of preparation of the coloring solution and the method of injection is described in detail. The advantages and disadvantages of this technique are also discussed. (*Skull Base Surgery*, 5(3):181–184, 1995)

Surgery of the skull base, a rapidly developing discipline, warrants a thorough and proper understanding of the complex anatomy of this region. Although phenomenal advances in imaging techniques are invaluable assets, the ultimate necessity of innumerable cadaveric dissections still remains unchallenged in the education of a skull base surgeon. These advances and the increasing awareness of this specialty demand and deserve qualitative improvement in the didactic material used to describe the surgical anatomy of the skull base, an area rich in crucial neurovascular structures.

Various techniques have been described before to study the anatomy of the skull base.^{1,2} We, after years of experience, currently practice a technique for injecting the arteries and veins in fresh temporal bones or fresh cadavers with a simple coloring solution that enables us to obtain a high quality of didactic and scientific material (slides, videotapes) and ultimately helps in the better understanding of the vascular anatomy of the skull base.

The aim of this work is to present a simple technique of perfusion of vessels of the skull base in fresh cadavers

and temporal bones and to discuss its advantages and disadvantages.

TECHNIQUE

Fresh cadavers or freshly obtained bones preserved in formalin are preferred. The temporal bones are immersed in water for 2 hours to get rid of the unpleasant odor of formalin. The specimens should not be left exposed overnight, as this causes dryness of the dura and soft tissues with subsequent change in their color and increased fragility. The internal jugular vein and the internal carotid artery are identified in the neck. The vertebral artery is dissected and identified, if necessary. A small incision is made on the vessel wall to permit insertion of a suitable sized catheter. The vessels are then repeatedly washed with tap water using a 20 cc syringe so as to remove all the coagula. A perfect and meticulous wash is fundamental in achieving better results as the presence of coagula impedes the entrance of the coloring agent in

small branches and vessels. Once these vessels are cleaned thoroughly, injection of the vessels with the coloring agent is begun.

We prefer to first perform the injection of the arteries (internal and external carotid artery and vertebral artery) followed by the venous system (transverse, sigmoid sinus, jugular bulb, and internal jugular vein). The arteries are injected at the level of the neck and the venous system preferably at the level of transverse sinus after prior sectioning of the internal jugular vein in the neck. Before the injection of color, the venous channel is again flushed with tap water by a catheter in the transverse sinus until there is an appearance of clear fluid through the sectioned jugular vein, thereby ensuring proper cleaning of the sigmoid sinus and the jugular bulb. The arteries are injected with a red color and the venous system with blue.

PREPARATION OF COLORING AGENT

Materials

The following materials are used:

1. Household transparent silicone, Sigil (Pigil s.p.a.)
2. Colors (fine oil colors, Maimeri & C. s.r.l.)
3. Solvent is commercially available benzene solution (N-esano and dicloropropane, Atena s.r.l.)
4. Plastic syringes, 20 cc; catheters; scalp vein sets; containers, etc.

To attain the required density of coloring solution, the constituents are mixed in a container (separate for artery and vein) in the following proportion: (1) Dense solution (used for injecting lateral sinus, jugular bulb): 20 ml silicone, 10 ml solvent, 5 cc of color; (2) intermediate density solution (used for injecting internal and external carotid arteries): 10 ml silicone, 10 ml solvent, 5 cc of color; and (3) fluid solution (used for injecting vertebral artery and small intracranial vessels): 15 ml silicone, 20 ml solvent, 5 cc of color.

Hints and Pitfalls

1. Best results are obtained on fresh specimens.
2. Wash all the vessels thoroughly before injection.
3. The catheter used for washing and injecting should be the largest possible in relation to the diameter of the vessel.
4. Inject both sides before commencing dissection on the side injected first.

Figure 1. Exposure of the vertebral artery (VA) and the internal jugular vein (IJV) during a lateral skull base dissection. Note that the colored vessels are seen very well amid the soft tissues at the base of the skull.

5. Prepare the coloring solution only after the vessels of both sides are dissected, identified, and lavaged, as otherwise it will solidify and injection would be very difficult.
6. The last part of the injection should be done with the gradual withdrawal of the catheter.

DISCUSSION

The increasing number of options and increased interest among related specialties have added a new dimension to the field of skull base surgery. With augmentation in both diagnostic and interventional neuroradiologic techniques, much of the previously encountered obstacles pertaining to vascular structures have now been overcome. Keeping in mind the vascular perspective of the skull base and its surgical implications, it has now become necessary to have good quality didactic presentations that include optimal photographic documentation of the surgical anatomy of the neurovascular structures as seen in cadaveric or temporal bone dissections.

A relatively simple technique has recently been practiced by us to study the vascular anatomy of the skull

base. A similar technique apart from some minor technical differences or modifications is also being used by others.^{3,4} With this method, we can now easily study in detail the anatomy of both the arterial system (carotid artery and its branches, vertebrobasilar system and branches) and the venous system (transverse sinus, sigmoid sinus, jugular bulb and vein, inferior and superior petrosal sinus, condylar veins, etc.).

In comparison to some described methods of vascular casting,¹ the most important advantage of our technique is its low cost. In fact, the total cost of one injection (arteries and veins of both sides) is less than \$10. The other significant advantages are the ready availability of materials and a very simple technique of injection. Furthermore, this method does not entail complex processing procedures and thereby it is time conserving. Moreover, the property of quick solidification of silicone makes the technique very rapid.

By altering the amount of constituents, the density of the coloring solution can be easily changed. A dense solution has the advantage of rapid hardening and also facilitates better filling of the large vessels having thin walls, such as the lateral sinus and jugular bulb. Also, minor injuries to the sinus or bulb during dissection will

Figure 2. The panoramic view of the intracranial vascular structures during dissection as seen through the petro-occipital transsigmoid approach. Note that even the minutest of the blood vessels can be injected well. 4: Trochlear nerve; 5: trigeminal nerve; 8: vestibulocochlear nerve; 7: facial nerve; 9: glossopharyngeal nerve; 10: vagus nerve; SCA: superior cerebellar artery; AICA: anterior inferior cerebellar artery; PICA: posterior inferior cerebellar artery.

not carry the risk of spreading the dye everywhere in the field, thereby avoiding poor aesthetic results. However, a dense solution may fail to pass through the smaller venous channels, such as the superior petrosal sinus. A medium density dye is used for injecting the carotid artery, and a fluid solution is used for the vertebral artery. Using a fluid solution allows good injection of the entire vertebrobasilar system along with its branches.

Following the technique detailed herein, it is now possible to visualize the vascular structures at the skull base more precisely. The color taken up by the vessels (red and blue for arteries and veins, respectively) allows better distinction of them amid the abundant soft tissues at the skull base (Fig. 1). Furthermore, a panoramic view of the intracranial vessels allows a better understanding of the complex intracranial vascular anatomy in relation to the important neural structures (Fig. 2). The color contrast achieved after the injection with this technique enables us to obtain a high quality of photodocumentation in the form of slides and videotapes.

The number of personnel required for this technique is small; in fact, only two persons are needed to carry out the whole procedure. The other advantage is the ease with which excess color or stains can be washed or sucked off with an aspirator after it has dried up.

The only disadvantage of this technique until now is

the occasional failure of the very fine bore vessels to be injected, and this usually can be overcome by sufficient and meticulous washing of the main vessel before injection.

CONCLUSIONS

Our technique of studying the vascular anatomy of the skull base by infiltration of the vascular structures is simple, rapid, and cost-effective.

By using varying density solutions for various structures, it is usually possible to achieve an optimal injection of vessels of all sizes.

By this technique of coloring, it is possible to obtain a very high quality of scientific and didactic material at a very low cost.

REFERENCES

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REVIEWER'S COMMENTS

The method described here for perfusing anatomic specimens, as acknowledged by the authors, is a technique that we have used for many years and one that we have taught to numerous individuals from other training centers who have visited our microsurgery laboratory. We congratulate Landolfi and his colleagues for making it available through this journal to all of those who may be interested in such studies.

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