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ORIGINAL ARTICLE

# Anatomical variations of the subscapular pedicle and its terminal branches: an anatomical study and a reappraisal in the light of current surgical approaches

Martin Lhuaire[1,2,3] · Mikael Hivelin[1] · Mohamed Derder[1] · Vincent Hunsinger[1] · Vincent Delmas[4] · Peter Abrahams[5] · Daniele Sommacale[3] · Reza Kianmanesh[3] · Christian Fontaine[2] · Laurent Lantieri[1]

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## Abstract

**Purpose** While anatomical variations of the subscapular vessels are frequently encountered during axillary dissection, little is found in the literature. The aim of this cadaveric study was to define arterial and venous anatomical variations and frequencies of the subscapular vascular pedicle and its terminal/afferent vessels in women.

**Methods** We performed 80 dissections of the axillary region on forty female formalin-embalmed cadavers. Each anatomical arrangement was photographed and recorded on a scheme before analysis.

**Results** We propose a new classification of the subscapular pedicle variations. We observed three types of subscapular arterial variation. The type Ia was the most frequent arrangement (71% of our dissections), the type Ib was observed in 11% and the type II in 18% of cases. We observed four types of subscapular venous variation. The type Ia was observed in 63% of cases, the type Ib in 14%, the type II in 14% and the type III in 10% of cases.

**Conclusions** This knowledge of the anatomical variation arrangement and frequencies of the subscapular vascular pedicle will assist the surgeon when dissecting the axillary region for malignant or reconstructive procedures.

**Keywords** Subscapular pedicle · Thoracodorsal pedicle · Circumflex scapular pedicle · Autologous microsurgical breast reconstruction · Axillary lymph nodes dissection · Vascular anatomy · Axilla · Anatomical variations

## Introduction

Progresses in surgical techniques still raise novel anatomical questions and stimulate reappraisal, expanding and sometimes correcting traditional anatomical knowledge. Anatomical variations are of surgical relevance. Indeed, it is currently well established that the knowledge of anatomical variations is an indispensable prerequisite for safe surgical practice [10, 11, 25, 39]. Subscapular vessels and their branches are of great importance in breast cancer and

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✉ Martin Lhuaire
martin.lhuaire@etudiant.univ-reims.fr

1 Department of Plastic, Reconstructive and Aesthetic Surgery, Hôpital Européen Georges Pompidou, Assistance Publique des Hôpitaux de Paris, Université Paris Descartes, Paris V, 20 rue Leblanc, 75908 Paris Cedex 15, France

2 Institute of Anatomy and Organogenesis, Faculté de Médecine Henri Warembourg, Université de Lille II, Lille, France

3 Department of General and Digestive Surgery, Hôpital Robert Debré, Centre Hospitalier Universitaire de Reims, Université de Reims Champagne-Ardenne, Reims, France

4 Institute of Anatomy, URDIA, EA4465, UFR Biomédicale des Saints-Pères, Université Paris Descartes, Paris V, Paris, France

5 Institute of Anatomy and Clinical Education, Warwick Medical School, University of Warwick, Coventry CV4 7AL, UK

reconstructive surgery. Subscapular and thoracodorsal vessels represent the posterior limit of the axilla lymph nodes clearance procedure following positive sentinel node dissection in invasive breast cancers. Its terminal branches, the thoracodorsal and circumflex scapular vessels, are used as recipient sites for autologous microsurgical reconstructions with free flaps such as deep inferior epigastric artery perforator (DIEP) or profunda femoris artery perforator (PAP) flap procedures [3, 4, 17, 19, 22, 24, 26]. Anatomical variations of these vessels, while frequently encountered during axillary dissection have been poorly studied and scarcely reported in the literature. It is explained by the lack of need for accuracy or the absence of need for microsurgical insert before the advent of microsurgical breast reconstruction by free flaps [20, 23]. Dedicated textbooks for anatomical variation offer a confusing display [5, 28], rendering it difficult for their immediate use in clinical practice. While vascular variations of large vessels are comprehensively described in these textbooks [5, 28], it is not the same for smaller vessels such as the subscapular vessels and still less so for thoracodorsal and circumflex scapular vessels. Moreover data about venous variations are even less studied. Studies based on clinical axillary dissections provided an attempt of systematic description of vascular variations for surgeons. However, they were limited by intraoperative morbidity, that cannot compare with any detailed anatomical dissection [20, 21, 23, 35].

We performed an anatomical cadaveric study with the aim to provide anatomical variations of the subscapular pedicle and its terminal vessels in the light of their surgical implication in women.

## Materials and methods

A monocentric prospective observational cadaveric study was conducted from June 2015 to June 2017. The 40 formalin-preserved Caucasian female cadavers, which were dissected bilaterally, were donated by the Institute of Anatomy of Lille Body Donation Program. The 80 axillary dissections were all performed by the same operator (ML). The dissection procedure was focused on the subscapular vessels with its terminal branches, the thoracodorsal and circumflex scapular arteries and veins. Each pedicle was widely dissected to assess their origins/ends and pathway within the axilla. Each anatomical pattern was photographed and recorded on a scheme throughout the dissections before final analysis. A descriptive analysis of each vessel's anatomy and variations including frequencies and percentages was made. Percentages were rounded to the superior or inferior unit according to decimals and condition of application. Quantitative data are systematically presented as mean values (range; standard deviations).

## Results

The mean age in the series was 80 years old (range: 46–102 years; SD: 12.3 years). The mean weight and height were 68 kg (range: 40–105 kg; SD: 14.2 kg) and 1.64 m (range: 1.50–1.75 m; SD: 0.63 m), respectively. The mean BMI was 25.5 kg/m$^2$ (range: 17–38 kg/m$^2$; SD: 4.7 kg/m$^2$).

### Arterial anatomy and variations

Three types of subscapular arterial variations were observed (Fig. 1). The first type, that we called type Ia, corresponds to the modal arrangement seen in anatomy textbooks and displays one subscapular artery which originates from the inferior border of the axillary artery and after a few centimetres divides into two branches: a vertical and a descendent one that becomes the thoracodorsal artery and the horizontal and external one that is the circumflex scapular artery. In this type, the mean length of subscapular arteries was 1.8 cm (range: 0.5–3.0 cm; SD: 0.7 cm) and was observed in 71% of cases ($n = 57$ cases/80 dissections). The second type, that we called type Ib, corresponds to the modal arrangement but it differs from type Ia only by the proximal origin of the subscapular artery from the inferior border of the axillary artery. In this type, the mean length of subscapular arteries was 5.1 cm (range: 1.5–7.0 cm; SD: 1.5 cm) and was observed in 11% of cases ($n = 9/80$). The third type observed, that we called type II, corresponds to the absence of the subscapular artery and the presence of two distinct origins of the thoracodorsal and circumflex scapular arteries from the inferior border of the axillary artery. Type II was observed in 18% of cases ($n = 14/80$). In addition, the incidence of arterial variations was of 29% of cases ($n = 23/80$).

### Venous anatomy and variations

Four types of subscapular venous variations were observed (Fig. 2). The first type, that we called type Ia, corresponds to the modal arrangement seen in anatomy textbooks and displays one subscapular vein of a few centimetres, which flows along the inferior border of the axillary vein and originates from the confluence of the thoracodorsal and circumflex scapular veins. In this type, the mean length of subscapular veins was 1.4 cm (range: 0.3–4.0 cm; SD: 0.9 cm) and was observed in 63% of cases ($n = 50$ cases/80 dissections). The second type, that we called type Ib, corresponds to the modal arrangement with a difference in the proximal end of the subscapular vein along the inferior border of the axillary vein. In this type, the mean length of subscapular arteries was 2.2 cm (range: 1.0–3.0 cm; SD: 0.7 cm) and was observed in 14% of cases ($n = 11/80$). The third type

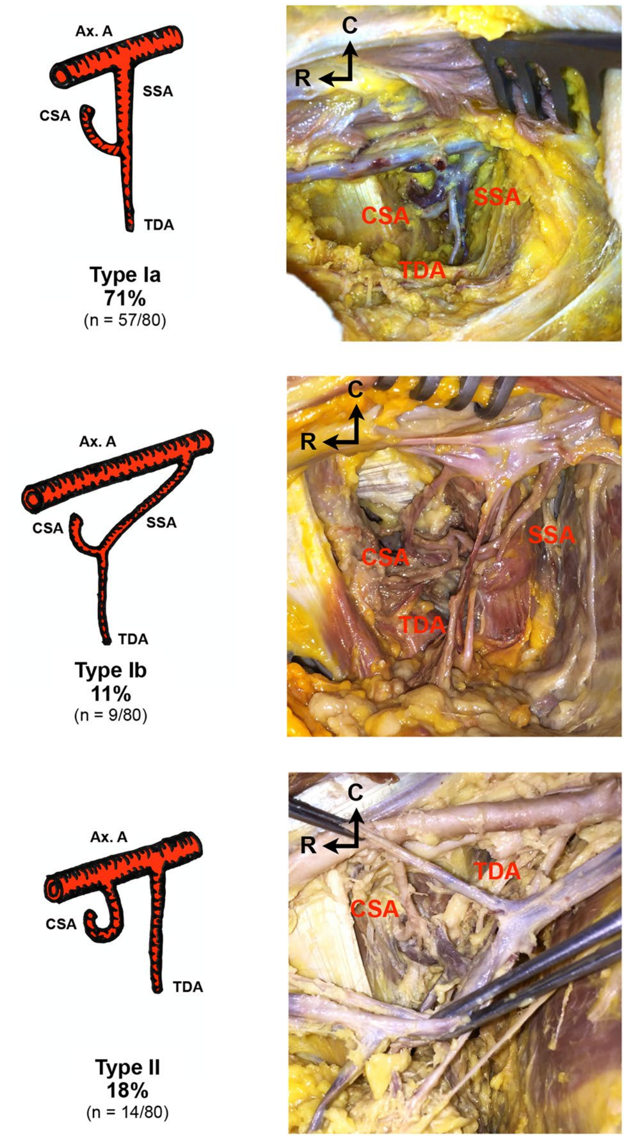



**Fig. 1** Description of the proposed classification of anatomical variations of the subscapular artery (SSA) and its terminal branches (the circumflex scapular (CSA) and the thoracodorsal (TDA) arteries). Type Ia arterial: modal arrangement. Type Ib arterial: modal arrangement with a proximal origin of the SSA from the axillary artery. Type II: absence of subscapular artery and distinct origins of the CSA and TDA from the axillary artery (Ax. A)

observed, that we called the type II, corresponds to the absence of the subscapular vein and the presence of two distinct ends of the thoracodorsal and circumflex scapular veins along the inferior border of the axillary vein. The type II was observed in 14% of cases ($n = 11/80$). The last type observed, that we called type III, associates type Ia, with the modal arrangement, with an additional circumflex scapular vein that flows separately to the axillary vein. In this type, the mean length of subscapular veins was 2.2 cm (range: 1.5–3.0 cm; SD: 0.5 cm), and was observed in 10% of cases ($n = 8/80$). In addition, the incidence of venous variations was of 38% of cases ($n = 30/80$).

## Association between arterial and venous arrangements

In a same subject, there was an association between right- and left-sided arterial arrangements or variations of subscapular pedicles in 67.5% of cases ($n = 27/40$ subjects) and in 42.5% of cases ($n = 17/40$ subjects) for venous arrangements or variations (Table 1). The most frequent arrangement or variations that are symmetrically observed between right and left sides were the arterial type Ia (74% of symmetric arterial cases; $n = 20/27$) and the venous type Ia (94% of symmetric venous cases; $n = 16/17$). The arterial and venous type Ib were symmetrically observed in a same subject in 11% ($n = 3/27$ of symmetric arterial cases) and in 6%, ($n = 1/17$ of symmetric venous cases) respectively. The arterial and venous type II were symmetrically observed in 15% ($n = 4/27$ of symmetric arterial cases) and 0% ($n = 0/17$ of symmetric venous cases), respectively. There were no symmetrical observations in the type III venous.

On the same side, there was an association between arterial and venous arrangements in 58% of cases ($n = 46$ cases/80 dissections) (Table 2). The most frequent arrangements between arterial and venous arrangements were for the modal arrangement (type Ia) found in 85% of cases ($n = 39/46$), followed by type II found in 11% of cases ($n = 5/46$), and then type Ib in 4% of cases ($n = 2/46$). When the arterial type Ia was observed there was an association with the venous type Ia in 68% of cases ($n = 39/57$). When the venous type Ia was observed there was an association with the arterial type Ia in 78% of cases ($n = 39/50$). When the arterial type Ib was observed there was an association with venous type Ib in 22% of cases ($n = 2/9$). When the venous type Ib was observed there was an association with the arterial type Ib in 18% of cases ($n = 2/11$). When the arterial type II was observed there was an association with the venous type II in 36% of cases ($n = 5/14$). When the venous type II was observed there was an association with the arterial type II in 45% of cases ($n = 5/11$).

## Discussion

The current work led us to propose a new classification of the subscapular arterial and venous anatomical variations with their respective frequencies in women. We found that three types of arterial and four types of venous variations exist. This finding confirms that the modal arrangement (Type Ia), corresponding to the usual description in anatomy textbooks [6, 11, 16, 33, 34, 37], is the most frequently encountered type in more than 70% of cases for arteries and in more

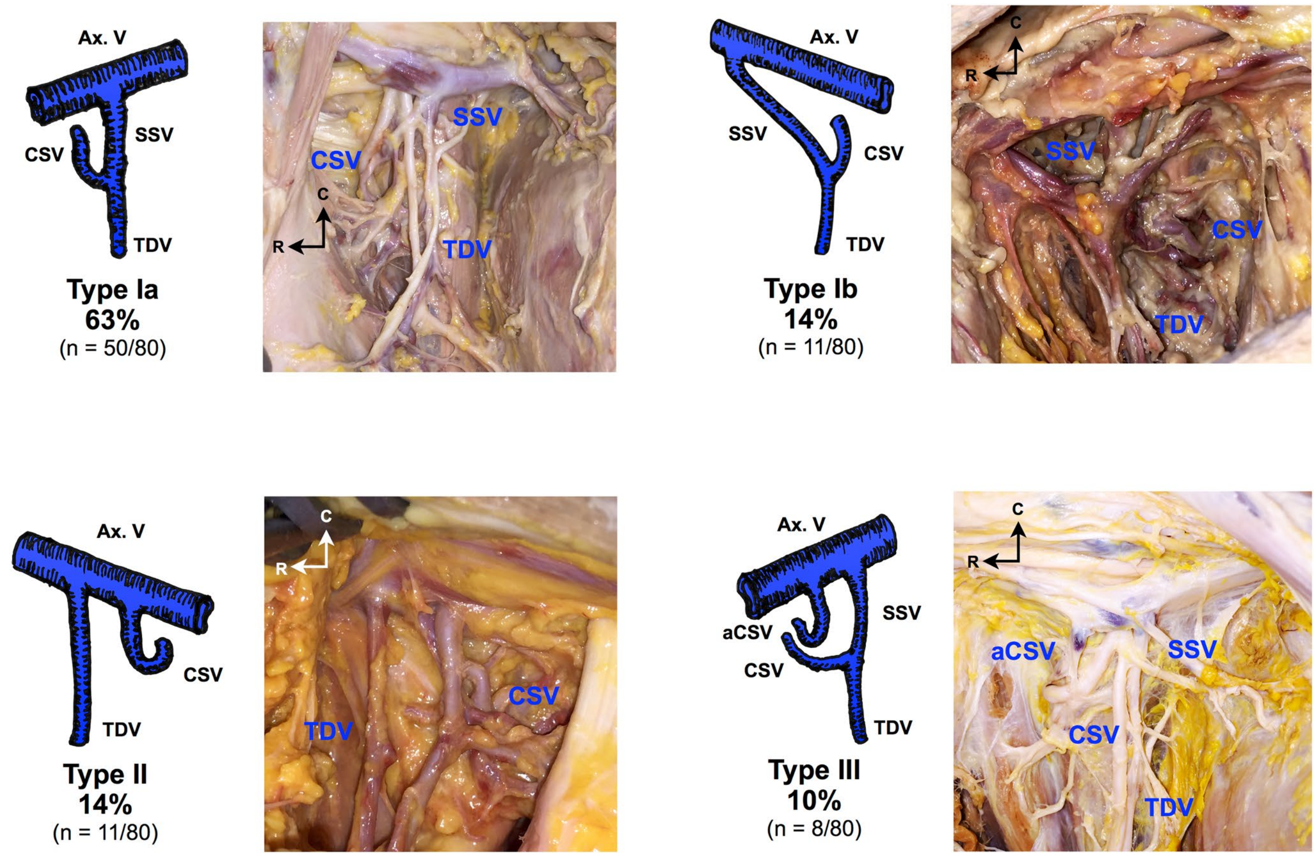



**Fig. 2** Description of the proposed classification of anatomical variations of the subscapular vein (SSV) and its terminal branches (the circumflex scapular (CSV) and the thoracodorsal (TDV) veins). Type Ia venous: modal arrangement. Type Ib venous: modal arrangement with a proximal end of the SSV within the axillary vein (Ax. V). Type II: Absence of subscapular vein and distinct ends of the CSV and TDV within the axillary vein. Type III: associates type Ia with an accessory circumflex scapular vein. aCSV: accessory circumflex scapular vein

**Table 1** Association between right- and left-sided arrangements

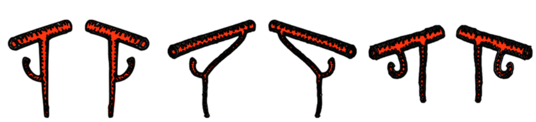
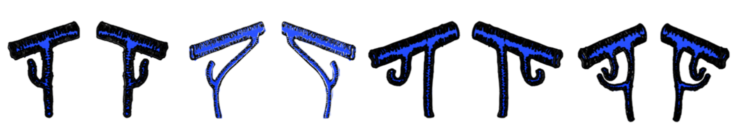
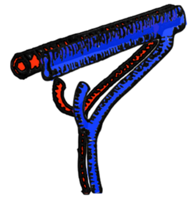
| TYPE | Ia | Ib | II | III | All confounded |
|---|---|---|---|---|---|
| Arteries |  | | | — | — |
| Arteries associations | 74% (n = 20/27) | 11% (n = 3/27) | 15% (n = 4/27) | — | 67.5% (n = 27/40) |
| Veins |  | | | | — |
| Veins associations | 94% (n = 16/17) | 6% (n = 1/17) | 0% (n = 0/17) | 0% (n = 0/17) | 42.5% (n = 17/40) |

**Table 2** Association between arterial and venous arrangements on the same side

| TYPE | Ia | Ib | II | All confounded |
|---|---|---|---|---|
| |  |  |  | — |
| **Associations** | 85% (n = 39/46) | 4% (n = 2/46) | 11% (n = 5/46) | 58% (n = 46/80) |

than 60% for veins. Incidence of anatomical variations corresponded almost to 30% and 40% for arteries and veins, respectively. Bourgery stated in 1831 general rules about vessel variations: 1, vessel variations seem to increase from arteries to veins and lymphatics because of their respective importance to maintain life; 2, for the same kind of vessel, variation incidence increases when they approach their termination; 3, the number of arterial variations is in general equal to that of veins, while the further away from the heart, venous variations are more numerous than the arterial ones; 4, variation of the origin is the most frequent kind of variations [6]. While our results confirm the first two rules, they did not confirm the fourth of Bourgery's statement. Indeed, the variation in terms of number was the most frequent one in the current study. On the same subject, we observed a symmetry between right- and left-sided arterial and venous arrangements of subscapular pedicles in more than 65% and 40% of cases, respectively. The most frequent arrangement observed symmetrically was the modal arterial and venous arrangements (Type Ia) in more than 70% and 90% of symmetric cases, respectively. Moreover, the incidence of a symmetrical variation is low (Table 1). Indeed, Bourgery already stated that inter-individual anatomical variations are numerous but in a same subject anatomical variations are rarely symmetric [6]. We also found at the same side an association between arterial and venous arrangements—or variations—in almost 60% of cases (Table 2). Moreover, we found that the modal arrangement (type Ia) is the most frequently symmetric type between arteries and veins at the same side in more than 80% of cases, whereas anatomical variations are found symmetric in less than 20% of cases. Therefore, we did not confirm Bourgery's statement that stated that "accompanying veins of arteries present generally similar variations" [6].

Several variations of the subscapular artery and vein have been reported in the literature (Table 3). Bourgery, 1831, reported a noteworthy variation of the origin of the subscapular artery, especially forming a common trunk with the other collaterals of the axillary artery [6]. He reported, without their respective frequencies, the possible existence of a common trunk with the lateral thoracic, the posterior circumflex humeral and the profunda brachii arteries [6]. Indeed, Natsis et al., gave an anecdotal description of a bilateral accessory thoracodorsal artery in an caucasian female cadaver that we have never found throughout our dissections [30]. Bourgery also gave a description of the subscapular vein and stated that its tributaries match the arterial divisions. He also mentioned an interesting fact: "collaterals veins are everywhere double in the upper limb, but concerning only tributary veins from the shoulder muscles in opposite to veins always alone from the thoracic wall muscles" [6]. We had also confirmed this statement in a previous study with an incidence of double circumflex scapular vein in 16% of cases compared to a very exceptional presence of double thoracodorsal vein (1% of cases) [26]. Dubreuil-Chambardel in 1926, reported several variations of the subscapular artery especially in its origin [12]. From 398 cadaver dissections, Adachi in 1928 gave a systematic description by types of anatomical variations of the subscapular artery with their respective frequencies in male and female subjects [1]. He defined six types that are very comparable to those of the present series, but he defined them by their relationships with the median nerve [1]. The Adachi's type I (incidence of 68%, $n=269/398$ cases, including Adachi's type I + type V) corresponds to the modal description and fits with the type Ia of our study (incidence of 71%, $n=57$ cases/80 dissections). The Adachi's type II (incidence of 24%, $n=96/398$ cases) corresponds to the proximal origin of the subscapular artery from the axillary artery and fits with the type Ib of our study (incidence of 11%, $n=9/80$ cases). Finally, the Adachi's type III (incidence of 8%, $n=33/398$ cases) correspond to the absence of the subscapular artery with two distinct origins of the thoracodorsal and the circumflex scapular artery that fits with the type II of our study (incidence of 18%, $n=14/80$ cases). Our findings are very similar to those from the Adachi's series. In addition, focusing only

**Table 3** Review of the literature about anatomical variation studies of subscapular vessels and comparison with the results of the present study

| Authors | Year | *n* Subjects | Types of anatomical variation | | Frequencies | Comparison with the current study |
|---|---|---|---|---|---|---|
| | | | SSA | SSV | | |
| Bourgery [6] (Anatomical textbook) | 1831 | NA | Yes<br>Forming a common trunk with other collaterals of the axillary artery | NS | NA | Not possible |
| Dubreuil-Chambardel [12] (Anatomical textbook) | 1926 | NA | Yes<br>Several variations in its origin | NS | NA | Not possible |
| Adachi [1, 2] (Anatomical study) | 1928 | 398 | Yes<br>Six types from their relationships with the median nerve | NS | Yes | Similar results for arteries only |
| Lippert and Pabst [28] (Anatomical textbook) | 1985 | Systematic review of cases published in the literature | Yes<br>Not specific variations of the SSA, but variations of axillary artery collaterals | NS | Yes | Similar results for arteries only |
| Tountas and Bergman [38] (Anatomical textbook) | 1993 | Systematic review of cases published in the literature | Yes<br>They describe the possible proximal origin of the SSA and also that TDA can arise directly from the axillary artery | NS | NA | Similar results for arteries only |
| Lantieri et al. [23] (Clinical study) | 1999 | 40 | Yes | Yes | Yes | Similar results |

*NS* not studied, *NA* not assessed

on arterial variations, Adachi also observed three types of arterial variations of the subscapular artery that he distinguished in six types following their arrangements with the constitution of the median nerve. Nevertheless, in the present study we made the choice to not report vessel variations as regard of adjacent nerves as Adachi's did. Firstly, to simplify the anatomy and secondly, because it seems to us that relationships of recipient vessels with adjacent structures are of secondary interest in clinical practice of breast reconstructive surgery. In 1933, Adachi published his study about variations of the venous system, but he did not undertake a study of peripheral veins [2]. Lippert and Pabst, in 1985, did not report specific variations of the subscapular artery but variations of the axillary artery collaterals in general [28]. They reported that the normal type (as shown in textbooks and corresponding to the Type Ia of the present study) as an incidence around 60% [28]. We confirm these data as in the present study the modal type (type Ia) showed an incidence of 71% of cases and was the most frequent arrangement. Lippert and Pabst's textbook considers only arterial variations without presenting venous variations. Tountas and Bergman reported in 1993 a proximal origin of the subscapular artery from the second part of the axillary artery with an incidence of 15% [38], which corresponds to our type Ib (incidence of type Ib: 11% of cases ; $n=9/80$). They also reported that Goldberg et al., 1990, stated that the thoracodorsal pedicle arises directly from the axillary artery and separately from the subscapular pedicle with an incidence of 3% of cases (vs an incidence of 18% of cases in our series, type II) [15, 38]. They did not present venous variations [38]. The aforementioned essential textbooks of anatomical variations consider almost exclusively arterial variations and venous variations are more often overlooked. To the best of our knowledge, very few reports consider venous anatomy and even less the venous variations of the subscapular pedicle [8, 20, 21, 31, 36]. Moreover these rare reports are debatable from the anatomical significance point of view of clinical applications.

It is generally assumed that embryology and especially organogenesis explains the existence of anatomical variants in adult subjects [25]. Rodriguez-Niedenführ et al., demonstrated that the developmental sequence of upper limb arteries takes place between D26 and D52 days of the human development (Carnegie stages 13–21) [32]. They put forward very strong arguments that the development of upper limb arteries follows a proximal-to-distal differentiation and a postero-anterior polar sequence. As they showed, arterial variations should result from a modification of the normal pattern of distal capillary maintenance and regression over development stages 13–21 [32]. This theory seems of value for arteries but inapplicable for veins for several reasons. First of all, it is stated in previous embryological works that the venous system seems to acquire its definitive morphology later than arteries during development, which suggests that definitive venous shaping arises after the final arterial morphology [25, 27]. Secondly, the primitive appearance of veins is electively observed as confluent plexus from periphery to the root of the upper limb [25]. Thirdly, the superficial venous system seems to appear before the deep venous system of the upper limb during human development [9]. Fourthly, the embryonic veins arise as capillary plexuses by sprouting and anastomosing [18], then fuse and enlarge to form real venous lakes especially at the root of the upper limb, later giving rise to fewer and smaller channels [25]. Fifthly, the beginning of the blood circulation around the fourth week of development implies local hemodynamic influences, such as rate and direction of flow and pressure of the blood, which determine the definitive morphology of the upper limb vessels [18]. Allowing that further large embryological observational studies are needed to conclude that, opposite to arterial development, venous differentiation of the upper limb arises later than the arterial one and follows a distal-to-proximal and from surface to deep sequence. Venous variations may be explained on the basis of this hypothetical theory by modifications of the normal pattern of venous lakes fusion and regression.

Our study presents several strong points. To the best of our knowledge, this is the first study to present comprehensively venous variations of the subscapular pedicle and its afferent branches. Indeed, in the field of perforator flap research it is striking to see that all the attention is given to the perforating arteries to the detriment of the perforating veins, yet the clinical impact of venous outflow complications on perforator flap surgery greatly surpasses arterial complication suggesting a fundamental role of veins in perforator flap physiology that therefore deserves special attention. Our study is in accordance with the recommendations of the anatomical community for anatomical variations studies [13, 14, 29]. From a methodological standpoint, our study displays 12/13 items of the QUACS scale (Quality Appraisal for Cadaveric Studies) [40]. The sample size for normative studies is in accordance with the standards of the literature [7]. However, our study has several weaknesses. We did not focus on and retrieve data about the possible common origin of the subscapular artery with others collaterals of the axillary artery. We believe the clinical significance of the possible common origin with other collaterals to be secondary in breast reconstructive surgery and we made the choice to focus only on the subscapular vessels and their terminal branches. In the same way, we did not retrieve variations to adjacent structures such as nerves as it seems to us to have no clinical implications especially in breast reconstructive surgery. Finally, it is naive to state that we described all the variations of the subscapular pedicle and its terminal branches that exist in human beings, but it seems acceptable to state that our present study comprehensively describes anatomical variations of the subscapular pedicle and its terminal branches.

To conclude, the results of our study require some clinical comments and surgical implications:

1. Anatomical variations of the subscapular pedicle and its terminal branches are frequent.
2. The circumflex scapular and the thoracodorsal vessels are highly constant and were present in 100% of cases in the present series.
3. Subscapular vessels may be absent in 18% and 14% of cases of the present series for arteries and veins, respectively.
1. Arteries were always single (100% of cases), while circumflex scapular veins were double in 16% of cases and thoracodorsal veins were almost always single (double in 1% of cases).
4. When an anatomical variation is present it does not modify the relationships of the subscapular vessels with adjacent anatomical structures with sufficient clinical significance to increase the difficulty of the dissection of these pedicles.
5. There is a perfect symmetry between left- and right-sided anatomical arrangements for arteries and veins in more than 65% and 40% of cases, respectively.
6. In a same side there was a perfect symmetry between artery and vein arrangements in almost 70% of cases (including modal and variants).

We hope the anatomical data presented in the current study on subscapular pedicle variants will be helpful to surgeons who are carrying out both cancer and reconstructive breast surgery.

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**Author contributions** All persons listed as authors have contributed substantially to the design, performance, analysis, and reporting of this work. ML, MH, MD, VH: collected data, analyzed data, wrote paper. VD, PH, DS, RK: analyzed data, wrote paper. ML, CF, LL: Designed study, analyzed data, wrote paper.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no competing interests.

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