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Multislice CT angiography as a roadmap for pedicle selection prior to breast reduction surgery

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Abstract

Background: Accurate knowledge of breast arterial supply on individual basis is crucial prior to breast reduction surgery to minimize the risk of post-operative necrosis of nipple-areola complex which is a well reported complication. The purpose of this cross-sectional study was to test the ability of multislice CT angiography to delineate the dominant arterial supply of nipple-areola complex to facilitate accurate breast pedicle selection to improve patient outcome.

Results: Twelve patients underwent multislice CTA of both breasts to delineate dominant arterial supply to NAC, internal mammary artery was the dominant arterial supply in most of breasts (87.5%) based on CTA findings and hence superomedial pedicle was the commonest pedicel chosen. None of patients experienced NAC necrosis post-operatively while minority of patients (16.6%) exhibited decreased NAC sensation bilaterally.

Conclusions: Multislice CT angiography is a useful pre-operative tool to minimize the risk of post-operative necrosis of nipple-areola complex in patients undergoing breast reduction surgery.

Keywords: Breast reduction, Nipple-areola complex, Multislice CT angiography

Background

Breast hypertrophy is a common condition among women of different ages which causes many physical problems like back pain, costochondritis, inframammary fungal infections and psychosocial stress. Breast reduction surgery aims to reduce breast volumes to alleviate patients' sufferings and to preserve esthetic and function of such organ as well [1].

One of the undesirable complications of such surgery is the necrosis of nipple-areola complex (NAC) due to interruption of its arterial supply during dissection and wrong pedicle selection. Different surgical techniques were described and further improved in order to minimize such complication, but they still necessitate long dissection time during surgery and some of them interrupt breast ductal system which does not suit young women [2].

In order to avoid necrosis of NAC, accurate pre-operative mapping of the dominant arterial supply to NAC is meaningful for optimal selection of vascular pedicle including NAC which is preserved during surgery, with safe removal of other breast tissue to obtain the desired size and volume ensuring uninterrupted arterial supply to NAC [3].

Different techniques were described for pre-operative mapping of breast arterial supply including physical examination, handheld Doppler sonography and color Doppler ultrasonography, the latter two methods were commonly used but they are operator dependent, time consuming, gives inconsistent results compared to operative findings and lack producible anatomical images to surgeons. All these issues necessitates the search for

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alternative imaging technique to improve patient outcome [4].

Multislice CT angiography has been widely used to image different body arteries including aorta, cerebral, carotid, renal and peripheral arteries with accurate results compared to conventional angiography. The use of visually appealing 3D reconstructions has gained surgeon interest due to its resemblance to gross anatomical images [5].

To the best of our knowledge, only few studies were published regarding the use of multislice CT angiography to delineate dominant arterial supply of NAC prior to breast reduction surgery. Our study aimed firstly to delineate the dominant arterial supply to NAC for each patient using pre-operative CT angiography and secondly to know if the routine use of such technique would prevent necrosis of NAC and so improve patient outcome and satisfaction.

Methods

Study population

This study was conducted prospectively on 12 patients complaining of breast hypertrophy and planning to do breast reduction surgery at plastic surgery department of our institution. They were referred for pre-operative delineation of the dominant arterial supply of NAC for each breast using multislice CT angiography. Written informed consent was obtained from all individuals participating in this study after explanation of the benefits and possible risks of the procedure. The study was approved by our local institutional ethical committee.

Multislice CT angiography

Pre-imaging preparation

We reviewed the result of recent renal function test for all patients to ensure the suitability for IV contrast injection. We also asked for pregnancy status and any previous allergies to IV contrast media necessitating premedication with prednisolone. All participants were asked to wear gown and to remove any metallic objects over chest area to avoid any undesirable streak artifacts over the area of interest. Those with extremely large breasts that extend outside CT imaging field of view were asked to wear soft bra to make breast tissue confined to the center of the gantry. 18 g IV cannula was inserted at right antecubital vein for all patients to ensure tight contrast bolus and to facilitate high injection flow rate. Instructions were given as regard warm sensation that will be encountered during IV contrast injection to alleviate anxiety. Breath hold instructions were also given to obtain motion-free images.

Scanning protocol

All CT angiographic studies were performed using 320-row multislice CT scanner (Aquilion One, Canon Medical Systems, Otawara, Japan) installed at our institution. After acquisition of antero-posterior and lateral scanogram to calculate optimal radiation dose on individual basis, planning of actual helical CT scan was done with scan range extending superiorly from just above clavicles down to inframammary fold to ensure imaging of breast arterial supply. Radiation dose was kept as low as reasonably achievable considering that breast tissue is a radiosensitive organ by reducing Kv setting to 100 and by the use of tube current modulation with variable mA according to body built of each patient which is calculated automatically by the scanner and finally by limiting scan range to the desired area of interest. Non-ionic IV contrast material Iopromide (Ultravist, 370 mgI/ml) was injected using dual-head automatic power injector (Stellant D, Medrad, USA) with a contrast volume of 60 ml followed by 50 ml saline chaser to ensure tight contrast bolus. Injection flow rate was set at 5 ml/sec for both contrast and saline chaser. Bolus tracking method was used to detect the arrival of contrast media at descending aorta opposite tracheal bifurcation level. The trigger threshold was set at high value (250 HU) to ensure proper filling of breast arteries till their peripheral ends but without venous contamination. Once the desired trigger threshold was reached breath hold command was played automatically and scan was started thereafter. Only one helical acquisition was done with scan time of around 3 s. The obtained dataset was reconstructed at 0.5 mm slice thickness with 0.3 mm interval with soft reconstruction kernel (FC08).

Image post processing and analysis

Reconstructed axial images were transferred to dedicated workstation (Vitrea 6.8, Vital Images, USA) for analysis of breast arterial supply. Bone removal was done automatically first with manual refining if necessary, then removal of the heart by manual cutting followed by tracing and segmentation of breast arteries on each side for each individual. The site of NAC was identified on 3D images by adjusting window setting to obtain skin surface image. The dominant arterial supply to NAC on each side was demonstrated, documented and results were conveyed to surgeon. Axial maximum intensity projection was created for each breast and was very informative to trace the dominant arterial supply to NAC from its origin till NAC. Semitransparent colored 3D volume-rendered images in both coronal and axial orientation were very helpful as well to demonstrate the arterial roadmap in a familiar

way to surgeons with the benefit of arterial course being demonstrated in relation to adjacent bony structures.

Results

The study included 12 female patients planning to do breast reduction surgery, their age ranged from 21 to 50 years with a mean of 35.3 ± 8.9 SD. Multislice CT angiography of both breasts was performed for all patients to delineate dominant arterial supply of NAC to aid in pedicle selection during surgery. A total number of 24 breasts was evaluated on 12 patients, Table 1 demonstrates detailed findings as regard the dominant arterial supply of NAC in each breast and corresponding pedicle selection based on CTA result. According to CTA results, internal mammary artery was the commonest dominant arterial supply to NAC being so in 87.5% of the studied breasts (Fig. 1) followed by lateral thoracic artery which was dominant in 16.6% of breasts. Anterior intercostal perforators and thoracoacromial artery were dominant in a minority of breasts (Table 2). Half of the studied patients demonstrated different dominant arterial supply to NAC in each breast (Fig. 2). Based on CTA findings, superomedial pedicle was the commonest pedicle chosen during surgery (79.2%), as the dominant arterial supply to NAC in most of cases was internal mammary artery either right or left. The remaining pedicles used are demonstrated in Table 3. Only one breast has no dominant arterial supply to NAC in which inferior pedicle was chosen.

Table 1 Dominant arterial supply to NAC based on CTA and pedicle used

Case No	Dominant arterial supply to NAC		Pedicle used
	Right	Left	
1	LTA	No dominant supply	Inferior pedicle
2	RIMA	LIMA	Superior pedicle
3	RIMA, LTA	LIMA	Superomedial pedicle
4	RIMA	LIMA	Superomedial pedicle
5	RIMA	LIMA	Superomedial pedicle
6	RMA, LTA	LIMA	Superomedial pedicle
7	RIMA	LIMA, 4th AIA	Superomedial pedicle
8	RIMA	LIMA	Superomedial pedicle
9	RIMA	LIMA	Superomedial pedicle
10	RIMA	LIMA	Superomedial pedicle
11	RIMA	LIMA	Superomedial pedicle
12	LTA	LIMA	Lateral pedicle on right, superomedial pedicle on left

LIMA Left internal mammary artery, *RIMA* Right internal mammary artery, *LTA* Lateral thoracic artery & *AIA* Anterior intercostal artery

Follow-up of cases during the early post-operative period revealed absence of NAC necrosis in all patients, none of the patients had lost NAC sensation. Only decreased NAC sensation was found in two cases (16.6%).

Discussion

Breast enlargement can adversely affect women physically and mentally. Over the last few decades, breast reduction surgery techniques became numerous to treat such condition. However, every reduction mammoplasty technique has its advantages and disadvantages with necrosis of NAC being the most undesirable complication due to poorly vascularized pedicle [6].

Traditionally recognized "safer" and more familiar techniques such as inferior pedicle and free nipple grafting in very large reductions, have already become well accepted methods to minimize nipple loss. However, NAC necrosis was still reported even with those techniques. Moreover, loss of NAC sensation is a well-established complication in those underwent free nipple grafting a technique that also interrupts breast ductal system as well [7, 8].

Different imaging modalities was therefore suggested by to delineate the dominant arterial supply to NAC before surgery to facilitate pedicle selection and minimize necrosis of NAC [9]. Such, imaging techniques included handheld doppler, duplex ultrasonography both of which are time consuming, operator dependent and does not provide clear angiographic roadmap to surgeons.

Being a well-established noninvasive vascular imaging modality, multislice CT has been widely used to image different body vasculature due to its wide availability, rapid acquisition times, different reconstruction techniques which resembles angiography images to which surgeons' eyes are familiar with [10]. Our study aimed to use such imaging modality to delineate dominant arterial supply to NAC to facilitate pedicle selection and hence aiming to improve patient's outcome.

In our study MIP images in axial plane was helpful to delineate the entire course of the dominant arterial supply from its origin to NAC within single thick-slab image (Fig. 3). However, certain patients specially the young ones who have dense glandular tissue may interfere with tracing of such arteries till NAC due to increased density of breast parenchyma (Fig. 4), an issue that could be problematic as well in patients with breast edema. Three-dimensional volume-rendered images in axial and coronal projections with semitransparent mode was helpful to delineate dominant arterial supply to NAC in relation to bony structures and to determine its entry point at NAC as well (Fig. 5).

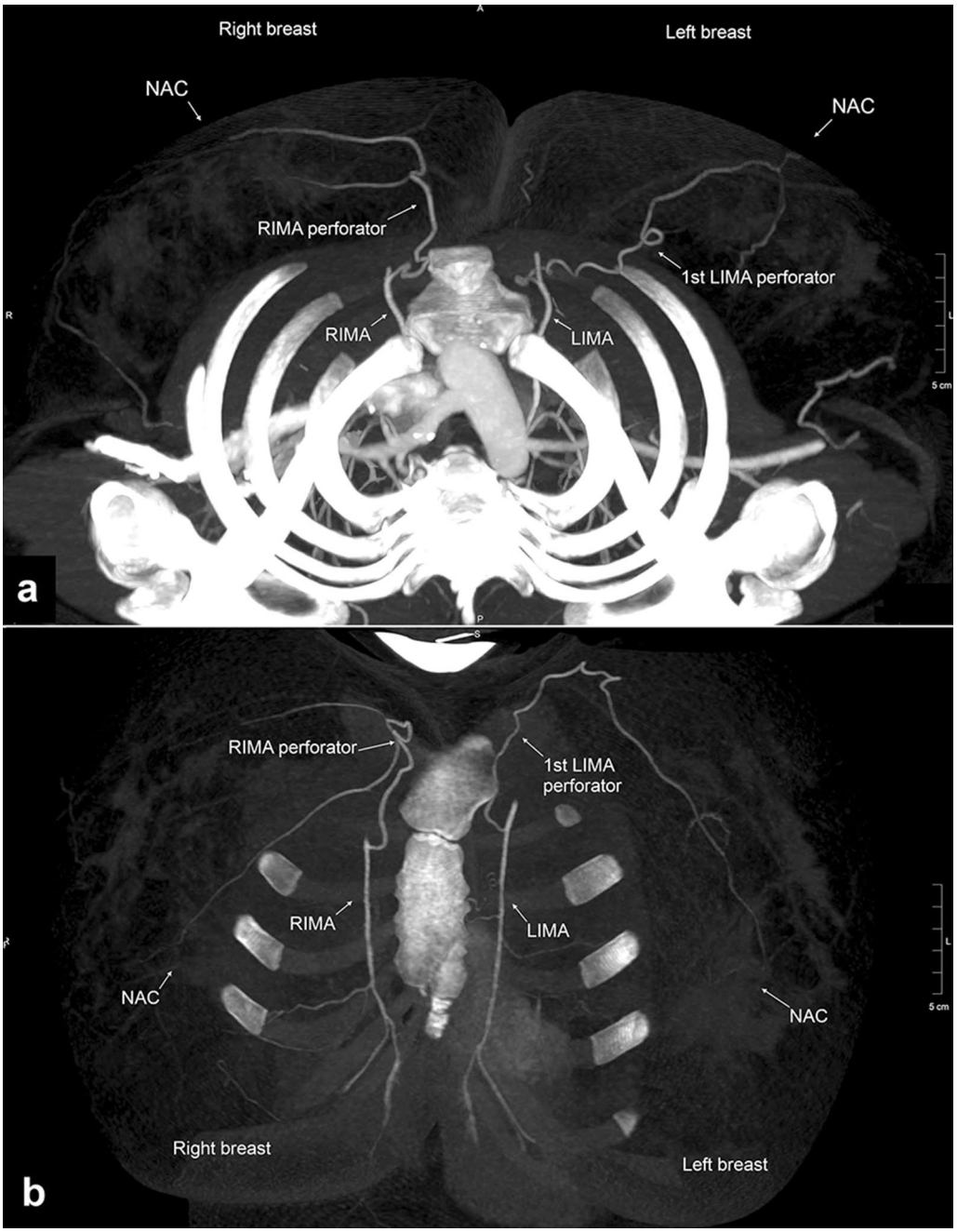

Fig. 1 Dominant internal mammary artery supply to NAC. Axial (**a**) and coronal (**b**) MIP images showing dominant right and left internal mammary arteries on both sides supplying sizeable perforator that reaches NAC on each side

Our study found that IMA perforators are the most dominant supply to NAC in 21 breasts (87.5%) followed by LTA dominance in 4 breasts (16.6%) with the remaining NAC being supplied dominantly by anterior intercostal arteries (4.1%) and thoracoacromial artery (4.1%). Such results are matching with Stirling et al. [11] results who found the same dominant arterial supply in their study. We also found difference in dominant arterial supply between right and left breast of the same individual in 6 (50%) of our cases. There was variability in the course of arterial supply of NAC in all cases as well. In another anatomical study done by van Deventer [12], he found an asymmetrical pattern of blood supply to breasts with variation between right and left

Table 2 Dominant arterial supply to NAC based on CTA

Dominant artery	No. of breasts ($N=24$)	%
IMA	21	87.5
LTA	4	16.6
AIA	1	4.1
Thoracoacromial	1	4.1
No dominant supply	1	4.1

IMA Internal mammary artery, *LTA* Lateral thoracic artery, *AIA* Anterior intercostal artery

Table 3 Summary of pedicle used based on CTA findings

Pedicle used	No. of breasts ($N=24$)	%
Inferior pedicle	2	8.3
Superior pedicle	2	8.3
Superomedial pedicle	19	79.2
Lateral pedicle	1	4.1

breasts in the same cadaver and hence concluded that it is impossible for surgeon to predict the blood supply of the breast that will operate upon. Our study solved these variability of the blood supply and facilitated the dominant breast pedicle selection.

Based on CTA findings in our study regarding dominant arterial supply to NAC, surgeons used superomedial pedicle technique in 19 breasts (79.2%), lateral pedicle in one breast (4.1%), superior pedicle in two breasts (8.3%). Our study was helpful as well to determine the entry point of the dominant artery into NAC using clock method. One breast showed no dominant arterial supply to NAC and inferior pedicle was considered safer based on entry point of different arteries to NAC which were more numerous at 7 O'clock position. The determination of arterial entry point to NAC was helpful as well to preserve as much of vascularized pedicle tissue during dissection to ensure viability of NAC thereafter.

None of the cases enrolled in our study experienced partial or total NAC necrosis after breast reduction surgery. The technique described in this study encompassing pre-operative detection of dominant artery to NAC, describing its course and entry point at NAC, then tailoring operative markings and dissection pattern accordingly to include them in the desired pedicle, has led to reduction of dissection time during surgery as surgeon already knows about the dominant artery and its entry point at NAC.

As regard radiation dose, we used 100 kv setting in all patients to minimize radiation dose considering that breast is a radiosensitive structure and most of our

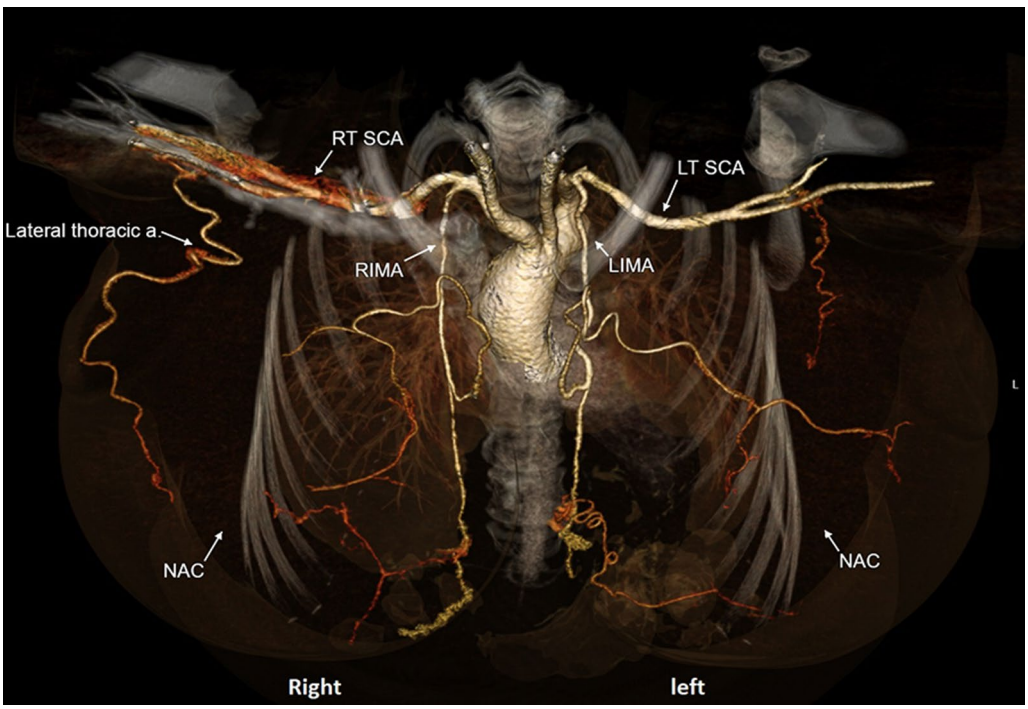

Fig. 2 Different dominant arterial supply to NAC in the same patient. Semitransparent 3D volume-rendered image showing Dominant lateral thoracic artery on the right side reaching NAC with dominant LIMA perforators on the left side reaching NAC

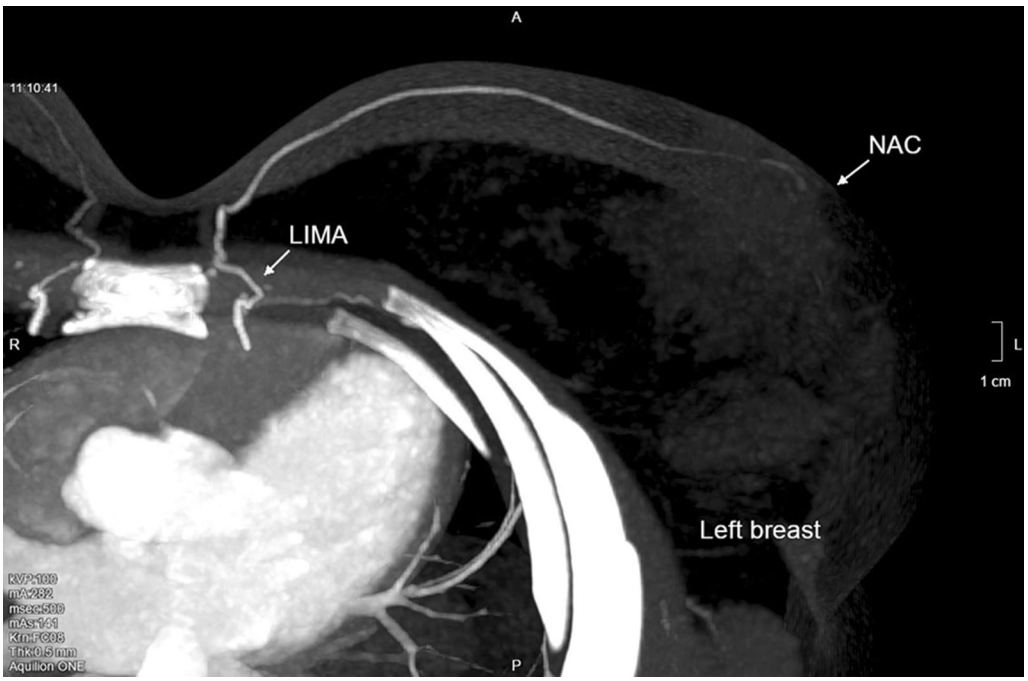

Fig. 3 MIP image demonstrating dominant arterial supply to NAC. A thick-slab axial MIP image of the left breast can trace dominant arterial supply to NAC arising from LIMA till it reaches NAC within single image

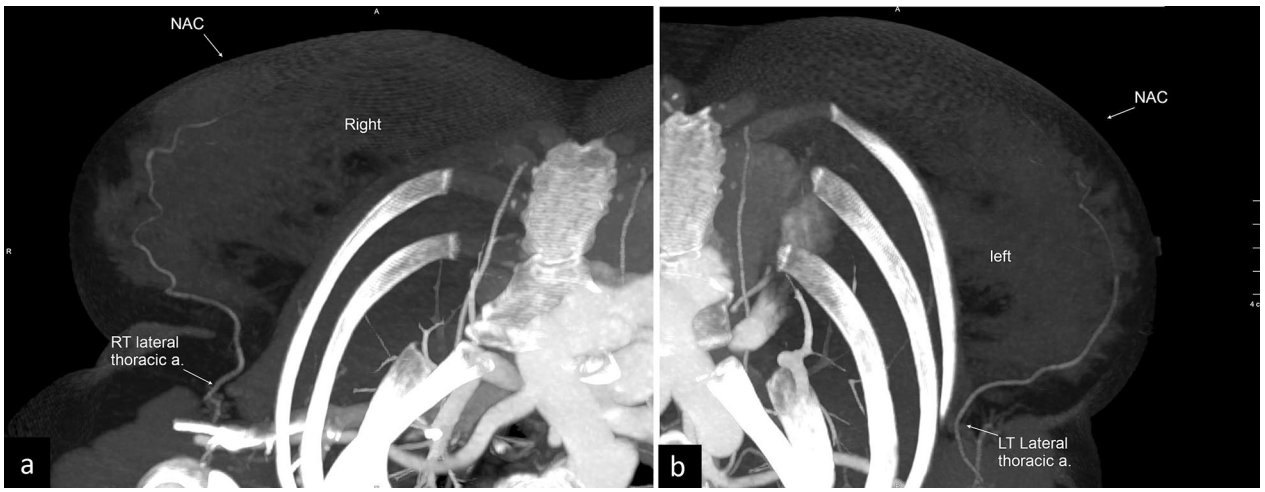

Fig. 4 Effect of dense breast parenchyma on MIP image. Axial MIP images of right (**a**) and left (**b**) breasts in a 22-year old female patient with dense glandular parenchyma. She has dominant lateral thoracic artery supply to NAC. However, the terminal end of the arterial supply could not be traced well due to dense glandular parenchyma which is an issue in young females

enrolled patients were of young age. The effective dose ranged from 3 to 6 mSv which is nearly the same or even less than annual background radiation exposure. Therefore, we consider the benefit of avoiding nipple necrosis postoperatively outweighs the risk of limited radiation exposure during pre-operative CTA.

The major limitation of our study was the small number of cases, an issue that could describe the low incidence of complications in this study. Further studies with larger number of patients may be needed to compare the actual incidence of complications following breast reduction

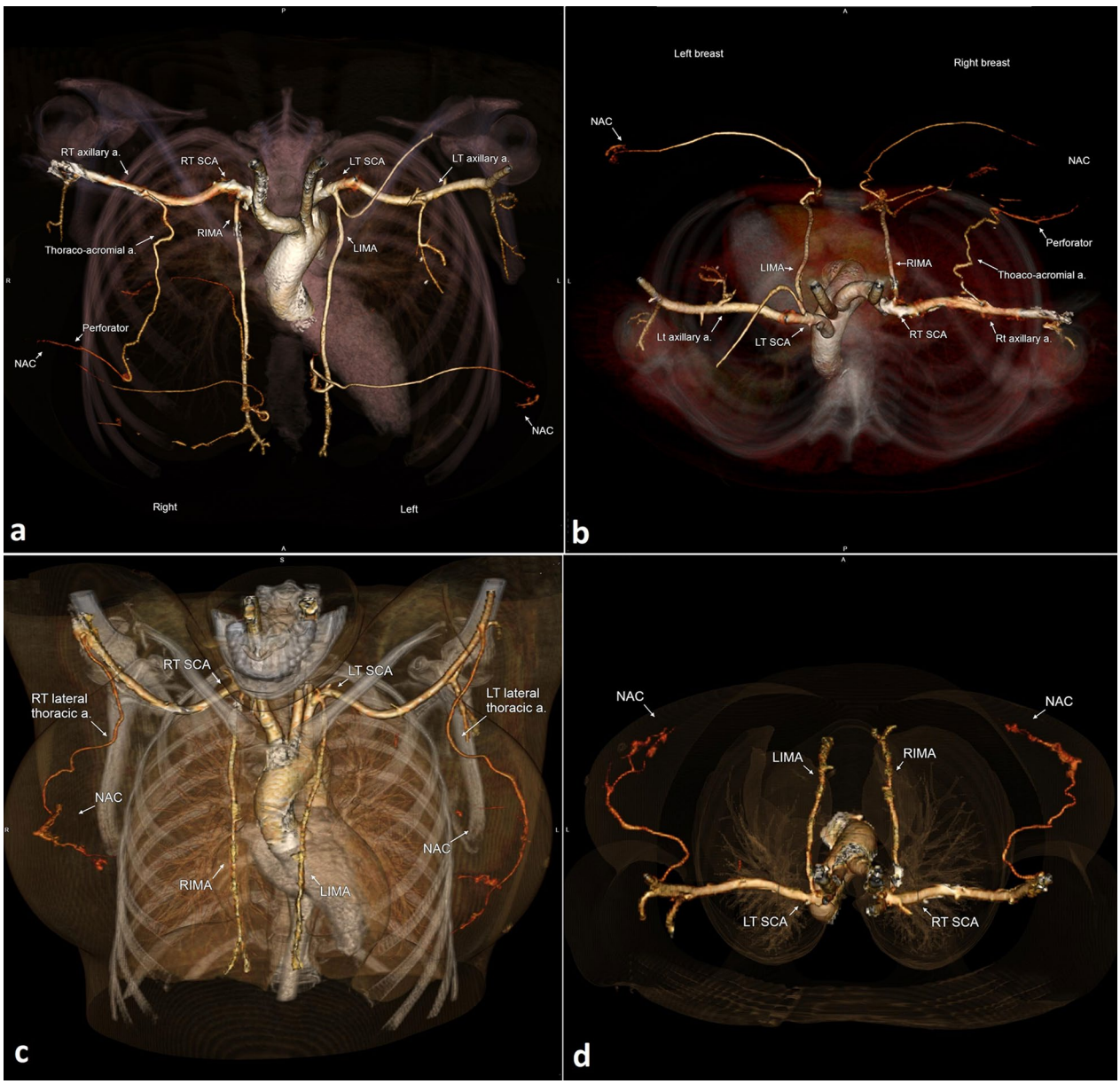

Fig. 5 Three-dimensional volume-rendered imaging of dominant arterial supply to NAC. Coronal (**a**) and axial (**b**) semitransparent 3D volume-rendered images of a patient with dominant supply from thoracoacromial artery and RIMA on the right breast reaching NAC. Another patient (**c** & **d**) shows dominant lateral thoracic artery supply on both sides. Note the relation of dominant arteries to bony structures and determination of entry site at NAC end

surgery planned with CTA to those who underwent surgery without pre-operative CT imaging, in order to validate the routine usage of CTA before such surgery.

Conclusions

Pre-operative planning of breast reduction surgery using multislice CT angiography, can delineate dominant arterial supply of NAC and facilitate optimal pedicle selection aiming to reduce the incidence of NAC necrosis and hence improving patient's outcome.

Abbreviations

3D: Three-dimensional; AIA: Anterior intercostal artery; CT: Computed tomography; CTA: Computed tomography angiography; HU: Hounsefield unit; IMA: Internal mammary artery; IV: Intravenous; Kv: Kilovoltage; LIMA: Left internal mammary artery; LTA: Lateral thoracic artery; MIP: Maximum intensity projection; NAC: Nipple-areola complex; RIMA: Right internal mammary artery.

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Author contributions
EM suggested the idea of this research work; NZ collected and analyzed patient's data throughout research process; OE revised study design and supervised research work; AM prepared the manuscript for publishing and made CT image post processing on workstation. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and analyzed in this study are available from corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Research Ethics Committee of Faculty of Medicine at Tanta University in Egypt. All patients included in this study gave written informed consent to participate in this research.

Consent for publication
All patients included in this research gave written informed consent to publish the data contained within this study. The authors grant the publisher the consent for publication of this work.

Competing interests
The authors declare that they have no competing interests.

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