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The Use of Computerized Tomography Angiography in the Detection of the Dominant Blood Supply for Facilitation of Breast Reduction Pedicle Selection

NOURA YOUSEF ZAKHARY, M.B.B.Ch.; EL SAYED MANDOUR, M.D. and TAREK GAMAL SHOUKR, M.D.

The Department of Plastic and Reconstructive Surgery, Faculty of Medicine, Tanta University

ABSTRACT

Background: It is not easy to define normal breast size. An accurate determination of breast size is useful in many areas of breast surgery.

Objective: The goals of this research are to use CT Angiography to examine the vascular supply to the nipple-areola complex (NAC) and to determine whether changing surgical planning based on preoperative CTA could decrease the frequency of NAC necrosis after breast reductions in cases that are thought to be at a high risk of nipple loss.

Patients and Methods: This single-arm interventional study was performed on 30 patients complaining of breast hypertrophy that were admitted to the Plastic and Reconstructive Surgery Department in Tanta University Hospitals. A single radiologist analyzed all of the patients' CT thoraces to identify artery sources, the intercostal space that was penetrated, the glandular/subcutaneous course, and the vascular entrance site into the NAC of each breast. By using the CTA, we knew the dominant blood supply of the breast and the point of its entry to the NAC by using a clock pattern. According to them, we chose the pedicle at the known time, number and position determined by CTA. Marking of the selected pedicle depending on the dominant blood supply of the breast and the NAC according to the results of the CTA.

Results: NAC necrosis and lost NAC sensation didn't occur in any patient. Bilateral decreased NAC sensation occurred in 6 (20%) patients.As regards aesthetic outcome, pseudo ptosis occurred in 3 (10%) patients, and asymmetry occurred in 2 (6.66%) patients only. As regards scar complications, hypertrophy and pigmentation didn't occur in any patients; widening occurred in 2 (6.66%) patients, and dog ear deformity occurred in 3 (10%) patients.

Conclusions: CTA identifies the dominant arterial supply and provides useful details that enable wise preoperative planning for breast pedicles. Although it is not indicated in the majority of cases, our technique would be of benefit in patients with gigantomastia and in cases of secondary reductions if the prior pedicle design was uncertain.

Key Words: *Nipple areola complex – Suprasternal notch to the nipple – Computerized tomographic angiography.*

Correspondence to: Dr. Tarek Shoukr,
E-Mail: tarekshoukr@yahoo.com

Ethical Committee: The Ethical Committee of Tanta University's Faculty of Medicine gave its authorization before the investigation was carried out. All patients provided written permission after being fully informed.

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INTRODUCTION

Breast hypertrophy is a widespread disorder characterized by abnormal breast growth that may last until each breast weighs more than 1.5 kilograms (macromastia) or even 2 kilograms (gigantomastia). In addition, hypertrophy means the presence of disproportionate large breasts in relation to body size **[1]**.

Although complications are prevalent and necrosis of the NAC is the most significant, women with large-volume breasts found that their quality of life was enhanced physically and psychosocially after breast reduction surgery. Postoperative nipple necrosis is more likely to happen after a hypertrophic breast reduction, a long distance from the suprasternal notch to the nipple (SSN-N), or a revisionary breast reduction **[2-4]**.

Breast-reduction mammoplasty aims to move the NAC to the appropriate place on a well-vascularized pedicle using a safe approach that avoids full amputation and subsequent grafting **[5]**.

In order to preserve blood flow to the NAC after breast reduction surgery, a pedicle is often combined with skin and parenchymal resection. The nipple should be able to move to its new, higher location with enough flexibility owing to this pedicle **[6]**. Understanding the breast's blood flow is essential for designing an effective pedicle. It could seem that the best choice would be a full-thickness dermoglandular pedicle **[7]**.

In order to reduce nipple necrosis and the need for free nipple grafts, it would be useful to do a detailed preoperative perforator mapping. This would help with the choice of perforators and flap design **[8]**. The vascular supply of perforator flaps may be found using a variety of techniques, such as a physical examination, portable Doppler, scanning laser Doppler, 2-dimensional color flow Doppler imaging, thermography, CTA, and MRI **[9,10]**. Doppler US and colored Duplex US have been the most commonly used of all these techniques. The journey for a better imaging modality is still ongoing, with a new interest in using CTA. This is because there are discrepancies between the surgical and Doppler US findings, as well as the less-than-ideal presentation of US data to the surgeon **[11,12]**.

Numerous studies have shown that CTA is a valid way to determine the dominating perforator's location, course, and caliber **[9]**. Improvements in preoperative decision-making and mapping prevent wasting crucial time throughout surgery. As a result, this quicker and safer surgery method significantly reduces the surgeon's stress **[13]**.

We explored the utility of CTA in identifying the predominant blood supply for pedicle choice during breast reduction surgery. Additionally, we looked at whether preoperative CTA may alter the surgical design in instances where nipple loss was thought to be a significant risk, reducing the occurrence of NAC necrosis following breast reductions.

PATIENTS AND METHODS

This single-arm interventional study was performed on 30 female patients with variable age groups and variable marital and maternal status complaining of breast hypertrophy and admitted to the Plastic and Reconstructive Surgery Department in Tanta University Hospitals from November 2018 to November 2020. The Ethics Committee of Tanta University's Faculty of Medicine gave its authorization before the investigation was carried out. All patients provided written permission after being fully informed.

Exclusion criteria were previous breast surgery, patients with unrealistic expectations, uncontrolled chronic medical co-morbidities (such as COPD, DM, and bleeding tendency), any emotionally unstable patient and clinically or radiologically detected breast lumps.

All patients were subjected to the following:

Preoperative work up:

Full history taking, general examination, local breast examination, routine laboratory workup andradiological investigations which include chest X-ray, and ECG for patients more than 45 years of age and those with a history of cardiac or chest-diseases.

The study followed a consistent protocol by using CT thoraces, which were all conducted at one center and evaluated by a single radiologist, to determine the sources of arteries. By using the CTA, we knew the dominant blood supply of the breast and the point of its entry to the NAC by using a clock pattern. According to them, we chose the pedicle at the known time, number and position determined by CTA. For example, 12 o'clock means directly ahead and thus we use superior or superiomedial pedicle, 3 o'clock means directly to the right and thus we use medial or superiomedial pedicle.

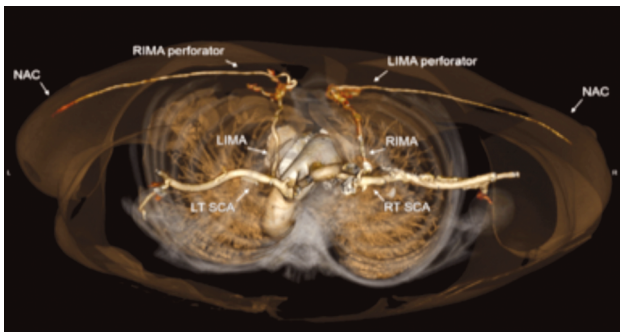

Fig. (1): Axial section of CTA of both breasts of one of our cases.

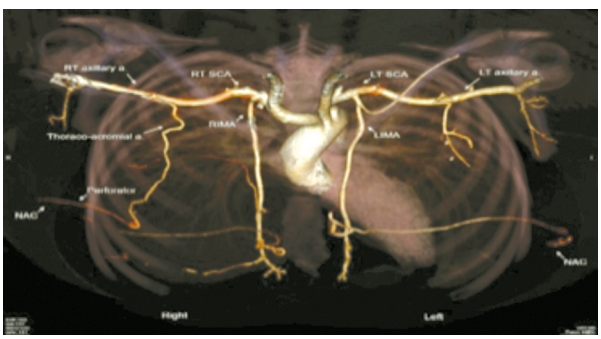

Fig. (2): Coronal section of CTA of both breasts of one of our cases.

Preoperative markings:

The surgeon reviewed preoperative photographs along with representative before and after photos to ensure that the patient had realistic expectations and understood the potential scarring. The patient was marked while they were standing erect, (Fig. 3). The surgeon marked the selected pedicle based on the dominant blood supply of the breast and NAC, as determined by the results of the computed tomography angiography (CTA), and marked the point of entry of the dominant blood vessel to the NAC based on the CTA results. The surgeon then marked the lower incision of the skin brassiere flap on the breast mound, with its central point located 6-8cm below the lower border of the new position of the NAC. To avoid a boxy appearance, smooth curves were drawn from this point medially and laterally to reach the medial and lateral IMF incision marks, respectively. The level of the IMF was determined to be the new areola's highest point. Taking breast size into consideration, the surgeon additionally drew a vertical line by shifting the breast superiolaterally and superiomedially, designating lines that would fall in line with the breast meridian and measure 6-8cm in length, and then joining the vertical lines to each other 3-5cm above the IMF. CTA was done in department of radiology in our university with a low price (400-600 Egyptian pounds).

Operative steps:

De-epithelialization of the pedicle was carried out while the patient was anesthetized (Fig. 4). Skin flaps were elevated, terminating their dissection at the superior 2nd intercostal space with a thickness of 1-2cm.

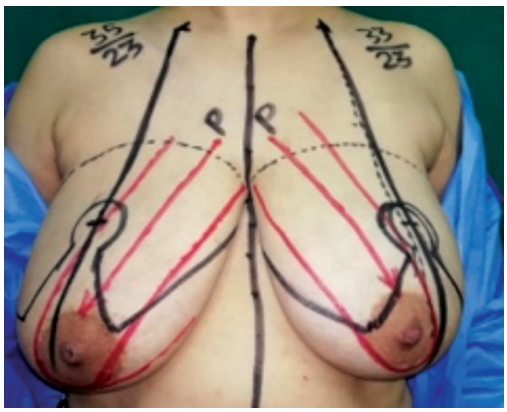

Fig. (3): Anterior chest wall of female breast and Preoperative marking showing the selected pedicle (superiomedial pedicle) and the dominant perforator IMA entering the NAC depending on the CTA results.

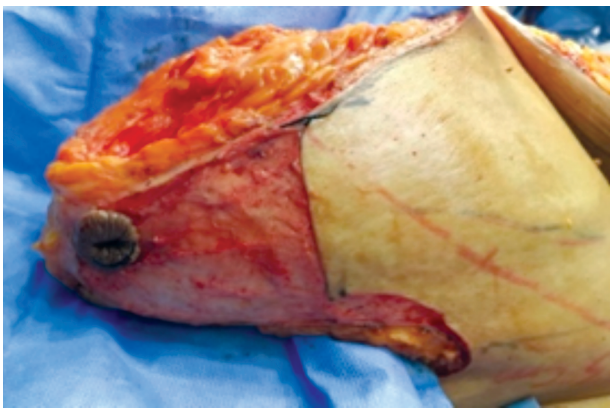

Fig. (4): Breast after subcutaneous dissection of superiomedial pedicle.

In order to prevent harm to the perforator, dissection of the skin flap was halted 1cm laterally to the perforator's location. 1cm medial to the location of the CTA discovered perforator; the dissection of the lateral skin flap is halted.

Recording of operative data for each patient was done including: Type of operation, operative time, condition of NAC immediately postoperative, weight of excised tissues in grams and distance of NAC elevation.

Post-operative care:

Each patient's discharge report was completed before release, including: Date of discharge, hospital stay, subjective assessment of sensation in NAC and breast skin,complications as NAC necrosis (partial or complete), wound sepsis, wound disruption, hematoma and fat necrosis. After their hospital release, participants were arranged for follow-up appointments after one week, one month, three months, and six months or longer. The operative surgeon evaluated and noted the healing process, breast form (bottoming), and subjective NAC feeling during these appointments. In addition to a clinical photography session, a fresh set of anthropometric measurements (as in preoperative evaluation), the follow-up duration, and any problems were recorded. The patients were asked to score their level of satisfaction with the following aspects on a scale of 1 (poor), 2 (good), and 3 (excellent): Shape, size, scar appearance, symmetry, nipple position, and general satisfaction degree.

Statistical analysis:

Data were analyzed using SPSS v25 (IBM Inc., Chicago, IL, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

RESULTS

Preoperative data:

The demographic data of the studied cases (age, weight, height, body mass index, marital status, and parity) were tabulated. Preoperative patients' complaints were neck pain in 16 (53.33%) patients, back pain in 20 (66.67%) patients, breast pain in10 (33.33%) patients, bra strap discomfort in 30 (100%) patients, difficulty in daily work in 17 (56.67%) patients, difficulty finding fitting clothes in 23 (76.67%) patients, difficulty in sleeping in 20 (66.67%) patients, and embarrassing comments in 25 (83.33%) patients. The most important affected life aspect was the physical life in 20 (66.67%) patients, social life in 6 (20%) patients, and sexual life in 4 (13.33%) patients.

Regarding preoperative breast examination, the right SSN-N distance of the studied patients ranged from 26 to 44 cm with a mean value (± SD) of 36.57 (±6.2) cm. The left SSN-N distance of the studied patients ranged from 27 to 45cm with a mean value (± SD) of 37.83 (±6.2) cm. Six (20%) patients had nipple retraction, 3 (10%) patients had visible asymmetry, and 2 (6.67%) patients had inframammary intertrigo, Table (1).

CTA dominant vessel and the pedicle used of the studied patients are shown in Table (2).

Operative data:

The operative time of the studied patients ranged from 145 to 191min with a mean value (± SD) of 168.1 (±14.53) min. The tissue excised of the studied patients ranged from 530 to 740gm with a mean value (± SD) of 646.8 (±57.86) gm on the right side. The tissue excised of the studied patients ranged from 530 to 755 gm with a mean value (± SD) of 645.6 (±63.69) gm on the left side. The nipple elevation of the studied patients ranged from 7 to 22cm with a mean value (± SD) of 14.53 (±4.59) cm on the right side. The nipple elevation of the studied patients ranged from 7 to 22cm with a mean value (± SD) of 14.2 (±4.65) cm on the left side. NAC viability immediately postoperative was good for all cases. Table (3).

Table (1): The demographic data and measurements of the studied patients.

Number of patients	30
Age (years)	34.4±8.14
Weight (kg)	88.3±8.8
Height (cm)	162.3±4.18
BMI (kg/m^2)	33.5±3.86
Marital status:	
Married	11 (36.67%)
Single	9 (30%)
Divorced	10 (33.33%)
Parity	1.8±0.92
Preoperative complaints:	
Neck pain	16 (53.33%)
Back pain	20 (66.67%)
Breast pain	10 (33.33%)
Bra strap discomfort	30 (100%)
Difficulty in daily work	17 (56.67%)
Difficulty finding fitting clothes	23 (76.67%)
Difficulty in sleeping	20 (66.67%)
Embarrassing comments	25 (83.33%)
Affected aspects of life:	
Physical life	20 (66.67%)
Social life	6 (20%)
Sexual life	4 (13.33%)
Preoperative breast examination	
Preoperative breast anthropometric data	
Right SSN-N distance (cm)	36.6±6.2
Left SSN-N distance (cm)	37.8±6.2
Nipple retraction	6 (20%)
Visible asymmetry	3 (10%)
Inframammary intertrigo	2 (6.67%)

Data were presented as mean ± SD or frequency (%).
BMI: Body mass index.
SSN-N: Suprasternal notch to nipple.

Table (2): CTA dominant vessel and the pedicle used of the studied patients.

	Number (%)
Right CTA dominant vessel:	
LTA	5 (16.67%)
RIMA, thoracoacromial	5 (16.67%)
RIMA, LTA	6 (20%)
RIMA	14 (46.67%)
Left CTA dominant vessel:	
No dominant supply	5 (16.67%)
LIMA	17 (56.67%)
LIMA, 4th AIA	8 (26.67%)
Pedicle used:	
Inferior pedicle	3 (10%)
Superior pedicle	7 (23.33%)
Superio-medial pedicle	18 (60%)
Lateral pedicle on the right side and superio-medial pedicle on the left side	2 (6.67%)

*LTA: Lateral thoracic artery.
*RIMA: Rt internal mammary artery.
*LIMA: Lt internal mammary artery.
*AIA: Anterior intercostal artery.

Table (3): The operative data of the studied patients.

	The mean
Operative time (min)	168.1±14.53
Right tissue excised (gm)	646.8±57.86
Left tissue excised (gm)	645.6±63.69
Right nipple elevation (cm)	14.5±4.59
Left nipple elevation (cm)	14.2±4.65

According to CTA results, in our study described that, IMA perforators (i.e. superior/superomedially based breast pedicles) are the most dominant and reproducible supply in 25 patients (83.3%). These should have vascular advantages over LTA sources in 5 patients (16.67%), AIA sources were found in 8 patients (26.67%), and thoracoacromial artery in 5 patients (16.67%). We also noticed a difference in blood flow between the patient's right and left breasts.

Postoperative data:

NAC necrosis and lost NAC sensation didn't occur in any patient. Bilateral decreased NAC sensation was 6 (20%) patients. As regards symptoms, breast, back, and neck pains, submammary intertrigo, difficulty in daily work, and difficulty in sleeping were all relieved in all patients. Bra strap discomfort was relieved in 23 (76.67%) patients, difficulty in finding fitting clothes was relieved in 26 (86.67%) patients, difficulty in sleeping was relieved in 21 (70%) patients, and embarrassing comments in 25 (83.33%) patients. As regards esthetic outcome, pseudoptosis occurred in 3 (10%) patients, and asymmetry occurred in 2 (6.66%) patients. As regards scar complications, hypertrophy and pigmentation did not occur in any patients; widening occurred in 2 (6.66%) patients, and dog ear deformity occurred in 3 (10%) patients.

We showed that CTA is a new investigation which may be useful as a preoperative tool to avoid NAC necrosis.

An example of a case: 47 years old patient with SSN-N distance of 29cm on the right side and 28cm on the left side and a resection weight of 610gm on the right side and 600gm on the left side. The pedicle used was a bilateral superiomedial pedicle. (Figs. 5,6).

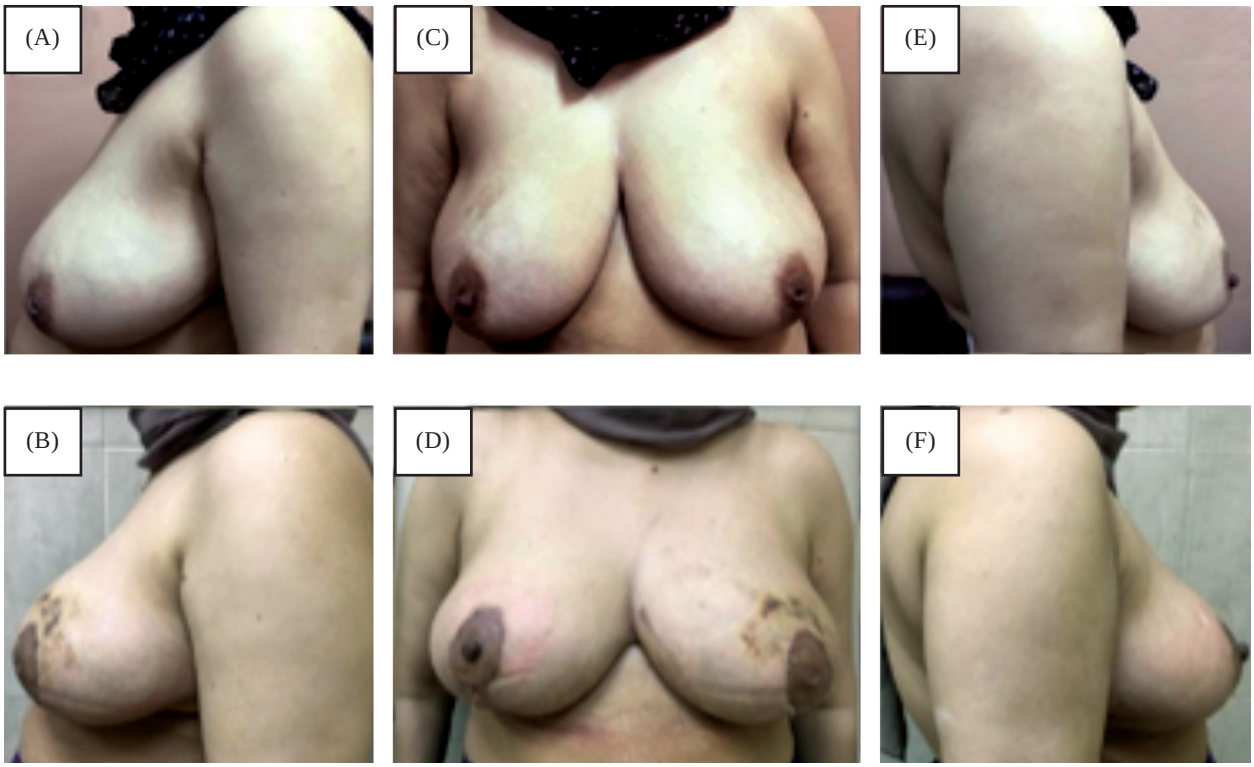

Fig. (5): (A, B): Lateral views of Lt breast pre and postoperative respectively (C, D): Anterior views of both breasts pre and postoperative (E, F): Lateral views of Rt breast pre and postoperative).

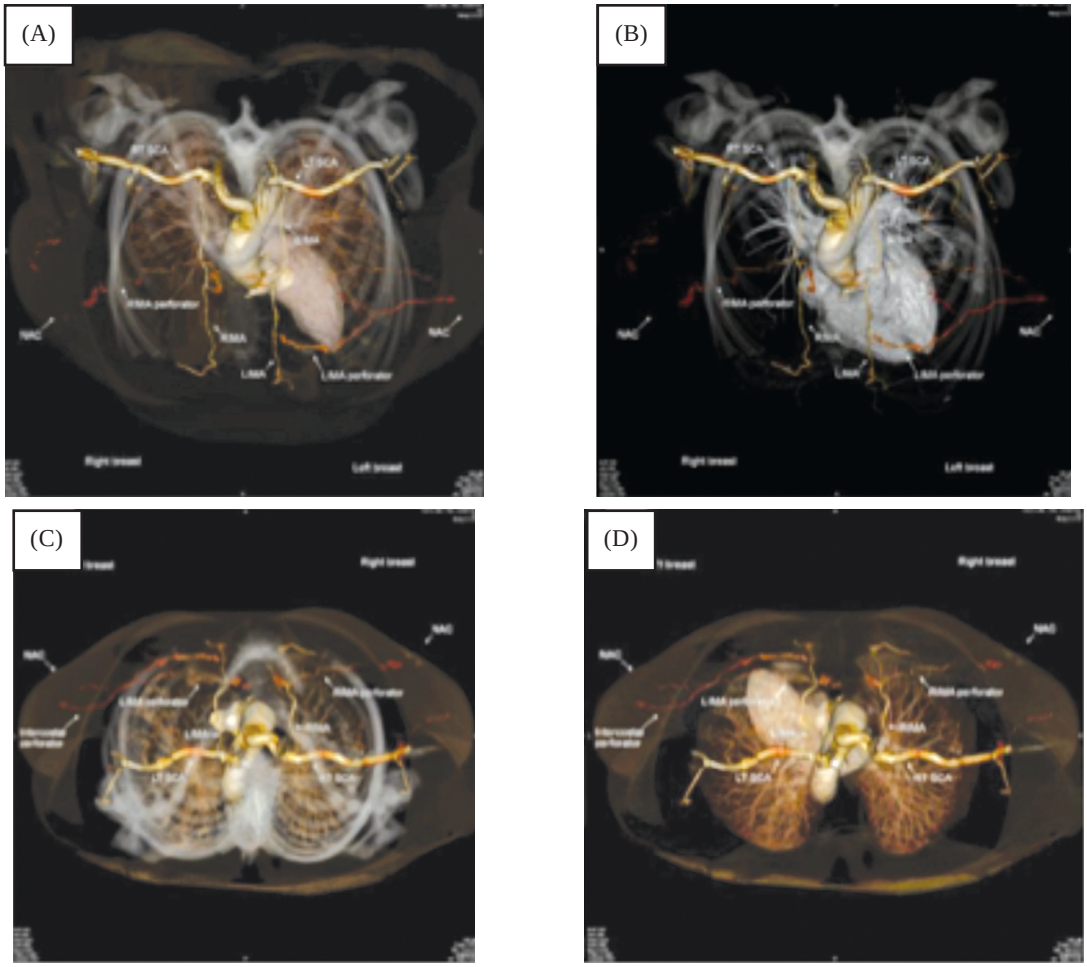

Fig. (6): Preoperative CTA (A, B: Coronal sections, C, D: Axial sections) showing that the dominant blood supply is the first RIMA perforator on the RT side(diameter = 2.2 mm), which enters the NAC at 1 O'clock position. On the Lt Side, the first LIMA perforator (diameter = 2.0mm) enters the NAC at 12 O'clock position, and the fourth anterior intercostal perforator (diameter = 1.8 mm) enters the NAC at its posterior aspect.

DISCUSSION

Breast reduction procedures have multiplied in recent decades. Nevertheless, there is no specific reduction mammoplasty approach that is appropriate in every scenario; each technique has benefits and drawbacks **[14]**.

In order to reduce nipple loss, previously acknowledged "safer" and more well-known treatments, such as the free nipple and inferior pedicle grafting in extremely big reductions, have already gained widespread acceptance **[15]**. The nipple can be protected by vertical scar patterns and/or superomedial pedicle procedures for moderate to large reductions, according to some early studies. Nipple loss has been observed in situations of both mastopexy and subsequent surgeries involving frail, poorly vascularized tissues **[16]**.

In our study, the mean NAC elevation was 14.53 (±4.59) cm on the right side and 14.2 (±4.65) cm on the left side ranging from 7 to 22cm. We reached these results using our technique that made us confident regarding the site of the dominant blood supply to the pedicle. Georgiade et al. **[17]** reported safe NAC elevation up to 18cm in the inferior pedicle inverted T reduction mammoplasty.

Regarding postoperative improvement, the same observations were reported by Saariniemi et al. **[18]**. They reported improvement in physical, social, and sexual life in 95.8%, 57.4%, and 70.2% of cases, respectively. Also, Collins et al., **[19]** found that 90% of cases reported problems in physical and social life preoperative, in contrast to only 5% who reported similar problems after breast reduction.

In our study, we found postoperative dog ear deformity in 10% of patients, which were treated by reconstruction under local anesthesia. Pseudoptosis occurred in 10% of patients. Kuzbari and

Schlenz **[20]** reported a lower incidence of pseudoptosis by the no vertical scar than by inverted T technique after reduction mammoplasty.

Our study described that IMA perforators (i.e., superior/superomedially based breast pedicles) are the most dominant and reproducible supply in 25 patients (83.3%). These should have vascular advantages over LTA sources in 5 patients (16.67%), AIA sources were found in 8 patients (26.67%), and thoracoacromial artery in 5 patients (16.67%). We also noticed a difference in blood flow between the patient's right and left breasts. In addition, the direction of blood flow to the right and left breasts varied in each case. In anatomical studies, Chiari revealed an asymmetric pattern of blood flow to the breast, with discrepancies between both the left and right sides of the same cadaver as a partial or complete absence of branches to the NAC from the main sources. He came to the conclusion that a surgeon cannot forecast the vascular flow of the breast they would be operating on **[21]**. According to the findings of a study conducted by O'Dey et al. **[22]** on 14 cadaveric breasts, microdissections of the anterior chest walls were performed after vessel filling with dye. The researchers discovered that the LTA provided the most repeatable supply (100%), followed by the IMA (86%) and the AIA (71%). The IMA, however, was more reproducible (100%) than LTA sources (70%), according to Van Deventer's research of 27 cadaveric breasts **[23]**. According to Giovanoli et al., the residual branches of the IMA or LTA make up the majority of the blood supply to the NAC in cases when one or more of the branches are absent **[24]**. This heterogeneity in blood flow was eliminated as a result of our research, which also aided the identification of the dominant breast pedicle.

In our study, we used the bilateral superomedial pedicle technique in 18 patients (60%) depending not only on the dominant supply reported by CTA but also on the entry point of that artery to the NAC, the bilateral superior pedicle in 7 (23.33%) patients because it was safer than the superomedial pedicle. In these cases, the IMA was dominant in both breasts, but the point of entry to NAC was superior to the medial (12 o'clock and 11 o'clock in the right and left breast, respectively), and bilateral inferior pedicle in 3 (10%) patients because the left breasts had no dominant blood supply but was supplied by small branches from the three main arteries, and the right breasts NAC was supplied by a sizeable branch of LTA that runs along the outer quadrants, mainly the lower and enter NAC at 7 O'clock position. It was safer to use the inferior pedicle technique in these cases. In 2 (6.67%) interesting cases, we used the lateral pedicle technique in the right breasts, as the right LTA was the dominant supplier, and we used the superomedial pedicle in the left breasts, as LIMA was the dominant artery.

By preoperatively identifying the path of the arteries feeding the NAC and including them in their pedicles, several surgeons attempted to reduce the occurrence of NAC necrosis. Basaran et al., made the first attempt to develop an image-guided pedicle in an effort to lower the events of nipple areola necrosis **[25]**. In patients with severe gigantomastia, they described a procedure for a US-determined breast pedicle. In order to determine the primary artery supply, a highly sensitive Doppler US was employed.

In 22 patients of reduction mammoplasty, Nahai **[26]** discussed the application of preoperative Doppler US to find perforators. In 16 patients of macromastia who underwent reduction mammoplasty, Thomas et al. **[27]** described the use of specially created pedicles that were based on predefined vessels by Doppler US. Nevertheless, US imaging has a number of drawbacks, such as operator dependency, unreliable real-time imaging, and diminishing resolution with tissue depth (i.e., the resolution is more challenging with deeper, smaller arteries). Because CTA has better resolution for the vasculature than both MRI and US modalities **[28,29]**, we employed it in our study. Therefore, no partial nor complete NAC necrosis occurred in any of our study cases. The method outlined in this paper relies on preoperative CTA identification of the perforators and their course, followed by customization of the preoperative markings and operational dissection pattern to incorporate them into the intended pedicle.

We believe that for higher-risk individuals, CTA is a trustworthy substitute for a "cross your fingers" strategy. The goals of surgical planning were to minimize risk and improve patient outcomes. Understanding vascular architecture is necessary to be able to lessen the chance of the NAC becoming necrotic **[14]**. This is particularly true if the breast has a large volume and is ptotic since this will cause the pedicle to be extremely lengthy and the blood to have to flow a great distance before reaching the NAC.

With the popularity of bariatric surgeries, the number of patients needing breast reductions after significant weight loss is rising **[30,31]**. These individuals are at a greater risk of having nipple

necrosis and probable nipple loss since many of them have a significant SSN-N distance **[4,6]**.

The vascular architecture is altered and unreliable in patients who have a revisionary breast reduction or breast reduction after breast cancer therapy. Patients are increasingly traveling abroad for surgery due to the growing internationalization of surgery, and it is not always possible to acquire the initial surgical technique's documentation. The use of a preoperative CTA, however, enables the surgeon to proceed with certainty regarding pedicle design and may lessen the danger of necrosis of the NAC while also reducing the necessity for free nipple grafting if there is inadequate intraoperative blood to the NAC.

The CTA used in the research had a dose of 3-6mSv of individual ionizing radiation exposure. This is equal to or lower than the yearly background radiation exposure average **[32]**. As a result, we believe that the potential benefits of preventing nipple necrosis in higher-risk breast reductions exceed the risks associated with the modest exposure to radiation that is experienced during the CTA.

It is essential to be aware that the predominant blood supply to the NAC is not necessarily symmetrical in every case. Two of our patients had a dominating blood supply that was fully asymmetrical to the NAC. After then, the topic of the asymmetrical method was brought up for discussion. We used an asymmetrical approach in two cases, the right lateral and left superomedial pedicle technique. In these cases, the LTA was dominant in the right breast and IMA dominant in the left breast.

The absence of major complications or necrosis of the NAC may suggest that it is preferable to design surgery and the kind of pedicle employing preoperative CTA depending on the dominant artery to the NAC. However, the study's low frequency of complications may have arisen by chance due to the limited number of patients.

Conclusions:

In conclusion, our study found that CTA effectively identifies the dominant arterial supply in the breast, providing crucial information for the preoperative planning of breast pedicles. Despite not being necessary for the majority of instances, the procedure may be particularly useful in gigantomastia and secondary reduction situations when the prior pedicle design is uncertain. Our findings suggest that CTA should be considered a valuable tool in the presurgical planning of breast pedicles.

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