Eur J Vasc Endovasc Surg **24**, 300–303 (2002)
doi:10.1053/ejvs.2002.1733, available online at http://www.idealibrary.com on IDEAL®

The Vascular Laboratory in Practice: a National Survey in The Netherlands

S. Spronk*[1], W. Dolman[1], R. U. Boelhouwer[2], H. F. Veen[2] and P. T. den Hoed[2]

[1]*Vascular Laboratory and* [2]*Department of Surgery, Ikazia Hospital, Rotterdam, The Netherlands*

Objectives: *to overview Dutch vascular laboratory practice and specifically the variation in duplex criteria.*
Methods: *a questionnaire was sent to all vascular laboratories in The Netherlands* (n = *140).*
Results: *the response rate of the inquiry was 64%* (n = *89). There is no consensus on interpretation of outcome. In 22% of the clinics* (n = *20) a diagnostic angiography will be omitted when a percutaneous angioplasty is advised on account of duplex ultrasound. Only 5%* (n = *4) relies upon duplex ultrasound for operation without diagnostic angiography. In 44%* (n = *39) a PSV (peak systolic velocity) of 125 cm/s is used to identify a* $> 70\%$ *or internal carotid artery stenosis. In 44%* (n = *39) a PSV of 210 cm/s and 10%* (n = *9) a PSV* ≥ 150 *cm/s is used. For grading a relevant stenosis in the femoro-politeal arteries a PSV ratio* ≥ 2.5 *is chosen in 75%* (n = *67). Criteria used for graft surveillance shows also a wide variation.*
Conclusions: *a commission for the accreditation of vascular laboratories should be established with the goal of creating standards and performing quality control.*

Key Words: Vascular laboratory; Vascular diagnostic criteria; Duplex ultrasound.

Introduction

Like many technical fields in medicine, non-invasive vascular testing had modest origins.[1] Introduction of the continuous wave Doppler velocity detector was responsible for the rapid growth of non-invasive testing of vascular diseases in the 1970s.[1] The application of ultrasound techniques in vascular diseases has played a major role. In 1974 it was Strandness, who first developed the combination of Doppler and real time ultrasound.[2] By the early 1980s, the duplex scanner became widely used and was introduced in The Netherlands. The first application of ultrasound techniques was used on the carotid artery. Later, the duplex technique was introduced for all kind of vascular disorders.

Herewith the vascular laboratory as a valuable, non-invasive institute was born. Although vascular testing grew rapidly in the 1980s, there was widely discussion about supervising a vascular testing facilities and/or participation in the interpretation of the tests. Other specialities, as neurology, cardiology and radiology, became aware of the value of non-invasive vascular diagnostic techniques. Radiologists had the background in ultrasound technique, however they were not educated in interpretation of the Doppler-curves in peripheral vascular disease. In general they were well equipped in ultrasonic instruments but missed the link to the continuous wave Doppler velocity detector with the application to measure systolic pressures in the extremities. Most of the technicians are still trained by a combination of didactic courses and hands-on instructions.

Non-invasive vascular imaging is an important part of everyday practices.[1,2] However, the correct interpretation of ultrasound gray-scale images, Doppler spectra, and color Doppler images is highly dependent on the user's experience and skill.[3]

In 1990 an institution (TechCare) in Haarlem (The Netherlands) was established with the aim to educate Vascular Diagnostic Technicians. To date, around 156 technicians have been certificated and registered. However, there are still many hospitals without a vascular laboratory and the non-invasive diagnostic tests are supervised by single specialities. At present there is still no transparency and no accordance about the place of the vascular laboratory in the hospital. This also counts for its procedures and its diagnostic criteria.

* Please address all correspondence to: S. Spronk, Department of Surgery, Ikazia Hospital, Montessoriweg 1, 3083 AN Rotterdam, The Netherlands.

1078–5884/02/040300 + 04 $35.00/0

The aim of this survey is to give an overview of the Dutch vascular laboratory system by investigating the history of its development and its place in the organisation. The secondary outcome of this study is to investigate the variation in duplex criteria used in the Dutch vascular laboratories.

Methods

A questionnaire was sent to the vascular laboratory of all hospitals in The Netherlands ($n=140$). After 3 weeks a reminder was sent to all non-responders. The questionnaires were mostly filled in by vascular technicians and only occasionally by surgeons. The inquiry was subdivided in several different sections. One contained questions about the historical development of the vascular tests in that specific hospital and how the vascular laboratory had originated. Another had questions about logistics, and about how policy is formulated, and who is responsible for the investigations and their interpretation. Another section dealt with looks the education of the technicians. The last section contained questions about the use of diagnostic criteria. At the TechCare a PSV (peak systolic velocity) of 210 cm/s is used as threshold value to identify a 70% or greater stenosis in the internal carotid. The PSV ratio (PSV_{ica}/PSV_{cca}) ≥ 4 is used as additional parameter.[4] For a 50% aortoiliac and femoro-popliteal stenosis, a PSV ratio ≥ 2.5 is used.[5] The criterion used for graft failure is a PSV ratio ≥ 3.[6] Answers were analysed using the SPSS-PC statistical package.

Results

The response rate was 64% ($n=89$). The majority (76%, $n=119$) of the qualified vascular technicians (TechCare educated) work in those clinics.

Thirty-two percent ($n=28$) and 49% ($n=44$) of the clinics had a vascular laboratory in the 1980's and 1990's respectively. The laboratories are supervised by the surgical unit (25%, $n=22$) or together with an other speciality (13%, $n=12$). In 28% ($n=25$) the laboratories were started as part of a department of biometrics, in 15% ($n=13$) as part of the neurology department and in 9% ($n=8$) as part of the department of radiology. Just 8% ($n=7$) of the vascular laboratories are independently managed and are organizationally self-employed. Although a commission of accreditation at vascular laboratories has been discussed by the association of vascular laboratories, at this moment the quality control only exists of committing refresher courses. Annually, the refresher courses are converted into accreditation points and are mandatory for the validity of the certificated Vascular Technicians.

At this moment 119 registrated vascular technicians participates in the laboratories of all responding clinics. The examinations are performed by or with the help of radiologists (9%, $n=19$), by qualified vascular technicians (56%, $n=119$), by educated vascular technicians (19%, $n=40$), or by other technicians (16%, $n=34$).

In 98% ($n=87$) of all responding clinics ankle-brachial indices and treadmill tests are done. In 74% ($n=66$), the laboratories are equipped with at least a continuous wave Doppler. In 73–79% of all responding clinics arterial as well as venous insufficiency are investigated: e.g. duplex ultrasound of aorto-popliteal level (79%, $n=70$), crural level (64%, $n=57$), carotid arteries (62%, $n=55$), grafts (76%, $n=67$), false aneurysm (65%, $n=58$), renal arteries (27%, $n=24$), dialyse shunts (28%, $n=25$), and perforating veins.

There is no consensus an interpretation of the results of the duplex investigations. In 44% ($n=39$) laboratories a PSV (peak systolic velocity) of 125 cm/s is used as threshold value to identify a 70% or greater stenosis in the internal carotid artery. In 44% ($n=39$) a PSV of 210 cm/s and in 10% ($n=9$) a PSV ≥ 150 cm/s is used. The remaining 2% ($n=2$) use a PSV ≥ 125 cm/s for grading 50–80% stenosis of the internal carotid artery. In 41% ($n=36$) the PSV ratio (PSV_{ica}/PSV_{cca}) is used as additional parameter, in 23% ($n=21$) the EDV_{ica} (End Diastolic Velocity) and in 19% ($n=17$) the PSV_{ica}/EDV_{cca} ratio. Other additional qualities are morphological, post-stenotic turbulence and diameter of the lumen and area measurement. Considering a 50% aorto-iliac stenosis, in 83% ($n=74$) a PSV ratio ≥ 2.5 is used, in 10% ($n=9$) a PSV ratio ≥ 3.0 and in 7% ($n=6$) a PSV ratio ≥ 2.0. A general accepted criterion for grading a stenosis in the femoro-politeal arteries is a PSV ratio ≥ 2.5. This criterion is used in 75% ($n=67$) of the clinics. In 19% ($n=17$) a PSV ratio ≥ 3.0 is used and in 6% ($n=5$) a PSV ratio ≥ 2.0.

Criteria used for graft surveillance shows also wide variation. In 17% ($n=15$) a PSV ratio ≥ 4.5 is used for a bypass at risk, in 22% ($n=20$) a PSV ratio ≥ 4, in 28% ($n=25$) a PSV ratio ≥ 3. The narrowest part of the graft is measured by a PSV ≤ 40 cm/s (31%, $n=28$)) or a PSV ≤ 45 cm/s (2%, $n=2$) and seen as graft failure. The different test criteria are used by unqualified as well as by qualified vascular technicians, although the qualified vascular technicians are all educated with the reference standard used at TechCare for Vascular Diagnostic Technicians education. The quality of the

Table 1. The use of Diagnostic Angiography (DA) after Duplex Ultrasound (DUS) in the Dutch clinics.

	Number of clinics
PTA on DUS only, without DA	20 (22%)
Surgical intervention on DUS only, without DA	4 (5%)
Surgical intervention on DUS and DA	47 (52%)
DA after every DUS	8 (9%)
DA in case of incomprehensible findings on DUS	6 (7%)
DA in case of a waiting list for DUS	2 (2%)
MRA on DUS and DA in case of discrepancy in MRA and DA	2 (2%)
IV-DSA on DUS and DA in case of discrepancy in IV-DSA and DUS	1 (1%)

duplex examinations cannot be assessed by questionnaires. Regarding the evaluation of the duplex ultrasound criteria versus a reference standard, 9% ($n=8$) of the centres use DSA, 2% ($n=2$) use magnetic resonance angiography (MRA) and 1% ($n=1$) use intravenous digital subtraction angiography (IV-DSA).

In just 22% ($n=20$) of the clinics, diagnostic angiography will be omitted when a percutaneous angioplasty will be advised on account of duplex ultrasound (Table 1). The reason to perform a diagnostic angiography in so many clinics (78%, $n=69$) may be the use of duplex ultrasound as a screening tool and not as a diagnostic tool upon which the physician will act. Besides, in 2% ($n=2$) of the clinics a MRA will be performed on account of duplex ultrasound and in 1% ($n=1$) IV-DSA. Other reasons for further diagnostic investigation by a diagnostic angiography were incomprehensible findings by duplex ultrasound (9%, $n=8$) and discrepancy in MRA or IV-DSA (2%, $n=2$). In only 5% ($n=4$) operation was instituted on account of duplex ultrasound. The other 95% ($n=85$) performs a diagnostic angiography if operation is considered.

Discussion

One of the purposes of the traditional non-invasive laboratories, is to screen patients with clinically suspected peripheral arterial disease (PAD). The value of the non-invasive vascular laboratories have considerably increased in the last decades. Vascular laboratory procedures are no longer limited to screening tests but often provide the definitive diagnosis for treatment.[7,8] Pressure measurements, ankle-brachial indices and treadmill tests are performed to confirm the presence of suspected arterial lesions.[9] Once identified, these patients undergo duplex ultrasound.[9] These non-invasive tests are able to demonstrated the number, size and extent of peripheral arterial lesions in patients and distinguish focal stenosis from an arterial segmental occlusion.[10,11] Almost all studies confirm that velocity ratios are more reliable than simple velocity thresholds in patients with PAD.[12–15] The appropriate ratio is remains controversial in literature.[12–15] Up till now, several studies have been performed that compared duplex ultrasound and angiography for assessment of the lower extremity arteries and the same holds true for the internal carotid artery and graft surveillance.[4–6,10–23] Due to differences in study populations, prevalence of disease, duplex ultrasound machines used, the use of color Doppler and duplex and various vascular technicians, the results of non-invasive tests should be validated by comparing these data by an accepted standard reference, i.e. angiography with intra-arterial pressure measurement. In addition, a reference standard like the criteria used at TechCare for Vascular Diagnostic Technicians education, should be supported by a commission for the accreditation. This may prevent a variation in test threshold such as is applied in Dutch vascular laboratories for internal carotid artery examination, where 44% apply the criteria described by Strandness and 44% by Moneta.[4,23] Remarkably, the inquiry makes clear that these vascular laboratories had qualified as well as unqualified vascular technicians and they often modify or combine diagnostic criteria from different sources. The application of different duplex ultrasound criteria may affect the patient outcomes. Despite the relatively low response rate of the inquiry of 64%, this substantial number of responding Dutch vascular laboratories ($n=89$) presumably represent the situation in The Netherlands.

Although attitudes regarding the need of diagnostic angiography before therapeutic intervention are changing, a lot of surgeons and radiologists at present still consider diagnostic angiography mandatory before therapeutic intervention and duplex ultrasound is therefore only used as a complementary diagnostic technique. This may explain that just 22% of PTA procedures are performed after duplex ultrasound only. Thus, despite all previous research the implementation of duplex ultrasound in Dutch clinical practice is still poor. As life expectancy increases in The Netherlands, there will be more patients with vascular diseases and so there will be an increased need for non-invasive investigations. A growth in non-invasive investigations will require more training of vascular technicians to carry out the investigations. A commission for the accreditation of the Dutch vascular laboratories should be established with the

goal of creating standards and performing quality control in order to offer an optimal diagnostic tool to the clinician and his patients.

References

1 Baker JD. The vascular laboratory. *Vasc Surg* 2000; **9**: 127–130.
2 Strandness DE Jr. History of ultrasonic duplex scanning. *Cardiovasc Surg* 1996; **4**: 273–280.
3 Klews PM. Physics and Technology of color duplex sonography. *Color Duplex Sonography* 1995; **17**: 245.
4 Moneta GL, Edwards JM, Chitwood RW *et al*. Correlation of North American Symptomatic Carotid Endarterectomy Trial (NASCET) angiographic definition of 70% to 99% internal carotid artery stenosis with duplex scanning. *J Vasc Surg* 1993; **1**: 152–157.
5 Elsman BHP, Legemate DA, van der Heijden FH, de Vos HJ, Mali WP, Eikelboom BC. Impact of ultrasonographic duplex scanning on therapeutic decision making in lower-limb arterial disease. *Br J Surg* 1995; **82**: 630–603.
6 Idu MM, Buth J, Hop WC, Cuypers P, van de Pavoordt ED, Tordoir JM. Vein graft surveillance: is graft revision without angiography justified and what criteria should be used? *J Vasc Surg* 1998; **3**: 399–411.
7 Derlu GP, Milite D, Damiani N *et al*. Carotid Endarterectomy without angiography: a prospective randomised pilot study. *Eur J Vasc Endovasc Surg* 2000; **20**: 250–253.
8 Zaag van der ES, Legemate DA, Nguyen T, Balm R, Jacobs MJ. Aortoiliac reconstructive surgery based upon the results of duplex scanning. *Eur J Vasc Endovasc surg* 1998; **16**: 383–389.
9 Kitslaar PJ. Consensus diagnosis and treatment of arterial intermittent claudication. Central Guidance Organization for Peer Review. *Ned Tijdschrift Geneeskd* 1997; **141**: 2396–2400.
10 Koelemay MJ, den Hartog D, Prins MH, Kromhout JG, Legemate DA, Jacobs MJ. Diagnosis of arterial disease of lower extremities with duplex ultrasound. *Br J Surg* 1996; **83**: 404–409.
11 Elsman BH, Legemate DA, de Vos HJ, Mali WP, Eikelboom BC. Hyperaemic colour duplex scanning for detection of aortoiliac stenosen. A cooperative study with intra-arterial pressure measurement. *Eur J Vasc Endovasc Surg* 1997; **14**: 462–467.
12 Heijden van der FH, Legemate DA, van Leeuwen MS, Mali WP, Eikelboom BC. Value of duplex scanning in the selection of patients for percutaneous transluminal angioplasty. *Eur J Vasc Surg* 1993; **7**: 71–76.
13 de Smet AA, Visser K, Kitslaar PJ. Duplex scanning for grading aortoiliac obstructive disease and guiding treatment. *Eur J Vasc Surg* 1994; **8**: 711–715.
14 Ranke C, Creutzig A, Alexander K. Duplex scanning of the peripheral arteries: correlation of the peak velocity ratio with angiographic diameter reduction. *Ultrasound Med Biol* 1992; **18**: 433–440.
15 Leng GC, Whyman MR, Donnan PT *et al*. Accuracy and reproducibility of duplex ultrasound in grading femoropopliteal stenosen. *J Vasc Surg* 1993; **17**: 510–517.
16 Sensier Y, Hartshorne T, Thrush A, Nydahl S, Bolia A, London NJ. A prospective comparison of lower limb colour-coded scanning with arteriography. *Eur J Vasc Endovasc Surg* 1996; **11**: 170–175.
17 Beidle TR, Brom-Ferral R, Letourneau JG. Surveillance of infrainguinal vein grafts with duplex ultrasound. *AJR* 1994; **162**: 443–448.
18 van der Heijden FH, Legemate DA, van Leeuwen MS, Mali WP, Eikelboom BC. Value of Duplex scanning in the selection of patients for percutaneous transluminal angioplasty. *Eur J Vasc Surg* 1993; **7**: 71–76.
19 Mattos MA, van Bemmelen PS, Hodgson KJ, Ramsey DE, Barkmeier LD, Sumner DS. Does correction of stenosis identified with color duplex scanning improve infrainguinal graft patency? *J Vasc Surg* 1993; **17**: 54–64.
20 Worthy SA, Henderson J, Griffiths PD, Oates CP, Gholkar A. The role of duplex ultrasound and angiography in the investigation of carotid artery disease. *Neuroradiology* 1997; **39**: 122–126.
21 Elgersma OE, van Leersum M, Buijs PC, van Leeuwen MS, van de Schouw YT, Eikelboom BC. Changes over time in optimal duplex threshold for the identification of patients eligible for carotid endarterectomy. *Stroke* 1998; **29**: 2352–2356.
22 Hood DB, Mattos MA, Mansour A *et al*. Prospective evaluation of new duplex criteria to identify 70% internal carotid stenosis. *J Vasc Surg* 1996; **2**: 254–261.
23 Strandness DE Jr, Taylor DC. Carotid artery duplex scanning. *J Clin Ultrasound* 1987; **15**: 635–644.

Accepted 14 June 2002