Banasiuk et al.
Medical Journal of Cell Biology 2026
DOI: 10.2478/acb-2026-0002
Received: 17.09.2025
Accepted: 30.03.2026

Accessory nerve: summarized anatomical topology in a narrative review

Marcin Banasiuk[1], Zuzanna Kopka[1], Katarzyna Majka[1], Julia Micał[1], Magdalena Mikłuszka[1], Hiba Al-Batool[1], Tymon Krzyżanowski[1]

Abstract

Introduction The spinal accessory nerve (cranial nerve XI) is a motor and proprioceptive nerve that supplies sternocleidomastoid and trapezius muscles, thus it is essential for proper shoulder function. Given its variable anatomy and clinical implications, this study aimed to review the currently knowledge of its topography, branching and clinical implications. Materials and methods We followed SANRA guidelines and performed literature search using PubMed, Web of Science, and Embase databases up to November 2024. Selected studies included written in English, original, peer-reviewed cadaveric, radiologic, and surgical articles with clearly defined objectives, methods, and results regarding accessory nerve anatomy. Two reviewers independently screened the studies, with consensus reached through a third reviewer when necessary. Results Extracted data included morphometric parameters, nerve course, branching, exit and ending points, and clinical considerations from 71 studies. Results highlighted marked variability in exit points, with the nerve commonly emerging at or near the sternocleidomastoid muscle, leaving the cranium through jugular foramen. Its relationship to the internal jugular vein and cervical plexus was inconsistent, presenting frequent anatomical variants that we described. Branching patterns to both sternocleidomastoid and trapezius muscles varied widely, with up to five branches. Discussion The clinical analysis led us to the conclusion that the nerve's superficial course through the posterior cervical triangle renders it especially vulnerable during lymph node dissection, biopsies, tumor removals and other surgical procedures. Injury leads to "shoulder syndrome", characterized by pain, weakness, and scapular winging, that often requires reconstructive intervention. Understanding the accessory nerve's anatomical variability is critical for surgical planning, intraoperative nerve preservation and improving patient outcomes.

Running title: Accessory nerve: a narrative review

Keywords: accessory nerve, spinal accessory nerve, cranial nerve XI, anatomy, neck surgery, accessory nerve damage

[1]Clinical and Dissecting Anatomy Students Scientific Club, Wroclaw Medical University, Wroclaw, Poland
***Correspondence:** marcin.banasiuk04@gmail.com
Full list of author information is available at the end of article

Introduction

Accessory nerve (IX) is one of 12 cranial nerves consisting of motor and proprioceptive fibers supplying sternocleidomastoid muscle and trapezius muscle, which is essential for proper shoulder movement. It consists of two roots – cranial and spinal – which join in the cranial cavity and separate again after leaving it through the lateral part of the cervical foramen. After separation, the cranial roots form the internal branch and the spinal roots form the external branch. The internal branch connects to the vagus nerve trunk, while the course of the external branch is traditionally described as anterior to the internal jugular vein, posterior to the styloid process and the posterior belly of the digastric muscle, heading downwards to the sternocleidomastoid muscle, piercing it and heading towards the trapezius muscle, supplying its middle and lower parts [1]. Nevertheless, this description does not always correspond to reality, and this should be kept in mind. The area through which it passes is sometimes exposed to iatrogenic damage caused by resection of the cervical lymph nodes and other procedures performed in this area. Damage to the accessory nerve can lead to shoulder syndrome, which reduces the quality of life and may result in further procedures aimed at its reconstruction. A thorough knowledge of the anatomy of the neck, what our team have proven in previous articles, can increase the effectiveness of procedures and minimise the risks associated with them [2-4].

Materials and methods

Study protocol and registration

This review followed the rigorous standards of conducting narrative reviews outlined in the Scale for the Assessment of Narrative Review Articles (SANRA) guidelines.

Search strategy

We searched all the literature on accessory nerve anatomy until November 2024. We searched PubMed, Web of Science and Embase databases. The search terms we used were accessory nerve, spinal accessory nerve, cranial nerve XI, 11th cranial nerve, anatomy, surface anatomy, variation, branches, division, classification, anastomosis, nerve injury, nerve damage, imaging. We did not make any language restrictions during the search. All references were exported to Mendeley. All references of the found studies were also screened; if any were deemed valid, we have included them in our review.

Selection criteria

To be included in the narrative review, the article had to meet specific criteria presented here in hierarchical order:

1. It had to be written in English.
2. It had to be an original work presented as a complete, peer-reviewed article.
3. It had to state its objectives, methods, and results clearly.
4. It had to discuss the anatomy of accessory nerve or its branches.
5. It had to be either cadaveric, radiologic or surgical study

Two independent reviewers screened the studies. The first screening was done by JM; the second was by HA. All the reviewers were familiar with the selection criteria. All were instructed to include studies they needed clarification on. If a consensus was not reached, the third reviewer, MM, was consulted to solve the problem. The third reviewer evaluated these studies and included or rejected them based on discussion.

Study appraisal

To decrease the risk of bias in our narrative review, we used study appraisal tools based on the current consensus on narrative review methodology. To assess the methodological quality, we used a SANRA checklist.

Data extraction

The primary data we collected were the first author's surname, publication year, the country where the study was conducted. More precise data we searched for included information on population size , age, sex and race, method used, side studied, parameters included, measuring tools, nerve exit point, topography, ending point, length and clinical parameters. Any discrepancies were dissolved by discussion between the team members until a conclusion was reached.

Outcomes analysis

Outcomes were analyzed qualitatively and quantitatively. This article is divided into four sections — introduction, methods, results, and discussion. In the discussion, we discuss the importance of anatomy of accessory nerve in modern evidence-based medicine.

Data reviewed

Exit point

13 authors found the nerve exit point to be at or near the sternocleidomastoid muscle. Mirialili et al. and Jones et al. found it at the SCM [5

6]. Leung et al. found it from within or immediately deep to the SCM and the investing fascia [7]. Dailiana et al. and Casembasi et al. found in to be penetrating through the SCM [8,9]. Aramrattana et al. and Haque et al. found it to exit at Erb's point [10,11]. Bertelli et al., Norkus et al., Kaiser et al., Anehosur et al., Vaid et al. and Symes et al. found the nerve to emerge from the posterior border of he SCM [12-17].

10 authors, namely: Kowalska et al., Bejjani et al., Canella et al., Brinzeu et al., Nason et al., Akdag et al., Saman et al., Pagedar et al., Lee et al., Caliot et al. found the nerve exit point to be at the jugular foramen [18-27].

Jobe et al. found it to be at the spinous process of the vertebral body and the lateral tip of the acromion [28].

Rhoton et al. found it to be sever millimeters caudal to the lowest cranial accessory fibers [29]. Pagedar et al. found it to be at the inferior border of the posterior belly of digastric [25].

Katsura et al. found it to be along the posterior margin of the inferior two-thirds of the olive and at the lower medulla and upper segments of the cervical cord [30].

Topography

The spinal accessory nerve leaves the cranial cavity through the pars venosa of the jugular foramen [23], alongside of CN IX, CN X and internal jugular vein. [10] Within the JF, the SAN runs posteriorly to the vagus nerve. [19] For the internal jugular vein a cadaveric study by Saman et al. revealed that the SAN was anteromedial to the IJV in 73 cases, posterior in 9 cases and medial in 2 cases. Then, at the base of skull, the SAN ran anteromedial to the IJV in 56 cases, medial in 21 cases and posterior in 7 cases.

In the anterior triangle of the neck, the SAN coursed anteriorly to the IJV in 57 cases, posteriorly in 16 cases and in one case the nerve traversed the vein. [24] However, at the level of the posterior belly of digastric, Christine B et al. found 198 nerves lateral and superficial to the IJV, 6 nerves medial and deep to IJV and 2 nerves pierced the IJV and one nerve running around (both medial and lateral) to the vein. In another study Taylor et al. located the SAN lateral, superficial and ventral to the IJV in 95,6% cases, medial, deep and dorsal to the IJV in 2,8% cases, piercing the IJV in 0,9% cases and running around the IJV in the remaining 0,48%. At the level of the superior margin of the posterior belly of digastric Hinsley and Hartig identified the SAN lateral to IJV in 112 cases, medial to IJV in 3 cases and in one case the nerve run through the vein. Vaid et al. reported the SAN to be ventral to IJV in 20 (67.7%) cases and dorsal to the IJV in 10 (32.3%) cases.

After the SAN passes the JF, it runs over the IJV and diagonally in a postero-inferior direction to finally innervate the deep surface of sternocleidomastoid muscle [10]. It enters the SCM at the level of the angle of mandible and C3 vertebra. [18] According to Bejjani and Sullivan, the SAN enters the SCM from medial or anterior side.The SAN was identified deep to SCM [6,25,27,31-37], anterior to SCM [38] or perforating the muscle [27,37,39]. Eastwood and George in 62.5% of cases reported a following arrangement of structures: the SAN transversing deep at the intersection with SCM and superior tendon of SCM most superficially along with the sternocleidomastoid branch of occipital artery. In 20.8% cases the SAN was superficial to the SBOA and lying at the level of the SCM tendon. In the remaining 16.6% cases both SAN and SBOA were at the level, but deep to the SCM tendon. The distance between the SAN and SBOA was 3.63+/-4.02 mm, while the distance between the tendon and SAN equaled 2.31+/-1.72 mm.The study of Hong et al. showed that 38% cases the SAN coursed superficial to the clavicular head of SCM and deep to its sternal head, while deep to both heads in 62%. Symes and Hills reported the SAN either enters the SCM deep surface between its sternal and clavicular heads or courses under the SCM. Cavalcanti et al. found the superficial segment of SAN in a triangle bordered anteriorly by IJV, posteriorly by SCM and superiorly by the posterior belly of digastric (80%) or occipital artery (20%). Following Raikos et al. the mean distance of the great auricular point to the exit of SAN at the posterior border of the SCM was 9.2 mm, with the minimal value equaling 0.3 mm and maximal value of 19.37 mm.

Cesmebasi and Spinner studied the relation between the transverse cervical nerve and great auricular nerve and SAN. The proximal SAN was found cephalic to TCN and GAN.

The accessory nerve was identified in both anterior and posterior cervical triangles in studies by Nason, Richard W et al. and Kierner A. C., et al. Prominently more frequently it was found in the posterior triangle of the neck [6,5,8,13,14, 22,32-35,37,38,40-44].

In the posterior triangle two layers of deep cervical fascia blanked AN, which is additionally surrounded by a layer of connective tissue [10]. The nerve in this triangle courses superficially and receives communicating branches to the cervical plexus [10].

Additionally in the omotrapezoid triangle accessory nerve also runs superficially [27].

Relative to levator scapulae, AN is located superficially [20] or, according to Symes and Hills, is located on this muscle, but between the muscle and the nerve lies a pre-vertebral layer of deep cervical fascia and layer of fat tissue. [17]. In this location, the superficial lymph nodes are connected with the accessory nerve [17,45]. The nerve was also observed within an adipose tissue layer in close proximity by Hong et al. This deposit of fat tissue was located precisely between the levator scapulae and the trapezius muscle [45].

The accessory nerve can emerge from the posterior triangle of the neck in several different ways. However, it is significant that AN runs in a deep layer of trapezius firstly after getting out the posterior triangle [43] and the most common course is along the anterior border of the trapezius muscle [8,20,40,44] where it branches off and innervate the superior part of the muscle [8]. Symes, Hills detailed that frequently AN runs lineal (in 74% cases) and less often tortuously (in 26% cases) on the lateral and deep part of trapezius up to finally perforate anterior margin of this muscle. Rarely, it follows the anterior margin in the direction of the clavicle finally piercing the trapezius (noticed in 14 cases). [17]. The accessory nerve may also course on the ventral surface of the trapezius [28,41], especially across the transverse part of this muscle [46] or additionally can run under the trapezius [37].

In relation to the structures of the scapula, Heo et al. pointed to scapular osteal landmarks. Under the superior border of the scapula, the accessory nerve was located medial (in 37% cases) and lateral (in 63% cases) to the transverse cervical artery. At the level of the superior angle of the scapula, the nerve coursed medially in 61% and laterally in 39% of cases, tending toward a lateral direction. Notwithstanding, in supraspinous fossa of scapula, accessory nerve was medial in 61% and lateral in 39% cases to the artery, and nearly spine of scapula, nerve was lateral in 44% and medial in 56% of cases to the artery, indicating a more medial tendency. At the height of spine of the scapula, the transverse cervical artery was located on average 7,5 mm lateral and 9,5 mm medial to the accessory nerve. [45].

Branching

The spinal accessory nerve (SAN) shows significant anatomical variation in branching patterns and in the length of the nerve, as well as in many cadaveric and imaging studies. Its innervation of sternocleidomastoid (SCM) and trapezius muscles is a heterogeneous collection of branching patterns and interconnectivities with the cervical plexus.

Regarding branching patterns, numerous studies have revealed a broad extent of morphological variation. Five SAN branching types were classified by Shiozaki et al. according to the number of branches reaching the anterior margin of the trapezius: Type 0 (none, 3.8%), Type 1 (single branch, 50%), Type 2 (double branches, 30.8%), Type 3 (three branches, 11.5%), and Type 4 (four branches, 7.9%) [47].

The same extent of variation was verified by Jobe et al., who described three to six major branches (mean 3.8), and Symes and Hills, who described that in 16% of specimens there were no trapezial branches, one branch in 18%, two branches in 28%, three branches in 22%, four branches in 14%, and five branches in 2% [17,28]. Moreover, in this study, SAN had no branches of the cervical plexus in 36% of dissections, whereas in the remaining 64%, one branch was found in 25 cases and two branches in seven cases. Anastomotic fibres arose primarily from C2–C3 and C3, and secondarily from C2 and C3–C4.

SCM innervation by more than a single branch of the spinal accessory nerve was common, with large anatomical studies showing extensive variation in the number of branches. Brînzeu and Sindou, and Caliot and Bousquet, provided strikingly similar distribution patterns: SCM was innervated by one branch in 17%, two in 25%, three in 27%, four in 23%, and five or more in 6% [21,27].

Branching patterns in the trapezius area were similar as well. Brînzeu and Sindou reported that in the omotrapezoid triangle, in 45% of the cases, there were no branches, and one, two, and three branches in 20%, 32%, and 3%, respectively [21]. Innervation of the supraclavicular triangle by the trapezius was provided by Caliot and Bousquet with the same order: 45% with no branches, 20% with one branch, 32% with two, and 3% with three branches [27].

Kaiser et al. noted that in 84% of the specimens, there were no more than two motor branches to the supraspinatus muscle, and in 48%, the infraspinatus had three or four branches equal in size [13]. Kierner et al. depicted one trapezius branch in 9% of the specimens, two in 61%, and three in 30% [41]. Eastwood reported bifurcation of the SAN into a trapezius and SCM branch in 29.1% of the specimens [48]. Matthews et al. reported an anatomical variation with bifurcated SAN and communication with C2 [38]. Mirande and Smith reported SAN fusion with LON in 3.77% of sides [35].

Vaid et al. delineated three SAN pathways to the SCM: in 6 of 31 dissections (Type A), the nerve ran along the deep border of the SCM but did not enter it; in 3 dissections (Type B), it entered and reemerged with branches; and in 22 cases (Type C), it coursed over the lateral surface of the muscle and then continued to the trapezius [16].

The SAN supplied two or three branches to the superior portion of the trapezius muscle before entering it.

A number of studies highlighted the foundational contribution of the cervical plexus to SAN innervation. Dailiana et al. noted that SAN innervated SCM with a single branch in 7 dissections and with 2–4 branches in 13 dissections [8]. The SAN also innervated two to three branches to the superior portion of the trapezius muscle prior to entering it. SAN to cervical plexus contacts were seen in all but one dissection. Most were deep to the SCM. In 13 cases, the SAN was adherent to one root (C2 in 9 cases, C3 in 3, and C4 in 1), and in 6 cases, more than one root was adherent (C2 and C3).

Tubbs et al. found C2, with or without C3, in 73%, C2 alone in 48%, C2 and C3 in 25%, and C3 alone in 4.5% [43]. Communicating branches from C2, C3, and C4 were identified by Gavid et al. in the majority of dissections: 18/23 from C2, 11/23 from C3, and 12/23 from C4 [49]. Symmetry occurred in 13 of 23 dissections and a single communicating branch occurred in 8 cases. Nason et al. also described SAN to be connected by C3 and C4 branches [22]. Oh, Chang S et al. described the McKenzie branch between CN XI and C1, while Oh, Seok Chang et al., Orhan et al., and Ouaknine and Nathan described four types of anastomoses between CN XI and the posterior root of C1 [50-53].

Segmental innervation of the trapezius was also more differentiated in Wang's et al. research, in which the average number of branches in the various regions of the muscle was counted: 3.8 in the descending part (range 0–5), 2.6 in the horizontal (range 1–4), and 2.2 in the ascending (range 1–4), with another 1.2 branches (range 0–3) originating pre-muscularly [44]. Anehosur and Kulkarni have reported that 71.4% of the nerves had trapezius branches [54]. Brînzeu and Sindou have determined equal omotrapezoid triangle variability in the branching schemes [21].

Anatomically, data also register a large range of sizes. Saylam et al. have typed all the connections between the posterior roots of the C2–C6 nerves and the accessory nerve as being at the level of the C2 segment. These connections have been sub-classified into six types (A–F), and the most common was type B (29%). Type A was the cervical posterior root crossing and joining the accessory nerve (2%). Type B revealed a rootlet joining the accessory nerve but without union with the spinal cord, with other rootlets of the same level joining the spinal cord; two specimens also had type C and E patterns. Types C, D, and E were a bridging fiber between the posterior root and the accessory nerve: lateral and superior to the root in type C (8%), lateral and inferior in type D (not found), medial and superior in type E (8%). Type F, not hitherto described, was a medial bridging fiber inferior to the posterior root (2%). The relations were bilateral in four bodies and unilateral in eight; three bilateral dissections were symmetrical and all type B, one of them having B on the right and B and E on the left [55].

The extracranial SAN length was by Durazzo et al. found to measure between 7 and 18.5 cm (mean 12.02 ± 2.32 cm) [56]. The posterior SCM to trapezius segment was 1.5 to 9 cm (mean 5.27 ± 1.52 cm). Wang et al. stated that the linear trajectory in the trapezius muscle measured 16.89 cm (range 12.70–20.50 cm) and that an additional segment of about 4.3 cm (± 0.79) existed from SCN origin to muscle entry [44].

Vaid et al. provided precise measurements: from mastoid tip to SAN entry at SCM anterior border was 5.18 ± 0.60 cm (range 3.93–6.68 cm), from SAN exit at SCM posterior border to clavicle was 10.56 ± 1.52 cm (range 9.03–14.83 cm), and from mandibular angle to SAN entry at anterior SCM was 4.30 ± 0.64 cm (range 3.23–5.45 cm) [16].

Amuti et al. provided a direct proportion between SCM and SAN lengths, with the SAN index of 0.299 for the left and 0.324 for the right [39]. Kaiser et al. stated that SAN was, on average, 8.5 cm lateral to the spine [14]. Aramrattana and Sittitrai stated the SAN entry into trapezius to clavicle distance as 2.6–6.9 cm (mean 4.5 cm) [10]. Caliot and Bousquet measured nerve entry into the muscle in the range of 3–5 cm above the clavicle but reported values in the range of 1.5–11 cm as well [27]. Kierner et al. measured mean entry distance as 8.2 ± 1.01 cm above the clavicle [46]. Dailiana et al. measured SAN distance between SCM and trapezius as 6 to 8 cm [8]. Pagedar and Hoffman determined a mean segment length of 2.5 cm (range 2.4–2.6 cm) [25].

Haque et al. investigated the possibility of utilizing SAN as a nerve graft and reported a mean available length of 15.85 cm and calculated graft requirements of 4.7, 5.9, 6.5, 7.1, and 7.8 cm to achieve C4, C5, C6, C7, and C8 levels, respectively [11]. Ayeni and Ohata reported that the cranial portion of CN XI contained 4–13 rootlets [57]. Absolute diameters were as follows: CN IX, 0.5–1.2 mm (mean 0.9 mm); CN X, 0.2–1.5 mm (rootlets).

Further morphometric information was presented by Pruksakorn et al., who measured SAN proximity as a ratio relative to spinal landmarks: 0.53 ± 0.07 to the C7 spinous process and 0.44 ± 0.08 to the T4 spinous process [58]. Jobe et al. placed SAN at 44% of the acromion-to-spinous process distance [28]. Rhoton et al. measured the course of SAN from C1 to the jugular foramen as 17.0–26.0 mm [29].

Ending point

17 authors, namely: Mirande et al., Norkus et al., Aramrattana et al., Symes et al., Maldonado et al., Mathialagan et al., Bertelli et al., Canella et al., Brinzeu et al., Mirjalili et al., Amuti et al., Anehosur et al., Caliot et al., Nason et al., Kowalska et al., Haque et al. and Tubbs et al., found the ending point of the spinal accessory nerve to be at the trapezius muscle [6,10-13,15,17,18,20-22,27,33-35,39].

5 authors, namely: Dailiana et al., Kazunari et al., Alibhai et al., Madani et al. and Matthews et al. found it to be both at the SCM and trapezius muscle [8,32,38,47,59].

4 authors, namely Rafferty et al., Lçvy, et al., Bejjani et al. and Pagedar et al. found it to be at the SCM [19,25,31,60].

Liu et al found it to be at the laryngeal muscles [61].

Jobe et al. found it to be at the inferolateral border of the scapula [62].

Clinical importance

The spinal accessory nerve (SAN) crosses the greater auricular nerve at Erb's point, passing over it before entering the posterior triangle [40] approximately 51.3 mm above the clavicle [63]. The SAN primarily innervates the trapezius muscle, with approximately 20% of its innervation arising from cervical nerves [64], and also provides motor function to the sternocleidomastoid muscle [19],The nerve exits the posterior border of the SCM at an average of 0.97 cm from Erb's point [56]. Recognizing the importance of preserving trapezius function, modified radical neck dissection techniques have been developed to spare the cervical spinal nerves supplying this muscle [5]. The SAN's anatomical course places it at significant risk of injury, especially during procedures involving cervical lymph nodes. The SAN's vulnerability, especially when embedded in lymphatic and adipose tissue, underscores the importance of surgical planning and anatomical knowledge for nerve preservation and reconstruction [8]. The SAN is especially exposed during biopsy, surgery, or neck dissection, in which damage to the nerve can lead to scapular winging [19] or "shoulder syndrome," marked by shoulder pain, drooping, and restricted movement [16], or even phrenic nerve palsy [12]. The location of the SAN in the anterior neck during selective neck dissection (SND) and its measured distances to the mastoid, SCJ, and C7 spine [20] have surgical relevance. Understanding the anatomical information of the accessory nerve is crucial for protecting it during surgery, particularly during lymph node dissections where the SAN lies close to lymph nodes and the internal jugular vein [60]. Notably, contrary to previous beliefs, the accessory nerve lacks a cranial root and consists solely of what was previously referred to as its spinal root [65]. The motor branches emerging from the spinal accessory nerve to the sternocleidomastoid muscle are vulnerable during posterior triangle surgery and skull base approaches, which may lead to a similar effect as damaging the SAN [19]. Anatomical landmarks are critical in order to reduce any iatrogenic injuries to the SAN: for example, the SAN is located at a mean of 1.90 cm posterior and 0.79 cm superior to the angle of the mandible, and at specific distances from the mastoid tip and the bifurcation of the common carotid artery [66]. Nevertheless, the SAN remains difficult to locate and easily damaged, which is why multiple anatomical landmarks and intraoperative nerve block techniques are being developed to improve outcomes. One useful method for locating the SAN intraoperatively is based on pinprick hyperaesthesia, which successfully identified the nerve in 46 out of 50 patients; failures were often due to insulation by surrounding fat tissue [68]. Other reliable intraoperative method includes: (1) unwrapping the fascia over the SCM's anterior surface, (2) clearing the deep surface to reveal the superficial superior tendon (SST), (3) tracing the tendon to locate the SBOA, and (4) bisecting the angle between SST and SBOA to find the SAN between fascial layers [48]. Additionally, stroking the skin with a needle and marking areas of hyperaesthesia can help map the nerve's course. Postoperative confirmation of SAN preservation should involve verifying its innervation to the SCM [9].

The SAN is frequently used in brachial plexus reconstruction and is affected by lesions typical in brachial plexus injuries [43]. Preserving the SAN is crucial to avoid complications such as accessory nerve palsy [59], transient paresis [42], and shoulder dysfunction [16]. The SAN's clinical relevance also extends to neurogenic tumors, meningiomas, leptomeningeal disease, neurovascular compression, and glomus tumors [68]. Schwannomas of the jugular foramen may lead to postoperative lower cranial nerve deficits such as dysphonia (47.8%), dysphagia (43.7%), sensorineural hearing loss, subcutaneous CSF accumulation (3%), and rhinorrhea [23] (1.5%). Connections of the SAN are implicated in spasmodic torticollis [51], where surgical treatments may include intradural selective rhizotomy and targeting the McKenzie branch [50]. Anatomical variations of the SAN highlight the importance of nerve preservation during radical neck surgeries, biopsies, and reconstruction procedures.

Other aspects

Some of the studies that we analyzed pointed out some interesting results associated with clinical and anatomical implications for SAN. Rao et al. [40] investigated an anatomical relationship between the SAN and the greater auricular nerve – calling it the "X pointer". In all the 100 cases – patients undergoing unilateral comprehensive neck dissection, the "X pointer" was identified as a constant anatomical relationship at the undersurface of sternocleidomastoid muscle that is irrespective of the patient's body habitus and nodal metastasis. Taylor et al. [69] indicates morbidity associated with iatrogenic injury of the SAN, stating that it is crucial for surgeons operating in the neck to recognize SAN variants, in order to avoid it. Papers that we've researched had some limitations specific to their own methods. Raikos et al. [70] pointed that dissections and measurements between anatomical landmarks were undertaken in formalin-fixed cadavers. Therefore, a slight difference can occur in comparison to measurements performed in fresh frozen or live tissue. Taylor et al. [69] in their research about intraoperative identification of spinal accessory nerve (SAN) highlights the possibility of intraoperative collapse of internal jugular vein (IJV) that can lead to false identification of the nerve medial to the IJV. Tubbs et al. [43] while describing novel method of lengthening the accessory nerve, emphasizes on the fact that in patients with complex SAN-SCM relationships, the muscle might need to be partially or completely divided during a procedure.

Review of importance

After exiting the posterior border at the junction located in ⅓ total length of the sternocleidomastiod, underneath the deep cervical fascia going on the levator scapulae across the posterior cervical triangle. In this particular location spinal accessory nerve goes superficially increasing chance of being damaged while performing neck surgeries. Spinal accessory nerve injury leads to a painful disability called "shoulder syndrome" [42]. Damage to the SAN is most often caused iatrogenically during lymph node biopsies in the posterior triangle of the neck, removal of a tumor, facelift in cosmetic surgery and vascular surgeries including carotid or internal jugular vein. The multitude of examples only confirms the benefits that can be gained from a thorough understanding of the anatomy of the accessory nerve. Surgeons should have extensive and up-to-date knowledge of the possible course of the accessory nerve and be able to locate it precisely during surgery. This will increase both the patient's comfort and reduce the total cost of treatment and surgery, eliminating the need for reconstruction and corrective surgery. Damage to the accessory nerve is not only iatrogenic in origin, as it can occur during sudden movement or trauma that penetrates the neck tissue and reaches the nerve or even form a tumor growing into the jugular foramen. Primary complaints associated with SAN injury are weakness and pain of the shoulder, which may radiate to the upper back, neck, and ipsilateral arm. The pain and decreased strength limit the range of motion of the shoulder supplied by the injured accessory nerve [71]. Treatment of accessory nerve injury depends on the extent of the damage and should be performed within 3 months due to degenerative processes that will occur without intervention. The nerve is surgically divided and the injured part is excised. Lastly end-to-end microsurgical anastomosis is performed. However, sometimes the nerve is too badly damaged, or too large a section is missing. In such cases, a graft is required. Usually, a greater auricular nerve is taken due to its similar quality and caliber. A small proportion of patients will also be amenable to conservative non-surgical treatment, which will produce the desired results in terms of pain relief and restoration of normal innervation. However, this must be monitored in clinical examinations, because if it is not effective, surgical methods must be used instead [72].

Conclusions

A thorough knowledge of the anatomy of the accessory may increase the effectiveness of procedures and minimise the risks associated with them providing more years spent in good health for patients and less costs for hospitals. Further studies in a matter of accessory nerve should be focused on its possible variations and clinical implicances of it as a part of evidence based medicine. Knowledge of not only the anatomy of the neck but also general human anatomy is crucial for achieving the best results in the field of surgery [73-76]. Our knowledge of neck anatomy, particularly that of the accessory nerve, is enhanced by cadaver studies, which form the basis for research into anatomical variability [77]. Some scientists have begun research into developing new methods of presenting human anatomy, which may lead to advances in basic science and clinical benefits in surgery and beyond in the future [78,79].

Ethical approval

The conducted research is not related to either human or animal use.

Acknowledgments

We would like to thank our department's technicians, Mr. Mirosław Łukaszun and Mr. Zbigniew Staszewski, for their kind support for our efforts.

Corresponding author

Marcin Banasiuk, Wroclaw Medical University, 6a Chalubinskiego street, 50-367 Wroclaw, Poland, email: marcin.banasiuk04@gmail.com, phone: +48733292756.

Conflict of interest

The authors declare no conflict of interest.

References

1. Bochenek A, Reicher M. Anatomia człowieka. Tom I. 13th ed. Warszawa: Wydawnictwo Lekarskie PZWL; 2022. 995 p.
2. Królikowska A, Stokłosa J, Patkowska A, Rudko W, Mazurek M, Domagała Z. Anatomical variations in the superior thyroid artery: a systematic review and implications for free flap surgery. J Clin Med. 2025;14(17),6250; DOI:10.3390/jcm14176250.
3. Dworski K, Mazurek M, Domański J, Posterior superior alveolar artery – an anatomical and clinical case report. Med. J Cell Biol. 2023;11(3):93-7; DOI:10.2478/acb-2023-0016.
4. Tulski M, Kita A, Bernacka N, Banasiuk M, Synal A, Michalak M, Bauer D, Wolak K, Tarkowski V, Surowiak P, Domagała Z. Venous vascularization of the forehead and clinical implications-A comprehensive review. J Anat. 2025;00;1-10; DOI:10.1111/joa.70022.
5. Jones T. A., Stell P. M., The preservation of shoulder function after radical neck dissection. Clin Otolaryngol Allied Sci. 1985;10(2):89-92; DOI:10.1111/j.1365-2273.1985.tb01173.x.
6. Mirjalili S. A, Muirhead J. C, Stringer M. D, Ultrasound visualization of the spinal accessory nerve in vivo. J Surg Res. 2012;175(1):e11-6; DOI:10.1016/j.jss.2011.10.046.
7. Leung M, Dieu T, Cleland H,. Surgical approach to the accessory nerve in the posterior triangle of the neck. Plast Reconstr Surg. 2004;113(7):2067-70; DOI:10.1097/01.prs.0000122236.00292.f7.
8. Dailiana ZH, Mehdian H, Gilbert A. Surgical anatomy of spinal accessory nerve: Is trapezius functional deficit inevitable after division of the nerve? J Hand Surg Br. 2001;26(2):137-4; DOI:10.1054/jhsb.2000.0487.
9. Cesmebasi A, Spinner RJ. An anatomic-based approach to the iatrogenic spinal accessory nerve injury in the posterior cervical triangle: how to avoid and treat it. Clin Anat. 2015;28(6):761-6.; DOI10.1002/ca.22555.
10. Aramrattana A, Sittitrai P, Harnsiriwattanagit K. Surgical anatomy of the spinal accessory nerve in the posterior triangle of the neck. Asian J Surg. 2005;28(3):171-3; DOI:10.1016/S1015-9584(09)60336-5.
11. Haque RM, Malone HR, Bauknight MW, Kellner MA, Ogden AT, Martin JH, Tanji K, Winfree CJ. Spinal cord bypass surgery with intercostal and spinal accessory nerves: an anatomical feasibility study in human cadavers. J Neurosurg Spine. 2012;16(2):178-86; DOI:10.3171/2011.9.SPINE10378.
12. Bertelli J, Ghizoni M. Combined injury of the accessory nerve and brachial plexus. Neurosurgery. 2011;68(2):390-5; DOI:10.1227/NEU.0b013e318201d7d9.
13. Norkus T, Norkus M, Ramanauskas T. Donor, recipient and nerve grafts in brachial plexus reconstruction: anatomical and technical features for facilitating the exposure. Surg Radiol Anat. 2005;27(6):524-30; DOI:10.1007/s00276-005-0024-5.
14. Kaiser R, Krajcova A, Makel M, Nemcova V. Anatomical aspects of the selective infraspinatus muscle neurotization by spinal accessory nerve. Plast Surg Hand Surg. 2021;55(4):220-225; DOI:10.1080/2000656X.2020.1856680.
15. Venkatesh A, Kaustubh K, Niranjan K. Variations in the anatomy of spinal accessory nerve and its landmarks for identification in neck dissection: a clinical study. J Maxillofac Oral Surg. 2021;20(3):426-31; DOI:10.1007/s12663-021-01542-z.
16. Vaid D, Singh I, Gulati A. Study of the anatomical variations of spinal accessory nerve seen during neck dissection. Indian J Otolaryngol Head Neck Surg. 2024;76(3):2295-2303; DOI:10.1007/s12070-023-04468-9.
17. Symes A, Ellis H. Variations in the surface anatomy of the spinal accessory nerve in the posterior triangle. Surg Radiol Anat. 2005;27(5):404-8; DOI:10.1007/s00276-005-0004-9.
18. Kowalska B, Sudol-Szopinska I. Normal and sonographic anatomy of selected peripheral nerves. Part II: Peripheral nerves of the upper limb. J Ultrason. 2012;12(49):131-47; DOI:10.15557/JoU.2012.0002.
19. Bejjani GK, Sullivan B, Salas-Lopez E, Abello J, Wright DC, Jurjus A, Sekhar LN. Surgical anatomy of the infratemporal fossa: the styloid diaphragm revisited. Neurosurgery. 1998;43(4):842-52; DOI:10.1097/00006123-199810000-00072.
20. Canella C, Demondion X, Abreu E, Marchiori E, Cotten H, Cotten A. Anatomical study of spinal accessory nerve using ultrasonography. Eur J Radiol. 2013;82(1):56-61; DOI:10.1016/j.ejrad.2011.04.038.
21. Brînzeu A, Sindou, M. Functional anatomy of the accessory nerve studied through intraoperative electrophysiological mapping. J Neurosurg. 2017;126(3):913-21; DOI:10.3171/2015.11.JNS15817.
22. Nason RW, Abdulrauf BM, Stranc MF. The anatomy of the accessory nerve and cervical lymph node biopsy. Am J Surg. 2000;180(3):241-3; DOI:10.1016/S0002-9610(00)00449-9.
23. Akdag U, Ogut E, Barut C. Intraforaminal dural septations of the jugular foramen: a cadaveric study. World Neurosurg. 2020;141:e718-e27; DOI:10.1016/j.wneu.2020.05.271.
24. Saman M, Etebari P, Pakdaman MN, Urken ML. Anatomic relationship between the spinal accessory nerve and the jugular vein: a cadaveric study. Surg Radiol Anat. 2011;33(2):175-9; DOI:10.1007/s00276-010-0737-y.
25. Pagedar NA, Hoffman HT. Anatomic variability of the accessory nerve: implications for dissection of level IIB. The Laryngoscope. 2024;134(1):154-9; DOI:10.1002/lary.30758.
26. Lee SH, Lee JK, Jin SM, Kim JH, Park IS, Chu HR, Ahn HY, Rho YS. Anatomical variations of the spinal accessory nerve and its relevance to level IIb lymph nodes. Otolaryngol Head Neck Surg. 2009;141(5):639-44; DOI:10.1016/j.otohns.2009.07.005.
27. Caliot P, Bousquet V, Midy D, Cabanié P. A contribution to the study of the accessory nerve: surgical implications. Surg Radiol Anat. 1989;11(1):11-5; DOI:10.1007/BF02102238.
28. Jobe CM, Kropp WE, Wood VE. Spinal accessory nerve in a trapezius-splitting surgical approach. J Shoulder Elbow Surg. 1996;5(3):206-8; DOI:10.1016/s1058-2746(05)80007-2.
29. Rhoton AL Jr, Buza R. Microsurgical anatomy of the jugular foramen. J Neurosurg. 1975;42(5):541-50; DOI:10.3171/jns.1975.42.5.0541.
30. Katsuta T, Rhoton AL Jr, Matsushima T. The jugular foramen: microsurgical anatomy and operative approaches. Neurosurgery. 1997;41(1):149-202; DOI:10.1097/00006123-199707000-00030.
31. Lévy D, Vacher C, Lézy JP. Relations of the accessory nerve with the internal jugular vein: surgical implications in cervical lymph node clearances. Surg Radiol Anat. 2001;23(3):155-7; DOI:10.1007/s00276-001-0155-2.
32. Madani A, Creteur V. Nerves Around the Shoulder: What the radiologist should know? J Belg Soc Radiol. 2017;101(Suppl 2):9; DOI:10.5334/jbr-btr.1382.
33. Maldonado AA, Spinner RJ. Lateral pectoral nerve transfer for spinal accessory nerve injury. J Neurosurg Spine. 2017;26(1):112-5; DOI:10.3171/2016.5.SPINE151458.
34. Mathialagan A, Verma RK, Panda NK. Comparison of spinal accessory dysfunction following neck dissection with harmonic scalpel and electrocautery – a randomized study. Oral Oncol. 2016;61:142-5; DOI:10.1016/j.oraloncology.2016.08.010.
35. Mirande MH, Smith HF. The potential roles of cervical plexus abnormalities in occipital neuralgia: an anatomic variant explored. Diagnostics (Basel). 2022;12(1):139; DOI:10.3390/diagnostics12010139.
36. Liu HF, Won HS, Chung IH, Kim IB, Han SH. Distribution of the internal branch of the human accessory nerve. Anat Sci Int. 2015;90(3):180-6; DOI:10.1007/s12565-014-0244-z.
37. Silkjær Bak S, Johnsen B, Fuglsang-Frederiksen A, Døssing K, Qerama E. Neuromuscular ultrasound of the scapular stabilisers in healthy subjects. Clin Neurophysiol Pract. 2021;6:72-80; DOI:10.1016/j.cnp.2021.01.003.
38. Matthews LA, Blythe JN, Brennan PA. High division of the spinal accessory nerve and communication with a C2 branch of the cervical plexus: a previously unreported anatomical variant. Br J Oral Maxillofac Surg. 2014;52(6):575-6; DOI:10.1016/j.bjoms.2014.03.022.

39. Amuti TM, Butt F, Otieno BO, Ogeng'o JA. The relation of the extracranial spinal accessory nerve to the sternocleidomastoid muscle and the internal juguar vein. Craniomaxillofac Trauma Reconstr. 2019;12(2):108-11; DOI:10.1055/s-0038-1641171.
40. Rao V, Subash A, Sinha P, Chatterjee S, Nayar RC. The X-pointer: a forgotten anatomical relationship of spinal accessory nerve and great auricular nerve. Surg Oncol. 2021;37:101522; DOI:10.1016/j.suronc.2021.101522.
41. Kierner AC, Zelenka I, Burian M. How Do the cervical plexus and the pinal accessory nerve contribute to the innervation of the trapezius muscle? As seen from within using Sihler's stain. Arch Otolaryngol Head Neck Surg. 2001;127(10):1230–2; DOI:10.1001/archotol.127.10.1230.
42. Amirlak B, Lu KB, Erickson CR, Sanniec K, Totonchi A, Peled ZM, Cheng JC. In-depth look at the anatomical relationship of the lesser occipital nerve, great auricular nerve, and spinal accessory nerve and their implication in safety of operations in the posterior triangle of the neck. Plast Reconstr Surg. 2020;146(3):509-14; DOI:10.1097/PRS.0000000000007049.
43. Tubbs RS, Maldonado AA, Stoves Y, Fries FN, Li R, Loukas M, Oskouian RJ, Spinner RJ. A novel method of lengthening the accessory nerve for direct coaptation during nerve repair and nerve transfer procedures. J Neurosurg. 2018;128(1):272-6; DOI:10.3171/2016.10.JNS161106.
44. Wang JW, Zhang WB, Li F, Fang X, Yi ZQ, Xu XL, Peng X, Zhang WG. Anatomy and clinical application of suprascapular nerve to accessory nerve transfer. World J Clin Cases. 2022;10(27):9628-40; DOI:10.12998/wjcc.v10.i27.9628.
45. Hong MJ, Baek JH, Kim DY, Ha EJ, Choi WJ, Choi YJ, Lee JH. Spinal accessory nerve: ultrasound findings and correlations with neck lymph node levels. Ultraschall Med. 2016;37(5):487-91; DOI:10.1055/s-0034-1385673.
46. Kierner AC, Burian M, Bentzien S, Gstoettner W. Intraoperative electromyography for identification of the trapezius muscle innervation: clinical proof of a new anatomical concept. Laryngoscope. 2002;112(10):1853-6; DOI:10.1097/00005537-200210000-00028.
47. Shiozaki K, Abe S, Agematsu H, Mitarashi S, Sakiyama K, Hashimoto M, Ide Y. Anatomical study of accessory nerve innervation relating to functional neck dissection. J Oral Maxillofac Surg. 2007;65(1):22-9; DOI:10.1016/j.joms.2005.11.091.
48. Eastwood MJ, George AP. A novel approach to identifying the spinal accessory nerve in surgical neck dissection. Otolaryngol Head Neck Surg. 2018;159(2):300-2; DOI:10.1177/0194599818766057.
49. Gavid M, Mayaud A, Timochenko A, Asanau A, Prades JM. Topographical and functional anatomy of trapezius muscle innervation by spinal accessory nerve and C2 to C4 nerves of cervical plexus. Surg Radiol Anat. 2016;38(8):917-22; DOI:10.1007/s00276-016-1658-1.
50. Oh CS, Chung IH, Lee KS. Topographical anatomy on the communicating branch between the spinal accessory nerve and the anterior root of the first cervical nerve. Surg Radiol Anat. 2003;25(3-4):207-9; DOI:10.1007/s00276-003-0108-z.
51. Oh CS, Chung IH, Koh KS, Kim HJ, Nam KI. Morphologic study of the connections between the accessory nerve and the posterior root of the first cervical nerve. Clin Anat. 2002;15(4):267-70; DOI:10.1002/ca.10026.
52. Ouaknine G, Nathan H. Anastomotic connections between the eleventh nerve and the posterior root of the first cervical nerve in humans. J Neurosurg. 1973;38(2):189-97; DOI:10.3171/jns.1973.38.2.0189.
53. Orhan M, Yurttaş Saylam C, Aktan Ikiz ZA, Uçerler H, Zileli M. Connections between the accessory nerve and the posterior root of the first cervical nerve. Surg Radiol Anat. 2009;31(2):107-11; DOI:10.1007/s00276-008-0414-6.
54. Anehosur V, Kulkarni K, Kumar N. Variations in the anatomy of spinal accessory nerve and its landmarks for identification in neck dissection: a clinical study. J Maxillofac Oral Surg. 2021;20(3):426-31; DOI:10.1007/s12663-021-01542-z.
55. Saylam CY, Orhan M, Aktan Ikiz ZA, Uçerler H, Zileli M. Connection types between the spinal root of the accessory nerve and the posterior roots of the C2-C6 spinal nerves. Surg Radiol Anat. 2009;31(6):419-23; DOI:10.1007/s00276-009-0460-8.
56. Durazzo MD, Furlan JC, Teixeira GV, Friguglietti CU, Kulcsar MA, Magalhães RP, Ferraz AR, Brandão LG. Anatomic landmarks for localization of the spinal accessory nerve. Clin Anat. 2009;22(4):471-5; DOI:10.1002/ca.20796.
57. Ayeni SA, Ohata K, Tanaka K, Hakuba A. The microsurgical anatomy of the jugular foramen. J Neurosurg. 1995;83(5):903-9; DOI:10.3171/jns.1995.83.5.0903.
58. Pruksakorn D, Sananpanich K, Khunamornpong S, Phudhichareonrat S, Chalidapong P. Posterior approach technique for accessory-suprascapular nerve transfer: a cadaveric study of the anatomical landmarks and number of myelinated axons. Clin Anat. 2007;20(2):140-3; DOI:10.1002/ca.20376.
59. Alibhai M, Shah M, Pawar R, Makdissi J, Cheng L. Ultrasound guided botulinum toxin injection for post operative accessory nerve palsy and supraclavicular neuralgia. Br J Oral Maxillofac Surg. 2014;52(8):e109; DOI:10.1016/j.bjoms.2014.07.201.
60. Rafferty MA, Goldstein DP, Brown DH, Irish JC. The sternomastoid branch of the occipital artery: a surgical landmark for the spinal accessory nerve in selective neck dissections. Otolaryngol Head Neck Surg. 2005;133(6):874-6; DOI:10.1016/j.otohns.2005.08.004.
61. Liu HF, Won HS, Chung IH, Kim IB, Han SH. Distribution of the internal branch of the human accessory nerve. Anat Sci Int. 2015;90(3):180-6; DOI:10.1007/s12565-014-0244-z.
62. Jobe CM, Kropp WE, Wood VE. Spinal accessory nerve in a trapezius-splitting surgical approach. J Shoulder Elbow Surg. 1996;5(3):206-8; DOI:10.1016/s1058-2746(05)80007-2.
63. Hone SW, Ridha H, Rowley H, Timon CI. Surgical landmarks of the spinal accessory nerve in modified radical neck dissection. Clin Otolaryngol Allied Sci. 2001;26(1):16-8; DOI:10.1046/j.1365-2273.2001.00396.x.
64. Miyata K, Kitamura H. Accessory nerve damages and impaired shoulder movements after neck dissections. Am J Otolaryngol. 1997;18(3):197-201; DOI:10.1016/s0196-0709(97)90082-x.
65. Lachman N, Acland RD, Rosse C. Anatomical evidence for the absence of a morphologically distinct cranial root of the accessory nerve in man. Clin Anat. 2002;15(1):4-10; DOI:10.1002/ca.1084.
66. Cavalcanti DD, Garcia-Gonzalez U, Agrawal A, Tavares PL, Spetzler RF, Preul MC. A clear map of the lower cranial nerves at the superior carotid triangle. World Neurosurg. 2010;74(1):188-94; DOI:10.1016/j.wneu.2010.03.024.
67. Fisher DA. A simple method of identifying the spinal accessory nerve. Dermatol Surg. 2000;26(4):384-6; DOI:10.1046/j.1524-4725.2000.99282.x.
68. Moon WJ, Roh HG, Chung EC. Detailed MR imaging anatomy of the cisternal segments of the glossopharyngeal, vagus, and spinal accessory nerves in the posterior fossa: the use of 3D balanced fast-field echo MR imaging. AJNR Am J Neuroradiol. 2009;30(6):1116-20; DOI:10.3174/ajnr.A1525.
69. Taylor CB, Boone JL, Schmalbach CE, Miller FR. Intraoperative relationship of the spinal accessory nerve to the internal jugular vein: variation from cadaver studies. Am J Otolaryngol. 2013;34(5):527-9; DOI:10.1016/j.amjoto.2013.05.008.
70. Raikos A, English T, Yousif OK, Sandhu M, Stirling A. Topographic anatomy of the great auricular point: landmarks for its localization and classification. Surg Radiol Anat. 2017;39(5):535-40; DOI:10.1007/s00276-016-1758-y.
71. AlShareef S, Newton BW. Accessory Nerve Injury [Internet]. Treasure Island (FL):StatPearls; 2025 [cited 2025 Aug 10]. 21 p. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532245/.
72. Chandawarkar RY, Cervino AL, Pennington GA. Management of iatrogenic injury to the spinal accessory nerve. Plast Reconstr Surg. 2003;111(2):611-9; DOI:10.1097/01.PRS.0000041943.47622.EB.
73. Mazurek M, Pioterek O, Drążyk M, Pozdnyakova D, Kozłowski O, Tarkowski J. Decoding the Mysteries of the Obturator Nerve. J Anat Soc India. 2024;73(1):64-9; DOI:10.4103/jasi.jasi_122_23.
74. Mazurek M, Pioterek O, Drążyk M, Wanał M, Kozłowski O, Domagała Z. Unusual pattern of branches and ganglions of cervical sympathetic trunk- single case study with clinical implications. Med J Cell Biol. 2023;11(2):50-4; DOI:10.2478/acb-2023-0008.
75. Mazurek M, Pioterek O, Drążyk M, Pozdnyakova D, Kozłowski O, Tarkowski V. An atypical obturator nerve: an anatomical and clinical case report. Med J Cell Biol. 2023;11(2):55-9; DOI:10.2478/acb-2023-0009.
76. Nowak B, Wanał M, Świątko A, Mirkowski K, Tarkowski V, Mrożek A, Mazurek M, Domański J, Domagała Z. Exploring the microscopic terrain of the small intestinal epithelium: a comprehensive overview of general architecture and the present understanding of intestinal stem cells. Med J Cell Biol. 2023;11(3):87-92 DOI:10.2478/acb-2023-0015.
77. Domagała Z, Drążyk M, Pioterek O, Kozłowski O, Lubieniecki P, Sroczyński M, Dudek A, Woźniak S, Tarkowski V, Mazurek M. Precision in preservation: mastering cadaver embalming with the femoral artery approach – a technical note. Folia Morphol (Warsz). 2025;84(1):243-8; DOI:10.5603/fm.99260.
78. Jakub J, Mazurek M, Gajda-Janiak A, Pioterek O, Drążyk M, Tulski M, Domański J, Domagała Z. Can we make anatomical specimen last forever? Technical note on photogrammetry. Med J Cell Biol. 2023;11(4):108-13; DOI:10.2478/acb-2023-0018.
79. Domagała Z, Mazurek M, Kozłowski O, Drążyk M, Tarkowski V, Domański J, Dąbrowski P, Woźniak S. Challenges associated with vascular access through the common carotid artery during embalming procedures in humans: a technical note. Folia Morphol (Warsz). 2024; 83(2):360-6; DOI:10.5603/fm.95539.