VIA MEDICA

ORIGINAL ARTICLE

Folia Morphol.
Vol. 83, No. 2, pp. 360–366
DOI: 10.5603/fm.95862

ISSN 0015–5659
eISSN 1644–3284
journals.viamedica.pl

Challenges associated with vascular access through the common carotid artery during embalming procedures in humans: a technical note

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[Received: 13 May 2023; Accepted: 7 December 2023; Early publication date: 19 December 2023]

Background: The teaching of anatomy is a key component in the training of physicians, and the foundation of this teaching is the human body, which must be properly prepared to be used as a teaching aid. Due to a lack of modern literature on this topic, we decided to write a technical note discussing access to the carotid artery.
Materials and methods: We pre-qualified 43 donor bodies for the study. The bodies had to meet standards such as no signs of post-mortem decomposition, preservation of body integrity, and the absence of known infections. Carotid artery access was performed based on descriptions of the types of vascular access performed in surgery and our own observations.
Results: We consider carotid artery access to be a convenient option due to its ease of location. When performed correctly and with attention to the surrounding structures, it is relatively low in tissue trauma, which translates into a higher quality of preparation. Data analysis has revealed several factors that can have a significant impact on the success of the embalming procedure.
Conclusions: Proper execution of minimally invasive access to the common carotid artery minimizes tissue damage and ensures a high success rate of the procedure. Knowledge of the types of vascular access is essential for preparing the highest quality specimens. (Folia Morphol 2024; 83, 2: 360–366)

Keywords: tissue fixation, human specimen, cadaver, embalming procedure, formaldehyde

INTRODUCTION

Adequate knowledge of human anatomy is essential for a physician's education. As part of a university medicine course, the study of human anatomy is typically conducted in the early years of study [2, 11]. During anatomy courses, educators use a variety of teaching tools that are available due to advances in modern engineering science [21]. However, the basis of didactics is always the human body and its anatomical structure [13, 15, 23].

It is used as an educational tool, both as a prosection, and as a dissection. They then gain additional,

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unique skills related to the acquisition of practical dissection skills useful in clinical practice [1, 28]. The preservation of cadavers has two main purposes: to protect the specimens from decomposition and to protect the preparator/dissector from infection caused by microorganisms that may be present. Both aspects are equally important [9].

The optimal embalming of a cadaver is influenced by factors beyond the embalmer's control, such as the time elapsed since the donor's death, the direct cause of death, or concomitant diseases that may affect damage to the vascular system. However, factors dependent on the operator of the procedure, such as the preservative used, the vascular access used, as well as the dynamics of the vascular filling process, are also important [16, 22].

An important element of the embalming/body preservation procedure must also be to ensure health and safety for the embalmer to maximize the protection of their body from the toxic and carcinogenic effects of the preservatives [3].

The aim of this study is to demonstrate the stages of optimal, minimally invasive vascular access to the arterial system of a deceased donor for the embalming of a cadaver.

MATERIALS AND METHODS

Forty-three donors who had joined the donation program during their lifetime were eligible for the project. They confirmed their willingness by providing a notarized letter of consent to participate in the university's donation program. The primary aim of the program was to make access to human bodies available to students at the pre-diploma stage. In addition, the program allowed the use of deceased donor bodies for scientific, experimental, and training activities. Cadavers that showed signs of accelerated decomposition or receding rigor mortis were disqualified from the project. Those who died from infectious diseases such as COVID-19, hepatitis, HIV, and tuberculosis were also not eligible for the study. Deceased without limbs or cadavers that had previously been dissected were also disqualified. The experiment received a positive opinion from the local bioethics committee — no. 135/2023. Furthermore to increase the practical value of the work, the local database of the donation program was used to compile the study, using data from 2015–2023.

The study was conducted based on the standards for creating technical notes published in 2010 [20]. The authors demonstrates proficiency in the formulation of technical notes papers [7, 8], showcasing adeptness in both the development and application of a diverse array of anatomical methodologies [9, 29].

Table 1. Relationship between selected embalming stages and procedure success

		Number of cases	Failure (cadaver no.)
TIME	≤ 72 h	35	1 (188)
	72–96	7	1 (174)
	≥ 96 h	2	2 (183; 170)
POSITION		42 (1 case — no data)	3
FREEZING	YES	13	0
	NO	30	4 (174,183,188; 170)
JUGULAR VEIN	YES	34	1(183)
	NO	9	2 (188,174)
SURGERY	YES	41	1 (188,174)
	NO	2	1 (183)
VELOCITY	LOW (average speed below 30 mL/min)	39	1 (183)
	HIGH (average speed over 30 mL/min	4	3 (188,174; 170)

RESULTS

Timing of the procedure

It was demonstrated that timing is an important factor that affects the success of body embalming procedures. Delayed transport of the deceased donor's body to the embalming unit is associated with a reduction in the probability of perfect preservation of the cadaver (Table 1). The success of the procedure was the dissection utility of the cadaver — that is, the possibility of using the cadaver in the dissection room classes for a minimum of six months (one year of the teaching cycle).

Recommendations:

1. It is essential that the time between the donor's death and the arrival of the deceased at the embalming unit be as short as possible. An optimal interval appears to be up to 72 hours.
2. It is necessary to keep the body of the deceased in a freezer (at a temperature between 0–4 degrees Celsius) between the time of death and the date of transport to the embalming unit [25].

Preparation of the deceased body

The body should be placed on the autopsy table in the anatomical position after initial preparation by the technicians, following hygienic procedures. It is recommended that a support should be placed under the body in the interscapular area. This location of the support will allow gravitational decompression of the neck and give the operator the possibility to rotate the neck freely, thus increasing the field of access to the vessels. The process of rigor mortis observed in deceased persons makes it more difficult to position the body properly. During the study, a lower post-mortem cadaveric rigidity was observed when the body was thawed. In this period, for a short time, it is possible to slightly modify the positioning of the deceased donor's body [5, 12].

Recommendations:

1. Technicians who receive the body of the deceased from the family should be trained on the optimal positioning of the body that is expected by the anatomists.
2. It has been observed that briefly freezing the body before the embalming procedure can allow for rotation of the limbs and better body positioning in some cases.

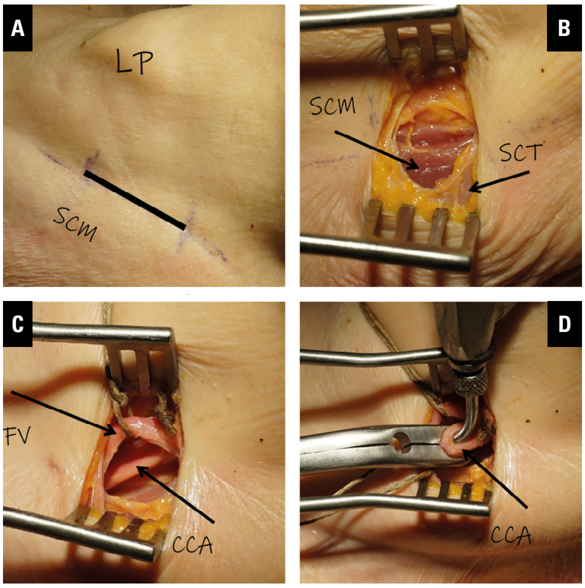

Figure 1. Stages (A–D) of vascular access to the CCA (common carotid artery); **A.** LP — laryngeal prominence; SCM— sternocleidomastoid muscle; **B.** SCM — sternocleidomastoid muscle; SCT — subcutaneous tissue; **C.** CCA — common carotid artery, FV — internal jugular vein; **D.** CCA — common carotid artery.

The acquisition of vascular access

Vascular access to the common carotid artery was developed based on surgical recommendations due to the lack of literature descriptions on the detailed steps of the procedure performed during cadaver embalming.

Technically, in the first stage, the head was rotated to facilitate access to the carotid artery triangle. It is recommended to select the right side of the body for the procedure, given the predominance of right-handed physicians. Furthermore, when considering the internal jugular vein as an alternative vascular access, the right vein is preferred due to its more direct connection to the right atrium of the heart, enhancing effectiveness. In the next stage, the anterior edge of the sternocleidomastoid muscle was located laterally, the larynx medially and, in its extension, the trachea, so as to be able to define the skin incision line. The upper edge of this line was defined based on the level of the upper edge of the thyroid cartilage.

The surgical knife was guided along the incision line approximately 2.5 cm caudally. The subcutaneous tissue was then dissected bluntly. Once the platysma muscle was visualized, it was cut with scissors and the wound was then dilated with a retractor. The superficial lamina of the cervical fascia was then bluntly dissected, passing along the anterior edge of the sternocleidomastoid muscle. It is worth noting the presence of the facial vein in this area.

Next, the location of the neurovascular bundle was determined by palpation. The fingers were directed medially and distally. The bifurcation of the carotid artery was explored. If dissection was necessary, it was executed with a blunt approach.

According to the available scientific data, the course of the carotid artery bifurcation is relatively constant and can therefore serve as a topographic marker [4, 6]. In the next stage, the carotid artery sheath was dissected and the internal jugular vein was repositioned, allowing access to the common carotid artery (Figure 1). It is worth noting the high topographical variability within the position of these vessels [24]. This venous vessel is susceptible to damage and, if cut, makes it very difficult or practically impossible to continue the procedure due to the flooding of the surgical field with blood.

It is not always possible to completely remove the incoming blood and obtain a good preparative view. Even after ligation of the vein, the problem is not solved, as it is difficult and time-consuming to effectively remove the remaining partially clotted and decomposing blood. In the final stage of the preparation, the arteries were prepared and visualized in such a way that a thread for ligation of the vessel could be passed underneath.

One vascular ligation was placed and tied on the distal part of the vessel. The ligation was located proximally to the division of the common carotid artery into the internal carotid artery and external carotid artery. Simultaneously, a second vascular ligation was applied to encompass and seal the catheter during the embalming process. Then, a small incision with a maximum length of 0.5 cm was made in the arterial wall, granting access to the lumen of the artery. Typically, a transverse cut was made using a scalpel. In situations where the carotid artery was severely atheromatous, a wedge cut was usually performed with double-pointed scissors

Recommendations:

1. It is worth paying attention to the correct course of the skin incision, as proper execution results in a shorter procedure time and a reduction in accompanying tissue damage.
2. The unfavourable position of the internal jugular vein may complicate safe vascular access. In the case of an intermediate position of the vessel, where it only partially covers the carotid artery, it may be possible to gently reposition the vessel to gain good access to the common carotid artery. In extreme cases where the internal carotid artery cannot be easily located, the internal jugular vein should be ligated both proximally and distally for safety before manoeuvring. This will help to limit bleeding if the vessel is accidentally ruptured during any attempts to visualize the artery.
3. When manipulating the carotid sheath, it is useful to locate the vagus nerve to avoid damaging it.

Embalming process

After assessing the patency of the common carotid artery, the embalming team inserted a pump catheter through the incision made earlier, directing it caudally. A vascular clamp was placed around the catheter on the artery to limit the outflow of fluid. The embalming procedure was then initiated. For the purposes of the experiment, mechanical support was abandoned, and the procedure was carried out using a hand pump. A standard preservative solution based on formaldehyde (40% per volume) and ethyl alcohol was used [3] .

In the initial stage, preservative fluid was introduced at a rate of up to 200 mL/minute to check the tightness of the access. Then, after transfusing approximately one litre of preservative fluid, the flow rate was gradually reduced to about 25 mL/minute.

During the procedure, symptoms indicative of successful embalming were observed, such as elevation of the abdominal wall, filling of the subcutaneous veins, and a change in body colour. The procedure was discontinued when there was significant resistance to pumping and leakage appeared at the cannula insertion site. At this stage, the embalming process had been completed.

Recommendations:

1. Assessment of Vascular Patency
   We recommend that prior to the embalming procedure, the patency of the vessel should be assessed by inserting a dissector of the appropriate diameter into the artery. This tool has a rounded, non-traumatic end and is ideal for this purpose. Furthermore, in the presence of small or large, but not overly long, ring-shaped atherosclerotic lesions, it is possible to mechanically break them up and achieve satisfactory flow.
2. Ensuring Tightness of the Connection.
   For the procedure to be successful, it must be performed in a minimally invasive manner. All vessels that cannot be bypassed should be ligated. A coagulating knife can also be used to improve efficacy, but in our opinion, a precise preparation is sufficient to achieve success.
3. Increasing the Probability of Success
   During the experiment, it was observed that prior freezing of the deceased body for several days at a temperature of -8 degrees Celsius increases the probability of successfully filling the vascular bed with embalming fluid.

CONCLUSIONS

In the evaluated period (2015–2013), the percentage of failures was 16.27%. However, in three cases, due to carotid atherosclerosis (two cases) and hypoplasia of the carotid artery (one case), it was possible to perform the procedure from an alternative access (via the femoral artery approach). Thus, in 9.3% of cases, for technical reasons (see Table 1), it was not possible to embalm the cadaver correctly and the body was prematurely damaged.

DISCUSSION

The common carotid artery is a useful vessel for the purposes of embalming. It is located in the anterior triangle of the neck and has no significant branches that make access to the vessel and the procedure difficult [10]. The right CCA, as an ascending branch of the brachiocephalic trunk (BT), averages 9.4 cm in length, while the left CCA, as a direct branch of the arch of the aorta, averages 13.4–14.4 cm; the calibre of both CCAs is approximately 6–7 mm [18, 27].

The diameter of the vessel, as well as its proximity to the aorta and heart, makes this a kind of gateway to the vascular system for the embalmer responsible for preserving the deceased donor. Important features that make this access more attractive are its superficial location and the relatively stable topographical puncture area [17].

Most importantly, as the common carotid artery is not the only vascular supply route to the head and neck, its distal ligation, which is necessary during a standard procedure, will not impede the embalming of the head and neck tissues. The other vessels present, such as the unilateral common carotid artery and the two vertebral arteries, provide an adequate supply route for the preservation fluid [30].

This paper demonstrates that occlusion or hypoplasia of the common carotid artery can pose a challenge for the embalmer, though this is relatively rare. In such cases, an alternative access is recommended [26].

However, our own experience suggests that this alternative access should be a large artery located in the lower part of the body due to the limited access to the bodies of deceased donors today [19, 20].

Dissection of both sides of the neck when seeking alternative access to a major artery can cause irreversible damage to this area, making it much less useful for student activities. Therefore, it is recommended to use another opposite artery as an alternative access in cases of hypoplasia or significant atherosclerosis of one of the arteries of the neck. It is worth noting the carotid sheath and its variability, as well as the variability of the course of the vagus nerve and the position of the internal jugular vein, which are important when obtaining a vascular approach in this anatomical location [24].

The lack of knowledge regarding the risks associated with the variable course and varying topographical relationships of the carotid sheath components can lead to the failure of the cadaver embalming procedure.

It has been demonstrated through many years of experience at our centre that the one-point injection embalming procedure is a viable option when utilizing standard preservative fluids. This contrasts with alternatives such as split injection or multipoint injection, which are typically reserved for specialized scientific applications or cases of technical difficulty.

It is without doubt that the most influential factors in determining the success of the procedure are the time between death and the start of the embalming process, as well as any dissection difficulties and the urgency of the task (the use of an excessively high pressure or too high flow dynamics through the intravascular catheter). Clearly, the high level of experience of the embalming team is an essential factor in ensuring success.

ARTICLE INFORMATION AND DECLARATIONS

Limitations of the study

An important limitation of the work is the small amount of analysed material, due to the specificity of the local donation program and the negative impact of the COVID-19 pandemic.

Acknowledgments

The authors would like to thank the technical staff of the department for their assistance in the preparation of the preservation fluids and for their many hours of help in improving the procedure.

The research results presented here, which were conducted within the framework of the topic registered in the S system with the number SUBK.A351.23.020, were financed by a subsidy granted by the Minister of Science and Higher Education.

The authors also wish to express their gratitude to all those who donated their bodies to medical science, allowing anatomical research to be conducted. Such research can potentially increase mankind's overall knowledge, which can then be used to improve patient care. Therefore, these donors and their families deserve our utmost gratitude [14].

Conflict of interest: All authors declare no conflict of interest.

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