Necrosis of the nipple-areola complex in breast reduction
Our personal way to solve problem

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Necrosis of the nipple-areola complex in breast reduction. Our personal way to solve problem

Necrosis of the NAC is a condition that penalizes patients who underwent breast reduction surgery or mastopexy. Breast reduction is a widely used technique for over-sized breasts. Breast hypertrophy, in fact, can cause the onset of many issues - both aesthetical and pathological - because of the excessive weight that the breasts exert on the patient's spine.
Aim and objective of our study is to suggest a systematic use of diagnostic imaging composed of pre-operative and intra-operative ultrasound with color-Doppler and pre-operative MRI.
Trying to solve this problem definitively, we relied on our notions of anatomy on ten fresh cadavers, on whose twenty breasts we could make very detailed dissections. The dissections led us to conclude that, albeit with their anatomic differences, each breast was characterized by a vascular-nervous pedicle coming out from the inter-costal spaces and aimed to the blood supply to the NAC. To overcome the anatomic variations between one subject and another - but also between one breast and the other from the same patient, we relied on diagnostic imaging, both in the pre-operative and in the intra-operative staging. This way we were able to intervene successfully with 15 patients, none of which has complained damages to the vascularity or innervation of the NAC so far. In conclusion we believe that pre and intra operative diagnostic imaging is the only way to completely eliminate any potential risk of NAC necrosis. Only by means of the systematic use of conventional imaging - especially during surgery - it is possible to constantly monitor the position of the NAC's pedicle in a breast that is being reduced in volume.

KEY WORDS: Breast reduction, Color doppler ultrasound, Magnetic Resonance Imaging (MRI), Mastopexy, Necrosis of the NAC, Vascular-nervous pedicle.

Introduction

Breast hypertrophy is a non-cancer problem that currently afflicts women. The consequences of this problem are not only aesthetic but also pathological as over-sized breasts can burden the spine with excessive weight.

Therefore the surgical breast reduction is a true therapeutic and prophylactic surgery.
It is characterized according to the alleged vascularity of the NAC or according to the scar that remains after surgery, this last can be: an inverted T; a vertical perioareolar scar; a vertical short infra-mammary scar; a perioareolar scar; an L-shaped scar or an oblique scar. Further classification marks the vascularity of the NAC in mono- or bi-pedicle surgery. As for mono-pedicled breast reduction techniques, we can remember: the superior pedicle technique, the inferior pedicle technique, the external pedicle technique and the internal pedicle technique. As for bi-pedicled breast reduction techniques (with two flaps to support the NAC) we remember: the exter-

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nal/internal pedicle; the superior-inferior pedicle, the superior-interior pedicle and the inferior-posterior pedicle. All the so far employed techniques [1] in breast reduction surgery have the common risk of NAC necrosis. Recently there has been an attempt to eliminate or at least reduce this risk by introducing Doppler controls in breast reduction surgical procedures [2]. A further attempt to reduce this risk has been made by other authors [3]. The aforementioned problems is not to be underestimated, and not yet definitively solved. Therefore in the last two years we attempted to refine our knowledge on the topic and performing very thorough dissections on some fresh female corpses in order to better study vascularity of the NAC. Once defined and identified exactly the anatomical portion containing vascularization and innervation to the NAC to be preserved during surgery, we endeavored to go beyond the innovations very recently proposed by other authors [1,2] and developed a management protocol that included both pre-and intra-operative monitoring of what had been previously identified by color-Doppler in the preparation and planning of the surgery, in order to avoid damages to the vascularity and innervation of the NAC. And then we tried to implement pre-surgical planning through a contrast-enhanced MRI study.

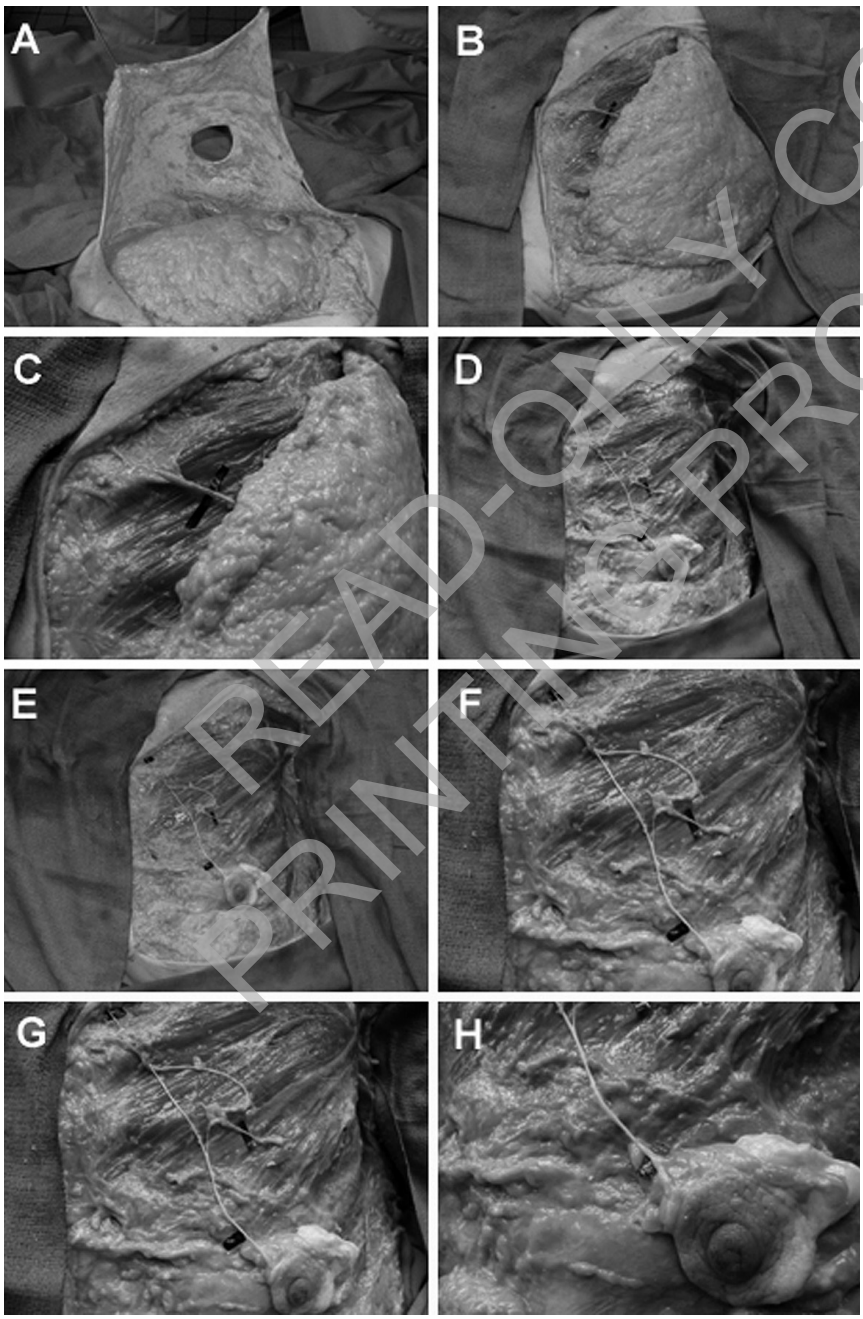

Fig. 1: Identification of the presence of the pedicle of blood supply and innervation to the NAC during the dissection of a cadaver. The vascular-nervous pedicle that supplies the NAC is clearly visible in the dissection, in particular, it is very evident in panels D and H.

Aim of our study is to show that our management protocol, characterized by using systematically (in every patients) both pre and intra-operative ultrasound with color-Doppler and pre-operative MRI, turned out to be much safer in ensuring the preservation of the vascularity and innervation of the NAC. This approach is suitable for all types of hypertrophy, including severe ones, and there is no need to change the composition and construction of the areola-containing pedicle because, unlike the aforementioned surgery procedures, it is based on real identification of a neurovascular bundle within the areola-containing flap, whose presence was identified during pre-operative stage and whose maintenance and subsequent permanence was verified during the intra-operative stage.

Material and Methods

Our study started from the anatomical dissection of 10 fresh cadavers, on which we were able to review the anatomy of breast in detail. Throughout the dissection, we found the existence of a vascular-nervous pedicle emerging from the inter-costal spaces, although with constant presence of individual anatomical variations, not only among each individual but also between two breasts from the same individual.

For this reason we tried to develop a systematic use of diagnostic imaging, and consequently decided to introduce the systematic use of radiological techniques in both the pre- and intra-operative stage as well, namely ultrasound and MRI which allows us to predict with accuracy the anatomical position of the vascular-nervous pedicleand to leave it intact during surgery.

In the study we considered 15 female patients aged between 47 and 63 years, and whose average age was 56 years. All women were subjected to reductive mastopexy. All 15 patients had the NAC located more than 28 cm far from the jugulum, up to the highest distance of 37 cm. The average volume removed per breast was approximately 550 grams, with a minimum of 350 grams and a maximum of 600 grams. The here reported data relate to two of the 15 patients.

For the mapping of the superomedial vascular pedicle, we used complementary pre-operative and intra-operative ultrasound (My Lab 50, ESAOTE, Italy) with color-Doppler and high frequency probes (13 MHz) and pre-operative MRI (Tin Avanto, 1.5 Tesla, Siemens, Germany). Color-Doppler makes it possible to observe the presence of the superomedial pedicle (Fig. 2A). The pre-operative ultrasound study was performed by manually tracing the path of the superomedial vascular pedicle (represented by artery/vein) that supplies the NAC, in order to identify both its inter-costal space of emergency and possible incidental anatomical variations, whose knowledge is essential for the success of the operation. MRI was essential to provide a more accurate vas-

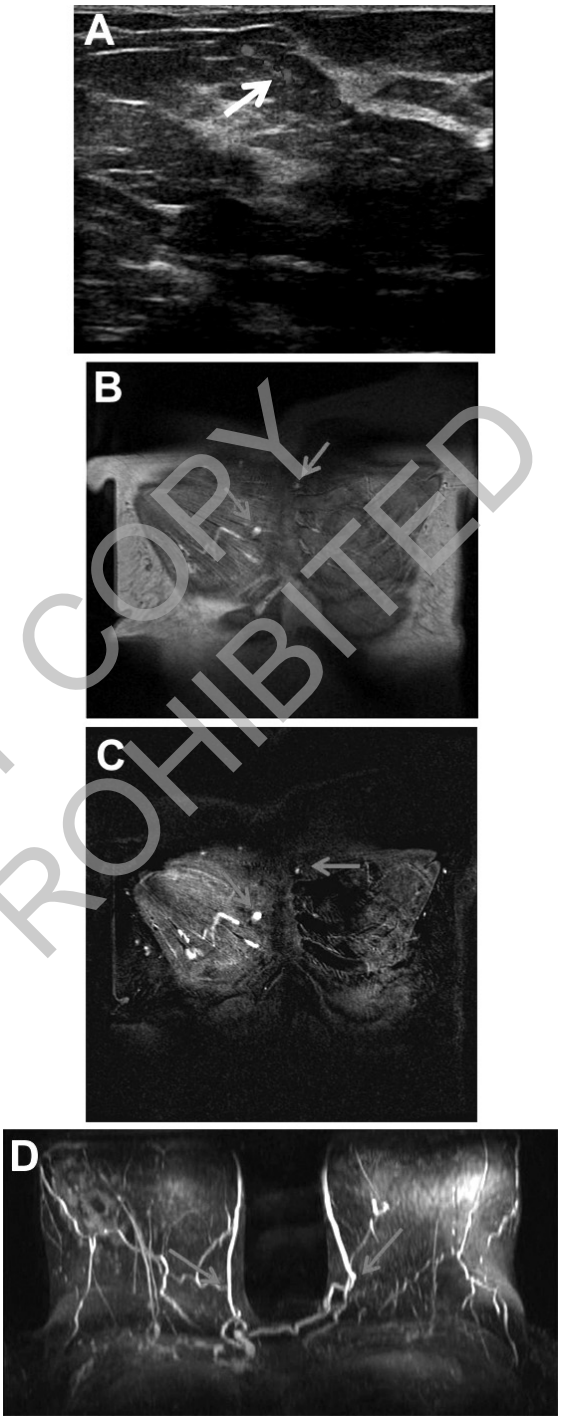

Fig. 2: Identification of the path of the pedicle and its inter-costal points of emergence through pre-operative radiological investigation. (A).The ultrasound image shows how, with the support of color-Doppler, it is possible to observe the presence of the superior-medial pedicle (white arrow). (B) The T2-weighted MRI sequence on coronal plane indicates the precise point of inter-costal exit of the two superomedial pedicles (respectively, from the third space on the right and from the second space on the left, as shown by the respective red arrows). (C) The 3D FLASH, T1 sequence on coronal plane, emphasizes the inter-costal space of emergence of the two superomedial vascular pedicles (third on the right and second on the left, as shown by the red arrows). (D) The MIP-MR image on axial plane, shows the progression of the superomedial vascular pedicles of both breasts (red arrows).

cular mapping of the breast, due to it is not operator dependent. Our study involves the intravenous administration of contrast medium in a dose proportional to the body weight of patients (MultiHance, GD-Bopta, Bracco Diagnostics, Italy), with T2 TIRM and 3D Flash sequences, both on sagittal plan (to demonstrate the emerging of the vessels from the inter-costal spaces at the level of the sternum), and on axial plan (with subsequent multi-planar reconstruction) [6]. Such MRI sequences (Fig. 2B) can emphasize the vascular structure in relation to the breast parenchyma, whose signal is suppressed [7]. In the operating room, before starting the dissection we check again with ultrasound study the inter-costal space of emergency of blood vessels and the pathway of the vascular nervous.; being the pathway so confirmed we are able to start with pedicle dissection and isolation without any doubts.

All 15 women submitted to breast reduction surgery were studied with pre- and intra-operative ultrasound and with pre-operative MRI. Since all of the operated patients showed no post-operative problems at all, we decided to report only 2 of 15 cases of the study.

Results

The protocol above described; characterized by pre and intra-operative ultrasound plus pre operative MRI, was applied for all the 15 patients who underwent breast reduction surgery. Among the fifteen women (i.e. a total of 30 breasts) so studied we specifically noticed that: 19 pedicles emerged from the 3rd inter-costal space whereas the remaining 11 pedicles emerged from the 2nd one (data not shown).

All of the 15 patients were discharged with a well-supplied and innervated NAC. None of them complained about any condition, including desensitization of the area in question. It is important to highlight that our protocol based on pre- and intra-operative ultrasound and complemented by pre-operative MRI, has shown that MRI was essential to the success of operations, since it always indicated the correct area of emerging of the neurovascular pedicle of the NAC (Fig. 2C). If we had relied merely on ultrasound (operator dependent imaging), we would have failed in three cases. In such cases, in fact, MRI completely changed the results of ultrasound (which in two patients showed the emerging of the pedicle from the second inter-costal space and in one patient from the third inter-costal space) (Fig. 2D).

Discussion

Our work started from the anatomical dissection of 10 fresh cadavers, on which we were able to review the anatomy of breast in-depth. Throughout the dissection, however, we realized that our expectations and our good intentions would inevitably be disappointed. In fact, it was not possible to define which pedicle to preserve during mastopexy. Or better, we apprehended of the existence of a vascular-nervous pedicle emerging from the inter-costal spaces, accompanied, however, by the constant presence of individual anatomical variations, not only among each individual but also between two breasts from the same individual. For this reason the need to develop a protocol to be used for every candidate which allows the accurate localization of the anatomical position of the vascular-nervous pedicle, to be able to keep it intact during surgery. We consequently decided to introduce some radiological techniques in both the pre- and intra-operative stage as well, such as ultrasound and MRI. In particular, ultrasound was utilized in both operative stages, whereas MRI was used in the pre-operative stage. In fact, the pre-operative investigation procedure, at present, usually utilizes ultrasound and color-Doppler. We added MRI to this procedure in order to better and clearly identify the vascular-nervous pedicle in those cases in which it was not clearly identifiable using the current techniques. Moreover, the preservation of the vessel highly reduces the risks also in patient having some risk factors, in which it is more probable that some post-operative problems could arise. In fact, in those cases in which patients had several and high risk factors and could thereby undergo complications post-surgery, the management of the possible complications should be more expensive than perform MRI. In patients not showing any risk factor should be better to associate Doppler investigation to ultrasound in the pre-operative stage. In fact, it is mandatory to perform ultrasound in order to evaluate cancerous formations of the breast parenchyma, whereas Doppler has the positive value to improve the final result highlighting the vessels that supply the NAC without increasing cost of investigation. We then performed mastopexy to 15 patients using routinely the aforementioned protocol. Thanks to high-frequency MRI (in pre-operative staging) and color-Doppler ultrasound probes (both in pre- and intra-operative staging) we were able to map and identify the superomedial vascular pedicle. Pre and intra operative ultrasound enabled us to manually trace the path of the superomedial vascular pedicle that supplies the NAC and the inter-costal space where the vessels emerge, including any anatomical variations. Of the 30 breasts examined, in 19 the pedicle emerged from the third inter-costal space and in 11 from the second inter-costal space. MRI also provided us with precise mammary vascular mapping. The study was carried out both on sagittal plane - to show the emergence of the vessels from the inter-costal spaces at the sternum level - and on axial plane with further multi-planar reconstructions. Thanks to MRI sequences, we could also emphasize vascularity with respect to the breast parenchyma.

Pre-and intra-operative imaging has allowed us to intervene successfully on all 15 patients, so that we could

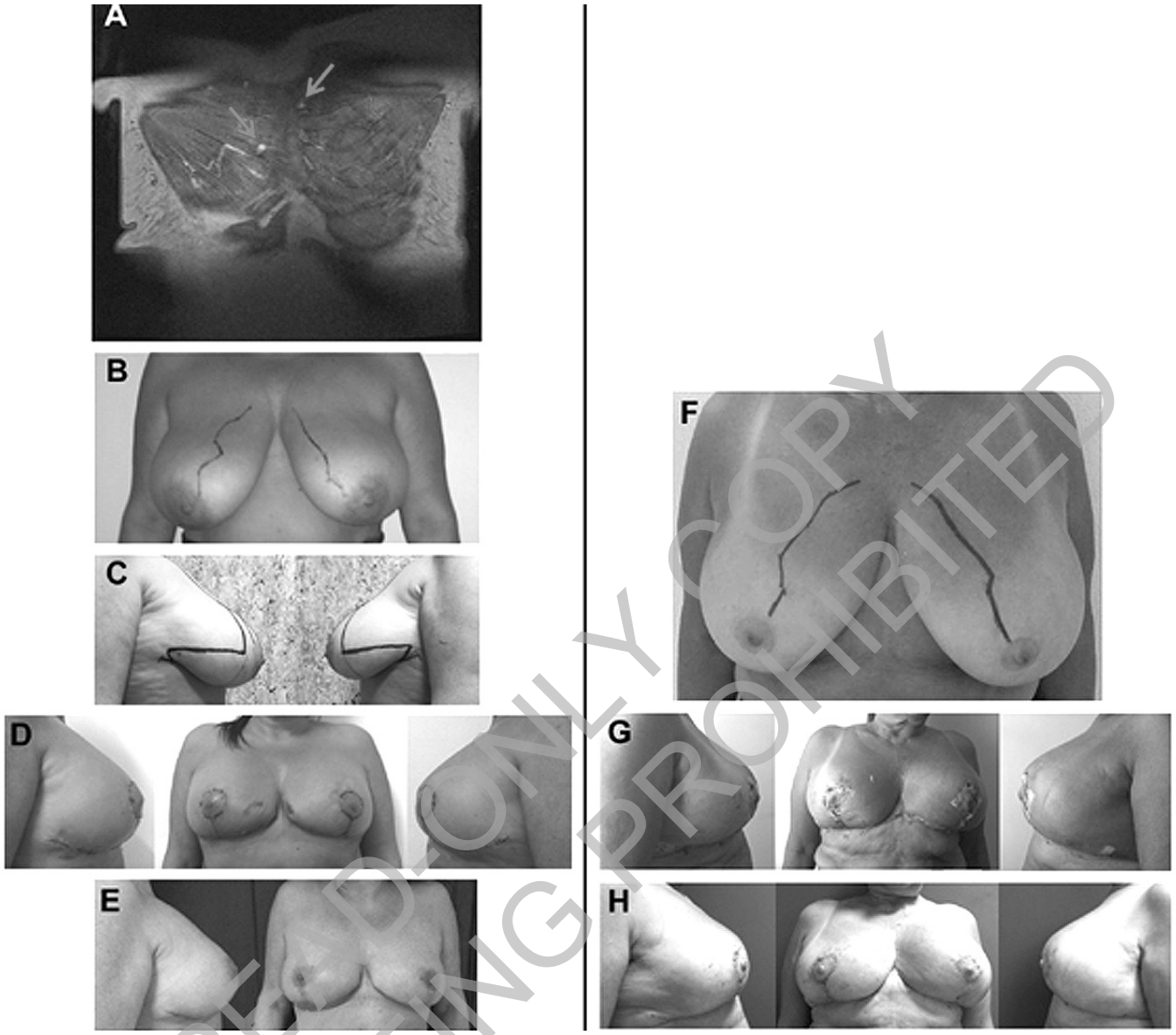

Fig. 3: Application of our management planning to patients. The figure shows the application of our management planning on two of the patients undergoing mastopexy. First patient. (A) MRI (B) Vascular map (C) pre-operation (D) two weeks post-operation (E) one month post-operation. Second patient. (F) Pre-operation (G) 5 days post-operation (H) 14 days post-operation.

verify the quality and feasibility of our guess. Of the 30 operated breasts, none suffered either in terms of NAC blood supply or of loss of sensitivity of the area. Since all of the treated patients have not complained about any post-operative problems, we chose to report only of two operations (Fig. 3).

As expected, our strategy based on pre- and intra-operative ultrasound and complemented by pre-operative MRI, has shown that MRI- being operator independent - was essential to the success of operations, since it always indicated the correct area of emerging of the neurovascular pedicle of the NAC (Fig. 2C). If we had relied merely on ultrasound, we would have failed in three cases. In such cases, in fact, MRI completely changed the results of ultrasound (which in two patients showed the emerging of the pedicle from the second inter-costal space and in one patient from the third inter-costal space)(Fig. 2D).

The technique we developed and illustrated in this article allowed us to perform 30 breast reduction operations without the risk of failure due to post-surgery lack of blood supply to the NAC. All of the 15 patients of which we report here, in fact, were discharged with a well-supplied and innervated NAC. None of them com-

plained about any condition, including desensitization of the area in question. We therefore believe that this method of management of patients can be successfully applied because it has the enormous advantage of allowing - in the intra-operative phase - direct identification of the nervous-vascular pedicle to be preserved, thus avoiding the incurrence of necrosis of the NAC.

During the planning of breast reduction or mastopexy, whatever the technique and except for the grafting of the NAC suggested by Torech, it is essential to maintain a large pedicle with random vascularity to keep NAC alive. Over the years this was the subject of discussion to define a *gold standard* technique. In fact, the grafting of the two flaps (lateral and medial) is more or less constant, whereas the variables are the NAC pedicles and the fourth flap, the latter functioning as a self-implant. For this reason, we reconsidered literature and our notions of anatomy to determine the best procedure for maintaining vascularity and innervation of the NAC and to find out whether there is a non-invasive diagnostic method that could help us for such purpose.

The description on breast blood supply by Carl Manchot was long considered a model of vascularity of the breast. It showed blood coming mainly from the mammary internal artery and only complementarily from the chest lateral artery and from the seventh inter-costal artery.

In 1934, Marcus examined 33 human breasts and found great individual differences in breast vascularity. With his work he identified supply coming from three main sources, with a variety of possible combinations: i) internal and lateral mammary artery ii) internal mammary artery and inter-costal arteries iii) a system made of the external-internal and the inter-costal arteries. Marcus also described three systems of blood supply to the nipple: i) an anastomotic circuit with dominant internal mammary artery, whose supply was estimated to be approximately 74%, ii) an anastomotic circuit with dominant external mammary artery, whose supply was estimated to be approximately 20%, iii) a radial distribution characterized by a set of anastomoses, whose supply was estimated to be approximately 6%.

In 1998, Elisabeth Wuringer and her colleagues [4] examined 28 female breasts, and described a horizontal septum that extends from the fifth rib to the nipple, dividing blood supply into a cranial vascular network and a caudal vascular network. The septum, with its vertical-medial and vertical-lateral ligaments would function as the mesentery in which the vessels run to the NAC.

In 2004 Van De[5] exaned the NAC blood supply dissecting 27 breasts of female cadavers. The study found many variables in the NAC blood supply. None of the dissected breast had the same NAC vascular structure, also when the breasts belonged to the same cadaver. It was therefore concluded that it would have been impossible for a surgeon to predict the exact vascular structure for the NAC in question. However, the most important finding was that, in all the dissected breasts, the NAC received one or more arteries from the four superior perforating arteries coming from the internal mammary artery. Consequently, a superomedial pedicle could have been used for a vascularized flap, if the branches coming from the perforating arteries of the internal mammary artery had been preserved during surgery. Otherwise there was risk for the flap to have a random blood supply. Van Deventer also found that the dominant perforating arteries were the third (45.7%) and second (25%). In 11 dissections by him performed, the NAC did not receive vascularity by the lateral artery, and in 13 dissected breasts there was no blood supply at all from the superior system.

These data coincide with the percentage of incidence of necrosis of the nipple in literature: 7.35% for the superior pedicle; 2.3% for the lateral pedicle and 0.8% for the inferior pedicle. Unfortunately, there are no statistical results so far on the incidence of NAC necrosis with superomedial pedicle.

According to literature, therefore, the perforating arteries from the thoracic internal artery are the most consistent and the most frequent source of blood vessels for the NAC [4,5]. The NAC blood supply, in rare cases, can also be provided by branches of the lateral thoracic artery and by the anterior inter-costal arteries. As for the venous vascularity, the distinction is among: a superficial system that drains into the external jugular vein, the cephalic vein and the abdominal subcutaneous vein; a deep system that drains into the superior epigastric veins, the thoracic-epigastric veins and the internal and external mammary veins.

In our study we focused on the blood supply system and the nervous junction of the breast, in order to avoid - or at least dramatically reduce - the risk of necrosis of the NAC. The period of learning and development of the surgical technique that we propose has been conducted at the Sophia Antipolis University of Nice Vile, where we had 10 fresh female cadavers at our disposal, and we studied a total of 20 breasts of which we deeply examined the neurovascular anatomy. In particular, as shown in Fig. 1, we focused on the neurovascular axis, which originates from the parasternal, inter-costal spaces (internal mammary artery, branches of the inter-costal nerves, branch of the internal mammary vein). When dissecting, we took a sample of pedicle from each side and we subsequently subjected it to histological investigation to verify the presence of arterial and venous vessels or peripheral nerve branches (data not shown).

During the dissection of the twenty fresh breasts we witnessed the constant presence of a main neurovascular pedicle (Figg. 1D-H) which, to all histological examinations proved to be made of at least one artery, two veins and a nervous peripheral branch and residing in the second or third inter-costal space, albeit with variations as described in literature. During dissection, however, we were also faced with the impossibility of predicting exactly where the innervation and vascularity of the breast

came from. Therefore, we were not able enough to define which the vascular-nervous pedicle of each breast was, with the consequence of failing once more to avoid or reduce the risk of necrosis of the NAC. That is why we believed necessary to rely, both in the planning of the operation and in the intra-operative phase, on a tool that could accurately identify the nervous-vascular pedicle of each of the operated breast. We reckoned that imaging and its methods of investigation were exactly what we needed.

Diagnostic imaging plays a major role in the planning of breast reduction surgery, both because before the operation a surgeon needs to know the possible presence of breast findings, benign or suspect (in the latter case, pre-operative studing is crucial), and for definitive identification of the vascular pedicle for the NAC blood supply. We then performed color-Doppler ultrasound and contrast-enhanced MRI in order to overcome the problems related to breast reduction surgery and to evaluate, in the form of volunteer screening, the presence of intra-mammary pathological findings.

Conclusions

Necrosis of the NAC is a frequent and significant post-operative complication of breast reductive surgery. If we add the fact that breast reduction is widely used to correct imperfections and pathologies related to over-sized breasts, the problem of vascularity and innervation to the NAC becomes of considerable importance.

For this reason recently, some authors [1,2] tried to improve the techniques used so far. Despite their best efforts to maintain blood supply and innervation to the NAC, the problem of necrosis has not been fully solved yet. This is why we tried to develop the techniques commonly followed and already examined by these colleagues. We believe the systematic use of diagnostic imaging composed of pre-operative and intra-operative ultrasound with color-Doppler and pre-operative MRI can solve definitively NAC necrosis. The systematic use of our above described protocol based on imaging techniques is in our experience highly helpful in avoiding or widely reducing the possibility of the occurrence of necrosis of the NAC in patient already having risk factors. The use of diagnostic imaging, especially during surgery, allows us to always find clearly the position and emergence of the NAC neuro-vascular pedicle in a breast to be reduced in volume, thus preventing from accidentally cutting it off. Only one can be sure of maintaining vascularity and innervation of the NAC this way, avoiding the patient the risk of necrosis or desensitization of the area.

Finally providing pre and intra-operative pedicle's recognition we believe this protocol could be a candidate to become *gold standard* for breast reduction and mastopexy.

References

1. Rinker B, Veneracion M, Walsh CP: *Breast ptosis: Causes and cure*. Ann Plast Sur, 2010; 64(5):579-84.

2. Horta R, Silva P, Filipe R, Costa J, Bartosh I, Amarante J, Silva A: *Use of doppler in breast reduction with superomedial or superolateral pedicles*. Aesthetic Plast Surg, 2010; 34:680-81.

3. Başaran K, Ucar A, Guven E, Arinci A, Yazar M, Kuvat SV; *Ultrasonographically determined pedicled breast reduction in severe gigantomastia*. Plast Reconstr Surg, 2011;128(4):252e-259e.

4. Würinger E, Mader N, Posch E, Holle J: *Nerve and vessel supplying ligamentous suspension of the mammary gland.* Plast Reconstr Surg, 1998; 101(6):1486-493.

5. van Deventer PV: *The blood supply to the nipple-areola complex of the human mammary glan*d. Aesthetic Plast Surg. 2004; 28(6):393-98.

6. Kuhl C:, Kuhn W, et al.: *Pre-operative staging of breast cancer with breast MRI: one step forward, two steps back?* Breast, 2007; Suppl2: S34-44.

7. Sardanelli F, Fausto A, et al.: *Breast vascular mapping obtained with contrast-enhanced MR imaging: implications for cancer diagnosis, treatment, and risk stratification*. Eur Radio, 2007; Suppl 6:F48-51.