Mapping of first perforator of thoracodorsal artery using hand-held Doppler and colour Doppler Ultrasound

[1]Joshua D Choji, [2*]Christopher Y Karago, [3]Anthony E Gabkwet, [4]Simon J Yiltok

Abstract

Background: The first perforator of the thoracodorsal artery is the largest and most reliable for the survival of the thoracodorsal artery perforator flap. Given the variation in the position of perforators, a reliable method for the precise identification of the pertinent perforator that would sustain the circulation to the flap would be extremely `valuable.

Methods: This was a comparative cross-sectional study. The Plastic Surgeon used the hand-held Doppler (HHD) to assess for perforator(s) outside the circle 1.5 cm centred on the first perforator point. The procedure was then repeated by a radiologist using the colour Doppler ultrasound (CDU).

The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 20. Statistical significance was determined using a dependent (paired) sample t-test. All tests with a p-value of less than 0.05 were considered significant.

Results: A total of 70 patients were recruited for the study. The age range was 18 to 65 years with a mean of 31.77 years ±11.72 years .There were 58 males (82.9%) and 12 females (17.1%) with a male-to-female ratio of 4.8:1.

Overall, comparing the two ultrasound modalities in mapping perforators outside the first perforator point, HHD = 9.3% and CDU = 10%. The CDU ($M = 0.20$, $SD = 0.40$) identified more perforators than HHD ($M = 0.19$, $SD = 0.39$) but was not statistically significant $t(69) = -1.000$, $p = 0.32$.

Conclusion: Both HHD and CDU showed variations in the location of the first perforator point. The location and suitability of the perforators may be determined with the CDU, while the HHD may then be used for monitor during surgery.

Keywords: mapping ,first perforator of thoracodorsal artery, hand-held, colour Doppler ultrasound

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Introduction

Thoracodorsal artery perforator (TAP) flap is versatile in its indications and provides large and thin skin paddle, as pedicled or free flap, for reconstruction of soft tissue defects in any part of the body.[1,2,3] The detailed knowledge of vascular anatomy of cutaneous perforators is of vital importance for the design and successful elevation of perforator flaps.[4] The thoracodorsal vessels most commonly divide into two primary muscular branches: the transverse branch, and the vertical (lateral or descending) branch. A perforator or combination of perforators of the distal main thoracodorsal and/or its lateral branch constitute the vascular supply of the TAP flap.[5] The dominant cutaneous perforators in the body are highly variable in position between persons, and asymmetric even for the same individual [6,7].

Hamdi et al[8] stated that thoracodorsal artery perforator flap with dimensions of up to 30 x 11 cm could be harvested based on one perforator. Also, Blondeel et al.[9] demonstrated that flaps with dimensions of up to 25 x 15 cm may be safely elevated on a single perforator and an average flap size of 20 x 8 cm has been described. The key element in predicting the survival of any cutaneous flap is the nature of the blood supply that is included. When designing a TAP flap the first perforator of the lateral or the descending branch should be included because it is the largest, most reliable and consistent.[3,10] Thus, a reliable method for the precise identification of the pertinent perforator that would sustain the circulation to the selected flap would be extremely valuable.[7]

The thoracodorsal artery gives off two to three cutaneous perforators. The first perforator exits the latissimus dorsi muscle into the subcutaneous tissue approximately 8 cm below the posterior axillary fold and 2 cm medial to the lateral border of the latissimus dorsi muscle. The second perforator arises 2 to 4 cm distal to the origin of the first perforator, and the third 2 to 4 cm from the take-off of the second perforator.[11] Angrigiani et al.[11] who dissected 40 fresh cadavers injected with coloured latex demonstrated that perforators were consistently found at the first perforator point in all subjects (100%). However, Lin et al.[3] compared their findings in 10 patients with anatomical landmarks presented by Angrigiani[11] and others. In five of the 10 patients they assessed, skin perforators were not found in the 3 cm diameter circle centred on the first landmark. The uncertainty of TAP-related landmarks has led to the need for a diagnostic modality to detect TAP perforators.[12] The hand-held Doppler (HHD) is a useful tool in the preoperative evaluation of these flaps. Though the colour Doppler ultrasound (CDU) provides more

[1]Department of Surgery, Jos University Teaching Hospital, Jos, Nigeria [2]Department of Plastic Surgery, Prince Mishari bin Saud Hospital, Baljurashi, Bahah Region, Kingdom of Saudi Arabia.[3]Department of Radiology, College of Health Sciences, University of Jos/Jos University Teaching Hospital, Jos, Nigeria.[4]Deparment of Surgery, College of Health Sciences, University of Jos/Jos University Teaching Hospital, Jos Nigeria. *Formerly of the Jos University Teaching Hospital, Jos .

All correspondences to:
Dr Joshua D. Choji,
Email: joshuachoji55@gmail.com

information ,but less portable ,and adds accuracy in planning perforator flaps ,especially in elective surgery,[13] the HHD is cheaper, easy to use, portable and available in low-resource settings.[14] It is imperative to compare HHD and CDU in the mapping of the first perforator of the thoracodorsal artery. This will aid in better planning and execution of reconstructive procedures using the TAP flap. The study aimed to map out the first perforator of the thoracodorsal artery to determine the prevalence of perforators outside a circle, 1.5 cm in radius, centred on the first perforator point using HHD and CDU.

Methods

Study design

This was a comparative cross-sectional study that used HHD and CDU to map out the first perforators of the thoracodorsal artery, and the prevalence of the perforators outside the first perforator point was determined among the study population.

Study location

The study was carried out in the Jos University Teaching Hospital (JUTH) located in Lamingo, Jos-North Local Government Area of Plateau State. It's a 600-bed capacity tertiary health institution and 187 beds are for surgery.

Study population

The subjects of the study were patients of JUTH. The research was conducted among the adult Nigerian population.

Sample size

The G*Power version 3.1.9.2 statistical power analysis programme[15] was used to calculate the minimum sample size. The following input parameters were used: The applicable test for the study is a t-test and the appropriate one selected for this study was the difference between two dependent means (Matched pairs)

Tails = two

Effect size = 0.5

Alpha level = 0.05

β error = 20% (0.20): the minimum acceptable probability for type 2 error

Power (1−β) ≥ 80% (0.80)

The minimum sample size was calculated as = 34 persons. In an attempt to increase the precision of estimation for the results obtained. The minimum sample size was then multiplied by two; 34x2 = 68 and rounded up to 70 persons.[16]

Inclusion criteria

Adult outpatients, between 18 to 65 years, attending clinics in JUTH

Patients that have not had surgery previously in the lateral thoracic area

Patients with no documented regional or systemic vascular anomalies

Exclusion criteria

Patients with major trauma to the lateral thoracic area

Presence of infection or ulcer at or around the lateral thoracic area

Data Collection

The participants were selected by consecutive sampling methods until a sample number of 70 was reached. The sample frame consisted of all the adult patients attending outpatient clinics in JUTH. Considering the adult outpatient clinics as clusters, the general outpatient department clinic was selected by random sampling technique. Informed consent was obtained from persons who presented to the clinic. Those who consented and met the inclusion criteria were recruited and filled out the questionnaires.

The Plastic Surgeon then examined the lateral thoracic areas for obvious scars, deformities or ulcers. For the patients that met the criteria, their weight and height were taken and recorded. They were then taken to the ultrasound room and made to lie down on a couch in lateral decubitus position, with the ipsilateral arm at ninety degrees (90°) abduction and the elbow flexed. The lateral border of the (Latissimus dorsi) LD muscle was palpated and marked on the overlying skin with a temporary marker .The first perforator point; 8 cm distal to posterior axillary fold and 2 cm medial to the lateral border of the LD muscle was marked. A compass was used and a circle 1.5 cm in radius was centred on this point. The Plastic Surgeon then used a Huntleigh hand-held Doppler model MD2, 8MHz (HHD), (Figure 1) to assess for perforators within the circle. The HHD was also used to assess for any perforator(s) outside the circle centred on the first perforator point, to the medial and lateral sides when the perforator was absent within the circle. The procedure was then repeated by a radiologist using a colour Doppler ultrasound GE model Logiq V5 (CDU), (Figure 2) at the same points as below (Figure 3). The procedure was also carried out on the contralateral sides as they met the inclusion criteria. Thus, the total number of lateral thoracic areas that were assessed, was 140.

Ethical Considerations

Informed consent was sought from all individuals that met the inclusion criteria. The authors certify that the necessary and appropriate consent was obtained from the patients to publish their clinical information and

images. The patients were made to understand their names and initials will not be published and all efforts will be made to conceal their identity. However, anonymity cannot be completely guaranteed.

Ethical clearance/approval was obtained from the ethics committee of Jos University Teaching Hospital JUTH.

Data analysis

After attaining the calculated sample size, the data was analysed, with the help of a statistician using the computer package, Statistical Package for Social Sciences (SPSS) version 20. The data was presented in tables and statistical significance was determined using a dependent (paired) sample t-test. All tests with p value less than 0.05 were considered significant.

Results

Age and sex distribution of the study

A total of 70 patients were recruited for the study. The age range was 18 to 65 years with a mean of 31.77 years ± 11.72 years .The number of subjects in the age group 18 - 20 was 10 (14.3%), age group 21 - 30 was 31 (44.3%) which had the highest number of patients ,age group 31 - 40 was 13 (18.6%), age group 41 - 50 was 10 (14.3%), and 51 - 65 was six (8.6%) which was the lowest. The demographic distribution for gender was as follows: there were 58 males (82.9%) and 12 females (17.1%) with a male to female ratio of 4.8:1.

Table 1: Prevalence of perforators outside a circle 1.5 cm in radius centred on the right first perforator point.

Point	Frequency	Percentage
Right(HHD)		
0	59	84.3
1	11	15.7
Total	70	100.0
Right(CDU)		
0	58	82.9
1	12	17.1
Total	70	100.0

Perforators outside a circle 1.5 cm in radius centred on the first perforator point.

The prevalence of perforators identified by HHD and CDU outside a circle 1.5 cm in radius centred on the first perforator point are as shown in the tables below. On the right, HHD picked perforators in 11(15.7%) patients, while CDU picked in 12 (17.1%) patients. (Table 1) On the left, each modality identified perforators in 2 patients (2.9%). (Table 2) The overall (both right and left) average for HHD = 9.3% and that of CDU =10%.

Table 2: Prevalence of perforators outside a circle 1.5 cm in radius centred on the left first perforator point.

Point	Frequency	Percentage
Left(HHD)		
0	68	97.1
1	2	2.9
Total	70	100.0
Left (CDU)		
0	68	97.1
1	2	2.9
Total	70	100.0

Figure 1: Hand-held Doppler

Overall (both right and left thoracic areas), comparing the two ultrasound modalities in mapping perforators outside a circle 1.5 cm in radius centred on the first perforator point, the CDU (M = 0.20, SD = 0.40) identified more perforators than HHD (M = 0.19, SD = 0.39) but was not statistically significant $t(69) = -1.000$, p = 0.32.

Figure 2: Colour Doppler Ultrasound

Discussion

Carl Manchot,[17] in 1889, published his work on the human cutaneous blood supply. He provided a detailed mapping of the cutaneous vascular territories of the entire human body. However, the concept of axial flaps was developed later in the 1970s.[18] The publication on latissimus dorsi musculocutaneous flap without muscle by Angrigiani et al.[11] in 1995 was the first TAP flap. Thoracodorsal artery perforators (TAPs) originate from the lateral or descending branch of the thoracodorsal artery, which travels along the lateral edge of the LD. The most proximal perforator is called the first perforator. The first perforator is reportedly routinely observed and reliable, owing to its thick diameter of 0.5 mm.[12] The anatomical basis of the TAP flap has been well described in the literature by cadaveric studies,[11, 19] in vivo descriptions[3], and by Doppler studies[12] with different findings .This study used the HHD and CDU in mapping the first perforator of the thoracodorsal artery to determine the prevalence of perforators outside a circle, 1.5 cm in radius, centred on the first perforator point.

The overall prevalence of perforators outside the circle for HHD was 9.3% which was a little lower when compared with CDU which was 10%. Overall (both right and left thoracic areas), comparing the two ultrasound modalities in mapping the first perforator, the CDU (M = 0.20, *SD* = 0.40) identified more perforators than HHD (M = 0.19, *SD* = 0.39) but was not statistically significant t(69) = - 1.000, *p* = 0.32.

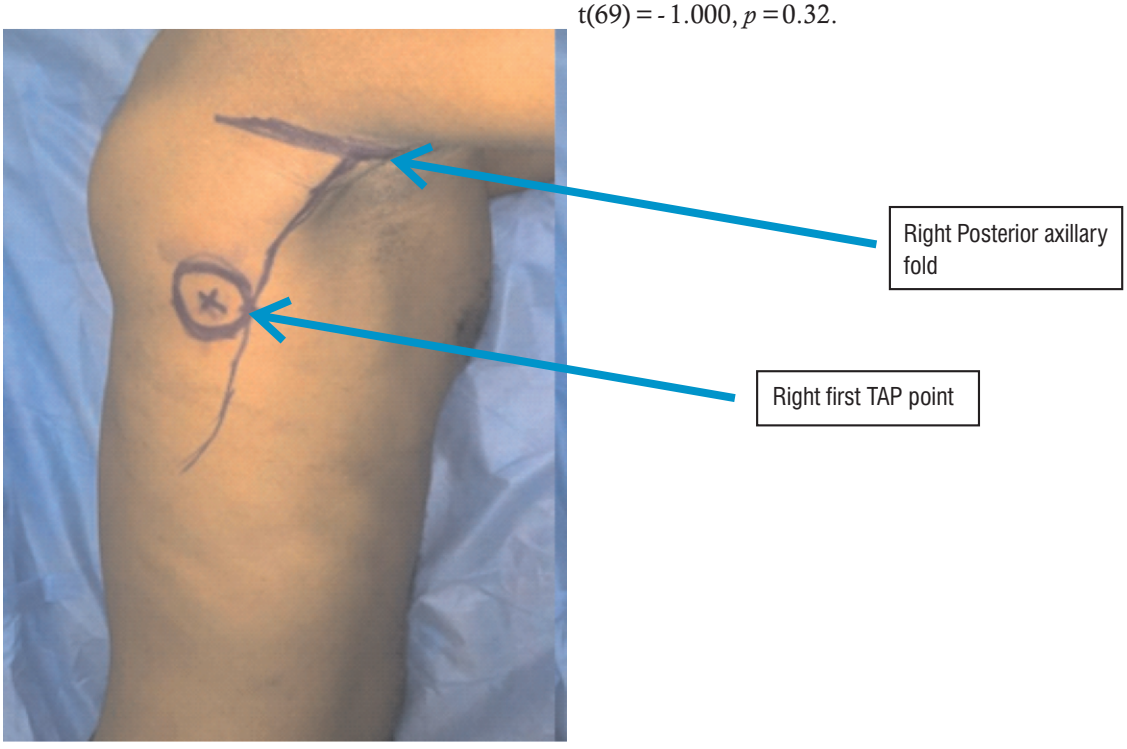

Figure 3: first perforator point of thoracodorsal artery: 8 cm distal to posterior axillary fold and 2 cm medial to the lateral border of the LD muscle

Findings in this study were less than that of Guerra et al.[10] at New Orleans , La who worked on 20 non-fresh cadavers and reported that in 15.0% of the subjects, perforators were not found within the circle, while in 85.0% of the subjects , perforators were found within the circle. The variation may be attributed to the fact that cadaver dissection with direct visualisation of perforators is more accurate than with ultrasound. Also, Lin et al.[3] in Taiwan performed 10 TAP flaps over a period of one year. They used TAP landmarks described by Angrigiani et al.[11] and Heitmann et al.[20] in mapping of perforators preoperatively and compared with intraoperative findings. They reported a higher proportion of patients (50%) had skin perforators outside the circle 3 cm in diameter, centred on the first anatomical landmark, compared to ours of 9.3% for HHD and 10% for CDU, and that only one skin perforator could be identified in the circle in each of the other five patients. The higher value may have been possibly due to the small sample size or the live surgery which was expected to give a more accurate idea of the position of the perforators. It could also have been due to the assertion by Hallock[7] that perforators are highly variable between persons and asymmetric even for the same individual .

Similarly, the observed result in our study was at variance with that of Angrigiani et al.[11] who dissected 40 fresh cadavers injected with coloured latex and demonstrated that perforators were consistently found at the first perforator point in all subjects (100%). This is likely due to the higher accuracy of dissection , compared to ultrasound for the identification of perforators in this work. In addition, the use of coloured latex could have also enhanced the identification.

The clinical implication of the variation in the first perforator position is that more time may be spent searching for the perforator and may necessitate modification of the flap design. This is because the first perforator is the largest and most reliable, and should almost always be included in the flap design.

The limitations of the study was that ultrasound examination was operator-dependent, and the researcher was expected to have some knowledge and familiarity with skin perforators. Also the study was limited to scanning modalities. Comparison of the results with intraoperative findings to verify the diagnostic accuracy of the modalities by establishing true perforator points would have probably improved the results.

Conclusion

Both HHD and CDU showed variations in location of the first perforator point but was not statistically significant. The location and suitability of the perforators may be determined with the CDU, while the HHD may then be used to map out perforators preoperatively and to monitor during surgery this may reduce time spent searching for the perforator and avoid unnecessary modification of the flap design intraoperatively.

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