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The cutoff value of saphenous vein diameter to predict reflux

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Purpose: Increased saphenous vein diameter is a common consequence of saphenous vein reflux. Until now, there have been no reports about the correlation between diameter and reflux of saphenous vein in Korea. The aim of this study was to investigate the correlation between saphenous vein reflux and diameter changes.

Methods: From April 2009 to August 2012, 777 patients were sent to the vascular laboratory for evaluation of venous reflux. The diameter of the saphenous vein was measured with B-mode imaging, and reflux was quantified based on valve closure time using Doppler spectral tracings. Receiver operating characteristics curve analysis was applied to determine the best saphenous vein diameter cutoff for predicting reflux.

Results: The mean diameters of normal great saphenous vein (GSV) and refluxed GSV were 5.0 ± 2.4 mm and 6.4 ± 2.0 mm, respectively. The mean diameters of normal small saphenous vein (SSV) and refluxed SSV were 3.1 ± 1.3 mm and 5.2 ± 2.7 mm, respectively. The diameter differences between the normal and refluxed GSV and SSV were 1.4 mm and 2.1 mm, respectively, and these differences were statistically significant ($P < 0.0001$). A GSV threshold diameter of 5.05 mm had the best positive predictive value for reflux. The sensitivity and specificity at 5.05 mm were 76% and 60%, respectively. The best SSV diameter for predicting reflux was 3.55 mm. The sensitivity and specificity at 3.55 mm were 87% and 71%, respectively.

Conclusion: GSV diameter of ≥5.05 mm had the best positive predictive value for pathologic reflux. For pathologic reflux of SSV, the best cutoff diameter was 3.55 mm.

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INTRODUCTION

Chronic venous disease (CVD) is a common problem, and comprises many pathologic conditions such as varicose veins, edema, skin changes, and ulceration. Among these, varicose veins are the most common. The prevalence of varicose veins is estimated to be between 5% and 30% in the adult population, but reports have ranged from less than 1% to greater than 70% [1]. The San Valentino Vascular Screening Project in Italy found a 7% prevalence of varicose veins in 30,000 subjects evaluated by clinical assessment and duplex ultrasound [2]. The incident rate for the development of varicose veins may also be estimated using the Framingham study, which reported an annual incidence of 2.6% in women and 1.9% in men [3]. Reflux of the saphenous vein is a typical pathologic finding in varicose veins.

Duplex ultrasonography has become the method of choice for the evaluation of varicose veins to confirm the diagnosis, and assess etiology and anatomy. It is a simple, reproducible method based on morphology and hemodynamics. A venous

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duplex examination combines B-mode and color-flow imaging for the evaluation of the presence of thrombus and the measurement of the diameter of these veins, and pulsed Doppler is used for assessment of the reflux time.

Increased diameter of the saphenous vein is a typical finding in varicose veins. Engelhorn et al. [4] evaluated the relationship between reflux and the diameter of the great saphenous vein (GSV). They found that using diameter thresholds equal to or greater than 7, 4, and 4 mm for predicting reflux of the GSV at the junction, thigh, and calf, one can accurately predict reflux 71%, 75%, and 74% of the time, respectively. Mendoza et al. [5] measured the GSV diameter at the sapheno-femoral junction (SFJ) and at the proximal thigh, 15 cm distal to the groin. GSV diameters of 10.9 mm at the SFJ and 6.3 mm at the proximal thigh revealed high sensitivity and specificity for predicting reflux.

Until now, there have been no reports about the correlation between the diameter of the saphenous vein and reflux in Korea. The aim of this study was to investigate the correlation between saphenous vein reflux and diameter changes, and to evaluate the best cutoff value for the saphenous vein diameter for predicting reflux.

METHODS

From April 2009 to August 2012, 777 patients were sent to the vascular laboratory for the evaluation of venous reflux. The examinations were performed by a registered vascular technologist, and all tests were interpreted by a registered physician for vascular interpretation.

All patients were evaluated with colorized duplex scanning in a warm, comfortable examination room. The examination was performed using a Vivid E9 scanner (GE Healthcare, Fairfield, CT, USA). With the patient supine, a 5-12 MHz linear transducer was used to rule out acute or chronic deep venous thrombosis (DVT). After evaluation for the presence of DVT, the diameters of the GSV and the small saphenous vein (SSV) were measured in supine position. With B-mode imaging, the inner anechoic diameter of the GSV was measured from the SFJ to 5 cm distal to the junction. The SSV diameter was measured in the same manner from the saphenopopliteal junction (SPJ) to 5 cm distal to the junction. The largest diameter was chosen to analyze the relationship between diameter and reflux. If an aneurysmal change was seen at these portions, the diameter was chosen at 1 cm distal to the aneurysm. If the patient had a larger accessory saphenous vein than a main saphenous vein, we excluded these patients from this study. As mentioned by other literature, there are several variations in the SSV. If there were cranial extension (CE) and a connection with the popliteal vein (PV), the diameter was measured in the same manner. If there were CE without a connection between the PV, and termination at the thigh or the GSV, the diameter was measured from the popliteal fossa to 5 cm distal to the knee crease.

Using color flow imaging in the longitudinal view, the valvular function of the GSV was evaluated at the SFJ, upper thigh, midthigh, lower thigh and below the knee. The valvular function of the SSV was evaluated at the level of the popliteal fossa. Flow direction was noted with distal compression and release, and reflux was quantified based on valve closure time, with the Doppler spectral tracings obtained in a longitudinal plane. Reflux was defined as being present if the valve closure time was greater than 0.5 seconds. Examination for reflux was made with the patients standing, with upper body elevation of more than 45°, or in reverse Trendelenburg position.

Data analysis was performed with the IBM SPSS ver. 19.0 (IBM Co., Armonk, NY, USA). To compare the mean diameter of normal and refluxed saphenous vein, Student t-test was applied. Receiver operating characteristics (ROC) curve analysis was applied to determine the best cutoff diameter of the saphenous vein for predicting reflux. A P-value < 0.05 was considered statistically significant.

RESULTS

We examined 1,554 limbs to evaluate reflux in 777 patients. Table 1 shows the patient demographics. The male to female ratio was 275:502, and the mean age was 54.5 ± 14.5 years (range, 17 to 93 years). The GSVs were evaluated in 1,043 limbs. Venous reflux tests were normal in 676 GSV's, while reflux was found in 367 GSV's. The SSV's were examined in 1,000 limbs. Among them, 907 limbs were normal by venous

Table 1. Demographics

Characteristic	Value
Sex	
Male	275 (35.4)
Female	502 (64.6)
Age (y)	54.5 ± 14.5 (17-93)
Limbs	1,554
Great saphenous vein	1,043
Normal	676 (64.8)
Reflux	367 (35.2)
Small saphenous vein	1,000
Normal	907 (90.7)
Reflux	93 (9.3)

Values are presented as number (%) or mean ± standard deviation (range).

reflux test, while reflux was found in 93 limbs.

Table 2 shows the diameter data for the saphenous vein. The mean diameter of a GSV with reflux was 6.4 ± 2.0 mm. This was larger than a normal GSV, which measured 5.0 ± 2.4 mm on average. The diameter difference between the normal and refluxed GSV was 1.4 mm, and statistically significant ($P < 0.0001$). The diameters of normal SSV, as well as refluxed SSV were smaller than those of the GSV. The mean diameter of normal SSV was 3.1 ± 1.3 mm, and refluxed SSV was 5.2 ± 2.7 mm. The diameter difference of 2.1 mm was also statistically significant ($P < 0.0001$). Table 3 shows the diameter differences between genders. The mean diameter of normal GSV between genders was not significantly different ($P = 0.153$). The SSV of male was larger than that of female with statistically significant ($P = 0.022$). The mean diameters of refluxed GSV and SSV between genders were not significantly different.

The ROC curves used to determine the best cutoff value of saphenous vein diameter for predicting reflux are depicted in Fig. 1. A GSV diameter threshold of 5.05 mm and greater had the best value for predicting reflux. The sensitivity and specificity at 5.05 mm were 76% and 60%, respectively. The best cutoff value for SSV diameter for predicting reflux was 3.55 mm by ROC curve analysis. The sensitivity and specificity at 3.55 mm were 87% and 71%, respectively.

DISCUSSION

The concept that reflux is more frequently found in large veins is common knowledge. However, there have been few studies that have quantified such a general concept with numerical analysis. Engelhorn et al. [4] found that GSV diameter thresholds equal to or greater than 7 mm, 4 mm, and 4 mm at the SFJ, thigh, and calf, respectively, most accurately predicted reflux. Navarro et al. [6] reported that a GSV diameter of 5.5 mm or less predicted the absence of abnormal reflux, with a sensitivity of 78%, a specificity of 87%, positive and negative predictive values of 78%, and an accuracy of 82%. A GSV diameter of 7.3 mm or greater predicted critical reflux with 80% sensitivity, 85% specificity, and 84% accuracy.

Table 2. Diameters of the saphenous vein

Vein	Normal (mm)	Reflux (mm)	Difference (mm)	P-value[a]
GSV	5.0 ± 2.4	6.4 ± 2.0	1.4	<0.0001
SSV	3.1 ± 1.3	5.2 ± 2.7	2.1	<0.0001

Values are presented as mean ± standard deviation.
GSV, great saphenous vein; SSV, small saphenous vein.
[a]By Student t-test.

Table 3. Diameter difference between genders

Sex	Normal GSV (mm)	Refluxed GSV (mm)	Normal SSV (mm)	Refluxed SSV (mm)
Male	4.8 ± 1.1	6.6 ± 2.0	3.3 ± 1.3	5.6 ± 2.1
Female	4.9 ± 1.3	6.4 ± 1.9	3.0 ± 1.3	5.1 ± 1.5
P-value[a]	0.153	0.323	0.022	0.153

Values are presented as mean ± standard deviation.
GSV, great saphenous vein; SSV, small saphenous vein.
[a]By Student t-test.

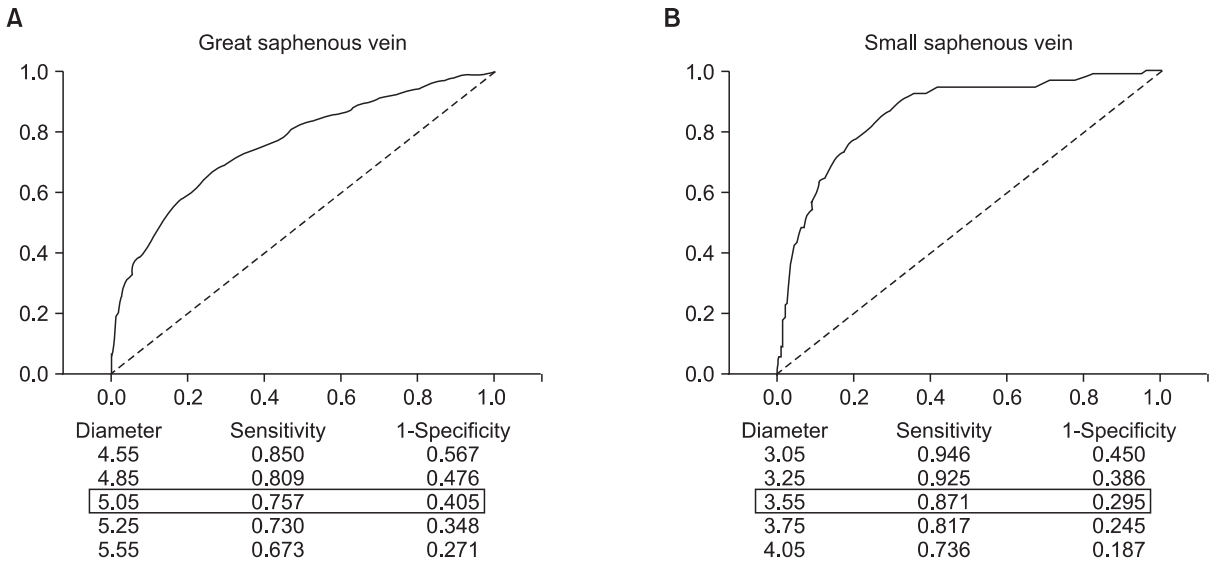

Fig. 1. Receiver operating characteristics curve analysis for determining the best cutoff value for diagnosing reflux. (A) For the great saphenous vein, 5.05 mm was the best cutoff value to predict reflux with the broadest area under the curve. (B) For the small saphenous vein, 3.55 mm was the best cutoff value to predict reflux.

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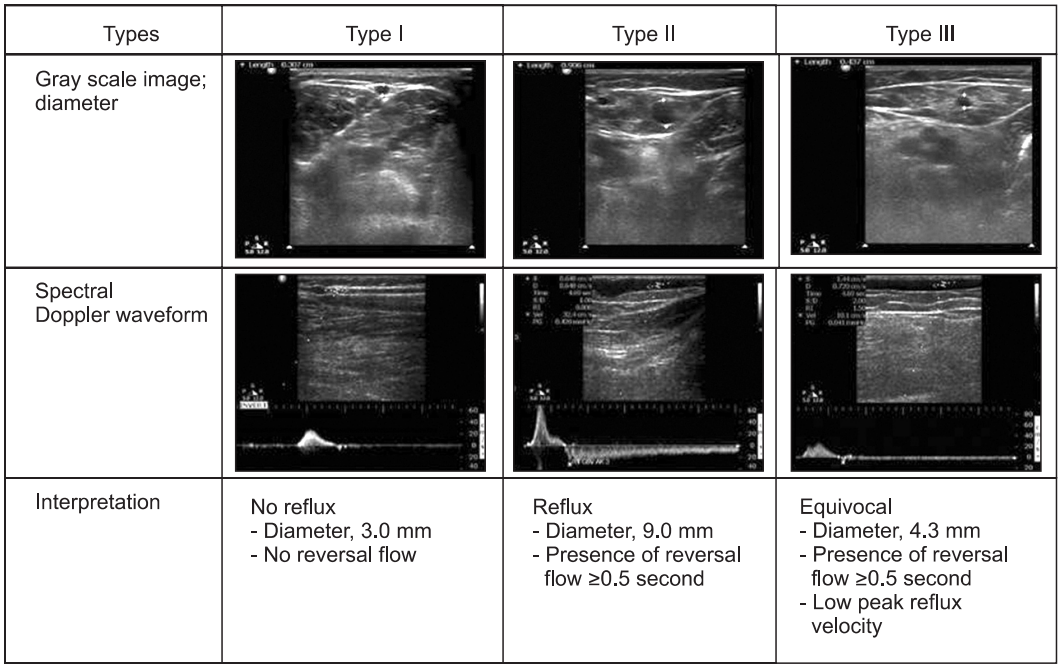

Fig. 2. Duplex findings and each interpretation for the evaluation of superficial venous insuffiency of the lower extremity. Type I is typical finding of absence of reflux; small diameter and no reversal flow. Type II is typical finding of presence of reflux; large diameter and reversal flow more than 0.5 second. Type III is equivocal finding. In spectral Doppler waveform, it shows presence of reversal flow more than 0.5 seconds with low peak reflux velocity. Diameter criteria can be used as an additional parameter in this case.

We have determined that certain specific diameter thresholds, 5.05 mm in the GSV and 3.55 mm in the SSV, were markers for high certainty of reflux.

Diameter of the saphenous vein can be affected by many variables such as patient position, central abdominal pressure, temperature of examination room, heart disease, etc. The criteria of saphenous diameter to predict reflux should not be used in clinical setting. It can be used as the additional parameter. Fig. 2 shows 3 types of spectral Doppler waveform during duplex scanning for evaluation of reflux. Type I is typical finding of normal saphenous vein. Type II is typical finding of reflux. It is rather difficult to interpret the finding of type III because the spectral Doppler waveform shows longer reflux time more than 0.5 second, but low peak reflux velocity. In this case, the diameter criteria can be used the additional parameter to interpret in clinical setting.

The diameter of the saphenous vein has been assessed at various sites of interest. Measurements are regularly made at the SFJ for GSV, above or below the preterminal valve, and anywhere at the thigh. A consensus of the Union Internationale Phlebologie (UIP) recommends two sites where GSV diameters should be measured, 3 cm below the SFJ and at the midthigh [7], while previous studies used a site 15 cm below the SFJ [8,9]. Thus far, neither the clinical relevance of these measurements nor the relative significance of the site of measurement has been clarified. Mendoza et al. [5] found that measurement at the proximal thigh revealed higher sensitivity and specificity to predict reflux. We measured the diameter 5 cm distal to the SFJ or SPJ. The measurement of SSV diameter should be carefully performed because of anatomic variation. If CE were present without a connection between the PV, and if there were terminations at the thigh or GSV, the diameter was measured from the popliteal fossa to 5 cm distal the knee crease.

The diameter measurement has been assessed with different techniques: upright or recumbent patient position and cross-sectional or longitudinal imaging. Venous diameter naturally changes according to patient position. The diameter measured in an upright position or upper body elevation will be larger than that measured in a recumbent position. It is warranted that diameter measurement should be done with a consistent method at each vascular laboratory. Upright position was most commonly used to measure the diameter of the saphenous vein [5]. However, some patients were not able to be upright for measuring the diameter due to other physical problems such as severe spinal stenosis or joint problems, as well as many other medical problems. Therefore, we adopted the recumbent position because the diameter measurement could be performed on most patients in this position. It was be recommended that examination was performed in consistent

position with a tilt-table.

In our study, saphenous vein reflux was defined as retrograde flow lasting for more than 0.5 seconds [10,11]. It is important to elicit reflux with a constant method as the maximal reflux time is used as a gold standard to define reflux. We performed distal compression and release to elicit reflux in all patients. For the proximal vein, we did compression and release of thigh or calf muscle. For evaluation of vein at the calf level, we did compression and release of the foot. Another method to elicit reflux includes pneumatic cuff inflation and deflation [12], active foot dorsiflexion and relaxation, and a Valsalva maneuver. Pneumatic cuff has been used to permit quantitative assessment of reflux. This may be the most reproducible method. We used distal compression and release in all patients to minimize the variation of results.

The duration of reflux is the most widely used value as a marker for superficial venous insufficiency. However, some researchers have suggested other parameters for superficial venous insufficiency such as venous diameter changes. Veins distend greatly in response to pressure or volume flow changes [13]. Venous diameter changes during rises in intravenous pressure may modify the venous valve function [14]. Jeanneret et al. [15] suggested that the increased distensibility correlates with venous reflux parameters in varicose vein patients. Lattimer et al. [16] suggested that pulsatile flow in the saphenous vein might be a marker of superficial venous insufficiency. Pulsatile flow in varicose veins has also been described previously to support a hypothesis of arteriovenous fistulae in the pathogenesis of varicose veins [17]. The morphologic changes detected by computed tomogram-venography (CTV) might be a clue to predict the saphenous vein insufficiency [18,19]. Lee et al. [18] evaluated CTV finding of saphenous venous insuffiency. The morphologic findings of the insufficient GSVs with varicosity were focal ectasia, diffuse dilatation of more than 6 mm, asymmetry, tortuosity, and direct connection to varicosity.

The relationship between the diameter of the saphenous vein and clinical severity has also been investigated. Mdez-Herrero et al. [20] revealed that a greater diameter correlated with a more severe clinical state. Mendoza et al. [5] measured GSV diameters at both the SFJ and proximal thigh (15 cm distal to the groin). They concluded that the GSV diameter correlated with clinical class, with measurement at the proximal thigh being more sensitive and more specific than measurement at the SFJ. However, there was the report that showed the opposite results. Gibson et al. [21] prospectively enrolled 91 patients with symptomatic varicose veins and GSV reflux. According to their report, there was a weak correlation between increasing GSV diameter and venous clinical severity score ($r = 0.23$, $P = 0.03$).

In conclusion, venous diameter is significantly related to reflux, as expected. GSV diameter of ≥5.05 mm had the best cutoff value for predicting pathologic reflux. For pathologic reflux of the SSV, the best cutoff value was 3.55 mm.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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