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Head and neck reconstruction in the vessel depleted neck using robot-assisted harvesting of the internal mammary vessels

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Abstract

We report a novel technique of robot-assisted harvesting of the internal mammary vessels to provide effective recipient vessels in a patient with bilateral vessel depleted neck (VDN). A 44-year-old with a Notani grade III osteoradionecrosis (ORN) of the anterior mandible underwent robot-assisted (Da Vinci® Surgical System, Intuitive Surgical) harvesting of the left internal mammary vessels (LIMA, LIMV). Reconstruction of the mandibular defect was done with a virtually planned composite fibular free flap and microvascular anastomosis of the peroneal vessels to the LIMA and LIMV. Successful reconstruction of the anterior mandible was achieved with excellent recipient arterial diameter and length, devoid of any significant thoracic morbidities resulting from robot-assisted harvesting of the internal mammary vessels. Robot-assisted harvesting of internal mammary vessels is a viable alternative to an open approach. The advantages in tissue handling, vessel length, and favourable profile of complications may extend the indications for this otherwise 'niche' solution in the VDN.

Keywords: Oncology; Head and neck cancer: reconstruction; Fibula free flap; Vessel deplete neck; Mandibular reconstruction; Robotic surgery

Introduction

Microvascular free flap reconstruction is considered the gold standard in reconstruction of defects of the head and neck.[1] As microsurgical techniques have improved alongside pre- and postoperative care, success rates in free flap reconstruction have exceeded 95%.[2] Those cases where patients have received radiotherapy, chemotherapy, a combination thereof and/or previous surgery often prove challenging due to the distortion of tissue planes and scarring of vessel walls all of which leave the neck deplete of viable recipient vessels.[3]

A vessel depleted neck (VDN) is seen in around 7% of all patients receiving microvascular reconstructions in the head and neck.[4] VDN is not precisely defined, but relates to the hostile environment created in the above situations with no suitable recipient vessels in the neck for anastomosis, in which the surgeon must explore alternative options. This is of increasing concern, as the increased incidence and improved prognosis of head and neck malignancy has been accompanied by wider application of chemoradiotherapy, and a resultant pool of cured patients with refractory Notani III osteoradionecrosis.[5]

Options in the VDN include the Corlett loop (or 'jump graft'), the subclavian or transverse cervical vessels, internal mammary vessels, and the superficial temporal vessels as suitable recipients outside the field of radiation and surgery (Table 1).[6–16] Other alternatives include the use of the radial artery, the cephalic vein rotated into the neck, the avoidance of free flaps and use of regional flaps such as the supraclavicular artery island flap (SCAIF), or pectoralis major flaps.

The use of the internal mammary vessels have been reported previously with reasonable success but this adds the morbidity and pain of a thoracic incision and division of costal cartilages to provide a recipient vessel of limited

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Table 1
Alternative options in the vessel deplete neck.

Donor vessel	Strengths	Limitations
Common carotid	Well tolerated and in reported cases, there were no incidences of neurological deficit postoperatively. [7,8]	Can lead to cerebral ischaemia, but has been proven viable where there is a patient ECA to maintain ICA perfusion.[8] Carotid atherosclerotic plaque build-up increases risk of thrombus and intimal separation.[9]
Superficial temporal	Easily accessible vessel if it remained unaffected by former irradiation aided by Doppler probe as its size and anatomy is consistent.[10]	The accompanying vein is usually thin walled and small calibre and alternative venous drainage in terms of cephalic vein transposition becomes inevitable.[10] Limited length and predisposition to kinking.[11] Facial nerve injury.[11]
Thyrocervical trunk (transverse cervical, supraclavicular, inferior thyroid)	Axis of the vascular pedicle lies in a longitudinal direction to the head and neck and provides good flow and blood pressure.[12] Often shielded under the fascia of a level 4 neck dissection, out of the previous operative and radiotherapy field.[3] TCA is a consistent vessel at the base of level 4.[11]	A long pedicle flap is needed as it is usually low in the neck and the calibre of the TCA is largest closest to the origin and greatly diminishes posteriorly, potentially more than 12 cm from the lower border of the mandible.[13]
Thoracoacromial	The thoracoacromial trunk is a feasible option even after radiation therapy or pectoral flap harvest and neovascularisation has occurred.[14]	May be unsuitable for anastomosis if a pedicle pectoralis flap has been raised shortly before.[14,15] Need for an interposition graft due to the caudal location of the vessel.[15]
Dorsal scapular	Distance from usual treatment fields.[3] Large calibre and favourable position arising from the subclavian artery.[3]	Caudal location of the vessel requiring a long vascular pedicle or vein graft; the vessel can be traced to its insertion to the scapula and reflected superiorly into the neck.[16]Potential risks include brachial plexus injury, pneumothorax, and chyle leak.[3]

length, and this has limited its more widespread application.[1,17–19] In this case we describe a novel approach using a Da Vinci® Surgical System (Intuitive Surgical) to assist in harvesting the full length of the left internal mammary vessels from their origin at the subclavian artery and vein to the distal bifurcation, reducing the burden of morbidity typically seen in open thoracic surgery including intercostal neuralgia, wound infection, chest wall herniation and parasternal contour defect, whilst providing a very long conduit.[20]

Case report

A 44-year-old male with no past medical history presented in 2009 with a T2N0M0 (TNM-7) squamous cell carcinoma of the left anterior tongue. He underwent a left partial glossectomy, left selective neck dissection and reconstruction of the defect with an anterolateral thigh free flap, utilising the left superior thyroid artery and internal jugular vein for microvascular anastomosis. In 2010, he developed a locoregional recurrence at the left floor of mouth (rT4aN1M0). He underwent further surgery comprising a Brown Class II mandibulectomy[21] including the overlying skin, right modified radical neck dissection in continuity, and reconstruction with a composite fibular free flap utilising the contralateral facial artery and internal jugular vein for microvascular anastomosis. He received postoperative chemotherapy and radiotherapy to both sides of the neck and primary site. In 2019, he had developed osteoradionecrosis of the anterior mandible with exposed bone visible in the oral cavity. He was commenced on PENTOCLO (pentoxifylline, sodium clodronate, tocopherol) but progressed to Notani grade III osteoradionecrosis with an extraoral fistula. The patient was understandably distressed by his appearance and unable to function, requiring daily dressing and nutrition through a percutaneous feeding tube.

In 2021, he underwent Brown Class II mandibulectomy with simultaneous robot-assisted harvesting of the left internal mammary vessels for microvascular reconstruction using a composite fibular free flap (Fig. 1). The peroneal artery was successfully anastomosed to the internal mammary artery (IMA). The associated two venae comitantes were anastomosed to the left internal mammary vein (IMV) and the cephalic vein (Fig. 2).

Operative technique – left internal mammary vessel harvest

The Da Vinci® Surgical System is composed of three major components namely the surgeon's console, the vision cart and the instrument cart providing a 10x magnified high-resolution 3D stereoscopic image. It allows remote, tremor-free, and scaled control of endoscopic surgical instruments with seven degrees of freedom[22] (Fig. 3).

Robot-assisted harvest of one or both internal mammary vessels is already routinely practiced in those cardiac surgical units with robotic programmes (only 29 centres in the whole of Europe). The left IMA is then used to revascularise the Left Anterior Descending (LAD) coronary artery either in a minimally invasive (4–8 cm mini-thoracotomy) or totally endoscopic fashion.[23,24]

A double lumen endotracheal tube allows for single right lung ventilation. The patient is positioned supine on the operating table with a bolster placed under the left scapula to elevate the left chest 30 degrees to the horizontal plane. Three 8mm ports are placed in the 2nd (right arm), 4th (camera) and 6th (left arm) intercostal spaces just anterior to the left anterior axillary line. Insufflation of the left chest is main-

Fig. 1. Completed surgery showing 8 mm right arm robotic port, 2 cm left first intercostal utility incision, donor site wound for cephalic vein harvest and skin paddle of fibular free flap.

tained with CO_2 at a pressure between 8-10mmHg in order to create working space between the pericardium and chest wall. Prior to beginning the vessel harvest it is important to identify the left IMA with its venae comitantes, left phrenic nerve, subclavian vessels and the first rib.[25] The endothoracic fascia and transversus thoracic muscle are first stripped from the posterior surface of the left internal mammary vessels to debulk the pedicle (Fig. 4). Using a combination of sharp and blunt dissection, the left IMA pedicle is then harvested from superior to the first rib to the distal bifurcation, and the branches are coagulated (unipolar or bipolar) or clipped endoscopically. After completion of the dissection, systemic heparinisation is administered to achieve an activated coagulation time between 300 and 400 seconds. A 2 cm utility incision is made just lateral to the sternum over the first intercostal space to allow control of the left IMA upon distal transection to prevent rotation. An atraumatic vascular clamp is placed on the pedicle and its distal extremity is transected thoracoscopically and the pedicle is delivered through the first intercostal utility incision. A 2–3 cm wide subcutaneous tunnel is then formed using blunt dissection from the utility incision to the surgical field in the neck passing superficial to the clavicle and lateral to the tracheostomy, and the pedicle is pulled through this.

In this case the 2 mm calibre left IMA was of excellent quality and of particularly impressive length, reaching 15 mm above the lower border of the mandible. The left IMV was however diminutive and thin walled (approximately 1.2 mm) but it was successfully anastomosed end to end to the smaller venae comitantes of the peroneal vascular pedicle despite significant mismatch. It was unclear if this vessel would adequately drain the fibular flap, so drainage was reinforced with a second vein anastomosis from the other venae comitantes to the cephalic vein, rotated up from the brachiocephalic groove on the ipsilateral arm, using a 3 mm venous coupler. The fibular flap was 100% successful and the postoperative course and wound healing unremarkable. Chest drains were removed by 48 hours and a very small residual pneumothorax resolved spontaneously. There were no other thoracic complications and minimal chest wound pain.

Discussion

Anatomical considerations

The IMA arises as a branch of the subclavian artery from a separate origin in 70% of cases.[26] In 30% of cases, it arises from a common origin with the thyrocervical trunk, scapular

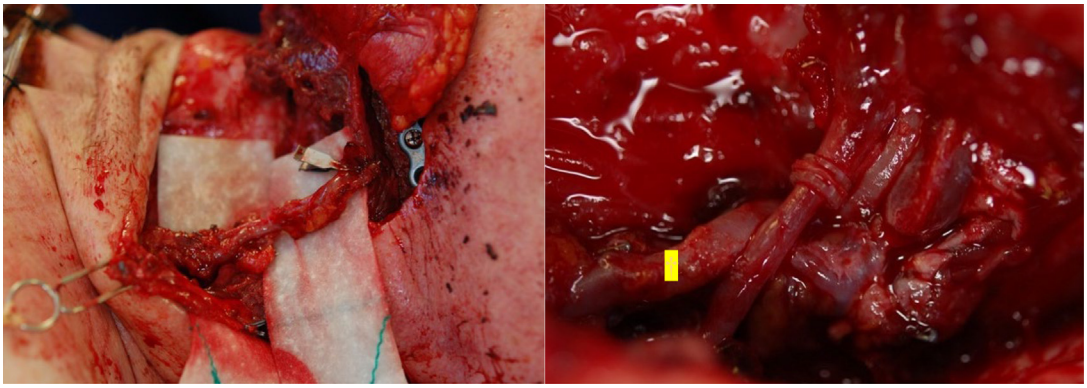

Fig. 2. Left internal mammary artery sited next to the peroneal artery prior to anastomosis; Left internal mammary vein and cephalic vein to the two venae comitantes (left); End to end venous coupler anastomosis of second larger venae comitantes of peroneal artery to cephalic vein (right) († marks the position of the internal mammary artery).

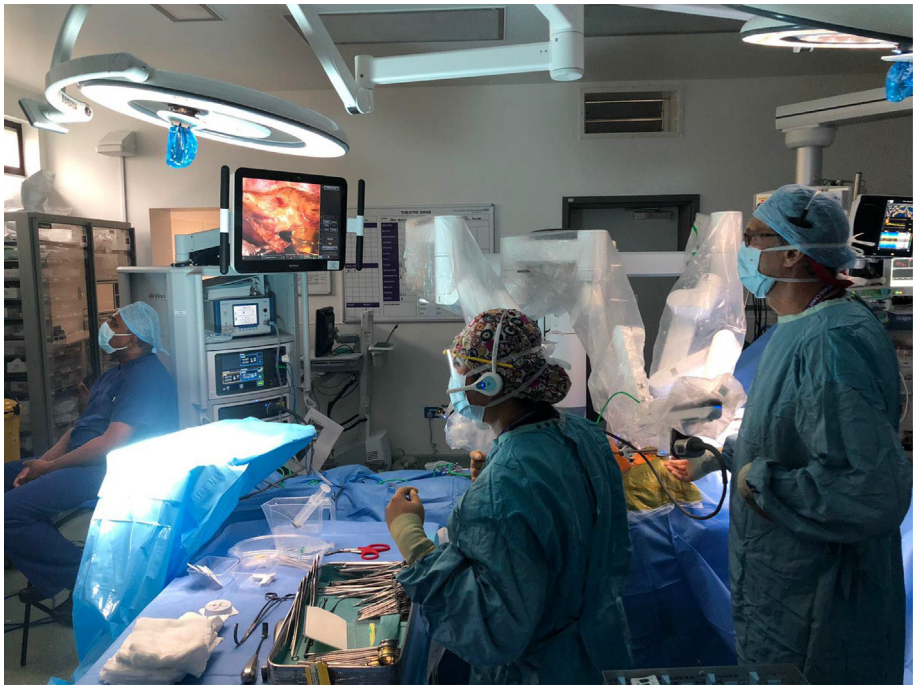

Fig. 3. Three-arm DaVinci® Surgical System with high-resolution monitors.

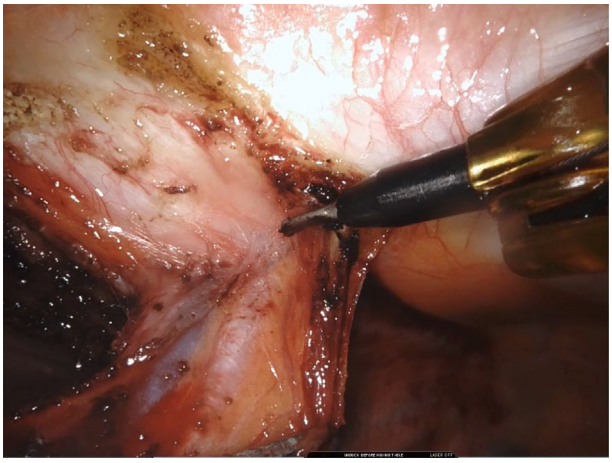

Fig. 4. View of identified left internal mammary vessels.

artery, dorsal scapular artery, thyroid artery or costocervical trunk.[27] Cadaveric studies show that the left IMA originates from the first portion of the subclavian artery in 92% of subjects.[26] It is accompanied by the IMV which drains into the brachiocephalic system.[28]

The IMA runs caudally from its origin, a distance between 6 mm and 24 mm from the lateral sternal border,[28] ventral to the parietal pleura along the under surface of the upper six costal cartilages.[29] From the third intercostal space, the IMA and IMV run between the transversus thoracis and the internal intercostal muscle layers, which separates the pedicle from the parietal pleura and deep to this the parenchyma of the lung.[1,27] The diameter of the IMA is variable at each of the intercostal levels. Arnez et al have shown that at the third intercostal space, the IMA has an average diameter of 2.8 mm, greater than the 2.6 mm measured at the fourth and fifth intercostal spaces.[9] Cadaveric dissections have also shown that the third intercostal space is the most consistent area for harvesting the distal IMV where it averaged 3 mm or more in 70% of subjects.[30] Caudal to the third intercostal space, the calibre of the IMV diminishes to less than 1.5mm, rendering microvascular anastomosis difficult.[1] The length of the LIMA from its origin to its termination point varies between 16.2 and 26.0 cm; mean (SD) 20.7 (2.1) cm, compared to the right side 20.1 (2.0) cm.[26]

Conclusion

Robotic internal mammary vessel harvest is a safe and low morbidity procedure that is an option in these infrequent cases where the neck is deplete of vessels. This is a well-documented minimally invasive technique, performed in high volumes in cardiothoracic units for coronary artery bypass grafting. In those units with expertise, appropriately skilled cardiothoracic surgeons and a multidisciplinary team approach this technique can be a viable option in head and neck reconstruction in the vessel deplete neck.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patient permission

Ethics approval not required. Signed consent form for publication.

References

1. Urken ML, Higgins KM, Lee B, et al. Internal mammary artery and vein: recipient vessels for free tissue transfer to the head and neck in the vessel-depleted neck. *Head Neck* 2006;**28**:797–801.
2. Suh JD, Sercarz JA, Abemayor E, et al. Analysis of outcome and complications in 400 cases of microvascular head and neck reconstruction. *Arch Otolaryngol Head Neck Surg* 2004;**130**:962–966.
3. Prince AD, Broderick MT, Heft Neal ME, et al. Head and neck reconstruction in the vessel depleted neck. *Front Oral Maxillofac Med* 2020;**2**:13.
4. Jacobson AS, Eloy JA, Park E, et al. Vessel-depleted neck: techniques for achieving microvascular reconstruction. *Head Neck* 2008;**30**:201–207.
5. Notani KI, Yamazaki Y, Kitada H, et al. Management of mandibular osteoradionecrosis corresponding to the severity of osteoradionecrosis and the method of radiotherapy. *Head Neck* 2003;**25**:181–186.
6. Wong KK, Higgins KM, Enepekides DJ. Microvascular reconstruction in the vessel-depleted neck. *Curr Opin Otolaryngol Head Neck Surg* 2010;**18**:223–226.
7. Hefel L, Schwabegger A, Ninkovi M, et al. Internal mammary vessels: anatomical and clinical considerations. *Br J Plast Surg* 1995;**48**:527–532.
8. Murray AC, Rozen WM, Alonso-Burgos A, et al. The anatomy and variations of the internal thoracic (internal mammary) artery and implications in autologous breast reconstruction: clinical anatomical study and literature review. *Surg Radiol Anat* 2012;**34**:159–165.
9. Arnez ZM, Valdatta L, Tyler MP, et al. Anatomy of the internal mammary veins and their use in free TRAM flap breast reconstruction. *Br J Plast Surg* 1995;**48**:540–545.
10. Clark 3rd CP, Rohrich RJ, Copit S, et al. An anatomic study of the internal mammary veins: clinical implications for free-tissue-transfer breast reconstruction. *Plast Reconstr Surg* 1997;**99**:400–404.
11. Walker RJ, Parmar S, Praveen P, et al. Jejunal free flap for reconstruction of pharyngeal defects in patients with head and neck cancer-the Birmingham experience. *Br J Oral Maxillofac Surg* 2014;**52**:106–110.
12. Lee HS, Park SY, Jang HJ, et al. Free jejunal graft for esophageal reconstruction using end-to-side vascular anastomosis and extended pharyngo- jejunostomy. *Ann Thorac Surg* 2012;**93**:1850–1854.
13. Chia HL, Wong CH, Tan BK, et al. An algorithm for recipient vessel selection in microsurgical head and neck reconstruction. *J Reconstr Microsurg* 2011;**27**:47–56.
14. Shimizu F, Lin MP, Ellabban M, et al. Superficial temporal vessels as a reserve recipient site for microvascular head and neck reconstruction in vessel- depleted neck. *Ann Plast Surg* 2009;**62**:134–138.
15. Breik O, Praveen P, Parmar S. The vessel-depleted neck in head and neck microvascular reconstruction: extreme solutions for extreme situations. *Curr Opin Otolaryngol Head Neck Surg* 2020;**28**:129–135.
16. Urken ML, Vickery C, Weinberg H, et al. Geometry of the vascular pedicle in free tissue transfers to the head and neck. *Arch Otolaryngol Head Neck Surg* 1989;**115**:954–960.
17. Reissis M, Reissis D, Bottini GB, et al. A morphometric analysis of the suitability of the transverse cervical artery as a recipient artery in head and neck free flap microvascular reconstruction. *Surg Radiol Anat* 2018;**40**:891–897.
18. Aycock JK, Stenson KM, Gottlieb LJ. The thoracoacromial trunk: alternative recipient vessels in reoperative head and neck reconstructive microsurgery. *Plast Reconstr Surg* 2008;**121**:88–94.
19. Harris JR, Lueg E, Genden E, et al. The thoracoacromial/ cephalic vascular system for microvascular anastomoses in the vessel-depleted neck. *Arch Otolaryngol Head Neck Surg* 2002;**128**:319–323.
20. Rosko AJ, Ryan JT, Wizauer EJ, et al. Dorsal scapular artery as a recipient vessel in the vessel-depleted neck during free tissue transfer in head and neck reconstruction. *Head Neck* 2017;**39**:E72–E76.
21. Jacobson AS, Smith M, Urken ML. Internal mammary artery and vein as recipient vessels in head and neck reconstruction. *JAMA Otolaryngol Head Neck Surg* 2013;**139**:623–628.
22. Buck PM, Wax MK, Petrisor DI. Internal mammary vessels: alternate recipient vessels in microvascular head and neck reconstruction. *J Oral Maxillofac Surg* 1896;**2016**(74):e1–e6.
23. Schneider DS, McClain L, Robb Jr PK, et al. Use of internal mammary vessels in head and neck microvascular reconstruction. *Arch Otolaryngol Head Neck Surg* 2012;**138**:172–176.
24. Majumder S, Batchelor AG. Internal mammary vessels as recipients for free TRAM breast reconstruction: aesthetic and functional considerations. *Br J Plast Surg* 1999;**52**:286–289.
25. Brown JS, Barry C, Ho M, et al. A new classification for mandibular defects after oncological resection. *Lancet Oncol* 2016;**17**:e23–e30.
26. Ishikawa N, Watanabe G, Iino K, et al. Robotic internal thoracic artery harvesting. *Surg Today* 2007;**37**:944–946.
27. Robin J, Bompard D, Tronc F, et al. Bilateral internal thoracic artery harvesting under robotic video-assistance. *Surg Endosc* 2001;**15**:755–756.
28. Cao C, Indraratna P, Doyle M, et al. A systematic review on robotic coronary artery bypass graft surgery. *Ann Cardiothorac Surg* 2016;**5**:530–543.
29. Liao KK. Robotic coronary artery bypass grafting. Operative techniques in thoracic and cardiovascular surgery. *Operative Techniques in Thoracic and Cardiovascular Surgery* 2010;**15**:194–205.
30. Henriquez-Pino JA, Gomes WJ, Prates JC, et al. Surgical anatomy of the internal thoracic artery. *Ann Thorac Surg* 1997;**64**:1041–1045.