Prevalence of venous reflux in the general population on duplex scanning: The Edinburgh Vein Study

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Purpose: **The prevalence of reflux in the deep and superficial venous systems in the Edinburgh population and the relationship between patterns of reflux and the presence of venous disease on clinical examination were studied.**

Methods: **A cross-sectional survey was done on men and women ranging in age from 18 to 64 years, randomly selected from 12 general practices. The presence of varicose veins and chronic venous insufficiency was noted on clinical examination, as was the duration of venous reflux by means of duplex scanning in 8 vein segments on each leg. Results were compared using cut-off points for reflux duration (RD) of 0.5 seconds or more (RD ≥ 0.5) and more than 1.0 second (RD > 1.0) to define reflux.**

Results: **There were 1566 study participants, 867 women and 699 men. The prevalence of reflux was similar in the right and left legs. The proportion of participants with reflux was highest in the lower thigh long saphenous vein (LSV) segment (18.6% in the right leg and 17.5% in the left leg for RD ≥ 0.5), followed by the above knee popliteal segments (12.3% in the right leg and 11.0% in the left leg for RD ≥ 0.5), the below knee popliteal (11.3% in the right leg and 9.5% in the left leg for RD ≥ 0.5), upper LSV (10.0% in the right leg and 10.8% in the left leg for RD ≥ 0.5) segments, the common femoral vein segments (7.8% in the right leg and 8.0% in the left leg for RD ≥ 0.5), the lower superficial femoral vein (SFV) segments (6.6% in the right leg and 6.4% in the left leg for RD ≥ 0.5), and the upper SFV (5.2% in the right leg and 4.7% in the left leg for RD ≥ 0.5) and short saphenous vein (SSV) (4.6% in the right leg and 5.6% in the left leg for an RD ≥ 0.5) segments. In the superficial vein segments, there was little difference in the occurrence of reflux whether RD ≥ 0.5 or RD > 1.0 was used; but in the different deep vein segments, the prevalence of reflux was 2 to 4 times greater for RD ≥ 0.5 rather than RD > 1.0. Men had a higher prevalence of reflux in the deep vein segments than women, reaching statistical significance ($P \leq .01$) in 4 of 5 segments for RD ≥ 0.5. In general, the prevalence of reflux increased with age. Those with "venous disease" had a significantly higher prevalence of reflux in all vein segments than those with "no disease" ($P \leq .001$).**

Conclusion: **The prevalence of venous reflux in the general population was related to the presence of "venous disease," although it was also present in those without clinically apparent disease. There was a higher prevalence of reflux in the deep veins in men than the deep veins in women. Follow-up study of the population will determine the extent to which reflux is a predictor of future disease and complications. (J Vasc Surg 1998;28:767-76.)**

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Duplex scanning has become the method of choice for the investigation of venous reflux.[1] It combines the assessment of anatomic structure and the functional evaluation of blood flow[2] to enable quantification of reflux duration in specific superficial and deep vein segments.[1] In addition, as a noninvasive and repeatable method of measurement, it is suitable for use in epidemiological studies.

Studies correlating reflux findings on duplex scanning with various stages of venous disease have increased knowledge of the patterns of reflux in venous patients.[3-6] In addition, the reflux patterns in apparently healthy volunteers were described in one small study.[7] In the Bochum Study, the venous Doppler and clinical findings on the lower limbs of a cohort of German schoolchildren were reported.[8] However, to our knowledge, no previous study has investigated the distribution of venous reflux on duplex scanning in a large random sample of the adult population.

The Edinburgh Vein Study was the first study in the United Kingdom to investigate venous disease in the general population, using duplex scanning as a means of measuring venous reflux. The prevalence of varicose veins and chronic venous insufficiency of the legs in the general population and the associations with a range of genetic and lifestyle factors were studied. We sought to determine the prevalence of reflux in the deep and superficial venous systems in the general population and to relate the patterns of reflux to the overall presence of clinical venous disease.

PARTICIPANTS AND METHODS

The Edinburgh Vein Study is a cross-sectional survey, with a target population comprising men and women aged 18 to 64 years who live in Edinburgh. An age-stratified random sample was selected from the computerized age-sex registers of 12 general practices, which served areas geographically and socioeconomically distributed throughout the city. A sample size of 1500 participants was estimated, based on the number required to give an adequate precision for prevalence, to detect a significant difference in prevalence between groups, and to enable a subsequent follow-up study to be conducted. Details of the methods and response in the Edinburgh Vein Study have been reported.[9]

Participants went to a clinic at the University of Edinburgh between May 1994 and April 1996 and were examined by 1 or more members of a research team, comprising a nurse, technician, and clinical research fellow. Participants completed a self-administered questionnaire that included personal and occupational details, relevant medical and family history, and possible risk factors for venous disease. The height of each participant without shoes was measured to the nearest 5 mm, using a free-standing metal ruler on a heavy base. Weight, without shoes or outer clothes, was measured to the nearest 100 g on a digital Soehnle scale.

The method of examination and classification of venous disease was adapted from the Basle Study.[10] (The CEAP classification for chronic venous disease, published in 1995,[1] was not available at the time of design and start of recruitment in the Edinburgh Vein Study. The Basle Study classification was considered to be the best available classification of venous disease at the time,[11] providing the best detail for the different degrees of varicose veins.) Participants stood on a raised platform with their feet in 3 standard positions and were asked to remain in a standing position for a minimum of 2 minutes to allow the blood to pool in the legs before classification of their veins. Varices were divided into 3 types: trunk varices (dilated, tortuous trunks of the saphena magna or parva vein and their branches of the first or second order), reticular varices (dilated, tortuous subcutaneous veins not belonging to the main trunk or its major branches), and hyphenweb varices (intradermal varices). Each of the 3 groups was subdivided into grades of severity from 1 to 3, determined according to the "degree and extent of tortuosity and prominence of the veins."[10] An additional category called "perforators" (soft lumps that reduced on pressure and disappeared on elevation of the leg) was included to allow the documentation of possible incompetent perforating veins or blowouts. The lack of sensitivity and specificity of this definition of perforators was recognized. However, such abnormalities were documented to avoid subsequent misclassification of participants with no trunk varices when grouping the study population into those with "venous disease" and those with "no disease" (see below). Each participant was also examined for the presence of any pitting ankle oedema and assessed for chronic venous insufficiency (CVI) graded 1 to 3. Grade 1 CVI was "corona phlebectatica/dilated subcutaneous veins;" grade 2 was "hyper- or de-pigmented areas with or without corona phlebectatica;" and grade 3 was "open or healed ulcus cruris."[10] (The grades of CVI correspond to the CEAP clinical classification for chronic venous disease[1] as follows: grade 1 CVI corresponds to class 1 [malleolar flare]; grade 2 CVI corresponds to class 4 [skin changes]; and grade 3 CVI corre-

sponds to classes 5 and 6 [healed or active ulceration].) For the purposes of this report, participants were divided according to venous disease status: the group with "no disease" comprised those participants with no trunk varices, CVI, perforators, or history of varicose vein treatment and a maximum of grade 1 hyphenweb and/or reticular varices; the group with "venous disease" included all participants with trunk varices and/or CVI.

The duplex scans were performed with a Diasonics Prisma VST duplex scanner (Diasonics Sonotron, Zug, Switzerland) with a 5.0 MHz linear array probe. Cephalad venous flow was induced by means of a pneumatic cuff placed around the calf (cuff width, 10 cm; length 50 cm), which was rapidly inflated and deflated using an automatic cuff inflator (Oak Medical, Scunthorpe, United Kingdom) to mimic a hand squeeze. For those calves of a larger diameter, a longer cuff was used (cuff width, 10 cm; length, 65 cm). A pressure of approximately 110 mm Hg was used to inflate the cuffs. If this standard pressure did not produce a forward flow equivalent to a minimum standard Doppler shift of 0.5 to 1.0 kHz in the vein segment under examination, then a manual squeeze of the calf was used to elicit augmentation of venous flow for examination of that vein segment. Occasionally, a manual squeeze of the thigh was used. The refill time between compressions was a minimum of approximately 5 seconds.

Each participant was examined on a tilting couch (Akron Therapy Products, Ipswich, United Kingdom) at a 45° angle. A pilot study conducted before the Edinburgh Vein Study reported that a significant number of young participants felt faint while standing on a tilting couch in the near upright position during duplex examination. Therefore, the 45° position was chosen to give participants some support, and to minimize fainting during the procedure while allowing gravity to act on blood within the leg. Any participant who felt faint at this angle was examined in the 30° head-up position. For examination of the thigh, participants stood with their backs to the couch, with the leg to be examined everted and slightly bent at the knee and the weight mainly on the opposite leg. When the segments behind the knee were examined, participants stood facing the couch, with the leg to be examined slightly bent at the knee and the weight mainly on the opposite leg.

Measurements were made in 8 vein segments along the deep and superficial veins of both legs: (1) the common femoral vein (CFV) proximal to the sapheno-femoral junction; (2) the superficial femoral vein approximately 2 cm distal to the confluence with the profunda femoris vein (upper SFV); (3) the superficial femoral vein in the lower third of the thigh (lower SFV); (4) the popliteal vein above the knee crease (above knee popliteal); (5) the popliteal vein below the knee crease (below knee popliteal); (6) the long saphenous vein just distal to the saphenofemoral junction (upper LSV); (7) the long saphenous vein in the lower third of the thigh (lower thigh LSV); and (8) the short saphenous vein just distal to the sapheno-popliteal junction (SSV). In addition, the presence of any dual superficial femoral veins was documented, and the duration of reflux in these veins was measured.

When cephalad venous flow was induced in the limb under examination, any reflux present was identified on the Doppler spectrum. Two typical spectra were selected at each site, and the duration of reflux was measured by placing the cursors at the beginning and end of the period of reflux. Time was calculated to the nearest hundredth of a second, to a maximum of 8 seconds as limited by the size of the screen. Reflux duration (RD) greater than 8 seconds was recorded as 8.00 seconds. Presence of any turbulent flow was recorded when it led to difficulty in accurately measuring the RD. The mean of the 2 readings at each point on the vein was used in all subsequent analysis. When there was a technical difficulty or query about part of the duplex scan, the participant was asked to return to have that part of the scan repeated by a radiologist (P.L.A.), who used an Ultramark 9 HDI color-flow duplex scanner (Advanced Technology Laboratories, Bothell, Wash). When the measurements from these 2 scans differed significantly, the results of the second scan were used in the analysis.

All 3 research team members were involved for the duration of the study, and there were no changes in personnel. Several measures were adopted before and during the study to limit observer variability. The research nurse and technician, who were the principal observers, were trained together initially in the method of classification of varices and chronic venous insufficiency. The photographic slides of participants' legs were analyzed and discussed weekly by all 3 observers, and reference photographs were reviewed periodically as a reminder of the original standard. From time to time during the study, sequential duplex scans were performed by all 3 observers on the same volunteers to allow interobserver comparison of results and identification and discussion of any problems.

After each participant's appointment, a report of the clinical findings was sent to the participant's gen-

Table I. Prevalence of reflux of 0.5 seconds or more duration and reflux more than 1.0 second duration in individual vein segments, for legs separately and together

	Right leg			*Left leg*			*Both legs*		
Vein segment	*Total (n)**	*≥0.5 sec %*	*>1.0 sec %*	*Total (n)**	*≥0.5 sec %*	*>1.0 sec %*	*Total (n)†*	*≥0.5 sec %*	*>1.0 sec %*
CFV	(1542)	7.8	2.1	(1539)	8.0	2.1	(1539)	2.5	0.6
Upper SFV	(1539)	5.2	1.2	(1540)	4.7	1.3	(1537)	1.7	0.3
Lower SFV	(1539)	6.6	2.5	(1538)	6.4	2.7	(1536)	2.2	0.8
Above knee popliteal	(1541)	12.3	5.0	(1541)	11.0	5.3	(1541)	3.9	1.3
Below knee popliteal	(1540)	11.3	4.7	(1541)	9.5	4.6	(1540)	3.3	1.0
Upper LSV	(1485)	10.0	9.6	(1477)	10.8	10.1	(1449)	4.8	4.6
Lower thigh LSV	(1422)	18.6	17.7	(1432)	17.5	16.7	(1363)	8.0	7.5
SSV	(1342)	4.6	3.7	(1351)	5.6	4.2	(1241)	1.6	1.1

*****Missing values included: vein segment not visualized (eg, after vein stripping); absence of flow in vein segment; participants unable to undergo all or part of the scan because of a pre-existing medical condition, feeling faint, or the examination being performed in their home.
†Reflux in "both legs" calculated as a percentage of those participants who had valid duplex measurements for that vein segment in both legs.
CFV, common femoral vein; *SFV,* superficial femoral vein; *LSV,* long saphenous vein; *SSV,* short saphenous vein.

eral practitioner. Those participants who wanted more information on varicose veins were offered a brochure and referred back to their general practitioners. "Home visit" appointments were made for 19 participants who were not able to go to the university clinic because of medical or social reasons. All study measurements, except the duplex scans, were performed during the home visits. Local ethics committee approval was given for the study, and informed consent was obtained from each study participant.

A survey of the "nonresponders" (ie, those who initially agreed to participate in the study but subsequently withdrew or failed to attend their appointments and those who declined to participate in the study from the beginning) was carried out in 4 of the 12 practices. This survey took the form of a 1-page questionnaire, which inquired about past history of venous disease and treatment for varicose veins.

Information from the recording forms and questionnaires was entered in a DBASE IV database. The data files were transferred to the Edinburgh University mainframe computer for analysis with the SPSS-X and SAS statistical packages. The following statistical tests were used: χ^2 test and Mantel-Haenszel test for linear association for categorical data, and Student *t* test for continuous parametric data. The age-adjusted percentages were calculated using a SAS macro (GLIMMIX), which fits generalized linear-mixed models. Results were compared with cut-off points for an RD of 0.5 seconds or more (RD ≥ 0.5) and for an RD of more than 1.0 second (RD > 1.0) to define reflux.

RESULTS

A total of 1566 participants, 867 women and 699 men, were examined. There were 1346 "nonresponders" (998 who refused to participate, and 348 who agreed to take part in the study but subsequently withdrew), resulting in a response rate of 53.8% of those contacted and still living in the area. The mean age of study participants was 44.8 years for women and 45.8 years for men. The age-adjusted prevalence of trunk varices was 39.7% in men and 32.2% in women ($P \leq .01$). Hyphenweb and reticular varices each affected more than 80% of participants, although most participants were affected to a mild degree only. The age-adjusted prevalence of chronic venous insufficiency was 9.4% in men and 6.6% in women ($P \leq .05$). In the survey of nonresponders, 6.5% of the 194 nonresponders who returned their questionnaire reported having received a doctor's diagnosis of varicose veins, compared with 13.3% of the study participants from the same practices who did respond ($P \leq .05$; figures adjusted for age and sex). Of the men, 6.7% of nonresponders and 9.1% of participants reported having received a doctor's diagnosis of varicose veins ($P > .05$), compared with 6.5% of female nonresponders and 16.7% of female participants ($P \leq .05$).[12] Table I shows the prevalence RD ≥ 0.5 and the prevalence of RD > 1.0 for each vein segment in right and left legs separately and in both legs together. (In addition, a dual superficial femoral vein was visualized in 471 participants in the right leg, in 458 participants in the left leg, and in 277 participants in both legs; however, in each leg only 2 participants [0.4%] showed RD ≥ 0.5 in this vein.)

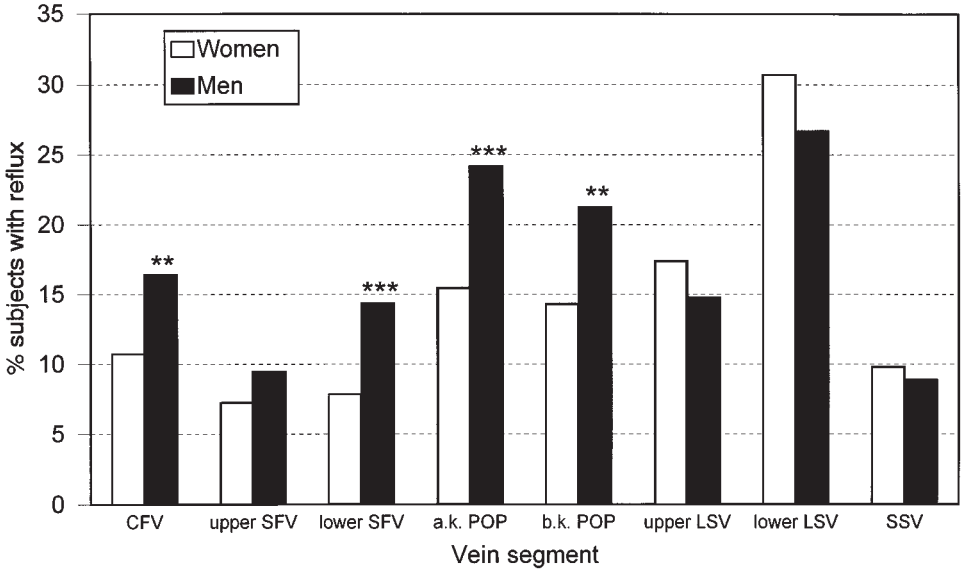

Fig 1. Proportion of participants with reflux of 0.5 seconds or more duration in either leg at individual vein segments, by sex (adjusted for age). *CFV,* common femoral vein; *SFV,* superficial femoral vein; *a.k. POP,* above knee popliteal; *b.k. POP,* below knee popliteal; *LSV,* long saphenous vein; *lower LSV,* lower thigh LSV; *SSV,* short saphenous vein.

There was little difference in the prevalence of reflux between the right and left legs for either RD ≥ 0.5 or RD > 1.0. The lower thigh LSV segment most often showed reflux, compared with all other deep and superficial vein segments examined, with 18.6% of participants having an RD ≥ 0.5 at this segment in the right leg, 17.5% in the left leg, and 8.0% in both legs. (Only 1241 of the 1566 participants had valid results for SSV segments in both legs. If a short saphenous vein could not be visualized or confidently identified as such, it was recorded as a missing value rather than assuming that there was no reflux present in the SSV.) Among the deep vein segments, the above knee popliteal segments most often showed reflux. In the superficial vein segments, there was little difference between the proportion of participants with RD ≥ 0.5 and participants with RD > 1.0. However, in the different deep vein segments, the prevalence of RD ≥ 0.5 was 2 to 4 times higher than the prevalence of RD > 1.0. The presence of turbulence was recorded in less than 2.5% of participants in each vein segment except the CFV segments, where it was documented in 8.0% of participants on the right leg and 9.8% of participants on the left leg.

Fig 1 compares the age-adjusted prevalence in men and women of RD ≥ 0.5 in either leg at individual vein segments. For all deep vein segments, men had a higher prevalence of reflux than women. This sex difference reached statistical significance in all deep vein segments except the upper SFV. Conversely, women had a higher prevalence of reflux in the superficial vein segments, although the sex differences in these segments were not statistically significant (all $P > .05$). If more women than men had their incompetent superficial veins surgically removed, resulting in missing values for some superficial vein segments, that would have led to a misleading reduction in this sex differential. Therefore, participants who had missing values for individual LSV segments on duplex scanning and who also reported having had previous varicose vein surgery were identified. Even assuming that all these participants would have had RD ≥ 0.5 in the missing LSV segments, the sex differential for reflux in the upper and lower thigh LSV segments did not attain statistical significance ($P > .05$). For RD > 1.0, men continued to have a higher prevalence than women of reflux in the lower SFV ($P \leq .01$) and the below knee popliteal ($P \leq .05$) segments. However, for RD > 1.0, the sex differential for the above knee popliteal segment decreased ($P > .05$), and in the CFV and upper SFV segments, the proportions of men and women with RD > 1.0 were almost identical (CFV, 3.7% of men and 3.5% of women; upper SFV, 2.2% of men and 2.3% of women) (both $P > .05$). For RD > 1.0, women had a higher prevalence of reflux in their superficial vein segments than men, although, again, the sex differences were not significant.

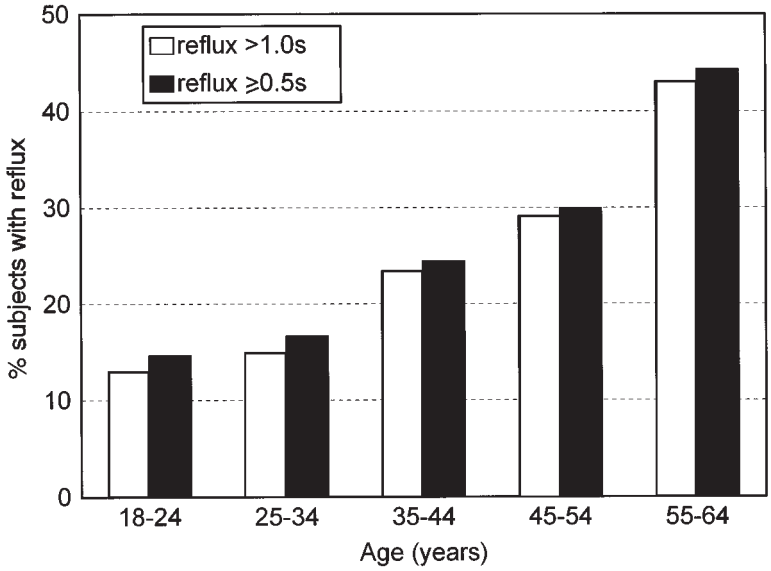

Fig 2. Proportion of participants with reflux of 0.5 seconds or more duration and reflux of more than 1.0 seconds duration in the lower thigh segment of the long saphenous vein in either leg, by age.

Table IIa. Patterns of reflux in the femoral and long saphenous veins

	Right leg (n = 1483) % with reflux		*Left leg (n = 1476) % with reflux*	
Vein segment	*≥0.5 sec*	*>1.0 sec*	*≥0.5 sec*	*>1.0 sec*
CFV (total)	7.4	2.0	7.5	2.0
CFV & upper LSV only	2.0	1.2	2.2	1.3
CFV & upper SFV only	1.1	0.1	0.9	0.1
CFV & upper SFV & upper LSV	0.5	0.3	0.5	0.3

(n), number of participants with complete duplex data for all relevant vein segments; *CFV,* common femoral vein; *LSV,* long saphenous vein; *SFV,* superficial femoral vein.

Table IIb. Patterns of reflux in the popliteal and short saphenous veins

	Right leg (n = 1341) % with reflux		*Left leg (n = 1351) % with reflux*	
Vein segment	*≥0.5 sec*	*>1.0 sec*	*≥0.5 sec*	*>1.0 sec*
Above knee popliteal (total)	12.5	5.0	11.0	5.3
Above knee popliteal & SSV only	1.0	0.6	0.8	0.5
Above & below knee popliteal only	5.7	1.9	5.0	2.4
Above & below knee popliteal & SSV	1.3	0.6	1.5	0.5

(n), number of participants with complete duplex data for all relevant vein segments; *SSV,* short saphenous vein.

In many of the vein segments, there was a trend toward a higher prevalence of reflux in the older age groups. Fig 2 shows the proportion of participants with RD ≥ 0.5 and RD > 1.0 in the lower thigh LSV segment of either leg, by age group. A highly significant linear association between prevalence of reflux and age was noted for both RD ≥ 0.5 and RD > 1.0 ($P \leq .001$).

Table IIa shows the patterns of reflux in the femoral and long saphenous veins. In the right leg, 7.4% of participants had RD ≥ 0.5 in the CFV segment, 2.0% in both the CFV and upper LSV segments, and 1.1% in both the CFV and upper SFV segments. Only 0.5% of participants had RD ≥ 0.5 in all 3 vein segments. The results were similar for the

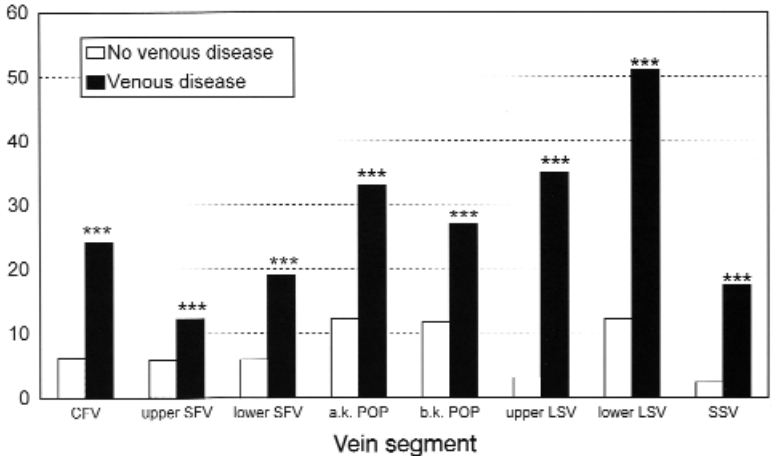

Fig 3. Age-adjusted and sex-adjusted prevalence of reflux of 0.5 seconds or more duration in either leg, at individual vein segments, in participants with and without "venous disease." *CFV,* common femoral vein; *SFV,* superficial femoral vein; *a.k. POP,* above knee popliteal; *b.k. POP,* below knee popliteal; *LSV,* long saphenous vein; *lower LSV,* lower thigh LSV; *SSV,* short saphenous vein.

left leg. For RD > 1.0, in each leg, 2.0% of participants had reflux in the CFV segment, and 0.3% had reflux in all 3 segments. Table IIb shows patterns of reflux in the popliteal and short saphenous vein system. In the right leg, 12.5% of participants had RD ≥ 0.5 in the above knee popliteal segment, 1.0% in both the above knee popliteal and SSV segments, and 5.7% in both the above knee and below knee popliteal vein segments. Only 1.3% had reflux in all 3 vein segments. The results were slightly lower for the left leg, whereas the prevalences were approximately halved for RD > 1.0.

When analyzed according to venous disease status (as defined in the methods section), 861 participants (516 women, 345 men) had "no disease," and 579 participants (282 women, 297 men) had "venous disease." The remaining 126 participants fell into neither category (because they had either perforators, previous varicose vein treatment, and/or grade 2/3 reticulars/hyphenwebs without trunks or CVI) and were excluded from this analysis. Of the 642 men, 46.3% had "venous disease," compared with 35.3% of the 798 women ($P \leq .001$). Those participants with "venous disease" were significantly older than those with "no disease" (mean age, 51.2 years, compared with 40.4 years) ($P \leq .001$). Fig 3 shows the age-adjusted and sex-adjusted prevalence of RD ≥ 0.5, at individual vein segments in either leg, by disease status. The prevalence of reflux was significantly higher at each vein segment in participants with "venous disease" ($P \leq .001$). Of the 630 "disease-free" participants with complete duplex data for all 16 vein segments, 411 (65%) had no evidence of RD ≥ 0.5 in any segment. For RD > 1.0, the prevalence of reflux was also significantly higher at each vein segment in those with "venous disease" (all $P \leq .001$), although there were very few participants with "no disease" who had RD > 1.0 in the CFV or SFV segments of either leg. (CFV, n = 4, 0.5%; SFV upper, n = 3, 0.4%; SFV lower, n = 8, 1.0% [percentages are age- and sex-adjusted]). Of the 630 "disease-free" participants described above, 518 (82%) had no evidence of RD > 1.0 in any vein segment.

Table III illustrates the distribution of reflux in individual vein segments in participants with and without "venous disease." For each participant, the value was taken from the leg that showed the longer RD for each vein segment. For all segments, the median, 75th, and 95th centiles were higher in participants with "venous disease" than participants with "no disease." In participants with "no disease," the 75th centiles were all less than 0.50 seconds. The 95th centiles for the upper LSV and SSV segments were less than 0.50 seconds, and for all other vein segments they were less than 1.00 second, except the lower thigh LSV segment (6.46 seconds). When analyzed according to sex, the difference between the median RD for men and women with "no disease" was no more than 0.05 seconds for any segment. In those participants with "venous disease," the median was highest for the lower thigh LSV segment (2.30

Table III. Distribution of reflux in individual vein segments in participants with and participants without venous disease

	No venous disease (n = 861)			*Venous disease (n = 579)*		
*Segment**	*Median*	*IQR*	*95th centile*	*Median*	*IQR*	*95th centile*
CFV	0.09	0.00–0.26	0.54	0.18	0.00–0.48	1.63
Upper SFV	0.11	0.00–0.25	0.52	0.15	0.00–0.33	1.14
Lower SFV	0.13	0.04–0.25	0.53	0.18	0.06–0.40	2.88
Above knee popliteal	0.17	0.10–0.32	0.84	0.25	0.13–0.68	2.63
Below knee popliteal	0.14	0.10–0.28	0.88	0.20	0.12–0.53	2.30
Upper LSV	0.00	0.00–0.10	0.29	0.15	0.00–4.30	8.00
Lower thigh LSV	0.11	0.05–0.16	6.46	2.30	0.10–6.97	8.00
SSV	0.10	0.00–0.14	0.27	0.13	0.10–0.24	4.08

*Value taken from the leg with the longer duration of reflux for each vein segment.
IQR, Interquartile range; *CFV,* common femoral vein; *SFV,* superficial femoral vein; *LSV,* long saphenous vein; *SSV,* short saphenous vein.

seconds). The 75th centiles for the CFV, upper and lower SFV, and SSV segments were all less than 0.50 seconds. Only the 75th centiles for the upper and lower thigh LSV segments were greater than 1.00 second (4.30 and 6.97 seconds, respectively). All the 95th centiles were greater than 1.00 second in participants with "venous disease." The sex differences in the median RD in those with "venous disease" were no more than 0.08 seconds for any segment, except the LSV segments. In participants with "venous disease," the median (inter-quartile range) RD in the upper LSV segment was 0.26 (range, 0 to 5.14) for women and 0.13 (range, 0 to 2.04) for men, and for the lower thigh LSV segment the median RD was 4.14 (range, 0.12 to 8.00) for women and 0.23 (range, 0.09 to 6.08) for men.

The relationship between duration of venous reflux in certain segments and the presence of "venous disease" in a participant was examined further. The sensitivities and specificities were calculated when different cut-off points for RD were used as a test for "venous disease." In the upper LSV segment, for a cut-off point of RD > 0.5 seconds, the sensitivity was 38.0% and the specificity 97.2%, whereas for a cut-off point of RD > 1.0 seconds, the sensitivity was 36.4% and the specificity 97.4%. In the below knee popliteal segment, for a cut-off point of RD > 0.5 seconds, the sensitivity was 26.0% and the specificity 87.9%, whereas for a cut-off point of RD > 1.0 seconds, the sensitivity was 14.2% and the specificity 95.7%.

DISCUSSION

Although duplex scanning has become the method of choice for investigation of venous reflux,[1] controversy about the method still exists. Different patient positions and techniques to elicit reflux have been evaluated in various studies,[13] but techniques still vary. There is also debate about what constitutes significant reflux.[14] Although some authors use duration of reverse flow of greater than 0.5 seconds as a definition for significant reflux[13,15-19] others argue that this definition would include individuals with normally functioning veins[14] and use a value of greater than 1 second duration.[20,21] Furthermore, a recent study suggested that although measuring duration of reverse flow on duplex scanning is a useful method for determining the presence of reflux, it does not correlate with the magnitude of reflux and should not be used to quantify the degree of reflux.[22] We aimed to describe the prevalence and duration of venous reflux in a random population sample, to relate patterns of reflux to the overall presence of clinical venous disease, and to examine further what constitutes significant reflux.

Overall, the prevalence of reflux was very similar in the right and left legs (Table I). Generally, if the right leg segment had reflux, the likelihood that the same segment in the left leg would also have reflux was 20% to 35%, and this likelihood rose to more than 40% in the LSV segments. The choice of cut-off point for significant reflux made little difference to results in the superficial vein segments, because most reflux of at least 0.5 seconds duration was, in fact, more than 1 second in duration. This was not the case in the deep veins, however, and although 9% to 12% of participants had RD ≥ 0.5 in the popliteal vein segments, only 4% to 5% showed RD > 1.

A higher prevalence of reflux in men as compared with women was found in the deep vein segments. However, this difference only reached statistical significance in 2 of the 5 deep vein segments for RD > 1.0, compared with 4 of the 5 for RD ≥ 0.5. This suggests that it may be appropriate to use different

cut-off points for RD to define significant reflux in the deep veins in men and women. This might be the case if, for example, men were generally found to have larger veins that could accommodate more forward and reverse flow than women. However, in participants with "no disease," the medians for RD in the deep vein segments were only 0.02 to 0.05 seconds longer in men than in women. In addition, the higher prevalence of reflux in men does correspond with the higher prevalence of varicose veins and chronic venous insufficiency in men compared with women in this study.[12] Conversely, a higher proportion of women than men had reflux in the superficial vein segments, although these sex differences failed to reach statistical significance. The overall sex picture in the Edinburgh Vein Study was similar to that found in the Bochum Study, which examined German schoolchildren on 3 occasions during their education, at ages 10 to 12, 14 to 16, and 18 to 20 years.[8] By the third examination, male participants had a higher prevalence of trunk varices, branch varices, and incompetent perforators than female participants, but female participants had a higher prevalence of reflux in the saphenous veins on Doppler examination. In addition, there was an increase in the prevalence of reflux, particularly in the external iliac and the saphenous veins, as the age of the children increased at successive examinations. In general, we also found a higher prevalence of reflux in the older age groups in the Edinburgh Vein Study.

When the patterns of reflux were examined, in both legs the proportion of participants with RD ≥ 0.5 in the CFV segments greatly exceeded the proportion who also had reflux in the LSV and/or SFV segments (Table IIa). However, for RD > 1.0, there was less of a discrepancy. The CFV segment was the one segment in which turbulent flow was often recorded, and it may be that the size of this vein allows it to accommodate forward and reverse flow to a greater extent than any of the other segments examined, without necessarily having an incompetent distal valve. Similarly, the proportion of participants with reflux in the above knee popliteal segments exceeded the proportion who also had reflux in the below knee popliteal or SSV segments (Table IIb). Possible explanations for this include the presence of reflux down incompetent gastrocnemial veins or unusual venous drainage in the popliteal area.[4,21] The latter possibly contributed to the relatively high number of missing results for the SSV segments in the Edinburgh Vein Study. We recognized that, by not scanning the calf veins, some questions in this study would be left unanswered. However, on balance, we considered that duplex scanning of the calf and perforator veins would be difficult, time-consuming, and of doubtful accuracy when a noncolor Doppler system was used in a population of more than 1500 participants.

Throughout this paper, results have been presented comparing RD ≥ 0.5 and RD > 1.0 as cut-off points to define significant reflux. Using RD ≥ 0.5 as a cut-off point decreases the specificity and risks defining more normal veins as incompetent, whereas using RD > 1.0 as a cut-off point decreases the sensitivity and risks defining more incompetent veins as normal. There are obvious limitations in using presence of reflux in individual vein segments as a test for the presence or absence of "venous disease." Accepting these limitations, calculations of sensitivity and specificity tended to support the use of 0.5 seconds as the cut-off point for RD in the below knee popliteal vein segment as a test for venous disease. In the upper LSV, however, there was little difference in the sensitivity and specificity between RD ≥ 0.5 and RD > 1.0. Further analysis of the relationships between RD in individual vein segments and specific clinical findings will be discussed in a future report. However, Table III illustrates the considerable overlap in RD in individual vein segments between those participants with and those participants without "venous disease." Although those participants with signs of venous disease had a higher prevalence of reflux in all vein segments, approximately 12% of those with "no disease" had RD ≥ 0.5 in the popliteal and lower thigh LSV segments (Fig 3). When RD > 1.0 was used, these figures dropped to 3% to 4% for the popliteal vein segments, but remained at 10.7% for the lower thigh LSV segment. Whether this reflux reflects a preclinical stage in these participants before the development of varices[8] and CVI will not be revealed until their long-term follow-up examinations.

In conclusion, we have described the prevalence of venous reflux in the general population and have shown the following results: the left and the right legs were equally affected; men had a significantly higher prevalence of reflux in the deep vein segments, whereas women had a (nonsignificantly) higher prevalence in the superficial veins; and reflux was related to the presence of "venous disease," but was also present in those without clinically apparent disease. By following-up this population, we should be able to determine the extent to which reflux can predict future occurrence of venous disease and of complications in those who already have disease.

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REFERENCES

1. Porter JM, Moneta GL, and an International Consensus Committee on Chronic Venous Disease. Reporting standards in venous disease: An update. J Vasc Surg 1995;21:635-45.
2. Thibault PK. Duplex Examination. Dermatol Surg 1995; 21:77-82.
3. Weingarten MS, Branas CC, Czeredarczuk M, Schmidt JD, Wolferth CC. Distribution and quantification of venous reflux in lower extremity chronic venous stasis disease with duplex scanning. J Vasc Surg 1993;18:753-9.
4. Labropoulos N, Leon M, Nicolaides AN, Giannoukas AD, Volteas N, Chan P. Superficial venous insufficiency: Correlation of anatomic extent of reflux with clinical symptoms and signs. J Vasc Surg 1994;20:953-8.
5. Labropoulos N, Leon M, Nicolaides AN, Sowade O, Volteas N, Ortega F, et al. Venous reflux in patients with previous deep venous thrombosis: Correlation with ulceration and other symptoms. J Vasc Surg 1994:20:20-6.
6. Labropoulos N, Delis K, Nicolaides AN, Leon M, Ramaswami G, Volteas N. The role of the distribution and anatomic extent of reflux in the development of signs and symptoms in chronic venous insufficiency. J Vasc Surg 1996;23:504-10.
7. Labropoulos N, Delis KT, Nicolaides AN. Venous reflux in symptom-free vascular surgeons. J Vasc Surg 1995;22:150-4.
8. Schultz-Ehrenburg U, Weindorf N, Matthes U, Hirche H. New epidemiological findings with regard to initial stages of varicose veins (Bochum study I-III). In: Raymond-Martimbeau, Prescott R, Zummo M, editors. Phlebologie '92. Paris: John Libbey Eurotext; 1992. p. 234-6.
9. Evans CJ, Fowkes FGR, Ruckley CV, Allan PL, Carson MN, Kerracher EMG, et al. Edinburgh Vein Study: Methods and response in a survey of venous disease in the general population. Phlebology 1997;12:127-35.
10. Widmer LK, editor. Peripheral venous disorders—Prevalence and socio-medical importance. Bern: Hans Huber; 1978.
11. Callam MJ. Epidemiology of varicose veins. Br J Surg 1994;81:167-73.
12. Evans CJ, Fowkes FGR, Ruckley CV, Lee AJ. Prevalence of varicose veins and chronic venous insufficiency in men and women in the general population: Edinburgh Vein Study. J Epidemiol Community Health. In press 1998.
13. Welch HJ, Young CM, Semegran AB, Iafrati MD, Mackey WC, O'Donnell TF. Duplex assessment of venous reflux and chronic venous insufficiency: The significance of deep venous reflux. J Vasc Surg 1996;24:755-62.
14. Lagattolla NRF, Burnand KG. Duplex ultrasonography for assessment of venous valvular function of the lower limb [letter]. Br J Surg 1995;85:855.
15. Sakurai T, Matsushita M, Nishikimi N, Nimura Y. Hemodynamic assessment of femoropopliteal venous reflux in patients with primary varicose veins. J Vasc Surg 1997; 26:260-4.
16. Masuda EM, Kistner RL, Eklof B. Prospective study of duplex scanning for venous reflux: Comparison of valsalva and pneumatic cuff techniques in the reverse Trendelenburg and standing positions. J Vasc Surg 1994;20:711-20.
17. Bays RA, Healy DA, Atnip RG, Neumyer M, Thiele BL. Validation of air plethysmography, photoplethysmography, and duplex ultrasonography in the evaluation of severe venous stasis. J Vasc Surg 1994;20:721-7.
18. Neglen P, Raju S. A rational approach to detection of significant reflux with duplex Doppler scanning and air plethysmography. J Vasc Surg 1993;17:590-5.
19. Araki CT, Back TL, Padberg FT, Thompson PN, Duran WN, Hobson RW. Refinements in the ultrasonic detection of popliteal vein reflux. J Vasc Surg 1993;18:742-8.
20. Labropoulos N, Leon M, Geroulakos G, Volteas N, Chan P, Nicolaides AN. Venous hemodynamic abnormalities in patients with leg ulceration. Am J Surg 1995;169:572-4.
21. Somjen GM, Royle JP, Fell G, Roberts AK, Hoare MC, Tong Y. Venous reflux patterns in the popliteal fossa. J Cardiovasc Surg 1992;33:85-91.
22. Rodriguez AA, Whitehead CM, McLaughlin RL, Umphrey SE, Welch HJ, O'Donnell TF. Duplex-derived valve closure times fail to correlate with reflux flow volumes in patients with chronic venous insufficiency. J Vasc Surg 1996;23: 606-10.

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