Turk Gogus Kalp Dama 2016;24(2):281-288
doi: 10.5606/tgkdc.dergisi.2016.12296

Original Article / Özgün Makale

Lower extremity venous Duplex ultrasonographic findings in nurses before and after nightshifts

Nöbet öncesi ve sonrası hemşirelerde alt ekstremite venöz Dupleks ultrasonografi bulguları

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ABSTRACT

Background: This study aims to investigate whether prolonged standing changed Duplex ultrasonography findings in nurses using two different reflux provocation techniques and to assess whether the findings of these techniques were in agreement.

Methods: Between February 2014 and July 2014, 32 nurses (30 females, 2 males; mean age 31.3±5.1 years; range 23 to 46 years) with a total of 64 lower extremities were evaluated prospectively using the Duplex ultrasonography before and after 12 hour nightshifts. Ultrasonographic examinations were performed by a single radiologist under similar conditions. Duration of working of the nurses was noted and examined prior to nightshifts and immediately following the nightshifts. Reflux was provoked by manual compression and Valsalva maneuver. Pretibial edema noted. Spectral data were obtained from deep and superficial vein segments.

Results: Prior to nightshifts, there was edema in only one nurse; however, bilateral edema developed in five additional nurses after nightshifts (p=0.002). Working duration of nurses with pretibial edema was significantly longer. In all vein segments, we found no significant differences in measurements before and after nightshifts using either technique (p>0.05). Manual compression and Valsalva maneuver showed either "no" or "poor" agreement in deep veins, while they showed either "fair" or "good" agreement in superficial veins.

Conclusion: Our study results show that both reflux provocation techniques yield similar outcomes before and after nightshifts with significantly increased pretibial edema after nightshifts.

Keywords: Doppler; Duplex ultrasonography; nurse; prolonged standing; venous insufficiency.

ÖZ

Amaç: Bu çalışmada hemşirelerde iki farklı reflü provokasyon tekniği kullanılarak uzun süre ayakta kalmanın Dupleks ultrasonografi sonuçlarını değiştirip değiştirmediği araştırıldı ve bu tekniklerin sonuçlarının birbiriyle uyumlu olup olmadığı değerlendirildi.

Çalışma planı: Şubat 2014 - Temmuz 2014 tarihleri arasında, 12 saatlik nöbet öncesi ve sonrasında Dupleks ultrasonografi ile 32 hemşirenin (30 kadın, 2 erkek; ort. yaş 31.3±5.1 yıl; dağılım 23-46 yıl) 64 alt ekstremitesi ileriye dönük olarak değerlendirildi. Ultrasonografik incelemeler aynı radyolog tarafından benzer koşullarda gerçekleştirildi. Hemşirelerin çalışma süresi kaydedildi ve nöbet öncesi ve nöbetin hemen sonrasında incelendi. Manuel kompresyon ve Valsalva manevrası ile reflü provoke edildi. Pretibiyal ödem kaydedildi. Spektral veriler, derin ve yüzeyel ven segmentlerinden elde edildi.

Bulgular: Nöbet öncesinde sadece bir hemşirede ödem vardı; ancak, nöbet sonrası ek olarak beş hemşirede iki taraflı ödem gelişti (p=0.002). Pretibiyal ödemli hemşirelerin çalışma süresi, anlamlı düzeyde daha uzundu. Tüm segmentlerde, iki teknik ile de nöbet öncesi ve sonrası ölçümlerde anlamlı bir fark yoktu (p>0.05). Manuel kompresyon ve Valsalva manevrası teknikleri derin venlerde "hiç" ya da "zayıf" uyumluluk gösterirken, yüzeyel venlerde bu "makul" veya "iyi" uyumluluk gösterdi.

Sonuç: Çalışma bulgularımız, nöbet sonrasında pretibiyal ödemde anlamlı artış ile her iki reflü provokasyon tekniğinin de nöbet öncesi ve sonrası benzer sonuçlar verdiğini göstermektedir.

Anahtar sözcükler: Doppler; Dupleks ultrasonografi; hemşire; uzun süreli ayakta kalma; venöz yetmezlik.

Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2016.12296
QR (Quick Response) Code

Received: August 17, 2015 *Accepted:* October 06, 2015

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Lower extremity chronic venous disease (CVD) and varices are among the most common pathologies of lower extremity venous circulation.[1] It is widely considered that prolonged standing causes varices and that CVD is an occupational disease associated with certain occupations, including nursing.[2] This possibility has been tested in several epidemiological studies.[3-8] Although many have found an association between CVD development and prolonged standing,[3-6] other high-quality epidemiological studies have come to the opposite conclusion or have shown a non-significant association.[7,8] The detailed pathophysiology of the disease still remains unclear and prolonged standing seems to be an aggravating factor rather than the primary cause.[9,10]

Duplex ultrasonography (DUS) (i.e., gray-scale ultrasonography featuring color Doppler and spectral analysis) is essential for the diagnosis and appropriate treatment of CVD.[11-13] Although DUS is a non-invasive, relatively safe, inexpensive, and easy to apply diagnostic test, its results are often user-dependent and the method per se has not been standardized globally. Therefore, it is advisable to test in the morning to increase repeatability and reproducibility.[14] Previously, we observed some interesting cases in our vascular imaging clinic; some nurses with previously normal DUS findings and early CVD symptoms such as telangiectasias, reticular veins or trunk varices with accompanying leg pain and edema showed positive venous reflux, when the test was repeated the morning after a busy nightshift. Therefore, in this study, we aimed to investigate whether prolonged standing during the nightshifts changed DUS findings in nurses and to compare two techniques, namely distal manual compression (MC) while standing and the Valsalva maneuver (VM) on supine.

PATIENTS AND METHODS

Between February 2014 and July 2014, a total of 64 lower extremities of 32 volunteer nurses (30 females, 2 males; mean age 31.3±5.1 years; range 23 to 46 years) who were scheduled for 12-hour nightshifts in the cardiovascular, anesthesiology, and internal medicine intensive care unit in our hospital were prospectively evaluated using DUS. Ultrasonographic examinations were performed by a single radiologist under similar conditions. Exclusion criteria were as follows: use of an oral contraceptive, breastfeeding, possible or certain pregnancy, active menstrual bleeding, previous deep vein thrombosis (DVT), congenital venous malformation in the lower extremities, and previous surgical or endovascular treatment of CVD. A history of medical treatment for CVD or the use of socks for varicose veins were not defined as exclusion criteria. However, all participants were asked not to use the socks or partake in medical treatment during the study period. The study protocol was approved by the Dokuz Eylul University Ethics Committee. A written informed consent was obtained from each participant.

All participants were questioned regarding the age, sex, height, body weight, number of pregnancies, smoking status, medical history, length of career as a critical care nurse, and duration of time spent standing during the day (including the nightshift) before examination.

The participants were evaluated twice. All examinations were performed in the morning between 7:00 AM and 10:00 AM in the same room at a constant air temperature. First, they were examined before the nightshift following a regular night sleep and a 12-hour fasting. They were, then, examined on another morning immediately following a 12-hour nightshift. Duplex ultrasonography was performed using an HD 11 ver. 4.1.110.0 (Philips Ultrasound, Andover, MA, USA) fitted with a 12-3 Mhz superficial transducer. All examinations were performed by a single radiologist with a three-year experience with venous imaging. Each examination took about 45 to 60 minutes.

Before the initial evaluation, the possibility of DVT was eliminated for each participant. Initially, distal MC was used in the standing position, placing all body weight onto the contralateral leg to provoke reflux. At the end of reflux assessment, grey-scale ultrasonography was performed on the distal one-third of the pretibial area to assess the presence of pretibial edema. The diameters of the great saphenous vein (GSV) and the small saphenous vein (SSV) were measured using the lowest possible level of transducer compression. The GSV diameter was measured at the proximal, medial, and distal portions of the vein (above the knee), and the medial portion of the vein (below the knee) and the mean diameters were calculated. The diameter of the SSV was measured only once, at the medial portion of the vein below the knee. The subjects were, then, asked to lie down in the supine position and venous reflux was provoked by using the VM; the popliteal vein and small saphenous vein were evaluated in the prone position. All nurses were instructed on how to effectively perform the VM in which a participant should hold abdominal pressure, as if she/he was defecating, for at least 3 seconds (s). Measurements were repeated, when the VM failed or was interrupted.

Spectral Doppler measurements were obtained in the longitudinal plane at a Doppler angle of ≤60 degree. The triplex mode of the device was used, in which B-mode, color flow, and spectral measurements can be observed in real time. Spectral measurements were obtained from the proximal femoral vein distal of the deep femoral vein bifurcation, from the proximal GSV adjacent to the saphenofemoral junction (SFJ), from the popliteal vein (PV) in the popliteal fossa, and from the SSV at the level of the saphenopopliteal junction (SPJ). In case of the Giacomini variation or when we were unable to detect the SPJ, measurements were obtained from the SSV at the level of the popliteal fossa.

Reflux was recorded, if available. Positive reflux cut-off times were defined as 0.5 s for each segment, when MC was used. When VM was applied in the supine position, the reflux cut-off times were defined as 1 s for femoral vein (FV) and PV, and 0.5 s for GSV and SSV, based on the published data. Finally, clinical-etiology-anatomy-pathophysiology (CEAP) C scores were determined based on the sonographic and physical examination findings prior to the nightshift examination.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 20.0 software (IBM Corporation, Armonk, NY, USA). Normal distributions of numeric variables were assessed using the Kolmogorov-Smirnov test, while DUS-measured variables were not normally distributed. Therefore, non-parametric methods were used in the analysis. The presence of linear relationships between the numerical and ordinal variables was studied by the Spearman correlation analysis. The differences in numerical variables before and after nightshifts were controlled using the Wilcoxon signed rank test. The differences in binary variables in terms of reflux cut-off values before and after nightshifts were adjusted using the McNemar test. The Kappa (κ) statistical method was used to analyze the extent of agreement between the MC and VM methods. κ values ≤0 indicates "no" agreement, 0.01-0.20 "poor" agreement, 0.21-0.40 "slight" agreement, 0.41-0.60 "fair" agreement, 0.61-0.80 "good" agreement, 0.81-0.92 "very good" agreement, and 0.93-1 "excellent" agreement between the two tests.[15] The Mann-Whitney U test was used to compare the relationship of the presence of edema with nursing career and time spent standing. All hypothesis testing was performed using an alpha (α)= 0.05 significance level. A *p* value of <0.05 was considered statistically significant.

RESULTS

Of the 30 women, only eight had an history of pregnancy (one or two pregnancies). No woman was in the menopausal period. The mean body mass index was 21.8±3.2 kg/m^2 (17.7-32.7 kg/m^2). The mean time spent nursing in a clinical care unit was 8.2±4.8 years (range, 1 to 20 years). From the time of awakening in the morning, the mean time spent on foot throughout the day and the following nightshift was 12.9±2.8 hours (range, 7 to 18 hours). Of 32 nurses, diagnoses were as follows: asthma, benign positional vertigo, celiac disease, diabetes, and previous Raynaud phenomenon in each. In total, 17 nurses smoked at least half a pack of cigarettes daily. Of the 64 legs, 31 were of CEAP C0, 31 CEAP C1, one CEAP C2, and one CEAP C4 status. We combined the CEAP C scores of both legs for each nurse and obtained the following scores: 15 CEAP C0 (46.9%), one CEAP C1 (3.1%), 14 CEAP C2 (43.8%), one CEAP C3 (3.1%), and one CEAP C5 (C4+C1) (3.1%). Although we did not found any statistical significance, the total CEAP C scores were poorly correlated with the duration of nursing (r=0.11, p=0.53) and the total time spent standing on the day of the nightshift (r=0.24, p=0.17).

The median, minimum, and maximum reflux time measurements observed using both methods and the GSV and SSV diameters before and after nightshifts are summarized in Table 1. We found significantly longer reflux times only when MC was used to evaluate FV (p=0.025) and GSV (p=0.014); reflux times obtained using the VM to evaluate proximal GSV were similar, although the p value was 0.054. Reflux times in the other vein segments did not differ significantly. The diameters of the GSV and SSV were increased statistically, although the difference was not distinctive clinically.

Before nightshifts, we found bilateral pretibial edema in only one subject who had bilateral C0 scores. After the nightshift, bilateral edema developed in five additional nurses, making six nurses in total (18.75%; p=0.002), of whom four had bilateral CEAP C0 scores and two CEAP C1 scores. When we compared the duration (years) of critical care nursing and the mean time (hours) spent on foot on the day of the nightshift between nurses with and without pretibial edema, the latter parameter did not differ between the groups, while the duration of the nursing in a clinical care unit was significantly longer in nurses with edema (Table 2).

In the deep veins, namely the FV and PV, we found no significant difference before and after the nightshift with either reflux provocation method using specific

Table 1. The median, minimum and maximum reflux time measurements using distal manual compression and the Valsalva maneuver and the great saphenous vein and small saphenous vein diameters before and after nightshift, according to the Wilcoxon signed rank test

	Before nightshift		After nightshift		After nightshift-before nightshift			
	Median	Min.-Max.	Median	Min.-Max.	Negative ranks	Positive ranks	Ties	*p*
Manual compression								
Femoral vein	0.24 s	0-1.3	0.31 s	0-1	22	40	2	0.025
Great saphenous vein	0.20 s	0-3.5	0.23 s	0-3.1	21	34	9	0.014
Popliteal vein	0.31 s	0-0.80	0.30 s	0-0.9	26	36	2	0.490
Small saphenous vein	0.14 s	0-3.1	0.14 s	0-2.7	22	23	19	0.680
Valsalva maneuver								
Femoral vein	0.23 s	0-5.53	0.28 s	0-4	30	29	5	0.499
Great saphenous vein	0.17 s	0-5.66	0.23 s	0-5.68	16	31	17	0.054
Popliteal vein	0.00 s	0-5.50	0.00 s	0-5.33	12	17	35	0.198
Small saphenous vein	0.00 s	0-5.60	0.00 s	0-5.60	3	8	53	0.182
GSV radius	3.73 mm	2.60-4.85	4.05 mm	2.87-5.37	18	45	1	0.001
SSV radius	3.86 mm	1.5-6	3.37 mm	2-6	19	41	4	0.001

Min.: Minimum; Max.: Maximum; s: Second; GSV: Great saphenous vein; SSV: Small saphenous vein.

cut-off values [VM data for the FV (p=0.37), MC data for the FV (p=0.54), Valsalva maneuver data for the PV (p=0.25), MC data for the PV (p=1)]. However, conflicting results were obtained with both methods; we found positive reflux after the nightshift in a few nurses who did not exhibit reflux before, whereas we found positive reflux before the nightshift in some nurses who did not have reflux after the nightshift (Figure 1a, b).

Furthermore, we compared the extent of agreement between the two methods before and after the nightshifts. The results are listed as follows: VM vs. MC before the nightshift in FV (κ=0.038), VM vs. MC after the nightshift in FV (κ= -0.098), VM vs. MC before the nightshift in PV (κ=0.20) and VM vs. MC after the nightshift in PV (κ= -0.1). According to these results, κ test revealed either "no" or "poor" agreement in deep veins (Figure 2a, b).

On the other hand, for the superficial veins, namely the GSV and SSV, we found no significant difference before and after the nightshift with either reflux provocation method using specific cut-off values [VM data for the GSV (p=1), MC data for the GSV (p=1), VM data for the SSV (p=1), MC data for the SSV (p=1)] However, conflicting results were obtained with both methods (Figure 3a, b). We compared the extent of agreement between the two methods before and after the nightshifts. The results are listed as follows: VM vs. MC before the nightshift in GSV; "fair" agreement (κ=0.52), VM vs. MC after the nightshift in GSV; "good" agreement (κ=0.79), VM vs. MC before the nightshift in SSV; "good" agreement (κ=0.66), VM vs. MC after the nightshift in SSV; "fair" agreement (κ=0.48). According to these results, κ test revealed either "good" or "fair" agreement in deep veins (Figure 4a, b).

DISCUSSION

Duplex ultrasonography results are user-dependent and the method has not been standardized globally. In our unit, some radiologists traditionally use VM on supine position to evaluate reflux, while the others use the distal MC method, although the recent studies suggest the use of distal MC method due to increased false positive and negative rates of VM.[14,16,17]

Table 2. The relationship between edema development after the nightshift, with duration of nursing career in a critical care unit, and time spent on foot during the day

Presence of edema (n)	Standing on foot (hours)			Nursing career duration (years)		
	Mean	Min.-Max.	*p*	Mean	Min.-Max.	*p*
No edema (n=26)	12.77	7-18	0.55	7.5	1-20	0.02
Edema (n=6)	13.50	11-17		11.3	8-14	

Min.: Minimum; Max.: Maximum.

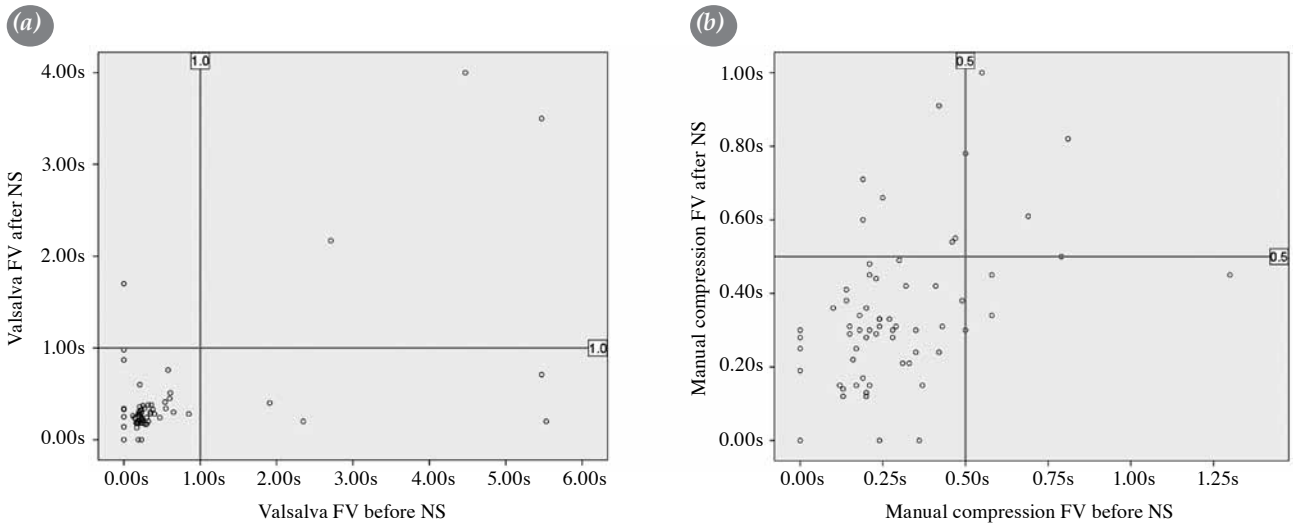

Figure 1. Comparison of data obtained before and after the nightshift using either method to evaluate the deep veins. The graphs show that the lower left areas exhibited no reflux on either examination, while the upper right area exhibited positive reflux on either examination. Dots in the upper left and the lower right areas show positive reflux data either before or after the nightshift. Chi-square scatterplot graphs are shown. **(a)** Valsalva maneuver data for the night shift (p=0.37) **(b)** Manual compression data for the femoral vein (p=0.54).

FV: Femoral vein; NS: Nightshift.

Based on the published data, we used specific cut-off times for distal MC while standing and the VM while lying down and explored whether the results were affected by prolonged standing during the nightshift. In the MC method, >0.5 s was used as the cut-off for each venous segment.[14,16,18] The cut-off values used for the VM in the supine position were defined as >1 s for the FV and PV, and >0.5 s for the superficial veins.[14,16,17,19-22]

Furthermore, we found that a significantly longer reflux time was evident after the nightshift compared to before the nightshift only when MC method was

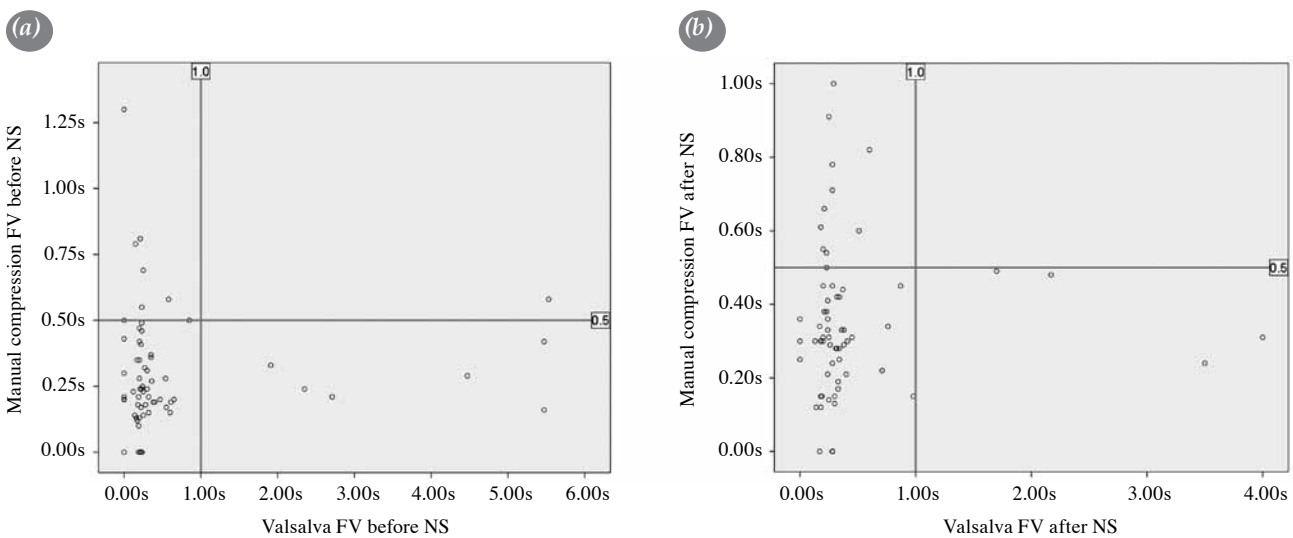

Figure 2. The extent of agreement between the two methods in terms of deep vein data before and after the nightshift. In the graphs, the lower left areas exhibited no reflux in either examination, while the upper right areas exhibited positive reflux in both examinations. Dots in the upper left and lower right areas indicate positive refluxes with either the Valsalva maneuver or manual compression. Scatterplot graphs are shown. **(a)** Valsalva vs. manual compression before night shift; femoral vein (κ=0.038). **(b)** Valsalva vs. manual compression after a night shift; femoral vein (κ= -0.098).

FV: Femoral vein; NS: Nightshift.

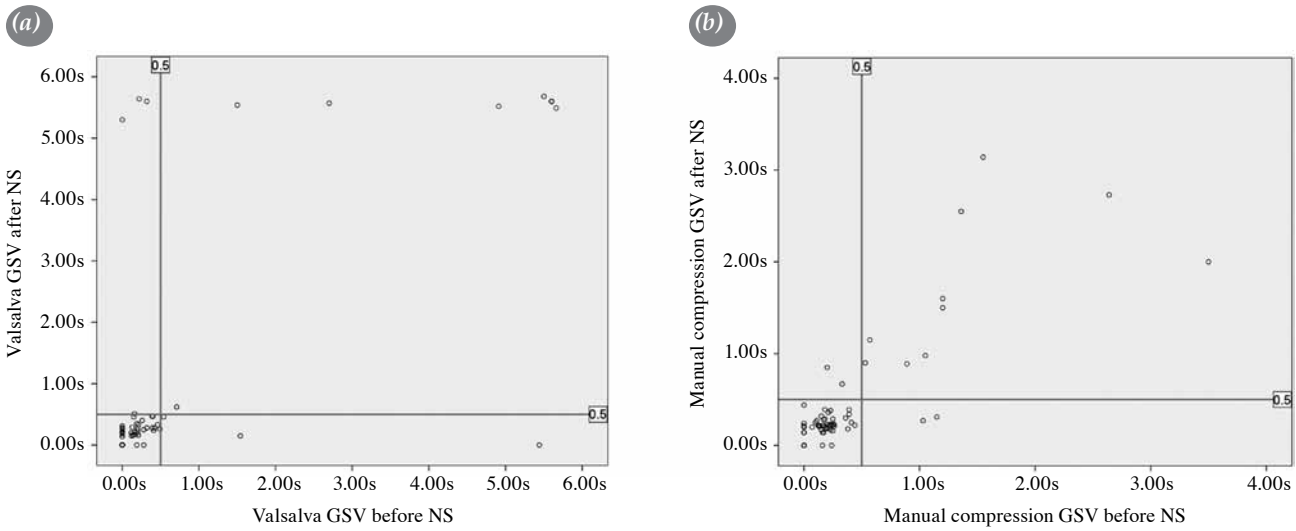

Figure 3. Comparison of data obtained before and after the night shift using either method to evaluate the superficial veins. In the graphs, the lower left areas exhibited no reflux in either examination, while the upper right areas exhibited positive reflux in both examinations. Dots in the upper left and lower right areas indicate positive refluxes either before or after the night shift. Chi-squared scatterplot graphs are shown. **(a)** Valsalva maneuver data for the great saphenous vein (p=1) **(b)** Manual compression data for the great saphenous vein (p=1).

GSV: Great saphenous vein; NS: Nightshift.

used to evaluate the proximal GSV and FV. In other venous segments, the Doppler findings did not differ significantly (Table 1). Although increased proximal GSV and FV reflux times after the nightshift were evident using the MC, the increase did not affect the final test results in terms of the cut-off values and the difference was clinically non-significant. One of the clinical implications of our study is that the two examination techniques yielded similar findings for both deep and superficial vein segments and there was

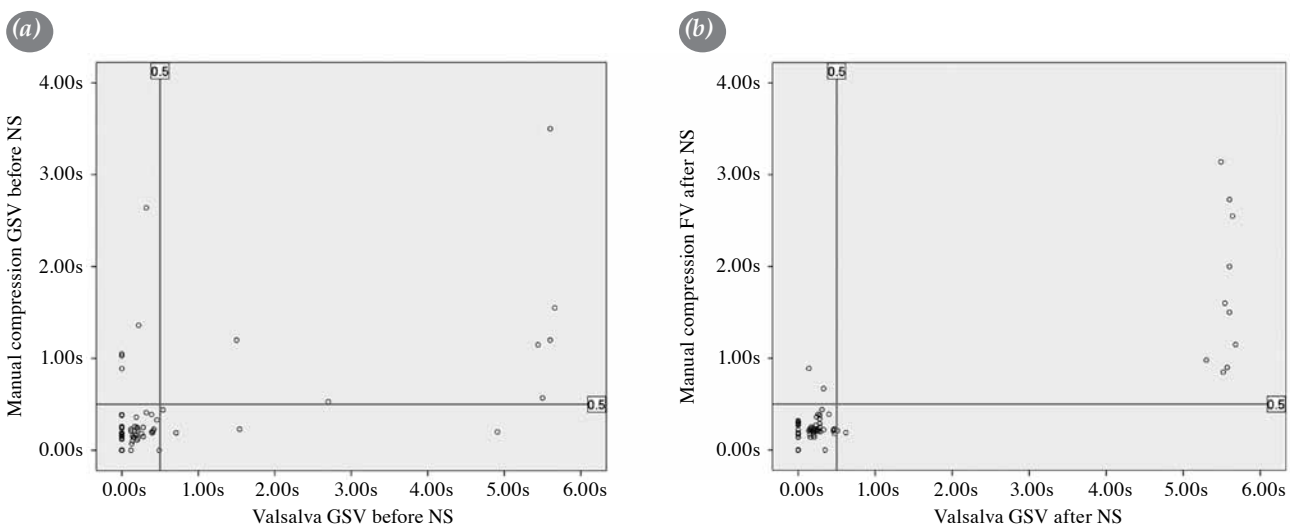

Figure 4. The extent of the agreement between data of the two methods used to assess the superficial veins before and after the night shift. In the graphs, the lower left areas exhibited no reflux in either examination, while the upper right areas exhibited positive reflux in both examinations. Dots in the upper left and lower right areas indicate positive reflux findings using either the Valsalva maneuver or the manual compression method. Scatterplot graphs are shown. **(a)** Valsalva vs. manual compression before night shift; great saphenous vein; fair agreement (κ=0.52). **(b)** Valsalva vs. manual compression after a night shift; great saphenous vein; good agreement (κ=0.79).

GSV: Great saphenous vein; NS: Nightshift.

no significant difference between before and after the nightshifts. However, we found positive reflux after the nightshift in a very few number of nurses who did not exhibit reflux before the nightshift and, conversely, we detected positive reflux before the nightshift in a few nurses who did not have reflux after the nightshift (Figures 1a, b and 3a, b). Such inconsistencies may be associated with the reflux provocation technique used, the ultrasonography machine, the examination room conditions, or the subjects.[22]

In the present study, we used two different reflux provocation methods. The VM applied in supine position is comfortable for both patients and the radiologist, is practical, and has been shown to be effective in assessing reflux in earlier studies.[19-21] On the other hand, many authors have suggested that VM data can easily be affected by respiration, muscle tone, and patient co-operation, and that the maneuver is not standardized.[14] Labropoulos et al.,[16] reported that the VM did not affect distal areas, when there was a patent proximal valve and concluded that the distal MC should be preferred. A multi-center study which used the latter method indicated that DUS data on deep veins were highly repeatable, being unaffected by factors such as examination time, patient position, or the reflux-provoking maneuver used.[14] We compared the extent of agreement between the two techniques before and after nightshifts. The κ test indicated that agreement was either "no" or "poor" when deep vein data were compared, and "fair" or "good", when superficial vein data were compared. Based on our findings and the recent literature, we suggest that the distal compression technique should be used to assess the deep veins; however, either method is adequate when examining the superficial veins.

In all nurses, total CEAP C scores did not significantly correlate with the total years of working as a clinical care nurse or the time spent on foot during the day of the nightshift. Although our study group was small compared to those of other epidemiological studies and the mean age of the study group was only 31.2 years, our findings support previous study findings, indicating that no relationship exists between prolonged standing and CEAP C scores.[6,8] In our study, almost all nurses complained painful and swollen legs after the nightshifts. Indeed, a significant increase (18.75%) in the number of nurses with pretibial edema was evident after the nightshifts. However, we expected the rate to be higher. Based on our findings, we suggest that the main cause of the leg pain was muscle tiredness rather than venous insufficiency. When we compared nurses with pretibial edema to those without, the duration of prolonged standing during the nightshift did not differ; however, the mean number of years spent working as a clinical care unit nurse was significantly higher in subjects with edema. This finding also supports the data of occupational epidemiological studies reporting a positive association between certain occupations and development of venous insufficiency.[2,4,5]

On the other hand, our study has some limitations. First, a single radiologist performed all DUS examinations; therefore, inter-observer variability was unable to be attained. We were unable to extend examination duration which took 45 minutes at least due to high workload of our clinic and higher rejection rates of a longer repeated examination by our study population. Second, our sample size was still small, although it was larger compared to many previous Doppler studies. In addition, our subjects were mostly of CEAP C0 or C1 status. It should be kept in mind that this is the main group for which DUS results might be controversial. Although, our study group was as homogeneous as possible, a large-scale patient group consisting of those with more severe symptoms would yield more definite data. Unfortunately, it is not easy to find a nurse with CEAP score of C3 or more which in that case it is extremely severe to work actively. Also, we did not use an automatic cuff inflator device, as they are not available in Turkey. Such devices create a standard distal compression pressure and may produce more reliable results. However, no difference was found between distal manual and automatic compression methods by different studies.[14,23,24]

In conclusion, we hypothesized that increased reflux would be evident in nurses after a busy nightshift compared to a routine morning following a regular night sleep. However, our findings do not support this hypothesis. In general, duplex ultrasonography data did not change after the nightshift and conflicting duplex ultrasonography results were obtained in a small number of subjects before and after nightshift using either the Valsalva maneuver in the supine position or the distal manual compression in the standing position. Therefore, anomalies were unable to be attributed to the reflux provocation method used. In addition, pretibial edema increased significantly after the nightshifts. Using either distal manual compression in the standing position or the Valsalva maneuver in the supine position, we found either "no" or "poor" agreement in deep vein data and "fair" or "good" agreement in superficial vein data.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

This study received financial support from Vamet medikal under the regulations of Dokuz Eylul University Hospital Supportive Scientific Projects (DAPS - study number 702) and Dokuz Eylul University Ethic Committee.

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