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ORIGINAL ARTICLE

Precision in preservation: mastering cadaver embalming with the femoral artery approach — a technical note

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ABSTRACT

Background: Human anatomy is a fundamental aspect of a physician's knowledge. While novel technologies offer innovative ways to teach anatomy, cadavers remain an essential component of anatomical education. The quality of specimens begins with well-preserved cadavers, and the chosen vascular access for injection plays a crucial role. Unfortunately, there is a lack of literature regarding embalming procedures, as discourse on such practices could enhance the quality, safety, and effectiveness of anatomical instruction.

Materials and methods: In this study, a femoral artery approach is described for embalming, which entails a meticulous process of cutting through the skin, navigating through fascias and adipose tissue by means of blunt dissection, ultimately reaching the artery for embalming injection. Tips and techniques pertaining to this technique are provided, including vital details for convenient accessibility and minimal impairment of tissue.

Conclusions: The objective of this study is to facilitate anatomists and technicians in the adoption of the femoral artery approach, and to encourage further exploration of alternative embalming methods, thus contributing to the continuous advancement of anatomical sciences.

Keywords: cadaver embalming, femoral triangle, fixation, human body

INTRODUCTION

The proficient understanding of human anatomy is imperative for medical students [30]. Despite advancements in technology, the use of human cadavers remains an essential aspect of anatomical education [20]. There is a widespread belief that this traditional approach is unparalleled in its effectiveness in fostering a comprehensive understanding of the human body. Hence, it is crucial that students have access to high-quality cadavers [9]. Proper preservation is necessary in order to use cadavers for education. A combination of embalming fluids is injected into the cadaver's vascular system for two purposes: to prevent decomposition and to safeguard anatomists and students from infections [2, 29]. Effective embalming necessitates precise access to the vascular system. However, the current literature lacks a comprehensive description of an approach that aligns with contemporary terminology and scientific standards. This dearth of literature results in a lack of standardization and leads to the implementation of different techniques in each embalming laboratory [22, 27].

In this work, we aim to outline the steps involved in embalming cadavers using the femoral artery as the primary entry point. We describe the methods of locating and dissecting this particular structure using anatomical and surgical techniques. We also discuss the advantages and disadvantages of employing this approach in the embalming process.

MATERIALS, METHODS AND RESULTS

The study was conducted based on the standards for creating technical notes published in 2010 [24]. The authors demonstrate proficiency in writing technical notes papers, showcasing adeptness in both the development and application of a diverse array of anatomical methodologies [5, 7].

The experiment received a positive opinion from the local bioethics committee — no. 135/2023. Furthermore, to enhance the practical applicability of the study, data from the local donation program database spanning from 2014 to 2023 was used (Table 1). The project successfully enrolled six donors who participated in the university's donation program from 2014 to 2023. These individuals submitted a notarized statement of intent to join the donation program, thereby affirming their commitment. The primary objective of this initiative is to provide students access to human bodies. Cadavers with infectious diseases or signs of advanced decomposition were deemed ineligible, as were those missing limbs or that had been previously dissected. In other cases, access to the cadaveric vascular system was achieved primarily through the common carotid artery (CCA), following the described procedure [6].

Technical note

The preparation of the deceased body

Prior to being placed on the autopsy table, the body must undergo initial preparation by the technicians in accordance with hygienic protocols. In cases where the cadaver retains partial mobility, it is advisable to laterally rotate the thigh at the hip joint to facilitate easier access to the femoral vessels through the femoral triangle. It should be noted, however, that the presence of rigor mortis in the cadaver hinders manipulation during the embalming process. Based on our experience, we have found that subjecting the cadaver to a brief period of freezing (e.g., 24–72 hours) can enhance limb mobility and enable more precise positioning of the body [6].

The acquisition of vascular access

During the initial stage, the position of the inguinal ligament (Poupart's ligament) was determined. In order to accurately identify its location, a line was drawn connecting the superior anterior iliac spine and the pubic tubercle. The midpoint of this line, which also represents the midpoint of the ligament, was utilized as a point of origin for the incision. The incision was directed distally and slightly medially, spanning a range of approximately 5–7

cm. To facilitate this procedure, it is recommended to pre-mark the aforementioned line with a suitable marker (Fig. 1a, b).

Afterwards, the skin was precisely cut using a scalpel and the subsequent steps involved a meticulous preparation of the subcutaneous tissue, adipose tissue, and fascia using the blunt preparation technique (Fig. 1c, d).

Furthermore, it should be noted that this sizeable vein is often filled with blood and may mislead the operator into incorrectly identifying the saphenous vein as an artery or the femoral vein. However, if the vein is situated on the surface of the thick, white fascia, without the fascia lata having been incised, it must unquestionably be the saphenous vein or one of its tributaries. It is important to note that the saphenous vein can serve as an instructive marker for the operator, leading towards the femoral vein. This is due to the fact that the saphenous vein enters the femoral vein at the femoral triangle, passing through the saphenous opening in the fascia lata [13].

When performing subcutaneous tissue dissection, it is recommended to properly orient and execute the dissection in a horizontal manner, following the incision line. This approach will afford the operator a clearer view of the vessel. Furthermore, a wider surgical field will facilitate access to the artery and assist in its elevation.

In the following stage of the procedure, the fascia lata was carefully cut using scissors, with utmost attention paid to preserving the integrity of the femoral artery, surrounding veins, and adjacent nerves. It should be noted that these vessels are enclosed within the femoral sheath [19, 21]. The femoral sheath is formed by the downward extension of the abdominal fascia, situated posterior to the inguinal ligament. The transverse fascia descends anterior to the femoral vessels, while the iliac fascia is positioned posterior to them. The femoral sheath is compartmentalized into two vertical compartments that extend between its anterior and posterior walls. The medial compartment contains lymphatic vessels, the intermediate compartment houses the femoral vein, and the lateral compartment accommodates the femoral artery. During dissection, it is important to remember that the femoral nerve is externally situated to the femoral sheath. It is also noteworthy that the branches of the genitofemoral and lateral cutaneous nerve of the thigh exhibit significant variability, as documented in literature. These branches may also be observed within the surgical field [10].

In the ensuing phase, the femoral sheath was incised. Subsequently, the femoral artery was identified and dissected. Two vascular ligatures were securely applied — one at the proximal and another at the distal ends of the intended transection point of the artery. The artery was then elevated upwards and laterally to facilitate dissection of the femoral vein,

which is positioned medially and proximally (Fig. 2a). It is of critical importance to exercise extreme caution during the dissection of the femoral vein, due to its fragile vessel wall and the presence of numerous tributaries that may be filled with blood [23]. In cases where the risk of damage to the femoral vessel is high, it must be considered whether to halt the dissection and ligation of the vein, as this may result in flooding of the surgical area and significantly impact the outcome of the procedure.

Embalming process

The dissected femoral artery was incised along its longitudinal axis in order to access its lumen. To secure the artery's position prior to the incision, a dissector or small surgical instrument may be placed underneath it. In cases where significant atherosclerotic lesions are present, a wedge incision can be made using double-pointed scissors. Subsequently, the patency of the artery was assessed by inserting a dissector into both the proximal and distal directions of the vessel. This instrument, with its rounded and non-traumatic tip, was deemed suitable for this purpose. Should small or moderate annular atherosclerotic lesions be present, they can be physically fragmented to ensure adequate blood flow. After confirming the patency of the femoral artery, the embalming team inserted a pump catheter through the previously made incision, directing it upwards. A vascular clamp was placed around the catheter and artery to prevent the efflux of fluid. In the subsequent stage of the procedure, an incision was made in the femoral vein and a drainage catheter was inserted into the lumen of the vessel, with the end of the catheter directed proximally. The catheter was secured by tightening one vascular ligation and completely occluding another to prevent blood flow from the distal side. It is recommended to maintain the venous ligation on the medial aspect of the thigh and the arterial ligation on the lateral aspect of the thigh (Fig. 2b) in order to ensure a structured surgical field. The embalming process was then initiated. To accurately evaluate the outcomes of the experiment, the use of mechanical support was discontinued and a hand pump was utilized instead (see Fig. 2c, d). A standard preservative solution containing 40% formaldehyde by volume and ethyl alcohol was used [4].

In contrast to the practice of injecting the human body via the carotid artery, it is recommended that a low flow rate of preservative fluid, approximately 25 mL/minute, be maintained throughout the procedure to ensure precise distribution. During the course of the procedure, several indications of successful embalming were observed, including the elevation of the abdominal wall, filling of the subcutaneous veins, and a noticeable change in body color. Upon encountering significant resistance during the pumping process, the

procedure was ceased and leakage was observed at the insertion site of the cannula. Following this, the arterial cannula was removed and the proximal segment of the femoral artery was successfully tied off. Afterwards, the cannula was carefully reinserted and directed caudally in an effort to repeat the embalming process and achieve satisfactory preservation of the lower limb. At this stage, approximately 350–500 mL of preservation fluid was successfully administered, thereby concluding the embalming procedure. All cannulas were subsequently removed and the femoral artery and vein were secured, with the possibility of suturing the incision line being taken into consideration.

DISCUSSION

The femoral artery is a continuation of the external iliac artery and originates below the inguinal ligament. It is the main vessel responsible for supplying blood to the lower limb [16]. While passing through the thigh, the artery traverses the femoral triangle before entering the adductor canal. From there, it proceeds towards the posterior aspect of the lower limb and culminates at the adductor hiatus, ultimately reaching the popliteal fossa [14]. Situated within the femoral triangle, the artery is flanked by the femoral vein and femoral nerve, typically positioned slightly more superficially and laterally in comparison to the femoral vein [25]. This highlights one of the significant advantages of using the femoral artery as an access route to the vascular system in a cadaver. Its relatively superficial location and considerable diameter render it convenient for the embalming team. It is important to note, based on the limited available literature, that the CCA is often considered the gold standard [6, 8, 17].

Scientific data suggests that both arteries exhibit comparable dimensions, usually ranging between 6 and 7 mm [1, 15]. Therefore, the femoral artery may serve as a viable alternative to the CCA, particularly in instances where neck dissection is contraindicated. For example, this may apply in cases where the donor's cause of death is related to neck injuries, such as in cases of suicide, traffic accidents, or war injuries [26, 28], as well as when preparing a high-quality head and neck specimen where embalming via the CCA is not advisable [12]. The use of the femoral access route should also be considered in patients with significant thyroid goiters or other challenging-to-define head and neck tumors. However, care must be taken to acknowledge the peripheral positioning of the artery when administering preservative fluids into the vascular system of a deceased individual. Factors such as the advanced age of the donor, presence of common atherosclerotic lesions, or complications associated with diabetes should be regarded as relative contraindications [18].

One of the primary limitations is the likelihood of atherosclerotic lesions impeding the efficient circulation of fluids delivered via the femoral artery towards the neck, upper limb, or head, particularly in the heart and major thoracic vessels. Moreover, clinical evidence suggests that selecting an arterial dissection on the left side of the body may be a comparatively less precarious alternative when utilizing the femoral approach [3].

A local limitation is the presence of significant amounts of adipose tissue in the femoral triangle, along with any nodal pathology or hernias, which can hinder and protract the dissection process.

CONCLUSIONS

In conclusion, we assert that the femoral access technique is a simpler and anatomically sound method. The process of locating the femoral artery is relatively straightforward, and the anatomical complexities involved in the procedure are minimal compared to that of neck preparation. Therefore, we highly recommend this method, particularly for embalming teams with limited preparation experience. The primary advantage of this technique is its ability to preserve the neck intact, which is of paramount importance from an anatomical teaching perspective. This is due to the intricacies of the neck anatomy, making it more challenging to obtain high-quality anatomical specimens of the neck compared to the lower extremities.

Limitations of the study

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

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

All important data are embedded in the article. In any doubts please ask corresponding or first author of the manuscript

Ethics statement

The experiment received a positive opinion from the local bioethics committee — no. 135/2023.

Author contributions

Zygmunt A. Domagala — conceptualization, development or design of methodology, conducting a research and investigation process, writing — original draft, writing — review & editing. Mateusz Drazyk, Oliwier Pioterek, Oskar Kozlowski, Pawel Lubieniecki — development or design of methodology, conducting a research and investigation proces. Maciej Sroczyński, Agata Dudek — development or design of methodology. Sławomir Wozniak — writing — review & editing, supervision. Victoria Tarkowski — conceptualization, writing — review & editing. Mateusz Mazurek — conceptualization, development or design of methodology, conducting a research and investigation process, writing — original draft.

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Conflict of interest

The authors declare that they have no conflict of interest.

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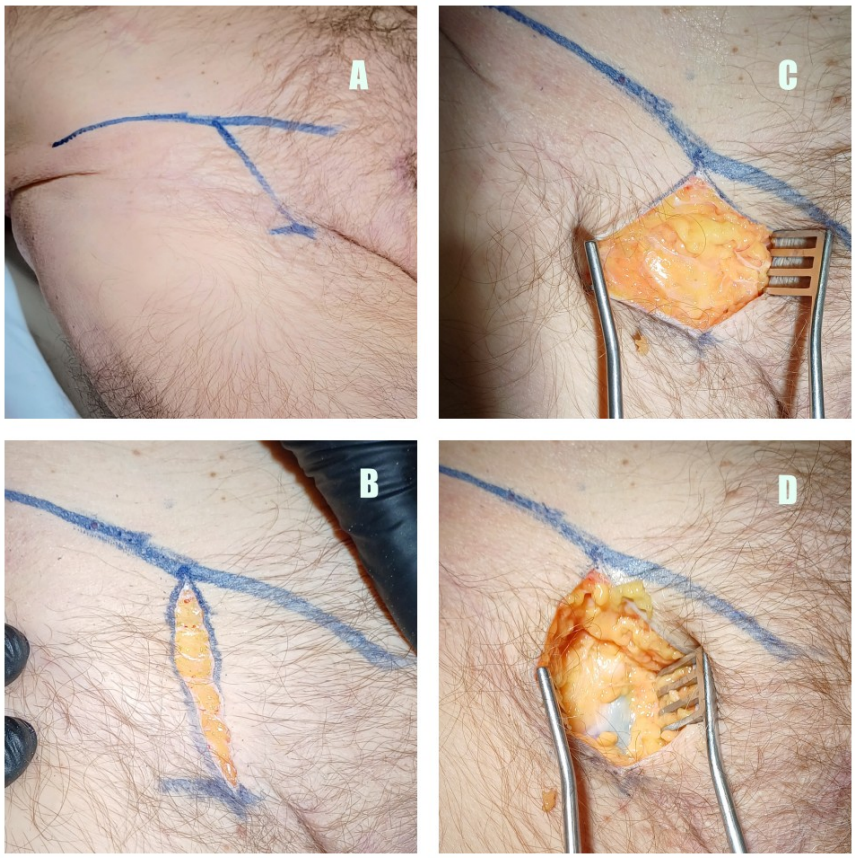

Figure 1. Initial stages of femoral access during cadaver embalming. **A–D.** Individual stages of reaching the fascia lata.

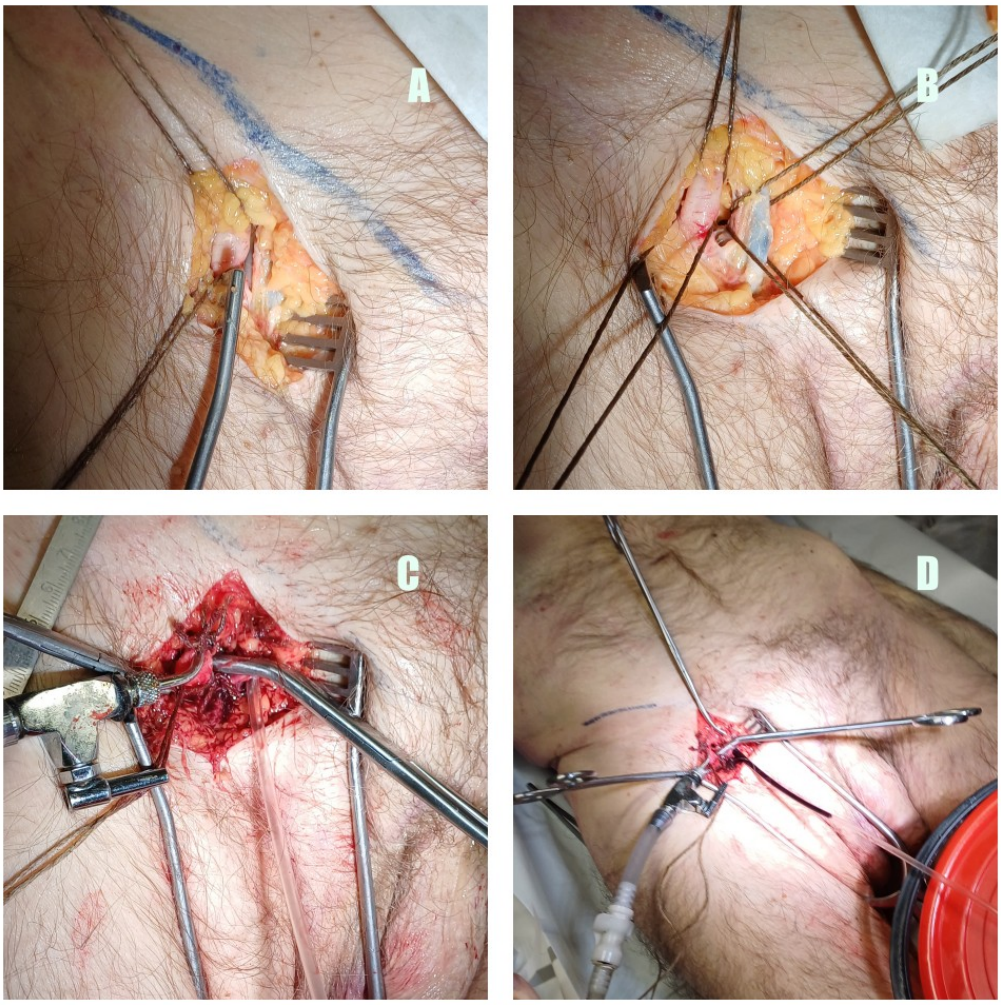

Figure 2. Femoral access. **A.** Ligated and elevated femoral artery; **B.** Ligated femoral artery (on the lateral side of the body) and femoral vein (on the medial side of the body); **C, D.** Insertion of a cannula into the femoral artery and drainage into the femoral vein.