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Diagnostic Accuracy of Peroperative Color Doppler Ultrasonography for Determining the Nature of Anterolateral Thigh Flap Perforators

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ABSTRACT

Objective: To determine the diagnostic accuracy of color Doppler ultrasonography for diagnosing the septocutaneous nature of anterolateral thigh flap perforators, taking peroperative findings as the gold standard among patients undergoing soft tissue reconstruction.

Methodology: A total of 100 patients undergoing soft tissue reconstruction using antero-lateral thigh flap perforators at the plastic surgery unit, Pak Italian Modern Burn Center, Multan from January 2018 to December 2020. Information regarding their demographic data was noted in the proforma. A high frequency color Doppler ultrasound was done by the consultant radiologist to determine the nature of the perforator as per operational definition. The anterolateral thigh thin flap was undermined, but kept in situ. The elevation was performed either on the superficial or sub-facial plane depending upon the situation and surgical plan, and the points of emergence through the deep fascia and nature of its perforators, as they appeared during surgery. All Data was entered and analyzed using SPSS version 24.0.

Results: Age distribution of the patients was done, it showed that out of 100 patients, 17 %(n=17) were in age group of 15-27 years and 83%(n=83) were in age group of 28-40 years and mean age was calculated as 33.96±5.72 years. Gender distribution of the patients was done. It showed that 88 %(n=88) were male whereas 12% (n=12) were females. In this study, the sensitivity and specificity of the septocutaneous nature of perforator was 78.41% and 83.33% respectively, and PPV was 97.18% and NPV was 34.48% and accuracy was 79%.

Conclusion: Color doppler ultrasonography is a reliable test for predicting the nature of the anterolateral thigh flap perforator.

Keywords: Color doppler ultrasonography, Anterolateral thigh flap, per-operative finding.

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Introduction

The Anterolateral Thigh (ALT) flap has grown in favor for all types of reconstructions, owing to its low donor site morbidity.[1] However, the variable nature and position of its perforator vessels makes it difficult to employ in surgical procedures.[2] Additionally, the thickness of its adipose under skin tissue may be incompatible with some reconstructions that require thinner, more flexible paddles. As a result, depending on the position of the perforators, surgeons prefer to harvest the flap in the superficial fascia plane or sub facial plane, which elevates an immediately thin skin paddle and makes locating and dissecting the perforator veins in these superficial layers even more difficult.[3] As a result, anticipating the nature, placement, and path of the perforators is critical for optimizing this technique. In one study, 4 (10.5%) of 38 anterolateral flaps were elevated as septocutaneous flaps.[7,8]

Color Doppler ultrasonography is a preoperative imaging modality that is among the safest among radiological modalities. It can aid in surgical planning by providing information about perforators, optimizing flap shape and elevation, and selecting the harvest site for each patient.[9]

Studies have shown that it can be utilized to obtain accurate preoperative information on the size and position of perforators.[10] However, there is limited evidence on its application in determining the perforator's type. For detecting nature and an intramuscular perforator component, a study found a sensitivity of 84 percent, specificity of 100 percent, positive predictive value of 100 percent, and negative predictive value of 79 percent.[6] However, there is no additional local or international research in this area.

The rationale of this study is to determine the diagnostic accuracy of color Doppler ultrasound in determining the nature of anterolateral thigh flap perforators among patients undergoing soft tissue reconstruction. Determination of nature and course of perforators is very crucial in the surgery using anterolateral thigh flap and a diagnostic aid can make surgeons work easier. Color Doppler ultrasound is a non-invasive and relatively safe technique that can be used to assess the perforators. However, the dearth of literature regarding its use in the determination of nature of perforators warrants a study. Thus, this study will provide further information to the surgeon regarding the role of color Doppler ultrasound so that evidence based management can be done to improve outcomes in these patients.

Methodology

This cross-sectional study was conducted at the Pak Italian Modern Burn Center, Multan, from January 2018 to December 2020. We included patients of both genders aged 15 to 40 years requiring soft tissue reconstruction by anterolateral thigh flap. Our exclusion criteria was extensive scarring on Thigh. The sample size was calculated by using the results of the previous study by Kuo et al.[7] A sample size of 100 cases was calculated with a 95% confidence level, using the expected percentage of septocutaneous flaps as 10.5%, sensitivity of 84% with a margin of error of 5%, and specificity of 100% with a margin of error of 5% for colour Doppler ultrasonography for detecting the nature of anterolateral thigh flap perforators. We adopted Non-probability consecutive sampling. The ethical approval was taken from the IRB Nishtar Medical College Multan. 100 patients undergoing soft tissue reconstruction using antero-lateral thigh flap perforators at plastic surgery unit, Pak Italian Modern Burn and Plastic Surgery Centre Nishtar Hospital, Multan, and fulfilled the selection criteria were approached. Informed consent was obtained from the patients before enrolling in the study. Information regarding their demographic data was noted in the proforma. A high frequency color Doppler ultrasound was done by the consultant radiologist to determine the nature of the perforator and the results were noted in the proforma. The anterolateral thigh thin flap was undermined, but kept in situ. The elevation was performed either on superficial or sub-facial plane depending upon the situation and surgical plan, and the points of emergence through the deep fascia and nature of its perforators, as they appeared during surgery, was noted in the proforma. The confidentiality of the data was ensured. Data was entered and analyzed using SPSS version 24.0. Mean and standard deviation were calculated for quantitative variables, i.e. age. Frequency and percentage were calculated for qualitative variables i.e. gender, presence of septocutaneous and nature of perforators on color Doppler ultrasound and peroperative findings. To control for effect modifiers, data was stratified by age, gender, and flap size, and the chi-square test was used after stratification, with p 0.05 considered statistically significant. Frequency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of color Doppler ultrasonography in detecting the septocutaneous nature of the perforators, taking peroperative findings as the gold standard as follows:

Type of test		Gold standard	
		Positive	Negative
Screening test	Positive	True positive (TP)	False positive (FP)
	Negative	False negative (FN)	True negative (TN)

Sensitivity = TP/ TP+ FN
Specificity = TN/ FP+TN
PPV = TP/ TP+FP
NPV = TN/ FN+TN

Results

Total of 100 patients fulfilling the inclusion and exclusion criteria were selected to assess the diagnostic accuracy of color Doppler ultrasonography for diagnosing the septocutaneous nature of anterolateral thigh flap perforators taking peroperative findings as gold standard among patients undergoing soft tissue reconstruction. Demographic characteristics and other parameters of the patients are summarized in Table I. The distribution of the presence of septocutaneous was done which was 33% (n=33). The frequency of nature of the perforator on color doppler ultrasonography was 88 %(n=88) and on per-operative findings was 71%(n=71).

In this study, sensitivity and specifity of septocutaneous nature of perforator was 78.41% and 83.33% respectively and PPV was 97.18% and NPV was 34.48% and accuracy was 79%. (Table II)

Table No I: Demographics and other characteristics (n=100)

	No of cases(n=100)	%age
Gender of patient		
Male	88	88
Female	12	12
Age range		
15-27 years	17	17 %
28-40 years	83	83%
Distribution of presence of septocutaneous		
Yes	33	33 %
No	67	67%
Nature of perforator on color doppler ultrasonography		
Yes	88	88.0
No	12	12.0
Nature of perforator on per-operative findings		
Yes	71	71.0
No	29	29.0

Table II: Diagnostic accuracy of color Doppler ultrasonography for detection of septocutaneous nature of perforator taking per-operative findings as gold standard

		Nature of perforator on peroperative		Total
		Yes	No	
Nature of perforator on color Doppler ultrasonography	Yes	69	19	88
	No	2	10	12

- Sensitivity: 97.18% a/a+c × 100
- Specificity: 34.48% d/d+b × 100
- Positive predictive value: 78.41`% a/a+b × 100
- Negative predictive value: 83.33% d/c+d × 100
- Accuracy: 79% a+d/ a+d+b+c × 100

Discussion

Head and neck reconstructive surgery has been transformed by microsurgical free-tissue transfer. Due to the availability of single-stage reconstructive options for most abnormalities, reconstructive oncological surgeons now have more freedom to execute radical tumor resections.[10-11] Patients with locally advanced or recurring disease, who were previously thought to be inoperable, can now be considered candidates for surgical treatment. [9, 11, 12] Among reconstructive surgeons, the Anterolateral Thigh (ALT) flap is a common choice.[13] The Anterolateral Thigh (ALT) flap is supplied by septocutaneous arteries arising from the descending branch of the lateral circumflex femoral artery, according to Song et al.[14] Because of its superficial and septocutaneous course, the harvest of anterolateral thigh flaps based on the proximal perforator is relatively simple and rapid, but the harvest of flaps based on the middle perforator is quite difficult and time consuming because to its musculo-cutaneous course and greater risk of problems. Handheld Doppler and colour Doppler ultrasonography (CDU) are the tools, which plastic and reconstructive surgeons employ to identify and locate perforators and design flaps for reconstruction.[15,16,17]

Preoperative mapping of perforators is also performed by angiography.[18] Angiography is an invasive nature of procedure and not without hazards. Handheld doppler is widely used to mark perforators before surgery. The handheld Doppler is commonly used to identify perforators.[19,20,21] Color Doppler ultrasonography, on the other hand, has an advantage over handheld Doppler in terms of detecting perforating arteries of the anterolateral thigh because it is more exact and dependable.[22,23] The perforator passage through the fascia can also be detected with colour Doppler ultrasonography, which is impossible with a handheld Doppler. In comparison to the handheld Doppler, colour Doppler ultrasonography identifies more cutaneous perforators. Furthermore, the handheld doppler mistakenly identified feeding vessels as perforators in certain cases. Handheld Doppler's have been shown to detect feeding vessels incorrectly by several researches.[25] The age distribution of the patients was determined to be 17 percent (n=17) in the 15-27 year age group and 83 percent (n=83) in the 28-40 year age group, with a mean age of 33.96 +5.72 years. The gender distribution of the patients was determined to be 88 percent male (n=88) and 12 percent female (n=12). PPV was 97.18 percent, NPV was 34.48 percent, and accuracy was 79 percent. The septocutaneous nature of the perforator was detected with 78.41 percent sensitivity and 83.33 percent specificity.

According to research conducted by Husnain Khan, the proximal perforator was consistently present as determined by Doppler in 85 percent of patients, indicating that 85 percent of patients have an AP over AK ratio of less than 0.45.[24] It is higher than 64% and 49% discovered by Kamita et al.[26] and Yu et al,[27] respectively. When Khan H[24] compared gender to the consistent presence of the proximal perforator by Doppler, he found that there was no significant difference, indicating that Doppler is effective in ruling out the effect of gender. However, per operative findings were quite different, with a trend of more non-consistency in females. We can

readily utilize this variable to determine the presence of the proximal perforator of the anterolateral thigh flap in all age groups because mean age had no effect.

Hu et al.[28] recently published a case report that illustrated the need to precisely measure the length of the ALT flap pedicle for effective surgical planning. As those authors shown, thorough preoperative evaluation can help minimize the necessity for later vascular grafting to prolong the pedicle, which is a complex and dangerous treatment. Furthermore, precisely establishing the pedicle length before to surgery would limit the requirement for pedicle-lengthening surgery to emergency scenarios or cases when no other method of repair is available. According to color Doppler ultrasonography is a good technique for evaluating the pedicle, according to a study by uczewski. In their work revealing the exact architecture of the vascular pedicle of ALT, Wong et al. confirmed that there are two variations of anatomical vascularization of the ALT lobe. The descending branch of the femoral artery supplies most blood; however, in a smaller percentage of cases, the oblique branch of the circumflex artery supplies the blood.[28,29,30]

The musculocutaneous perforators must be carefully dissected into the underlying muscle to elevate the ALT flap. Another problem with the flap is its variability in the position and size of the perforator vessels.[6,7] We used colour Doppler ultrasound to find the cutaneous perforators preoperatively to overcome these anatomic variances and make flap harvesting easier and safer.[4]

According to several researchers, colour Doppler ultrasound and computed tomography (CT) are the most commonly used imaging techniques for perforator vascular exams, and numerous circumstances can influence the outcome of colour Doppler ultrasound, resulting in some false-positives and false-negatives in the measurement. colour Doppler ultrasonography is used to examine the ALT flap perforator vessels and concluded that colour Doppler ultrasound was considerably more accurate than handheld Doppler in assessing the ALT flap perforator vessels. Color Doppler ultrasonography, on the other hand, is mostly used to identify whether there are perforator vessels and to find the spot where the perforator vessels enter the skin. A septocutaneous perforator and a myocutaneous perforator are not distinguishable.[4] If the perforator vessel could be detected before surgery using a colour Doppler ultrasonography, donor sites may be altered if necessary, and surgery time, risk, and cost could be reduced. Color Doppler ultrasound can be used to identify the supplying vessel on the body surface, measure the elevation of the ALT flap, and rule out the possibility of vascular variation or absence. The ALT flap is defined as either a musculocutaneous perforator flap or a septocutaneous perforator flap, and its perforators have anatomic diversity, which can make it difficult to employ. The most common is the musculocutaneous perforator flap, which frequently necessitates transmuscular pedicle dissection and so takes a lengthy period. Furthermore, the flap can be harvested without the use of perforators. It can be difficult to tell whether the descending branch of the lateral femoral circumflex artery supplies the flap. When the tiny capillary perforators are inspected with colour Doppler ultrasound, it is much easier. The amount of time required is reduced, and the success rate of harvesting flaps is significantly raised.[4]

Tong XJ[29] used colour Doppler ultrasound to determine the course and diameter of the ALT perforators prior to flap elevation in a study. Using colour Doppler ultrasound to identify the perforators of the ALT flap before surgery was quite accurate. They discovered that none of the flaps required a change in the donor location after elevating them. According to the findings, colour Doppler ultrasound was useful in evaluating the perforator vessels of the ALT flap and creating the surgical incision, making the process easier and faster for the surgeons. Yet, the technology has some false-negatives and false-positives. However, depending on the results of the colour Doppler ultrasound, find a useful perforator vessel during the operation.

Conclusion

In this study, we found the diagnostic accuracy of color Doppler ultrasonography for diagnosing the septocutaneous nature of anterolateral thigh flap perforators, taking peroperative findings as the gold standard among patients undergoing soft tissue reconstruction. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of color doppler ultrasonography was 78.41%, 83.33%, 97.18%, 34.48% and 79%. Color Doppler ultrasonography is the most reliable test for the prediction of the nature of the anterolateral thigh flap perforator.

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