Quantification of Superficial Venous Reflux by Duplex Ultrasound - Role of Peak Reflux Velocity and Reflux Time in the Assessment of Varicose Vein

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ABSTRACT

Background: The study compared the peak reflux velocity and reflux time in cases of varicose veins and non-varicose veins with a focus on quantifying the reflux parameters.

Methods: This is a hospital based observational comparative study. The limbs with CEAP Clinical classification of C2 or more were taken as diseased limbs and contra-lateral limbs with no symptoms or disease were taken as control limbs.

Results: Altogether 792 limbs (452 diseased limbs and 340 control limbs) were evaluated with color duplex. Mean Great Saphenous Vein diameter was 5.68 ± 2.07 mm and 4.00 ± 1.34 mmin diseased limbs and control limbs respectively (p=0.0001). Mean sapheno-femoral junction diameter was 8.23 ± 2.64 mm and 6.16 ± 1.93 mm in diseased limbs and control limbs respectively (p=0.0001). Mean peak reflux velocity in diseased limbs was significantly higher than control limbs (77.38 cm/sec vs 7.95 cm/sec; p=0.0001). Similarly mean reflux time was significantly longer in diseased limbs than non-diseased limb (406.58ms and 67.28 ms respectively; p=0.0001). An optimal cut-off point of 27.4 cm/s for peak reflux velocity and 250 ms for the reflux time at Sapheno-Femoral junction had a discriminatory power between the two groups.

Conclusion: The quantification of peak reflux velocity seems to be more consistent than reflux time in determining the superficial venous reflux. An optimal peak reflux velocity cut off point of 27.4 cm/sec has the discriminatory power between diseased and non-diseased limb.

Keywords: Peak reflux velocity; reflux time; superficial venous insufficiency; ultrasound color duplex; varicose veins

INTRODUCTION

Dilated veins, usually in the lower limbs with or without pain, pigmentation, discomfort and sometimes ulceration are the features of varicose veins. 15% of men and 25% of women in the western population are affected by this disease condition.[1] This is one of the commonest problems that affects the young group of population which is the working group of individuals. For a developing country like ours this becomes a contributing setback in the development of country.

To assess the anatomy and hemodynamics of the lower limb veins, Ultrasound Color Duplex has been considered standard tool of investigation. Development in the technicality of ultrasound in last two decades has made this tool a wonderful assessing tool for the vascular surgeons.[2]

The aim of the study is to compare and quantify the superficial venous reflux in terms of Peak Reflux Velocity (PRV) and Reflux Time (RT) between varicose veins and non-varicose veins patient.

METHODS

This is a hospital based observational comparative study conducted after getting ethical clearance from Institutional review committee (IRC) from January 2018 to October 2019. All the patients with clinically diagnosed varicose veins, with or without symptoms of varicose veins like pain (musculoskeletal and other

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causes ruled out), pigmentation and discomfort were screened with Ultrasound Color Duplex. The limbs with clinical classification (CEAP: Clinical Etiological Anatomical Pathological classification)[3] of C2 or more were taken as diseased limbs (Group I). The contralateral limb which had no symptoms or disease were taken as control limbs (Group II). During the screening, the limbs with significant perforators of more than 3.5 mm along with reflux joining deep veins with Great saphenous venous system were also taken as diseased limbs.

All cases of clinical varicose veins that were either referred or were evaluated as a preoperative assessment during the study period were included in the study. Previously operated varicose veins, presence of deep vein thrombosis (DVT) and/or superficial thrombophlebitis, patient with pregnancy and patient with vascular malformations were excluded from the study.

All the 792 limbs underwent Ultrasound Color Duplex of lower limb using Siemens Acuson P300 ultrasound Machine or KALAMED ultrasound (KUP-211) using linear transducer probe of 5-12 MHz. These patients underwent Color Duplex Scanning in standing position and with forced Valsalva maneuver to quantify the reflux. Measurement of great saphenous Vein (GSV) diameter was done at the level of femoral condyle (Figure 1) in Bmode and quantification of reflux was done by Doppler spectrometry at sapheno-femoral junction (Figure 2). External diameter of the vein was measured at the defined anatomical location at standing position without any Valsalva maneuver. When venous aneurysm was present at the level of femoral condyle, 1 cm distal or proximal was taken as landmark to measure the GSV diameter. Same process was done for control limbs as well.

Ultrasound was performed by a vascular surgeon when a patient visited the out-patient department of vascular surgery. This was a multiple operator procedure done according to the departmental set protocol.

All data were analyzed using the SPSS software package (Version 25.0). Comparisons of numerical data between groups of patients were made using Student's t-test. Continuous data were expressed as mean ± standard deviation (SD). A 'p' value of <0.05 was considered to indicate statistical significance.

RESULTS

We conducted study on 396 patients (452 Diseased Limbs and 340 Control Limbs) with varicose vein. Among the diseased cases, 47.50 % (142) were male and 52.50% (157) were female. Varicose veins were commonly observed in age group of 30-60 years (72.20%) and least common in age group more than 60 years (12.4%). Total of 82.6% cases had occupation where they had to stand up for more than 6 hours.

The baseline characteristics of the two groups are shown in Table number 1. There were 452 limbs in Group I (Diseased Limbs) and 340 Limbs in Group II (Non-Diseased Limbs). The mean age of Group I was 44.22 years ± 14.21 and Group II was 43.55 years ± 14.07. There was female predominance of 50.9% in Group I and female predominance of 57.1% in Group II.

Duplex derived parameters are mentioned in Table number 2. The mean cross section diameter of GSV at the level of Femoral condyle was 5.68 mm ± 2.07 in Group I and 4.00 mm ± 1.34 in Group II. The mean Sapheno-Femoral Junction diameter was 8.23 mm ± 2.64 and 6.16 mm ± 1.93 in Group I and Group II respectively. Mean Peak Reflux Velocity was 77.38 cm/sec in Group I and 7.95 cm/sec in Group II. Mean Reflux Time was 406.58 ms in Group I and 67.28 ms in Group II.

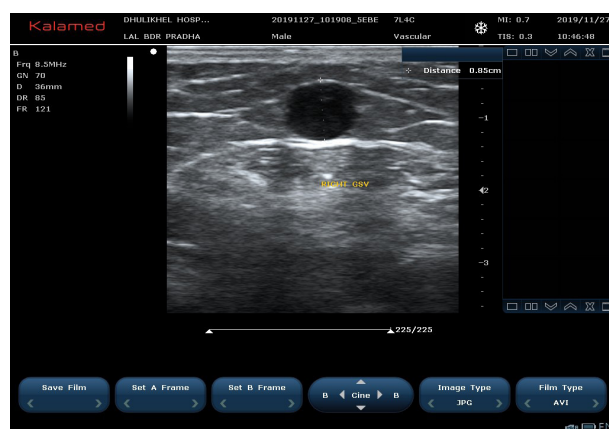Figure 1. Showing GSV measurement done at the level of Femoral Condyle.

Figure 2. Showing Doppler Spectrometry.

### Table 1. Baseline Characteristics of Study Groups.

Mean Value +/- SD	Group I (Diseased) n=452 Limbs	Group II (Non-diseased) n=340 Limbs	Unpaired t test Two tailed P* value
Age (Y)	44.22 ± 14.21	43.55 ± 14.07	0.5097
Female Gender(%)	50.9%	57.1%	0.4537

Table 2.Duplex Derived Parameters.

| Mean Value +/- SD	Group I (Diseased) n=452 Limbs	Group II (Non-diseased) n=340 Limbs	Unpaired t test Two tailed P* value
GSV Diameter (mm)	5.68 ± 2.07	4.00 ± 1.34	0.0001
SFJ Diameter (mm)	8.23 ± 2.64	6.16 ± 1.93	0.0001
Peak Reflux Velocity (cm/sec) at Sapheno-Femoral junction.	77.38 ± 118.99	7.95 ± 20.10	0.0001
Reflux Time (ms) at Sapheno-Femoral junction	406.58 ± 332.26	67.28 ± 165.22	0.0001

*P value of Difference of Two groups.

We generated Receiver Operating Characteristic (ROC) curve to see the cut off value of Peak Reflux Velocity (PRV) and Reflux Time (RT). From the ROC, definitive discriminating cut off value (Figure Number 3-4) was obtained. An optimal cut-off point of 27.4 cm/s for the peak reflux velocity at Sapheno-Femoral junction (SFJ) had a discriminatory power between two groups with receiver operating characteristic (ROC) curve area of 0.849. Sensitivity of this cut off point was 74% and specificity was 94%. Similarly, an optimal cut-off point of 250 ms for the reflux time at sapheno-femoral junction (SFJ) had a discriminatory power between two groups with receiver operating characteristics (ROC) area under Curve of 0.828. The sensitivity and specificity were 63% and 92% respectively for this cut-off value.
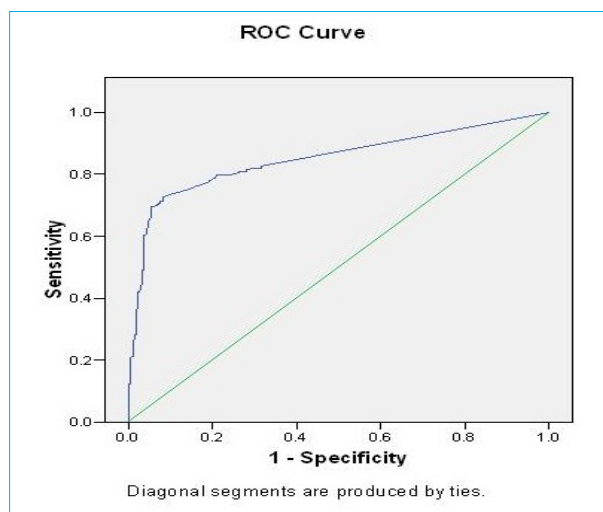
Figure 3. ROC curve for peak reflux velocity (PRV) at Saphenofemoral junction (SFJ). Area under the curve (AUC) = 0.849.
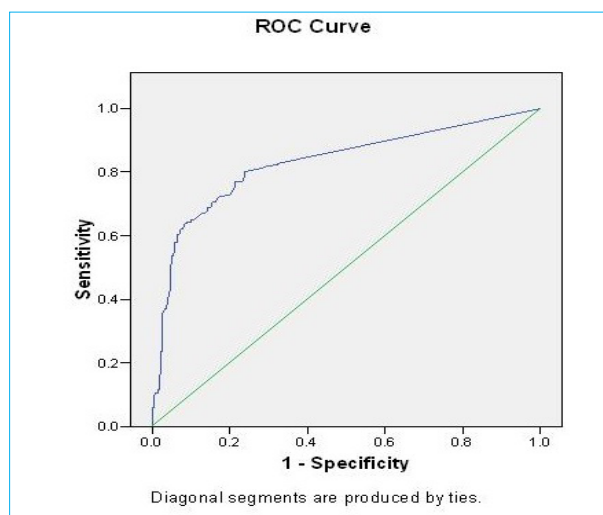
Figure 4. ROC curve for reflux time (RT) at Saphenofemoral junction (SFJ). Area under the curve (AUC) = 0.828

DISCUSSION

Superficial venous reflux in a case of varicose vein is associated with higher symptoms of varicose veins.[2] The attempt to quantify the venous reflux was done long back. The first attempt was made by Bjordal in 1977 where he used electromagnetic flowmeter to quantify

the reflux. Later in 1988, Christopoulos et al did Air Plethysmography to determine the superficial venous reflux.[4] Lastly came the ultrasound color duplex scan, non-invasive method to quantify the venous reflux.

The venous reflux was first described by Trendelenberg in 1891 and at that time he tried to quantify it with the use of water displacement.[5] In this study, thus, we wanted to evaluate whether the peak reflux velocity (PRV) and the reflux time (RT) have the power to discriminate between insignificant and significant superficial venous reflux. We also intended to study the cut off value for significant reflux in terms of PRV and RT.

Duplex ultrasound finding of reflux time (RT) more than 500 MS for superficial venous reflux and more than 1000 MS for deep venous reflux has been indicated by various studies as the presence of significant reflux.[6-8] Peak reflux velocity of more than 30 cm/sec is considered to be significant reflux.[9] One study showed reflux time as being the least consistent parameter in determining the superficial or deep venous reflux and suggested to use only peak reflux velocity (PRV) to determine the significant reflux.[10]

Quantifying the superficial venous reflux is important because many authors have described the role of superficial venous Insufficiency in production of venous ulceration and its contribution to chronic venous insufficiency.[6-10]

This disease condition is found to be more common in female and this is said to be attributed to hormonal factors and physiological changes in female development.[1,11] Our finding is also similar to these study as the number of female diseased limbs were more; however, it wasn't statistically significant.

Nepal being an agricultural country, majority of the affected cases are farmers. 82.6% of total diseased patients were those whose occupation demanded standing for more than 6 hours. Studies have shown that farming, security persons, pregnancy and obesity are common risk factors for varicose veins.[12] In this study, 52.8% of the diseased limb was Left limb thus making left limb involvement in varicose veins more common than the right. However, there are several studies done in the past which state that there is no such difference in the site of involved limb.[13,14]

Role of superficial venous reflux in case of varicose veins and its severity has been described by many authors.[1,15-17] Since then many authors have made an attempt to

quantify the venous reflux. In 1996, Weingarten et al gave validation that reflux time is important in quantification of venous reflux and it plays a major role in determining the severity of chronic venous insufficiency. However, they didn't mention the cut off values.[18] Later Labropoulos strongly stated in his study that venous ulceration is highly associated with reflux.[19]

Our study shows that diseased limbs have significantly higher reflux than control limbs. This study is comparable to many studies done in the past which show the role of venous reflux in the severity of the venous disease. The mean peak reflux velocity of diseased limbs in this study was 77.38 cm/sec which is significantly higher than the control group. A study done in Tokyo by Yamaki et al over 146 patients documented that Peak Reflux Velocity over 30 cm/sec was associated with venous incompetence.[2] In our study, an optimal cut-off point of 27.4 cm/s for the peak reflux velocity at Sapheno-Femoral junction (SFJ) had a discriminatory power between two groups with receiver operating characteristic (ROC) curve area of 0.849.Sensitivity of this cut off point was 74% and specificity was 94%. van Bemmelen PS et. al.[6] did a study on larger group and found that PRV of 26.2cm/sec had discriminatory power between significant and insignificant refluxes. Peak reflux velocity that defines the significant reflux at GSV are similar to studies done in past.[6,9]

In our study, the mean reflux time was 406.58 ms. Similar study done by van Bemmelen et al[6] on larger patient group found that mean RT at SFJ was 4.65 s which is much larger value than our study. Valentín et al[9] evaluated 5717 limbs and quantified the variables which could determine the superficial venous reflux. In his study he mentioned RT as the least consistent variable of all to determine the superficial venous reflux. Even in our study we found that there is huge variation in the reflux time even in diseased limbs. We think this variation could be due to difficulty in making the patient understand the forced Valsalva maneuver. During the forced Valsalva maneuver, when we asked the patients to perform this maneuver, some patients, intentionally or unintentionally, could not perform it as desired. This affects the time graph and hence the reflux time. However, since the peak reflux velocity is the highest peak taken, it is least affected. Valentin et al[9] has also mentioned in his study the difficulty in making patients understand the proper Valsalva maneuver. Thus, in our study we found that RT was the least consistent parameter in quantifying the reflux. We emphasize on considering the peak reflux velocity as the most consistent parameter to define superficial venous reflux.

We suggest understanding of color duplex spectrometry is must in defining the severity of the varicose vein and also planning the management. The use of doppler ultrasound by an operating surgeon can make the management decision easier.

Larger study group and better understanding of forced Valsalva maneuver among the patients could change parameters of quantification.

CONCLUSIONS

The quantification of peak reflux velocity seems to be more consistent than reflux time in determining the superficial venous reflux. An optimal peak reflux velocity cut off point of 27.4 cm/sec can discriminate between diseased and non-diseased limbs.

CONFLICTS of INTEREST

The authors declare that they have no conflicts of interest.

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