

## The Blood Supply to the Nipple-Areolar Complex. A Literature Review

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### Abstract

**Introduction:** The review of the articles, which explain the blood supply to the nipple-areolar complex (NAC), is presented in this article.

**Objectives:** Clarifying the blood supply to the NAC.

**Materials and Methods:** The continuous sampling method that has been used in scientific databases' articles, which satisfy three criteria: the descriptions of the NAC's blood supply variety, the description of some blood sources, and the anatomic substantiation. The available anatomic and surgical textbooks were also analyzed.

**Results:** In clinical use the NAC vascularity was grouped in three systems: superficial medial, deep central and mixed lateral. The medial system shows maximal anatomic stability. It consists of superficial branches of a.thoracica interna and a more superficial venous system, which flows into the v.thoracica interna system. The central system includes the a. thoracoacromialis and aa. Intercostales perforators. They support the medial and lateral vascular systems by anastomosing with them on various levels. Occasionally this system is the main system that supplies the NAC (in 1,92% cases). The lateral system consist of vessels which variably originate from a.thoracica lateralis, a.axillaris and a. thoracoacromialis. There is the only one superficial a.thoracica superficialis in this zone, which goes to the NAC in subdermal fatty layer in 14% cases, others originate deeply. Some of them going directly from deep to the NAC.

**Conclusion:** In extensive resections the medial vascular system can be used for NAC preservation. Should not use the only central vascular system, because then the NAC's necrosis risks are increased. This system can be used only as a supplement. The lateral system can be used for NAC preservation only if the blood supply is confirmed. The medial vascular system underlies the thin supero-medial NAC pedicle, but its' safety requires additional analysis.

**Keywords:** Breast Anatomy; Blood Supply to the NAC; Nipple-Areolar Complex

### Introduction

Performing complex operations on the mammary glands (MG) requires deep knowledge of anatomy. One of the important part of the breast anatomy is the blood supply to the breast itself and the nipple-areolar complex (NAC) in particular. However, there are still conflicting information and uncharted territory in the angioarchitectonics of MG and NAC, so this problem slowly but surely will be solved with new published articles.

### Aim of the Study

The aim of our work was to clarify the angioarchitectonics of the nipple-areolar complex, which will improve oncological, reconstructive and aesthetic operations on the breast, minimizing the likelihood of compromising blood supply to the NAC. This is especially true in oncology, where the frequency of necrosis of NAC can reach 5.9% with nipple sparing mastectomy [5].

### Materials and Methods

A search for vascular anatomy was performed in scientific databases without a time limit using Google Scholar (<https://scholar.google.com/>) in 2017. The keywords were “blood supply to the anterior chest wall”, “blood supply to the mammary gland” and “blood supply to the nipple-areola complex”. The blood vessels found and described in the articles were additionally used as keywords for additional search in scientific databases using Google Scholar without a time limit. The interconnections of the blood vessels were identified and described by layer.

### Results

Branches of *a.thoracica interna*, *a.thoracoacromialis*, *aa.intercostales* and *a.thoracica lateralis* were most often mentioned in the literature as the dominant sources of blood supply to the breast and, in particular, NAC. These arteries supply the anterior chest wall with abundant anastomosis with each other [13,16, p. 947,19]. According to the anastomosing of *a.thoracica lateralis* and *a.thoracica interna*, van Deventer PV, *et al.* in a review article concludes that the blood supply to the mammary gland is segmental [19], however, Elizabeth J. Hall-Findlay makes adjustments, arguing that despite segmental blood supply to the mammary gland, the blood supply to the NAC is axial, and the branch of the internal mammary artery is the dominant source, which approaches the NAC from above and may sometimes be absent [2]. This statement is confirmed by a number of publications that describe the dominant vessels of NAC from the basins of *a.thoracica interna* and *a.thoracica lateralis* [10,11]. We consider the work of Seitz IA, *et al.* to be one of the most interesting works, in which the dominant blood supply of NAC was analyzed intravitaly in a large sample of 52 breasts (26 patients) using MRI with vascular contrast. The paper describes that in 53.9% of cases, NAC has only a medial source of blood supply, in 1.92% only a lateral source, in 1.92% an isolated central one. Double blood supply due to medial and lateral sources has 38.46% of cases, medial and central in 3.84% of cases [15].

After analyzing the literature, we divided the sources of blood supply into three zones: medial superficial, central deep and lateral mixed.

The medial zone includes the branches of *a.thoracica interna* and *a.thoracica suprema*. Central includes branches of *a.thoracoacromialis*, *a.thoracica lateralis* and *aa. Intercostales*.

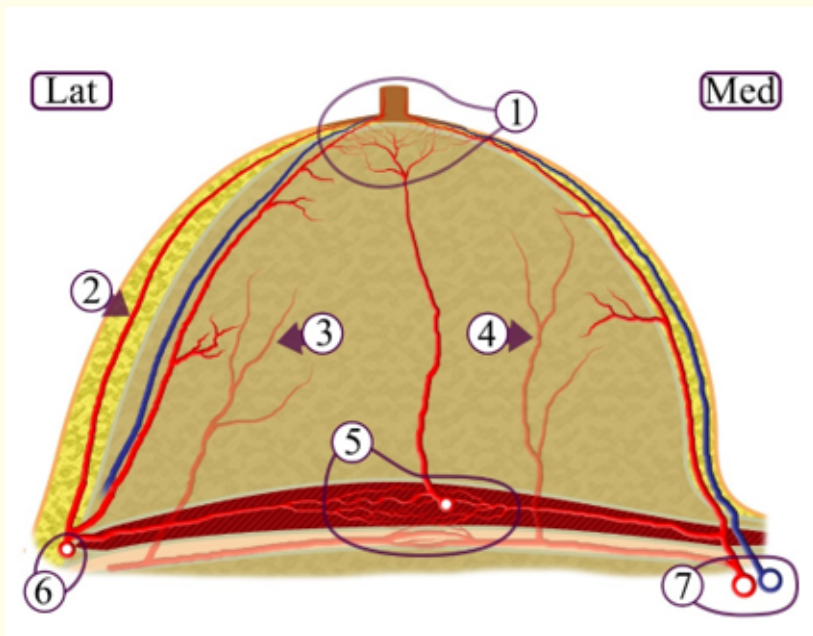
The lateral zone includes the deep branches of *a.thoracica lateralis* and the superficial *a.thoracica superficialis*.

### Medial zone

Palmer J. H. and Taylor G. I. describe *a.thoracica interna*, which branches are divided into lateral and medial. The zone of interest includes lateral branches, which, in turn, are divided into three levels:

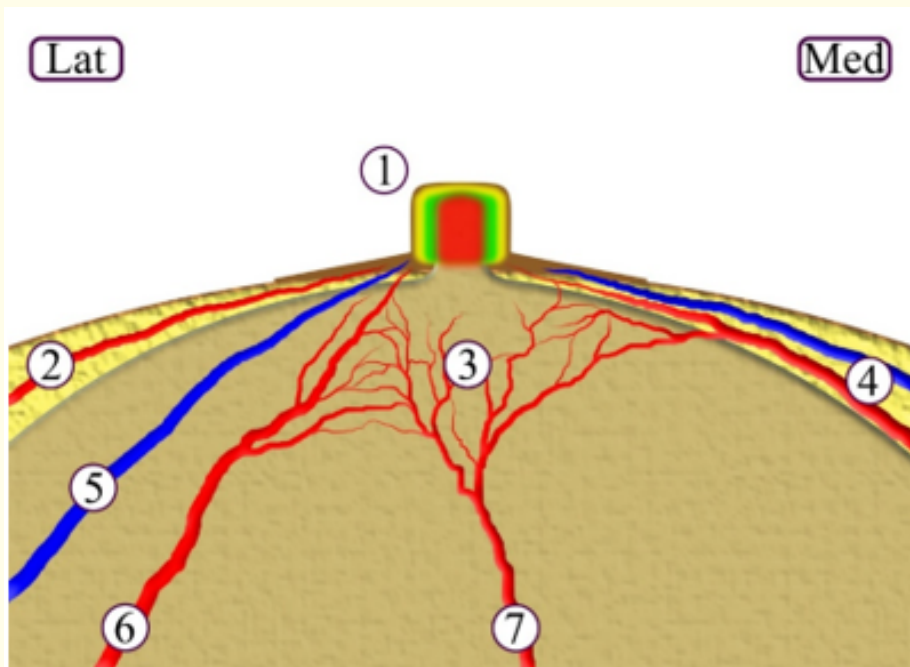
- The first and deepest level contains *aa.intercostales interiores*, which anastomose with *aa.intercostales posteriores* and supply blood to the chest.

- The second level consist of muscle branches to the pectoralis major muscle (PMM), which form at approximately the midclavicular line level spiral and narrowed anastomoses (choke vessels) with a.thoracoacromialis (Figure 1).
- The third level consist of direct skin branches.



**Figure 1:** 1. NAC; 2. a.thoracica superficialis; 3. aa.intercostales posteriores; 4. aa. Intercostales anteriores; 5. anastomoses between a.thoracoacromialis and a.thoracica lateralis, anastomoses between aa.intercostales posteriores and aa. Intercostales anteriores marked pale red. They anastomose with a.thoracoacromialis branches through muscle fixation zones; 6. a. thoracica lateralis 7. a. and v. thoracica interna.

The article provides information that at least one large perforant a.thoracica interna is always found in the first four intercostal spaces. Analysis of the dominant blood supply to the breast showed that the breast is supplied in 68% of cases from a.thoracica interna, due to a.thoracica lateralis in 20% of cases, double blood supply is present in 12% of cases [12]. The branches of the artery pass to the NAC in the subcutaneous fat. They reach NAC on the upper medial border with an average occurrence depth of  $1.5 \pm 0.4$  cm [10]. Under the areola there is adipose tissue, which disappears at the level of the nipple [21]. Blood supply to the nipple is carried out along the subdermal vascular circle, which contains 66% of all nipple vessels at the depth up to [14] (Figure 2). At the border of the NAC, the branches of the artery can be find lie at an average depth of  $10.3 \text{ mm} \pm 2.5 \text{ mm}$ . For 3cm more medially at an average depth of  $14.2 \text{ mm} \pm 4.6 \text{ mm}$  [7]. Also described is a.thoracica suprema, originating from a.axillaris, sometimes from a.thoracoacromialis or a.thoracica interna. It supplies blood to the NAC in 57% due to its surface branches [10,16, p. 828]. Venous outflow in the medial direction is carried out in the v.thoracica interna system. At the border of the NAC, the veins lie at a depth of  $2.6 \text{ mm} \pm 1.4 \text{ mm}$ . 3 cm from the NAC at a depth of  $3 \text{ mm} \pm 0.8 \text{ mm}$ . Medial veins are located more superficial than lateral, that pass deep in the glandular tissue [7,8].



**Figure 2:** 1. Zones of vessel density in NAC: maximum density marked green, minimum density marked green. 2. Branches of *a.thoracica superficialis*; 3. Anastomoses between branches *a. thoracica interna*, *a.thoracoacromialis* u *a.thoracica lateralis*; 4. Branches of *a. and v. thoracica interna*; 5. The deep veins; 6. Branches of *a.thoracica lateralis*; 7. Branches of *a.thoracoacromialis*.

### Central zone

Thoracoacromialis in the literature is most often associated with the blood supply to the PMM, since *a.thoracoacromialis* is the most popular pedicle for the pectoralis muscle flap. It is interesting to mention that *a.thoracoacromialis* anastomoses with *a.thoracica lateralis* and *a.thoracica interna* [1,12,16,p. 820,18], therefore, this artery is the central connecting link between the lateral and medial blood supply systems of the NAC. The branches of *a.thoracoacromialis* are closely related to the horizontal Würinger's septum. This septum is located at the level of 5 ribs and is supported by lateral and medial fibrous strands [20]. Fibrous strands contain *a.thoracica interna* perforants from 2 - 4 intercostal spaces from the sternal side, and *a.thoracica lateralis* branches also appearing at the level of 2 - 4 intercostal spaces from the lateral side. Vascular layers covers the caudal and cranial sides of the septum and going to the NAC. The cranial vascular layer includes branches of *a.thoracoacromialis* originating at level 4 of the intercostal space and branches of *a.thoracica lateralis*. The caudal layer contains anastomoses of perforators 4 - 5 *aa. intercostales* [20]. Mon O'Dey D., *et al.* describe that blood supply to the breast through the branches *aa. intercostales anteriores* is carried out in 71% of cases [10].

Würinger's septum is used by many authors during operations to increase the reliability of blood supply to the NAC [3,4]. However, according to the article with a small sample made by Nakajima H., *et al.* the branches of *a.thoracoacromialis* do not pass directly to the NAC. They form an abundant network of anastomoses with branches of *a.thoracica lateralis*, *a.thoracica interna* and perforants *aa. intercostales*, of which only branches from the basins of *a.thoracica lateralis* and *a.thoracica interna* go directly to the NAC, while the dermal and subdermal plexuses practically do not involved in the blood supply to the NAC [11] (Figure 2).

### Lateral zone

The anatomy of a.thoracica lateralis is very variable. In a study on a large sample (420 fixed corpses) it was shown that in 67.62% of cases, the artery comes from a.thoracoacromialis, in 17.02% from a.axillaris, from a.thoracodorsalis in 5% of cases, from a.subscapularis in 3.93%, multiple arteries were found in 3.09%, complete absence of artery in 3.33% [9]. The artery is deep, anastomoses with other arteries, and from the depth gives up to 3 straight branches to the NAC. In some cases, there is a.thoracica superficialis laterally, passing in the subcutaneous fat, reaching NAC in 14% of cases [10]. It can be a branch of a.thoracica lateralis in 42% of cases, a branch of a.thoracoacromialis in 38% of cases, and a.axillaris in 19% of cases [6]. In the lateral direction, venous outflow from NAC occurs in the deep veins located in the thickness of the breast [7] (Figure 2).

### Discussion

It is worth noting some interesting points that arose in the analysis of the literature.

Würinger E., *et al.* describe the caudal vascular layer adjacent to the horizontal septum. It contains anastomoses perforators aa. intercostales of 4 and 5 intercostal space [20]. An interesting coincidence is found in mon O'Dey D., *et al.* where aa. intercostales anteriores are predominantly concentrated at levels 4 and 5 of the intercostal space [10]. Palmer JH and Taylor GI describe aa. intercostales in the 5<sup>th</sup> and 6<sup>th</sup> intercostal spaces are usually the widest [12]. This coincidence may indicate that the dominant deep blood supply to the breast is projected at the level of 4 - 6 intercostal spaces, which can help in planning surgical interventions. This assumption requires additional verification.

The article describes the results of two major studies, the results of which may seem contradictory. Palmer J. H. and Taylor G. I. in their work describe the dominant blood supply to the breast [12], and Seitz IA., *et al.* describe blood supply to the NAC [15]. Therefore, these works with a large sample may show different data, although Palmer J. H. and Taylor G. I. have a smaller sample than Seitz IA., *et al.*

Mon O'Dey D., *et al.* describe blood supply to the NAC through the superficial branches of a.thoracica suprema [10], however, according to the work of Nakajima H., *et al.* direct blood supply to the NAC is provided only by branches a.thoracica lateralis and a.thoracica interna [11]. It is possible that due to a small sample in the work of Nakajima H., *et al.* a.thoracica suprema was described as a branch of interna, which can arise from thoracica interna, or a.axillaris or a. thoracoacromialis [10,16, p. 828].

Le Roux CM., *et al.* describe that NAC is located at the intersection of choke vessels between three angiosomes represented by branches from the basins a.thoracica interna, a.thoracica lateralis and a. thoracoacromialis [7]. These anastomoses can compensatory expand and redistribute blood [17], which can increase the survival of NAC during surgical interventions, but this assumption requires clinical verification.

Based on several publications, it can be assumed that the dominant blood supply to the NAC is mainly due to the branches a.thoracica interna, a.thoracica lateralis, a. thoracoacromialis and aa. Intercostales [10,16, p. 947,19] along the Würinger septum along the vascular layers and lateral fibrous cords. On the medial and lateral side, this corresponds to the level of 2 - 4 intercostal spaces, and in the central zone, 4 - 6 intercostal spaces [10,12,20]. This concept agrees with the theory of angiosomes, in which blood supply to tissues is carried out from the motionless zones to the moving ones, and goes well with the work of Seitz IA., *et al.* [12,15,17]. In the deep sections, all the described vessels abundantly anastomose [1,12,16, p. 820,18], and near the NAC, in most cases, systems from the basins of a.thoracica interna and a.thoracica lateralis are dominant [11] (Figure 1). This assumption requires additional verification.

### Conclusion

The blood supply of NAC for clinical use can be divided into the medial superficial, central deep and lateral mixed vascular systems. The greatest anatomical constancy is in the medial vascular system, represented mainly by the branches of a.thoracica interna, which

pass through the subcutaneous fat to the NAC, and the more superficially located venous system that flows into the v.thoracica interna system [7,10]. The central deep vascular system is represented by branches a. thoracoacromialis and perforants aa. Intercostales. It is the connecting link between the lateral and medial vascular systems, as it anastomoses with them at several levels [1,12,16, c. 820,18]. The branches of the central system rarely supply blood to the NAC due to direct branches (1.92% of cases) [15]. Most often, they anastomose with branches from the basins of a.thoracica lateralis and a.thoracica interna, which are axial for NAC [11]. The lateral vascular system consists of many branches that can come from a.thoracica lateralis, a.axillaris and a. thoracoacromialis. Most of these branches lie deep, some of them go directly to the NAC, rising from the depths, but there is a.thoracica superficialis, which in some cases (14%) passes in the Subcutaneous fat directly to the NAC [6,9,10]. Considering the described variations in the relationship of arteries in the lateral zone, it is impossible to accurately predict the angioarchitectonics of the lateral zone of the breast without additional preoperative examination, however, these arteries always contribute to the blood supply to the NAC due to various anastomoses.

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