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Clinical Research

Correlation of Clinical Class with Duplex Ultrasound Findings in Lower Limb Chronic Venous Disease

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Background: This study investigated the distribution of valve incompetence in patients with chronic venous disease (CVD) and its correlation with the clinical category of the clinical, etiological, anatomical, and pathophysiological (CEAP) classification.
Methods: In total, 1,386 limbs with clinically suspected CVD were categorized according to the CEAP classification and consecutively underwent duplex ultrasonography between April 2017 and December 2020.
Results: There were 362 limbs in male patients and 1,024 limbs in female patients. The limbs were classified as C0s–C1 (608 limbs, 43.8%), C2 (727 limbs, 52.5%), or C3–C6 (51 limbs, 3.7%). The prevalence of saphenous vein incompetence in CEAP C0s–C1 limbs was 43.6%. The saphenofemoral junction (SFJ) was competent in 37% of CEAP C2–C6 limbs. The CEAP C3–C6 category was not correlated with reflux patterns of the saphenous vein system (Cramer's V=0.07), incompetent SFJ (Cramer's V=0.07), deep vein reflux (Cramer's V=0.03), or the distribution of incompetent segments in the great saphenous vein (GSV) (Cramer's V=0.11).
Conclusion: Duplex ultrasonography is necessary to formulate a proper treatment plan for limbs categorized as CEAP C0s–C1. The SFJ was competent in more than one-third of CEAP C2–C6 limbs with GSV reflux; as such, flush ligation of the GSV may be unnecessary in these patients. The CEAP C3–C6 category showed no correlations with reflux patterns of the saphenous vein system, SFJ reflux, deep vein reflux, or the distribution of incompetent segments in the GSV.

Keywords: Duplex ultrasonography, Venous insufficiency, Saphenous vein

Introduction

Duplex ultrasonography (DUS) is the imaging method of choice to evaluate the venous system for the management of chronic venous disease (CVD) of the lower limbs because it is non-invasive, cost-effective, and reliable. DUS is the only diagnostic modality that provides information on both the function and anatomy of the veins. The treatment strategies for CVD are based on DUS findings. Reliable clinical information can only be obtained from DUS by staff who have clinical experience and a detailed knowledge of the pathological conditions of the venous system. Therefore, it is ideal for surgeons, vascular specialists, and phlebologists to perform their own investigations. According to the guidelines of the First International Consensus Conference on Endovenous Thermal Ablation for Varicose Vein Disease, it is recommended that healthcare providers should possess the competence required to diagnose venous disorders and establish an appropriate treatment plan [1].

CVD has a wide spectrum of presentations. The various clinical features that manifest as a result of venous insufficiency can be classified using the clinical, etiological, anatomical, and pathophysiological (CEAP) classification. The clinical class (C) includes the full spectrum of CVD from C0 to C6. Even for clinical features belonging to the same clinical class of CEAP, the patterns of venous insufficiency on DUS are heterogeneous. The various patterns of venous insufficiency in the same clinical class of CEAP could be explained by the pathogenesis of CVD. It has been tradi-

tionally believed that venous insufficiency in the lower extremity begins at the saphenofemoral junction (SFJ) and progresses distally; this is known as the "descending theory" [2]. However, most studies have reported that venous insufficiency could develop in any segment of the lower extremity venous system irrespective of the clinical stage [3-9]. Therefore, meticulous preoperative DUS for the investigation of individual patterns in patients with venous insufficiency is very important for making a proper treatment plan.

Several studies have reported the correlations of DUS findings with the clinical category of the CEAP classification [9-15]. However, the relationship of segmental patterns of reflux in the great saphenous vein (GSV) with the CEAP clinical class (C0s–C6) has not been analyzed on a large scale.

This study aimed to investigate the various patterns of valve incompetence in limbs with primary CVD and its correlation with the CEAP clinical class (C0s–C6) to help formulate an appropriate treatment plan.

Methods

Patients and procedures

This retrospective analysis complied with the Declaration of Helsinki and was approved by the institutional review board of the National Health Insurance Service Ilsan Hospital (no., 2020-03-012-002). This study reviewed all medical records of consecutive patients who visited the outpatient clinic for consultations on signs or symptoms suggesting CVD and received DUS examinations between April 2017 and December 2020. The requirement for informed consent from individual patients was omitted because of the retrospective design of this study.

Patients were excluded from the analysis if they had limbs with reflux in the anterior accessory saphenous vein or limbs that had already undergone treatments for truncal veins (including surgery, endovenous thermal ablation, and sclerotherapy).

All patients underwent a complete physical examination, and their medical histories were recorded with a focus on the signs and symptoms of CVD. Basic demographic data were also recorded. The clinical features were graded according to the C category of the CEAP classification [16]. They were classified from C0s to C6, and DUS confirmed the presence of primary reflux of the deep vein, superficial vein, and perforating vein in all of the patients. All limbs belonged to the Ep As, d, and/or p Pr categories (L II). The clinical signs were classified according to the CEAP clinical classification: (1) C0s: limbs with venous symptoms, no visible or palpable signs of venous disease; (2) C1: telangiectasias or reticular veins; (3) C2: varicose veins; (4) C3: edema; (5) C4a: pigmentation or eczema; (6) C4b: lipodermatosclerosis or atrophie blanche; (7) C5: healed venous ulcer; (8) C6: active venous ulcer.

DUS was performed in the standing position and involved investigation of the patient's non–weight-bearing limb with LOGIQ5 PRO using a 5–12 MHz linear probe (GE Healthcare Korea, Seongnam, Korea). Venous reflux was defined as retrograde flow with a duration greater than 0.5 seconds for the saphenous veins and 1.0 seconds for the deep veins after the provocation maneuver (distal compression and rapid release). The investigation of venous segments included the common femoral vein, the popliteal vein, the GSV, the anterior accessory saphenous vein, the small saphenous vein (SSV), and the perforating vein. The GSV trunk was examined for diameter and reflux at the saphenous arch (between the terminal and preterminal valves), mid-thigh, knee level, and proximal calf. The SSV was examined at the knee crease and proximal calf. The saphenopopliteal junction was not routinely examined because there are many anatomic variations in this area. In many cases, the SSV extends cranially without connection with the popliteal vein [17]. DUS of the perforating veins was performed selectively for limbs with healed or open venous ulcers.

Statistical analysis

The data were analyzed using IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA). The correlations between variables were analyzed using Cramer's V.

Results

During the study period, there were 995 consecutive patients, of whom 199 patients were excluded because of a medical history of previous vein treatment and 11 were excluded because of reflux in the anterior accessory vein. The study population consisted of 1,386 limbs (785 patients), and the male-to-female ratio in terms of limbs was 1:2.83. Each limb was considered as a case. The mean±standard deviation (SD) age of the patients included in this study was 54.4±12.7 years, and patients' age ranged from 18 to 86 years. There were 703 (51%) left limbs and 683 (49%) right limbs. The mean±SD body mass index (BMI) was 23.5±3.5 kg/m^2 and 29 patients (3.7%) were obese (BMI >30 kg/m^2).

The limbs were classified as follows according to the clinical category of the CEAP classification: 171 limbs were classed as C0s (12.3%), 437 as C1 (31.5%), 727 as C2 (52.5%), 13 as C3 (0.9%), and 38 limbs met the criteria for C4 to C6 classification (2.8%). The saphenous veins were competent in 462 limbs, of which 83 (18%) were classified as C0s, 260 (56.3%) as C1, 113 (24.4%) as C2, and 6 (1.3%) as C3–4. The remaining 924 limbs had incompetent saphenous veins and were classified as C0s in 88 limbs (9.5%), C1 in 177 limbs (19.2%), C2 in 614 limbs (66.5%), and C3–6 in 45 limbs (4.8%).

The distribution of venous insufficiency in the 924 limbs with incompetent saphenous veins was as follows: 656 limbs (71%) had reflux isolated to the GSV, 158 limbs (17.1%) had reflux in both the GSV and SSV, and 110 limbs (11.9%) had reflux isolated to the SSV.

Relationships of the reflux patterns in the saphenous vein system with the CEAP clinical class

In limbs with reflux in the saphenous vein system, the relationships of the reflux patterns of the saphenous vein system with the CEAP clinical class are detailed in Table 1. The reflux pattern of the saphenous vein system showed no correlation with chronic venous insufficiency (Cramer's V=0.07).

Relationships of SFJ reflux with the CEAP clinical class

Table 2 shows the prevalence of SFJ reflux and its correlations with the CEAP clinical class in limbs with GSV reflux, including limbs with both GSV and SSV reflux. The presence of an incompetent SFJ showed a strong correlation with the distribution of incompetent segments in the GSV (Cramer's V=0.56) and no correlation with chronic venous insufficiency (Cramer's V=0.07).

When GSV reflux was isolated to the above-knee segments, the SFJ was competent in 34% of limbs (112/331). In limbs with GSV reflux isolated to below-knee segments, the SFJ was competent in all cases (172/172).

Relationships of incompetent segments of the GSV with the CEAP clinical class

In limbs with GSV reflux, including limbs with both GSV and SSV reflux, the correlations of incompetent segments of the GSV with the clinical category of the CEAP classification are detailed in Table 3. CEAP C3–C6 showed no significant correlation with the distribution of incompetent segments in the GSV (Cramer's V=0.11).

Relationships of deep vein insufficiency with the CEAP clinical class

In limbs with reflux in the saphenous vein system, the correlation of deep vein insufficiency (DVI) with the CEAP clinical class is presented in Table 4. Among the limbs with DVI, 98% (141/144) had popliteal vein insufficiency and 2% (3/144) had femoral vein insufficiency. DVI

Table 1. Relationships of reflux patterns in the saphenous vein system with the CEAP clinical class

CEAP	Incompetent segments of saphenous vein		
	GSV	SSV	GSV+SSV
C0s (n=88)	63 (9.6)	12 (10.9)	13 (8.2)
C1 (n=177)	122 (18.6)	33 (30.0)	22 (13.9)
C2 (n=614)	433 (66.0)	64 (58.2)	117 (74.1)
C3–6 (n=45)	38 (5.8)	1 (0.9)	6 (3.8)
Total (n=924)	656 (71.0)	110 (11.9)	158 (17.1)

Values are presented as number (%).
CEAP, clinical, etiological, anatomical, and pathophysiological; GSV, great saphenous vein; SSV, small saphenous vein.

Table 2. Relationships of saphenofemoral junction reflux with the CEAP clinical class

CEAP clinical class	Saphenofemoral junction	
	Competent	Incompetent
C0 (n=76)	55 (72)	21 (28)
C1(n=144)	107 (74)	37 (26)
C2 (n=550)	203 (37)	347 (63)
C3–C6 (n=44)	14 (32)	30 (68)
Total (n=814)	379 (47)	435 (53)

Values are presented as number (%).
CEAP, clinical, etiological, anatomical, and pathophysiological.

Table 3. Relationships of incompetent segments of the great saphenous vein according to the CEAP clinical class

CEAP	Incompetent segments of great saphenous vein		
	Above knee	Below knee	Above and below knee
C0s (n=76)	28 (37)	29 (38)	19 (25)
C1 (n=144)	47 (33)	70 (49)	27 (19)
C2 (n=550)	241 (44)	70 (13)	239 (43)
C3–C6 (n=44)	15 (34)	3 (7)	26 (59)
Total (n=814)	331 (41)	172 (21)	311 (38)

Values are presented as number (%).
CEAP, clinical, etiological, anatomical, and pathophysiological.

Table 4. Relationships of deep vein insufficiency with the CEAP clinical class

CEAP clinical class	Deep vein	
	Competent	Incompetent
C0 (n=88)	78 (89)	10 (11)
C1 (n=177)	159 (90)	18 (10)
C2 (n=614)	507 (83)	107 (17)
C3–C6 (n=45)	36 (80)	9 (20)
Total (n=924)	780 (84)	144 (16)

Values are presented as number (%).
CEAP, clinical, etiological, anatomical, and pathophysiological.

showed no correlation with the CEAP C3–C6 categories (Cramer's V=0.03) or the distribution of incompetent saphenous vein segments (Cramer's V=0.11).

Discussion

The proportion of limbs categorized as clinical class C3–C6 in this study was 3.6%, which is very low compared with the results of previous studies, where this proportion ranged from 14.8% to 66% [10-15]. The reason for the low proportion of complicated CVD in this study is uncertain. However, the prevalence of obesity (BMI >30 kg/m^2) was only 3.7% of all cases, which is much lower than the rate of 30% reported in the literature [18]. Obese patients have a significantly higher prevalence of skin changes and venous leg ulcers than normal-weight patients [18,19]. Therefore, the lower proportion of obese patients in this study could have influenced this result.

The proportion of CVD without varices (CEAP C0s–C1) was 43.8% in this study, which is higher than has been reported in previous studies, where it ranged from 0.1% to 15.2% [10-15]. Some healthcare providers do not perform DUS investigations for limbs categorized CEAP C0s–C1 because those limbs are not considered as having functional disorders. At our institution, DUS is routinely performed for limbs of CEAP C0s–C1 to evaluate saphenous vein competence. The prevalence of incompetent saphenous veins in CEAP C0s–C1 limbs was 44% in this study, while 7.5% of CEAP C0s–C1 limbs demonstrated GSV reflux in both above- and below-knee segments. This means that leg symptoms in many patients with CEAP C0s–C1 limbs could be caused by saphenous vein insufficiency. Reflux in the early stages of CVD is not always associated with varicose veins [20]. Kostas et al. [21] reported that 25% of limbs presented an extension of reflux in pre-existing reflux sites with an increase of their C score of 2 or more grades during a 5-year follow-up. Pannier and Rabe [22] reported that 57.8% of all CVD patients showed progression of the disease during a 13.4-year follow-up period. Therefore, DUS is necessary for CEAP C0s–C1 limbs to evaluate saphenous vein insufficiency and make an appropriate treatment plan.

Although endovenous treatments, such as endovenous thermal ablation or endovenous non-thermal ablation, are currently prevailing treatments, conventional surgical treatment involving flush ligation of the GSV at the SFJ, including the ligation and division of all upper GSV tributaries, continues to be performed by many surgeons. In this study, the SFJ was competent in 37% of CEAP C2–C6 limbs with GSV reflux. This result means that flush ligation at the SFJ may be unnecessary in more than one-third of CEAP C2–C6 limbs with GSV reflux. Therefore, to prevent unnecessary procedures, the competence of the SFJ should be evaluated on preoperative DUS. Pittaluga et al. [23] reported that preserving the saphenofemoral confluence while stripping the GSV gave good results with regard to neovascularization on the saphenofemoral confluence and varicose vein recurrence. Mariani et al. [24] also reported a lower rate of SFJ neovascularization after ligation of the SFJ keeping some of the tributary veins.

In this study, as Cooper et al. [5] reported, SFJ reflux was more prevalent in limbs with incompetence in both above- and below-knee segments of the GSV, whereas it occurred in only 33% of limbs with reflux isolated to above-knee segments of the GSV. There was no case of SFJ reflux in limbs with reflux isolated to below-knee segments of the GSV. Therefore, SFJ reflux is considered to represent not an initiating factor in the development of CVD, but a sign of widespread valve incompetence.

With respect to chronic venous insufficiency, Danielsson et al. [25] reported that the presence of axial reflux in the GSV did not increase the prevalence of skin changes as compared with superficial segmental reflux. However, most researchers observed that reflux in both above- and below-knee segments of the GSV was accompanied by a more advanced clinical stage [11-13]. Regarding DVI, Lin et al. [26] reported that SSV reflux showed strong association with DVI. The result of this study showed that the CEAP C3–C6 categories were not correlated with the distribution of incompetent segments in the GSV, and DVI was not correlated with the distribution of incompetent saphenous vein segments or chronic venous insufficiency. However, since the number of CEAP C3–C6 limbs was small in this study, further research with a large number of these cases is necessary.

The main limitations of this study are its single-center

study design and the relatively small number of CEAP C3–C6 limbs. Further studies with a larger number of patients with advanced CVD are necessary to clarify these results.

In conclusion, this study revealed that a considerable number of limbs without varices (CEAP C0s-C1) had incompetent saphenous veins. The SFJ was competent in more than one-third of limbs with GSV reflux in the CEAP C2–C6 categories; as such, flush ligation of the GSV may be unnecessary in these patients. CEAP C3–C6 limbs showed no significant correlations with the reflux patterns of the saphenous vein system, SFJ reflux, and the distribution of incompetent segments in the GSV. DVI showed no significant correlation with the CEAP C3–C6 categories or reflux patterns in the saphenous vein system.

Conflict of interest

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

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