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New surgical technique: Simultaneous use of contiguous intercostal spaces during total rib preservation exposure of the internal mammary vessels in microvascular breast reconstruction

Georgette Oni[a], Charles M. Malata[a,b,c,*]

[a] Department of Plastic and Reconstructive Surgery, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge CB2 0QQ, UK
[b] Cambridge Breast Unit, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge CB2 0QQ, UK
[c] Anglia Ruskin University School of Medicine, Cambridge and Chelmsford, UK

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Summary *Introduction:* Microvascular free tissue transfer is the gold standard for autologous breast reconstruction. For many surgeons, the internal mammary vessels (IMV) are the preferred recipient vessels. The merits of the rib preservation technique have been previously discussed. There are, however, instances in which greater access than afforded by one intercostal space (ICS) may be required, for example, multiple or redo anastomoses or inadvertent recipient vessel damage. We therefore have refined this technique further to allow exposure of two ICSs without sacrifice of the intervening rib cartilage.
Method: We identified all patients who had simultaneous contiguous ICSs dissected whilst preserving the intervening costal cartilage for microvascular anastomoses for breast free flaps. The indications, surgical technique, and its refinements are described.
Results: Simultaneous exposure of the IMVs in both the second and third ICSs whilst preserving the intervening costal cartilage for microvascular anastomoses was successfully performed in 15 patients with no flap failures. Indications included bipedicled DIEP flaps (9), bipedicled DIEA/SIEA flap (1), stacked DIEP flaps (4), and salvage (1). One flap was successfully re-explored for venous congestion. There were no intraoperative complications.

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* Corresponding author at: Charles M. Malata, Consultant Plastic and Reconstructive Surgeon, Department of Plastic and Reconstructive Surgery, Addenbrooke's Hospital, Cambridge University Hospitals NHS Foundation Trust, Cambridge, CB2 2QQ, UK.
E-mail address: Charles.malata@addenbrookes.nhs.uk (C.M. Malata).

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Conclusion: We have demonstrated that simultaneous contiguous ICS exposure of the internal mammary recipient vessels with total rib preservation is technically feasible, has no adverse patient sequelae, and has the benefit of allowing multiple anterograde and retrograde microvascular anastomoses (even in patients with narrow ICSs). This technique preserves the intervening rib and is of particular utility in bipedicled flaps when multiple "extra-flap" anastomoses may be required.

Introduction

The benefits of total autologous breast reconstruction are well documented, and techniques in microsurgery have dramatically evolved during the last few decades. Free tissue transfer, especially, abdominal based flaps, is the gold standard method for breast reconstruction, and it is therefore not surprising that an increasing number of women are opting for this.[1] In most cases, this can be accomplished by utilizing the lower abdominal tissue based on a single vascular pedicle, but it is sometimes necessary to transfer more than one free tissue source or anastomose more than just one artery and one vein to achieve the total autologous goal. The use of such techniques to achieve the desired breast volume has been aided by developments in our understanding of perforator flap anatomy.[2-4] Either multiple anastomoses of paired arteries and veins or indeed the inclusion of a second vein can help ensure adequate circulation to the transferred tissue or increase the size of the flap.

The internal mammary vessels (IMVs) are the preferred recipient vessels for many surgeons, and currently, total rib-preservation techniques for their exposure are well established. First described for the 3rd intercostal space (ICS) by Parrett et al. in 2008, the senior author has previously published on the benefits of total rib preservation technique for IMV exposure in the 2nd ICS.[5,6] There are, however, instances in which greater access than afforded by one ICS may be required. These include bipedicled DIEPs (deep inferior epigastric artery perforator)/SIEAs (superficial inferior epigastric artery) or stacked (two separate hemi abdominal-based flaps to reconstruct one breast) free flap transfers where both pedicles are independently connected to the recipient vessels (extra-flap anastomotic configuration), redo anastomoses, and in salvage/tertiary breast reconstruction situations or inadvertent damage to the recipient vessels. In particular, bipedicled free tissue transfer can be configured as two paired anastomoses of both arteries and veins of the two vascular pedicles. Our 2nd rib preservation technique comfortably allows one paired anastomoses but can sometimes prove challenging when two sets are required and the interspace is less than 20 mm.[2] We therefore have refined this technique further to allow exposure of two ICSs without sacrifice of the intervening rib cartilage. The surgical technique and refinements of this procedure are described, particularly, access to adjacent ICSs, the dissection, and how to deliver the retrograde vessels into the caudal contiguous space without partial or total sacrifice of the intervening 3rd rib cartilage.

Method

All patients who had consecutive ICSs dissected to expose the internal mammary vessels (IMVs) during their microvascular reconstructive breast surgery were included in this retrospective case note review. Patient demographics such as age, indication for surgery, and type of reconstruction were noted. In addition, intraoperative information, recorded prospectively, was collated specifically looking at which spaces were exposed, space width, time taken for IMV exposure, flap weight, type of anastomoses, and any intraoperative complications.

Surgical technique

Rib-preserving exposure of the IMVs proceeds as previously described.[6] With this refinement, the key difference is in the splitting of the pectoralis major muscle fibers, which is done overlying the 3rd costal cartilage to provide equal access to both the 2nd and 3rd ICSs (Video 1). Following exposure of the adjacent ribs, a partial perichondriectomy is performed and then excision of the intercostal muscles in both the rib spaces, thus exposing the IMVs (Figure 1). Dissection of the IMV begins in the cranial space. The artery and the vein are freed from the areolar tissue, and any connecting vessels (both arterial branches and venous tributaries) are divided (Video 2). The same is performed in the caudal space. This now leaves only the portion of the vessels deep in the rib cartilage to be freed.

The following maneuvers are then performed to dissect the IMVs under the 3rd costal cartilage and deliver them into the 3rd ICS without damaging them.

- Traction is exerted with a DeBakey forceps on each of the vessels in turn to partially deliver them into the 2nd ICS. All the connective tissues around them are divided with the tenotomy dissecting scissors.
- Any side branches/tributaries are ligated with microliga clips and divided.
- These 2 steps (a and b) are repeated in the 3rd ICS. Most branches off the vessels are arterial side branches or venous tributaries, which are located at the caudal border of the 3rd costal cartilage.
- Alternate caudal and cranial traction is gently exerted on the IMA and internal mammary vein (with a DeBakey forceps) in turn to clear all the (adventitial) soft tissue/fibrous attachments/adhesions from the parts of the vessels, which lie underneath the rib. This step

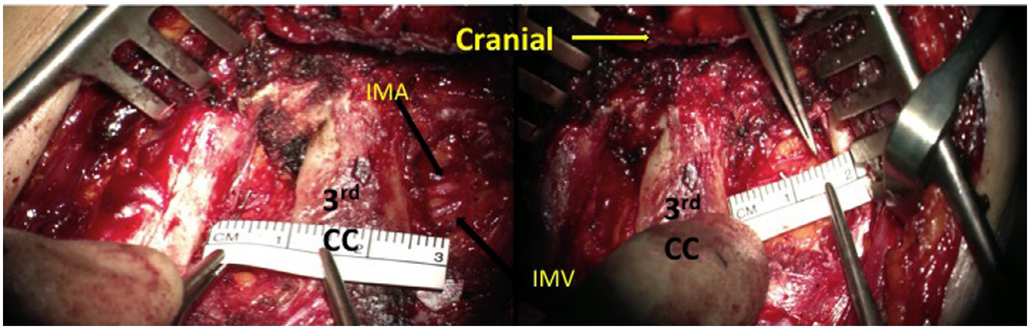

Figure 1 Exposure of the internal mammary vessels (IMV) in the 2nd and 3rd intercostal spaces – perichondriectomy has been performed, followed by excision of the intercostal muscles in both the rib spaces, thus exposing the IMVs. Note the narrow 3rd intercostal space compared to the second. *CC – costal cartilage, ICS – intercostal space, IMA – internal mammary artery, IMV internal mammary vein.*

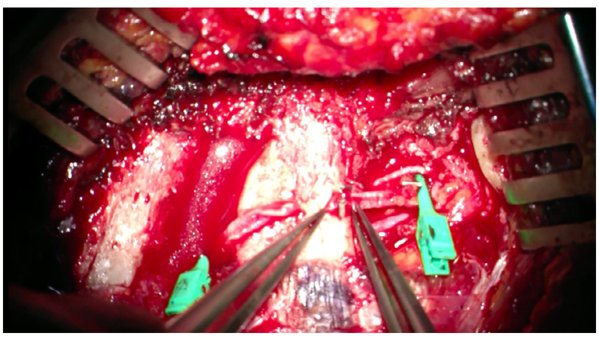

Figure 2 The extra vessel length is seen on the retrograde portion of the internal mammary artery, which is achieved by delivering the vessel from beneath the rib.

exploits the anatomical fact that, in practice, there are no branches or tributaries of the IMVs under the rib costal cartilage (Video 3).

- Once the vessels are freed up, disposable Acland clamps are applied across them at the caudal border of the 2nd costal cartilage (in the 2nd ICS) and the cranial border of the 4th costal cartilage (in the 3rd ICS).
- Each vessel is then in turn divided at the cranial border or upper border of the 3rd costal cartilage with a tenotomy scissors, leaving the maximum length of vessel in the 2nd ICS. The portion under the rib cartilage also increases the vessel length in the 3rd ICS. This increased length is important, as the 3rd ICS is narrower than the 2nd ICS, and the planned retrograde anastomoses require sufficient vessel length (Figure 2).
- The vessel in the 3rd ICS is then carefully delivered from under the 3rd costal cartilage by a combination of gentle traction and sharp scissors division of any remaining "adhesions" (Video 4).
- The artery and the vein are now in the 3rd ICS and are ready for the retrograde anastomoses, and the artery and vein in the 2nd ICS are used for the anterograde anastomoses (Video 5).

Results

The simultaneous exposure of the IMVs in multiple ICSs while preserving the intervening (costal) cartilage for microvascular anastomoses was successfully performed in 15 patients undergoing free flap breast reconstruction with no flap failures. The average patient age was 46.8 years (range 34–66 years). The average flap weight was 573.6 g (range 340–797 g). In all patients, both the second and third rib spaces were utilized. The indications for this technique were bipedicled flap configurations in ten patients, stacked unilateral reconstructions in a further four patients, and a flap salvage situation in one patient for venous congestion. This patient, who had a unilateral DIEP 12 h previously, required a vein graft from the superficial inferior epigastric vein to the retrograde portion of the internal mammary vein, which was delivered into the third ICS at the time of salvage.

The average distance of the second ICS was 20.7 mm (range 15.3–25.7 mm), and the average distance of the third ICS was 12.0 mm (range 7.3–18 mm). The average time to expose the second ICS was 39.1 min (range 10–83 min) and that to expose the third ICS was 34.6 min (13–101 min).

There were no intraoperative complications such as pneumothorax, uncontrolled bleeding underneath the rib, hematoma formation, need for partial cartilage sacrifice, inability to execute the anastomoses, poor access/damage to the vessels, or kinking of the venous anastomoses over the intervening rib. One flap returned to theatre on day 6 for venous congestion. The vein draining the medial of her two flaps was found to be tented over the pectoralis major muscle, which was further split to good effect. The second more lateral flap remained problem free. All of the free flaps survived.

Discussion

Free autologous tissue transfer is ideal for breast reconstruction because it most closely approximates with the native breast in terms of feel, size, and shape, can withstand adjuvant radiotherapy with fewer sequelae, and, during the lifetime, will result in less ongoing surgical intervention than implant-based reconstructions with a higher patient satisfaction.[7,8] However, in some instances, to achieve this goal, more than one artery and vein may need to be anastomosed, either as part of a true bipedicled flap transfer or the necessity for combination of free flaps from different or the same donor sites. These multiple anastomoses mandate adequate recipient vessels.

The total rib preservation technique for exposure of the internal mammary recipients in two adjacent spaces has not previously been described. We believe that this evolution of the rib preservation technique, as first described by Parrett et al., is a further refinement to microsurgical breast reconstruction.[5] In the same way as muscle-sparing free TRAM, DIEP, and SIEA flap surgeries have evolved to minimize the donor site morbidity of the conventional TRAM flap, the rib preservation technique has evolved to minimize the recipient site morbidity.[9] In our series, patients with the bipedicled and ying yang flap had a minimum of two paired anastomoses each within their own separate spaces. As illustrated by the low flap weights in our cohort, this was necessary, as the whole lower abdominal tissue was required to build like-for-like total autologous reconstructions. This study shows the versatility of this technique for a variety of flap configurations.

In addition, this technique actually affords longer recipient vessel length of good caliber to be exposed, as it is the retrograde end of the vessel from the second ICS delivered into the third. The increased length of IM vessels that is achieved by the rib preservation technique across two spaces gives more flexibility to the microsurgeon in terms of not only potential re-anastomoses at the time of primary surgery in the salvage/"take back" situation but also positioning and shaping of the flap.[10] In addition, two independent, so-called "extra-flap" pedicles, supporting the flap, may be better than the dependent one "intra-flap" anastomotic configuration, that is, piggybacking one vascular pedicle onto the other and performing a single set of anastomoses at the recipient site. Reasons for this include the benefit of dual supply/drainage and the reassurance of this anatomical arrangement, as if one pedicle is compromised, flow may still be preserved through the second and still salvage the situation even though there is potential for fat necrosis in part of the flap if the latter occurs. It is well documented now that retrograde flow through the IM vessels is sufficient to adequately perfuse a DIEP free flap.[11-13] None of our patients developed fat necrosis confirming the excellent vascularity of the "extra-flap" configuration.

The rib preservation or rib-sparing technique for exposure of the IM vessels has already been shown to reduce recipient site morbidity, avoid chest wall deformities, shorten recovery time, and significantly reduce early postoperative analgesic requirements.[6,14,15] The senior author was an early adopter of the general rib preservation technique, first described by Parrett et al. in 2008, but promptly modified it to the 2nd ICS.[16] This technique comes into its own when the 2nd ICS is narrow as previously others had advocated "nibbling back" the 3rd costal cartilage or its total removal to provide more space for the microsurgery. Our previously published experience of total rib preservation IM vessel exposure is one of the largest in the literature, and in our cohort of patients, there were no postoperative chest wall pain issues or concerns over chest wall deformity.[6] This may be particularly pertinent in patients who do not have upper pole fullness (as in our cohort of thin/slim patients) or slightly more ptotic breasts in whom positioning the flap in such a way to disguise the depression left by cartilage resection may cause asymmetry with the contralateral side.

Although it is acknowledged that the dissection beneath the rib may be more challenging, it allows for all the benefits of the rib preservation technique whilst maintaining vessel length either for primary anastomoses or for subsequent revision microsurgery.

In our series, there were no intraoperative complications and only one return to theater for venous congestion, and ultimately, all flaps survived. None of our patients had issues with pneumothoraces, persistent or uncontrolled bleeding from under the rib or damage to the retrocartilaginous portion of the IMVs. This dissection is not done blind, but as demonstrated through gentle traction and counter traction to divide fascial attachments under vision alternately in both spaces. If bleeding were to occur, it is easy to control, as direct pressure can be applied in both spaces. Although we encountered no uncontrollable bleeding, if necessary, the intervening rib cartilage could be removed, as is the case for single space surgery to gain full control of the vessels if that ever became necessary. To avoid this sequelae, dissection under the rib should be performed

Conclusion

The rib preservation technique, as utilized by the senior author, of exposing the IMVs (in the 2nd ICS) minimizes the local tissue trauma caused during free tissue transfer in breast reconstruction. We have further modified this technique to allow exposure of the IMVs in contiguous spaces without removal of the intervening rib. In our series, this allowed successful anterograde and retrograde anastomoses without complication. This technique can be used for a variety of indications in which multiple anastomoses may be required using the IMVs as the recipients.

Conflict of interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjps.2019.05.017.

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