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

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Abstract

Introduction: This article presents a database review, which explain the blood supply to the nipple-areola complex (NAC).

Objectives: Clarify the blood supply to the NAC.

Materials and Methods: The sampling method that has been chosen for search in scientific database and textbooks, includes the next three criteria: the descriptions of the NAC’s blood supply variety, the description of the blood sources and anatomic substantiation.

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 the 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. Inter-costales perforators. They support the medial and lateral vascular systems by anastomosing with them on some levels. this system is the main NAC’s blood supply system. The lateral system consist of vessels which variably originate from a.thoracica lateralis, a.axillaris and a.thoracoacromialis. In 14% cases there is only one superficial a.thoracica superficialis in this zone, which goes to the NAC through the subdermal fatty layer. Some of another deep vessels go directly from deep to the NAC.

Conclusion: During extensive resections the medial vascular system can be used for NAC preservation. Shouldn’t be used only the central vascular system, because then the NAC’s necrosis risk is increased. This system can be used only as secondary option. The lateral system can be used for NAC preservation only if the blood supply is confirmed. The medial vascular system underlies the thin superomedial NAC pedicle, but its’ safety requires additional analysis.

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

Introduction

Performing complex mammary gland’s (MG) surgeries requires deep knowledge of anatomy. One of the most 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 angio-architecture of MG and NAC, this problem slowly but surely will be solved with new published articles to come.
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Aim of the Study

The aim of our work was to clarify the angio-architecture of the nipple-areolar complex, to improve oncological, reconstructive and aesthetic breast surgery, minimize the probability of compromising blood supply to the NAC. This is especially true in oncology, where the frequency of the 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 extra search in scientific databases using Google Scholar without a time limit. The interconnections of the blood vessels were identified and described by layer.

Results

The 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, specially to NAC. These arteries supply the anterior chest wall with abundant anastomosis that interconnects each other [13,16, p. 947,19]. According to the anastomosing of a.thoracica lateralis and a.thoracica interna anastomosis, 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 branches 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 NAC’s vessels 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 NAC’s dominant blood supply was analyzed on live models 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 blood supply sources into three zones: medial superficial, central deep and lateral intermedial.

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

The lateral zone includes 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, lateral and medial. The zone of interest includes the lateral branches, which, in turn, are divided into three levels:

- The first and deepest level contains aa.intercostales interiors, 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. a. and v. thoracica interna. 2. a. thoracoacromialis. 3. aa. intercostales. 4. aa. intercostales anteriores perforators, they anastomose with a. thoracoacromialis branches through breast parenchyma and muscle fixation zones. 5. a. thoracica superficialis 6. a. thoracica lateralis.

The article provides information that at least one large perforator from a thoracica interna is always found in the first four intercostal spaces. An analysis of the dominant blood supply to the breast showed that the breast is supplied by the a. thoracica interna in 68% of the cases, by a. thoracica lateralis in 20% of the cases and by double blood supply in 12% of the cases [12]. The branches of the artery pass to the NAC through the subcutaneous fat and reach the NAC on the upper medial border with an average occurrence depth of 1.5 ± 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 mm ± 2.5 mm. 3 cm more medially at an average depth of 14.2 mm ± 4.6 mm [7]. a. thoracica suprema is also described, originating from a. axillaris, sometimes from a. thoracoacromialis or a. thoracica interna. It supplies blood to the NAC in 57% due to its superficial 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 mm ± 1.4 mm. 3 cm from the NAC at a depth of 3 mm ± 0.8 mm. Medial veins are located more superficial than lateral, that pass deep in the glandular tissue [7,8].

Central zone

In the literature the thoracoacromial artery 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 2th-4th intercostal spaces from the sternal side and a.thoracica lateralis branches also appearing at the level of 2th-4th intercostal spaces from the lateral side. Vascular layers covers the caudal and cranial sides of the septum and go to the NAC. The cranial vascular layer includes branches of a.thoracoacromialis originating at level of the 4th intercostal space and branches of a.thoracica lateralis. The caudal layer contains anastomoses of the 4th and 5th intercostal perforators[20]. Mon O’Dey D., et al. describe that blood supply to the breast through the aa. intercostales anteriores branches 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 perforators, is important to know, that 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).

**Figure 2:** 1. Branches of v. thoracica interna. 2. Branches of a. thoracica interna. 3. Zones of vessel density in NAC: maximum density marked green, minimum density marked red. 4. Anastomoses between branches a. thoracica interna, a.thoracoacromialis and a.thoracica lateralis. 5. Branches of a.thoracica superficialis.
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Lateral zone

The anatomy of the 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 the a.thoracoacromialis, in 17.02% from the a.axillaris, from a.thoracodorsalis in 5% of cases, from a.subscapularis in 3.93%, multiple arteries were found in 3.09% and a 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 through the subcutaneous fat, reaching the NAC in 14% of cases [10]. There can be a branch of a.thoracica lateralis in 42% of cases, a branch of a.thoracoacromialis in 30% of cases and a.axillaris in 19% of cases [6]. To the lateral direction the 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 aa. Intercostales perforators anastomoses on the 4th and 5th intercostal space [20]. An interesting coincidence is found in mon O'Dey D., et al. where aa. intercostales anteriores are predominantly concentrated at the level of the 4th and 5th intercostal space [10]. Palmer JH and Taylor GI described that aa. intercostales in the 5th and 6th 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 4th - 6th 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 a.thoracica 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, the vascular layers and lateral fibrous cords. On the medial and lateral side, this corresponds to the level of the 2nd and 4th intercostal spaces, the central zone and the 4th - 6th 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 the NAC for clinical use can be divided into 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 vthoracica interna system [7,10]. The central deep vascular system is represented by branches a. thoracoacromialis and aa. intercostales perforators. 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, but 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.

Bibliography

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Volume 10 Issue 5 May 2021
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