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Original Contribution

Clavipectoral fascia plane block in midshaft clavicle fractures: A cadaveric study

Hipólito Labandeyra, MD [a], Cristina Heredia, MD [b], Luis Fernando Váldes-Vilches, MD [c], Alberto Prats-Galino, PhD [d], Xavier Sala-Blanch, MD [a,*]

[a] *Human Anatomy and Embryology Unit, Faculty of Medicine and Health Sciences, Universitat de Barcelona, Barcelona, Spain*
[b] *Anesthesia, Hospital de la Santa Creu I Sant Pau, Barcelona, Spain*
[c] *Anesthesia, Hospital Costa del Sol, Málaga, Spain*
[d] *Laboratory of Surgical Neuroanatomy (LSNA). Human Anatomy and Embryology Unit, Faculty of Medicine and Health Sciences, Universitat de Barcelona, Barcelona, Spain*

HIGHLIGHTS

- CPB in Clavicular Fractures: Examining periosteum distribution.
- CPB Impact: Superficial muscle plane affected deep muscular plane unaltered.
- CPB in the clavicular periosteum: Anterosuperior influence.
- Fracture's Effect in CPB: No enhancement in postero-inferior periosteum.

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Upper limb
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ABSTRACT

Study objective: The objective of this anatomical study was to investigate the distribution of a solution administered using the Clavipectoral Fascia Plane Block (CPB) technique in a series of cadaveric models with midshaft clavicular fractures. The study aimed to address the knowledge gap regarding the impact of clavicular fractures on the distribution pattern of the CPB-administered solution.
Design: Observational cadaveric study.
Setting: The research was conducted in the laboratory setting of the University of Barcelona, adhering to the institution's ethical guidelines and standards.
Patients: Five unembalmed human cadavers were used, generating ten clavicle samples.
Interventions: A postmortem fracture was induced in the middle third of the clavicle using a blunt-edged hammer, simulating a midshaft clavicular fracture.
Measurements: Anatomical dissection was performed in three layers: the superficial muscle plane, deep muscle plane, and clavicular periosteum plane. Dye staining with methylene blue was utilized to assess the distribution pattern.
Main results: In the superficial muscular plane, methylene blue was observed in the deltoid (100%), pectoralis major (100%), sternocleidomastoid (SCM) (70%), and trapezius muscles (100%). Conversely, the deep muscular plane, including the subclavius muscle, pectoralis minor, and Clavipectoral Fascia (CPF), exhibited no staining. At the clavicular periosteum plane, methylene blue distributed predominantly to the antero-superior region (57.3%), with a minimal impact on the postero-inferior area (6.5%).
Conclusions: The study reveals that the presence of a midshaft clavicular fracture does not significantly alter the diffusion pattern of the CPB-administered solution, maintaining a consistent distribution in both intact and fractured clavicle models.

* Corresponding author at: Department of Anesthesiology, Hospital Clinic, University of Barcelona, C/ Villarroel 170, 08036 Barcelona, Spain.
E-mail address: xsala@clinic.cat (X. Sala-Blanch).

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1. Introduction

The clavipectoral fascia plane block (CPB) has garnered significant clinical interest for its role in anesthetic and analgesic management in midshaft clavicular fractures [1–4]. This technique involves blocking the terminal nerve branches responsible for innervating the clavicle [5,6]. Anatomical studies conducted on intact clavicle models [7–9] using the CPB have indicated that the CPF does not create a circular encasement around the clavicle. Moreover, these studies [7–9] have demonstrated that the CPB block effectively distributes the administered solution to the anterosuperior region of the clavicular periosteum, while leaving the posteroinferior region unaffected. However, fractures disrupt the periosteum's continuous integrity and the adherent fascia, potentially creating a conduit between the anterior-superior and posterior-inferior regions. This phenomenon raises the possibility of the administered solution, using the CPB technique, diffusing throughout the posterior clavicular periosteum, including the focus of the fracture.

The objective of this anatomical study is to assess the distribution of the solution administered through the CPB technique in a series of cadaveric models presenting midshaft clavicular fractures.

2. Methods

2.1. Sampling

Following approval from the Research Ethics Committee of the University of Barcelona (UB), Barcelona, Spain, a cadaveric study was conducted at the Anatomy Laboratory of the Department of Embryology and Human Anatomy at the Medical School of the UB. A total of five unembalmed human cadavers, devoid of any history of prior trauma or surgical interventions to the shoulder girdle, were included in the study, resulting in a total of ten clavicular samples.

To ensure optimal specimen conditions, the cadaveric models were stored at a constant temperature of 4 °C for 36 h, in accordance with standard safety criteria for dissection. During the preservation period, a postmortem fracture was intentionally induced in the middle third of the clavicle using a blunt-edged hammer, resulting in direct trauma to the midclavicular line. Following the fracture, we observed a slight displacement.

2.2. Description of injection technique

CPB blocks were performed, as described by Váldes-Vilches et al. [2–4] by two experienced anesthesiologists in ultrasound-guided regional anesthesia (HL; XSB), using a high frequency (6–13 MHz) linear transducer (HFL38x) and a M-Turbo ultrasound machine (Sonosite, Fujifilm, Bothell, Washington, USA).

The CPB was performed with the cadaver in a supine position, using a linear probe placed over the clavicle in a parasagittal plane. The ultrasound beam was directed caudally, ensuring it was perpendicular to the superior surface of the clavicle, visualizing it as a hyperechoic line parallel to the skin. A complete scan of the entire length of the clavicle was then conducted until identifying the fracture site. The transducer was then moved to identify the healthy periosteum, the clavipectoral fascia just above it, and the pectoralis major muscle caudally. On both sides of the fracture, two injection points were identified: the first injection point was located at the medial border of the clavicular insertion of the trapezius muscle, and the second injection point was at the lateral border of the clavicular insertion of the sternocleidomastoid muscle (SCM). An in-plane approach was employed, using a 22-gauge needle with a 30-degree bevel and a 50 mm insulated needle (Stimuplex 360, B Braun, Melsungen, Germany).

The needle was advanced in-plane from the chest side in a caudal to cranial direction. The periosteum of the clavicle, seen as a hyperechoic line, was visualized with the ultrasound transducer, and the bundle of the pectoralis major muscle, the CPF, and the subclavius muscle were

Table 1
Summary of methylene blue distribution after performing the CPB technique in the series of cadaveric models with midshaft clavicular fracture. The table includes information on the surface area of the stained and unstained regions, as well as the percentage of the clavicular periosteum that was stained.

Cadaver sample	Side	Superficial Muscle Plane				Deep Muscle Plane			Clavicular Periosteum			
		Superficial Cervical Plexus	Deltoid	Pectoralis Major	Sternocleidomastoid	Trapezius	Pectoralis Minor	Fascia Clavipectoral	Subclavius	Antero-superior	%	Infero-posterior	%
1	**right**	+	+	+	–	+	–	–	–	+	64%	+	6%
	left	+	+	+	+	+	–	–	–	+	43%	+	4%
2	**right**	+	+	+	+	+	–	–	–	+	57%	+	7%
	left	+	+	+	+	+	–	–	–	+	44%	+	12%
3	**right**	+	+	+	+	+	–	–	–	+	72%	+	8%
	left	+	+	+	–	+	–	–	–	+	67%	+	5%
4	**right**	+	+	+	+	+	–	–	–	+	77%	+	9%
	left	+	+	+	+	+	–	–	–	+	69%	+	11%
5	**right**	+	+	+	–	+	–	–	–	+	46%	–	0%
	left	+	+	+	+	+	–	–	–	+	54%	+	3%
Summarize #		**100%**	**100%**	**100%**	**70%**	**100%**	**0%**	**0%**	**0%**	**100%**	**57,3% (45–68)**	**90%**	**6,5% (3–9)**

Data expressed as percentages of cases or median (interquartile range 25–75) according to variables.

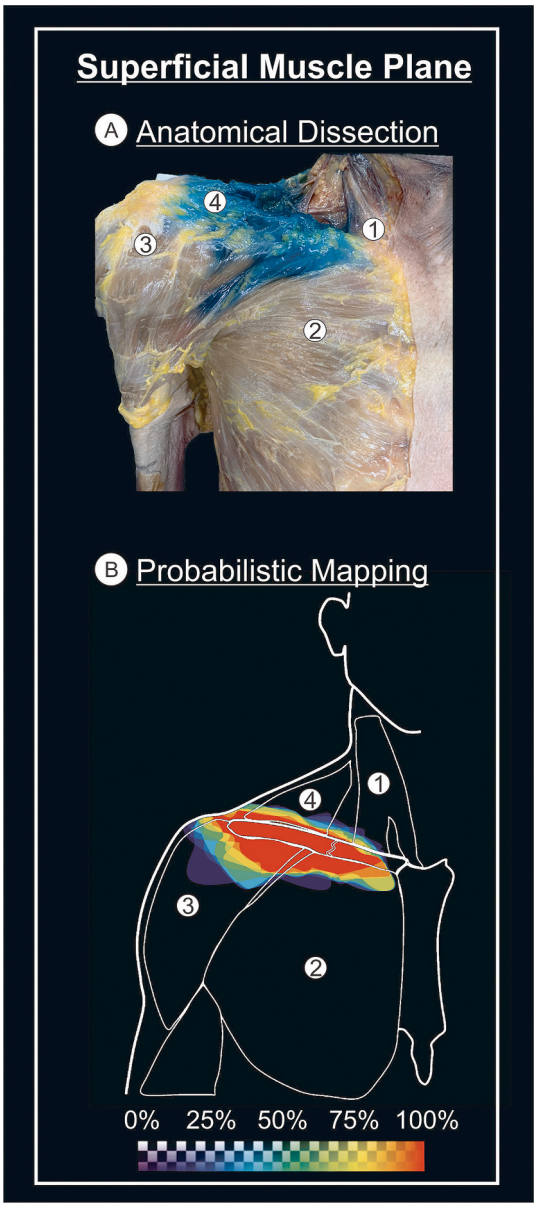

Fig. 1. Fig. 1A: Anatomical dissection of the superficial muscular plane showing the distribution of methylene blue in sternocleidomastoid (1), pectoralis major (2), deltoid (3), and trapezius (4). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
B: Probabilistic map of the color spectrum and temperature, illustrating methylene blue distribution in the superficial muscular plane. Highlighted in red and yellow are pronounced impregnations in pectoralis major (2), deltoid (3), and trapezius (4), with a more moderate effect in the sternocleidomastoid muscle (1) (in green and blue). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

clearly identified caudally to the clavicle. The needle was advanced until contact was made with the clavicular periosteum and then slightly withdrawn before injecting a 10 ml solution containing a mixture of sterile saline with methylene blue 0.02% (methylene blue 1%, sterile solution CSP 5 ml, Allon Padial) at each of the previously described injection points. The fascia was clearly seen lifting off the periosteum when observing a caudal to cephalic spread of the injectate.

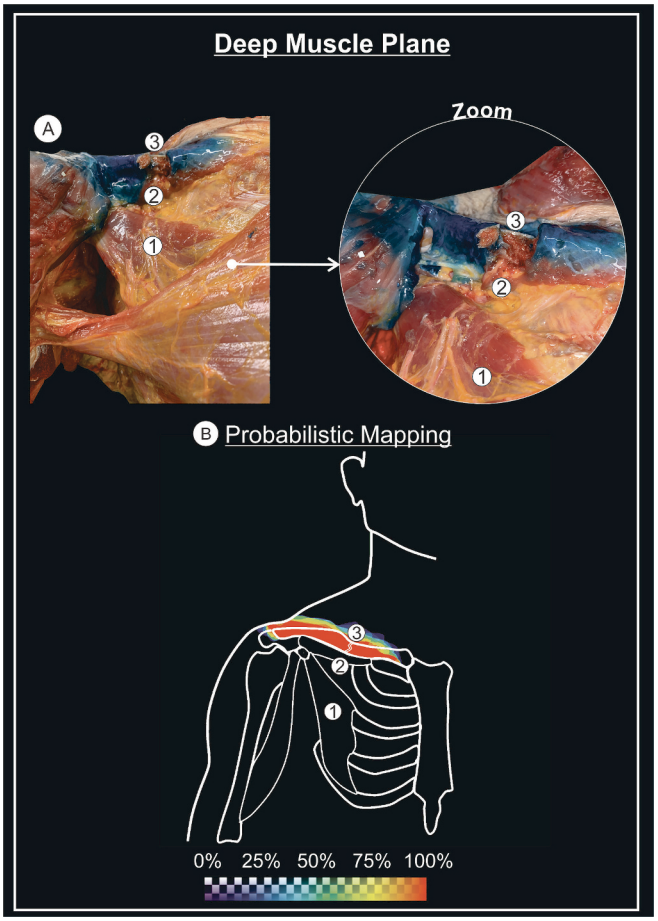

Fig. 2. Fig. 2A: Detailed depiction of the absence of staining in the deep muscular plane, including the pectoralis minor muscle (1), subclavius muscle (2), and clavicle fracture (3). Notice the lack of staining at the fracture site (3) (zoom).
B: Probabilistic map of the color spectrum and temperature in the deep muscular plane, focusing on methylene blue diffusion in the anterosuperior region of the clavicular periosteum, particularly in the middle and outer thirds of the clavicle, with minimal effect on the inner third. No staining is observed in the pectoralis minor muscle (1), subclavius muscle (2). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2.3. *Anatomical dissection and probabilistic mapping*

Anatomical dissection of the clavicle area was conducted on five cadaveric models, examining both hemibodies to assess the presence and distribution pattern of methylene blue within the tissues. The dissection followed a standardized protocol, consisting of four layers and a waiting period of at least 4 h post-injection, maintaining a temperature range of 22–23 °C to facilitate solution spread and staining in the cadaveric tissues. The dissection progressed through each layer, starting with the skin, subcutaneous tissues, and the supraclavicular nerves (medial, intermediate, and lateral) located over the clavicle.

Initially, the dissection focused on the superficial muscle plane (level one), encompassing the deltoid, trapezius, sternocleidomastoid (SCM), and pectoralis major muscles. Subsequently, it advanced to the deep muscle plane (level two), involving the subclavius muscle, pectoralis minor, and CPF, before reaching the clavicular periosteum plane (level three).

To ensure a consistent distribution pattern of methylene blue in each anatomical plane, a probabilistic map incorporating the color spectrum and temperature was generated for the entire sample. Following this, the stained area of the dye in each anatomical dissection plane of each

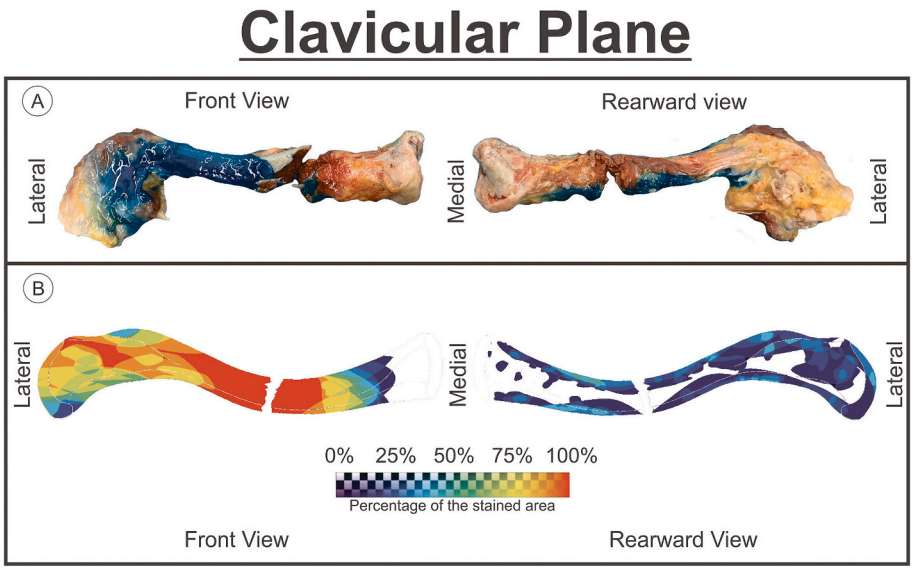

Fig. 3. Fig. 3A (Upper): Dissection of the clavicular periosteum, showing staining over the antero-superior area of the clavicle, while the postero-inferior region remains unstained.
B: (Bottom): Probabilistic map illustrating the percentage of the stained area in the anterior and posterior periosteum.

cadaveric sample was delineated on an anatomical figure employed as a reference model for the superficial muscle plane, deep muscle plane, and clavicular plane. In total, 30 figures were generated, with 10 for each anatomical plane. Each drawing was then digitized, and a 1:1 scale plane was established utilizing Corel Draw X7 software (Corel Corporation, Ottawa, Canada).

The resultant files were exported in JPG format and imported into Amira Visage Imaging Inc. software (San Diego, California, USA) to segment the diffusion on each surface. The segmentations were overlaid and summed to produce a probabilistic map, combining the color spectrum and temperature, wherein blue (representing cold) denoted a staining percentage of 0%, and red (representing hot) corresponded to a staining percentage of 100%.

3. Results

Anatomical dissection revealed the presence of methylene blue on the medial, intermediate, and lateral supraclavicular nerves originating from the superficial cervical plexus in all cases (100%)(Table 1). In the superficial muscular plane (first level), the presence of methylene blue was observed in the deltoid (100%), pectoralis major (100%), sternocleidomastoid (SCM) (70%), and trapezius muscles (100%) (Fig. 1A, Table 1).

In the deep muscle plane (second level), none of the components, including the subclavius, pectoralis minor, and Clavipectoral Fascia (CPF), showed any staining in any of the cases (Fig. 2A, Table 1). Upon completing the dissection of the clavicular periosteum plane (third level), a longitudinal distribution of methylene blue was observed. This distribution pattern encompasses 57,3% of the antero-superior surface, with the postero-inferior area exhibiting a minimal effect of 6,5% (Fig. 3A, Table 1).

A probabilistic map of the color spectrum and temperature was constructed to depict the distribution pattern of methylene blue and the stained surface area in all anatomical planes of the cadaveric models subjected to anatomical dissection. In the superficial muscle plane (first level) (see Fig. 1B), a significant impregnation of methylene blue was observed in the deltoid, trapezius, and pectoralis major muscles (indicated in red), with a moderate effect on the SCM (indicated in green). In the deep muscle plane (second level) (see Fig. 2B), none of its components exhibited any staining (indicated in blue). Finally, in the clavicular plane (thirth level) (see Fig. 3B), the distribution pattern on the antero-superior face was observed to affect the middle third (indicated in red) and outer third (indicated in yellow) of the clavicular periosteum, with a minimal effect on the inner third (indicated in blue). The area with the most intense methylene blue staining (indicated in red) was noted at the junction of the middle third with the outer third of the clavicle. However, on the postero-inferior face, the distribution pattern was limited to the margins of the clavicular periosteum (indicated in blue) (see Fig. 3B).

Table 1 summarizes the characteristics of methylene blue distribution following the implementation of the CPB technique in the series of cadaveric models with midshaft clavicular fractures.

4. Discussion

The fracture focus at the midshaft of the clavicle disrupts the continuity of the periosteum and adhering fascia, including the Clavipectoral Fascia (CPF). This disruption may facilitate the diffusion of the administered solution using the Clavipectoral Fascia Plane Block (CPB) technique towards the postero-inferior region of the clavicular periosteum and deeper planes. Our results suggest that the initially proposed hypothesis for this study is null, as a similar pattern of solution diffusion can be observed in both intact clavicle models and those with a fracture focus.

When comparing our study's results with previous anatomical studies in intact clavicle models, which are similar and closely related, they do not support the widely held belief that the CPF completely encases the clavicle. The distribution pattern observed in this study implies that the CPF originates from the lower edge of the clavicular periosteum and surrounds the subclavius muscle, without connecting to other fasciae in the neck or thorax.

However, our study is not without limitations. (1) The sample size was relatively small, which may not fully account for the spectrum of possible anatomical variations. (2) Dye injectate spread in cadaveric specimens may not precisely replicate in vivo conditions due to differences in tissue elasticity, permeability, and irrigation characteristics. (3) The waiting time between injection and dissection is distant from clinical practice, where the clinical effect is established within about 30 min. We believe we might be overestimating the clinical effect. (4) All cadaver specimens were obtained from elderly individuals with osteoarthritic and degenerative changes, potentially affecting dye distribution. (5) The staining pattern of nerves, while informative, cannot

definitively confirm analgesic effects and will require further clinical evaluation. (6) it is essential to acknowledge that clavicular fractures in cadaveric models do not exhibit the physiological changes seen in living models, such as fracture displacement, hematoma formation, edema, inflammation, or thrombosis.

In light of our study's findings, we can assert that a midshaft clavicular fracture does not significantly alter the diffusion of the solution administered using the CPB technique from the anterior-superior region of the clavicular periosteum to the posterior-inferior region, including the fracture focus.

5. Conclusion

Our investigation demonstrates that the application of the CPB technique in cadaveric models with midshaft clavicular fractures produces a distribution of the administered solution in a manner similar to that in cadaveric models with intact clavicles. The CPB primarily affects the antero-superior region of the clavicular periosteum, the superficial muscle plane, and the supraclavicular nerves, without significantly impacting the posteroinferior region of the clavicular periosteum and the deep muscle plane, including the fracture focus.

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CRediT authorship contribution statement

Hipólito Labandeyra: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Cristina Heredia:** Conceptualization, Methodology, Validation, Writing – review & editing. **Luis Fernando Váldes-Vilches:** Formal Analysis, Supervision, Validation, Writing – review & editing. **Alberto Prats-Galino:** Formal analysis, Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing. **Xavier Sala-Blanch:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare no conflicts of interest.
AI is not used in this study.

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