The British Association of Plastic Surgeons (2003) **56**, 684–688

ELSEVIER

BJPS
An International Journal of Surgical Reconstruction
www.bjps.com

The anatomical evaluation of internal mammary vessels using sonography and 2-dimensional computed tomography in Asians

Sanghoon Han[a], Sang Yup Yoon[b,*], Jeong Mi Park[c]

[a]*SU Plastic Surgery Clinic, 580-5, Shinsa-Dong, Gangnam-Gu, Seoul, South Korea*
[b]*Department of Plastic Surgery, Asan Medical Center, College of Medicine, University of Ulsan, 388-1, Pungnap-Dong, Songpa-Gu, Seoul 138-736, South Korea*
[c]*Department of Radiology, Asan Medical Center, College of Medicine, University of Ulsan, 388-1, Pungnap-Dong, Songpa-Gu, Seoul 138-736, South Korea*

Received 11 February 2003; accepted 8 July 2003

KEYWORDS
Anatomical evaluation; Internal mammary vessel; 2-Dimensional reconstructive computed tomography; Doppler ultrasound

Summary The aim of this study is to get anatomical information on internal mammary vessels in Asians. Cadaver study is very limited in our country due to sociocultural backgrounds. We used two dimensional reconstructive computed tomography (2DCT) and Doppler ultrasound for anatomic study. The branching patterns, level of bifurcation, size of vessels and distance from the sternal edge to the internal mammary vein (IMv) were measured. This study was performed in 60 breast cancer patients from May 1999 to May 2001. Patient's age ranged from 30 to 63 years (average 46). One artery and one vein on both sides were the most common types that were observed in 44 of 60 patients. The diameter of the internal mammary artery (average 2.1 mm) was constant but that of the IMv had a wide variation (ranged 0.8–4.8 mm). The distance from sternum to internal mammary artery gradually decreased as it passed caudally. Compared to Caucasians, in Asians, the cases of IMv bifurcation were fewer. The level of IMv bifurcation was higher than that of Caucasian. The level of choice for anastomosis was 3rd intercostal space in Asians due to their shorter chest. The combination of 2DCT and Doppler ultrasound provided us with a useful preoperative information as well as general anatomical data in Asians.

Introduction

The internal mammary vessels (IMV) are becoming more significant as recipient vessels in free flap breast reconstruction. So far, many anatomic reports of IMV are based on Caucasians[1–8] and very few on Asians. Arnez described the anatomy of 61 internal mammary vein (IMv) in the 3rd, 4th and 5th intercostal spaces in 34 fresh cadavers.[2] The report of Clark's fresh cadaver dye study was to determine the consistency of the anatomy of the IMV as a recipient vein.[3] Ninkovic's study was performed on 86 cadavers and 50 female patients and

*Corresponding author. Tel.: +82-2-3010-3604; fax: +82-2-476-7471.
E-mail address: pssurgeon@korea.com

S0007-1226/$ - see front matter © 2003 The British Association of Plastic Surgeons. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/S0007-1226(03)00360-6

volunteers by surgical dissection and color Doppler ultrasound (US).[4] Scatarige reported the use of computed tomography (CT) and US as means of investigations for assessment of IMV's architecture.[5] Glassberg described the distance between the IMV and the sternum by means of CT, in order to avoid sacrificing these vessels during percutaneous transthoracic procedures.[6] Also, Schwabegger reported a classification system containing categories based on the number of comitant veins at the cranial edge of the 4th rib.[7] We used Schwabegger's classification basically but slight modifications were made to fit our study. The reports on Asians are limited because cadaver dissection is not readily accepted in Korea. This present study was designed to compare Caucasians with Asians and discuss the usefulness of two dimensional reconstructive computed tomography (2DCT) and US as a preoperative study tools.

Patients and methods

From May 1999 to May 2001, 60 patients with breast cancer underwent anatomical study of IMV using 2DCT and US. Examinations were done mainly on the 2nd, 3rd, and 4th intercostal spaces. US verified the numbers and the location of IMa and IMv. 2DCT showed continuous image-branching patterns of IMv (Fig. 1).

For US, Ultramark 9 (ATL, Bothell, WA, USA) was applied and 5–10 MHz linear probe was used. IMVs were assessed in the 2nd, 3rd, 4th intercostal spaces in B-mode bilaterally and confirmed with color Doppler. Duplex pulsed Doppler differentiated between artery and vein. The sternomanubrial junction was marked on skin with US then 2DCT was performed (Fig. 2).

For CT, Somatom plus-S (Siemens Medical systems, Erlangen, Germany) was used. Bolus injection of 120 cc of contrast material (Iopamiro 2300, Bracco, Milano, Italy) was done with 2.5 cc sec^{-1} injection rate. Spiral CT was done with 3 mm collimation and 4 mm table speed (pitch 1.3). Scan delay time was 35 sec. The scanning area included 12 cm from sternomanubrial junction downward with FOV of 5, which is the maximal covering area with one breath-hold. Image reconstruction was done with 2 mm interval and we selected the best plane on which bilateral IMV were seen. Measurement was done for the size of vessel as well as evaluation of the branching patterns (Fig. 2).

Results

In every case, only one artery was present each side; there were never more than two veins. Our anatomical studies revealed that the IMa and IMv commonly have large caliber lumens, which are adequate for anastomosis. The distance from the sternum to IMa has some variation (range 3.8–11.5 mm). Because of the topographic variations of the IMv, we modified the Schwabegger' classification[8] based on vein distributions as shown in Fig. 2.

Type I (one artery and one vein on both sides) was found in 44 out of 60 cases. There were 12 cases of type II in which both veins were divided into two, therefore each side have one artery and two veins. In four of these 12 cases, both sides of the veins branched in 2nd intercostal space (ICS). And in six cases, the vein on the left side branched in 2nd ICS with the right side branching in 3rd ICS. In the remaining two case, both sides of the veins branched in 3rd ICS. In two women of type III the vein branched only on the right side and the level was 3rd ICS. There were two cases of Type IV in which the vein branched only on the left side in 4th ICS (Fig. 2).

The distance from the sternal edge to the IMa tended to become narrower as it goes caudally, ranging from 3.8 to 11.5 mm. (Table 1)

When a single vein was present, it ran medially to the artery without exception. The mean diameter of IMa was 2.1 mm and showed consistency, however, the vein showed variations and the average diameter of right side was larger than that of the left side (Rt: 3.37 mm $>$ Lt: 2.21 mm). The vein measurements ranged from 0.8 to 4.8 mm.

Discussion

Until now, veins of the axillary (subscapular) system, such as thoracodorsal vein, are most widely used as recipient vessels in breast reconstruction with free flaps.[3,7,9–14] But one disadvantage is damage to these vessels due to radiotherapy,[3,10,12–16] and these required long flap pedicles or even vein grafts for optimal flap positioning and vascular anastomosis. However, IMa and IMv are suitable as recipient vessels because they are centrally located and usually less affected by radiotherapy.[1]

Many anatomical studies were based upon postmortem examinations.[1,2,5] In Asia, cadaver study is restricted due to sociocultural backgrounds. So, we performed anatomical study on living patients by 2DCT and US. US have several merits in the

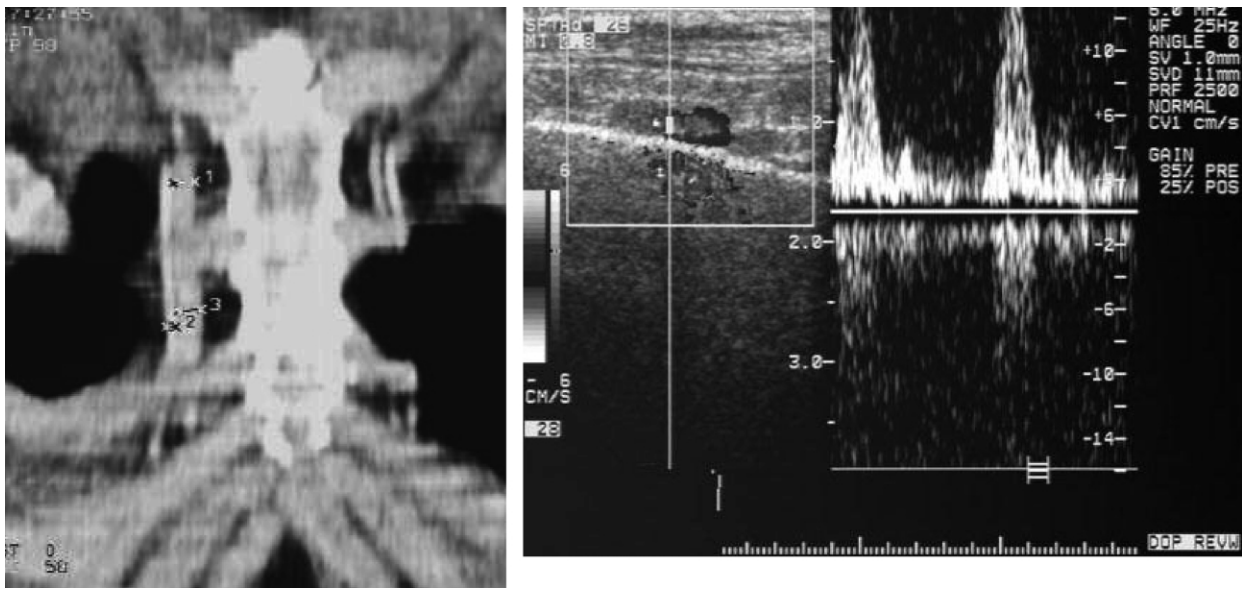

Fig. 1 2-Dimensional reconstructed computed tomography and Duplex Doppler sonography image for right internal mammary vessels in a patient. (Left) Coronal 2-dimensional computed tomography shows medially located larger right internal mammary vein (measurement 1, 3) and laterally located smaller internal mammary artery (measurement 2). Measurements were done in 2nd and 3rd intercostal spaces, respectively. Left internal mammary vessels are partially seen in 2nd and 4th intercostal spaces. (Right) Duplex Doppler sonography image shows right internal mammary vessels. Laterally located smaller vessel shows arterial flow.

assessment of vessel's diameter and differentiation between arteries and veins. 2DCT can provide the continuous branching image of vessels. Scatarige[5] and Glassberg[6] investigated the IMV architecture with the aid of CT as well as US scans by measuring the vessel diameter, but that their CT did not provided two-dimensional reconstructive views but one-dimensional horizontal images. So, we applied the 2DCT for more definitive images.

The similarity of this study with previous reports focused on Caucasians was that the diameter of the right vessel was larger than that of left vessel. In cases where the vein was bifurcated, the diameter was too small to use for anastomosis. Some veins showed diameters below 1.0 mm, which were too small to operate.

In Ninkovic's study,[4] only one artery and one vein (type I, newly calculated by us, Fig. 2) occured in 40%. In Clark's study[3], estimated frequency of type I was below 25%. In this study, the frequency of type I was 22 of 30 cases (Table 2). We found that type I constitute the greater proportion in Asians compared to those of previous studies (Table 2). Another difference is in the level of bifurcation of IMv. But in this study in 14 of 28 cases the vein bifurcated at the 2nd ICS, the frequency decreasing caudally. According to Clark's study,[3] the IMv bifurcated in only 15 percent (three of 20 cases) at the second rib interspace, the percentage increasing caudally. But in this study, in 14 of 28 cases, the vein bifurcated at the 2nd ICS was the frequency decreasing caudally. In comparison with Clark's report, the bifurcated vein level was found to be higher.

In this study, the mean diameter of the IMa was 1.78 mm, which was smaller than that of Ninkovic's measurements[4] of 1.84 mm at the cranial of the 4th rib cartilage. From our study, the mean diameter of IMa diameter in the 3rd ICS was 2.26 mm. Hefel[1] thought that anatomically the IMa and IMv(s) were suitable vessels for microsurgery at the level of the 4th rib. But our data on Asian suggested that the third rib interval would be an acceptable site for microsurgical anastomosis.[3] This may be related to

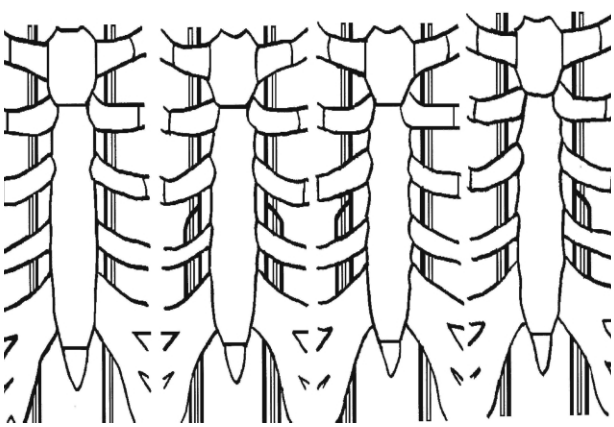

Fig. 2 Four patterns of internal mammary vessel anatomy according to Schwabegger's classification.

Table 1 The sizes of internal mammary vessels and distance from sternum to internal mammary vessels (average ± standard deviation)

Right				Left		
Artery	Vein	Distance[a]		Distance[a]	Vein	Artery
2.35 ± 0.80	3.53 ± 1.04	6.42 ± 2.23	2nd ICS[b]	7.45 ± 2.55	2.30 ± 0.72	2.07 ± 0.56
2.60 ± 0.68	3.09 ± 0.91	6.30 ± 2.41	3rd ICS[b]	6.50 ± 2.51	1.85 ± 0.73	1.91 ± 0.52
1.79 ± 0.44	2.59 ± 0.85	4.87 ± 3.34	4th ICS[b]	6.33 ± 2.84	1.70 ± 0.57	1.76 ± 0.40

[a] Distance from the sternal edge to internal mammary vessel.
[b] Intercostal space.

the short chest of Asians. The mean height of evaluated Asians in this present study was 156 cm.

Branching pattern and adequacy of vein size are important factors providing useful information on availability of vessels and appropriate level for anastomosis. The frequent appearance of two comitant veins on both sides might offer the chance to make two vein anastomoses in order to reduce venous congestion. A small vein is inappropriate because of difficulty for anastomosis. But bifurcation sites of vessels tend to be greater in diameter, which is suitable for easier anastomosis.

The author operated on 20 of the patients who were included in this study. Direct measurements of vessel parameters such as diameter, obtained during operations were found to be consistent with those results evaluated preoperatively by means of 2DCT and US. But in one patient, a 0.15 mm small adjacent vein, which ran parallel to the IMv, was not detected preoperatively by our method. All the flaps in the ten patients survived excellently and no reoperation for vascular revision was needed.

From the result of our measurements, we conclude that Asian women tend to possess lesser bifurcation rate and higher level of bifurcation. Direct intraoperative measurement was found to be consistent with preoperative evaluations. Fair objective images of the continuity and the branching configurations of IMV can be obtained for preoperative evaluation, which is useful in confirming the integrity of these vessels before planning of free flap operation.

Table 2 The comparison of the type based on bifurcated level between Caucasian and Asian

	Ninkovic's[a] ($n = 136$)	Han[b] ($n = 60$)
Type I (both, one artery and one vein)	40	73
Type II (both, one artery and two veins)	27	20
Type III (only right one artery and two veins)	9	3.5
Type IV (only left one artery and two veins)	21	3.5

[a] Sixth reference, newly calculated data.
[b] Author.

References

1. Hefel L, Schwabegger AH, Ninkovic MM, Wechselberger G, Moriggl B, Waldenberger P, Anderl H. Internal mammary vessels: anatomical and clinical considerations. *Br J Plast Surg* 1995;**48**:527–32.
2. Arnez ZM, Valdatta L, Tyler MP, Planisek F. Anatomy of the internal mammary veins and their use in free TRAM flap breast reconstruction. *Br J Plast Surg* 1995;**48**:540–5.
3. Clark III CP, Rohrich RJ, Copit S, Pittman E, Robinson J. An anatomic study of the internal mammary veins: clinical implications for free-tissue-transfer beast reconstruction. *Plast Reconstr Surg* 1997;**99**:400–4.
4. Ninkovic MM, Schwabegger AH, Anderl H. Internal mammary vessels as a recipient site. *Clin Plast Surg* 1998;**25**:213–21.
5. Scatarige JC, Hamper UM, Sheth S, Alen III HA. Parasternal sonography of the internal mammary vessels: technique, normal anatomy, and lymphadenopathy. *Radiology* 1989; **172**:453–7.
6. Glassberg RM, Sussman SK, Glickstein MF. CT anatomy of the internal mammary vessels: Importance in planning percutaneous transthoracic procedures. *Am J Roentgen* 1990;**155**: 397–400.
7. Schwabegger AH, Ninkovic MM, Moriggl B, Waldenberger P, Brenner E, Wechselberger G, Anderl H. Internal mammary veins: classification and surgical use in free-tissue transfer. *J Reconstr Microsurg* 1997;**13**:17–23.
8. Feng LJ. Recipient vessels in free-flap breast reconstruction: a study of the internal mammary and thoracodorsal vessels. *Plast Reconstr Surg* 1997;**99**:405–16.
9. Harashina T, Imai T, Nakajima H, Fujino T. Breast reconstruction with microsurgical free composite tissue transplantation. *Br J Plast Surg* 1980;**33**:30–7.
10. Arnez ZM, Bajec J, Bardsley FA. Experience with 50 free TRAM flap breast reconstruction. *Plast Reconstr Surg* 1991; **87**:470–82.
11. Shaw WW. Breast reconstruction by superior gluteal microvascular free flaps without silicone implants. *Plast Reconstr Surg* 1983;**72**:490–9.
12. Arnez ZM, Smith RW, Eder E, Solinc M, Kersnic M. Breast reconstruction by the free lower transverse rectus abdominis musculocutaneous flap. *Br J Plast Surg* 1988;**41**:500–5.

13. Arnez ZM, Scamp T. The bipedicled free TRAM flap. *Br J Plast Surg* 1992;**45**:214—8.
14. Holmstrom H. The free abdominoplasty flap and its use in breast reconstruction. *Scand J Plast Surg* 1979;**13**:423—7.
15. Paletta EC, Bostwick III J, Nahai F. The inferior gluteal free flap in breast reconstruction. *Plast Reconstr Surg* 1989;**84**: 875—85.
16. De Mey A, Lejour M, Declety A, Meythiaz AM. Late results and current indications of latissimus dorsi breast reconstruction. *Br J Plast Surg* 1991;**44**:1—4.