WINTER 2001

1

The Heart & Vascular Institute
Excellence in patient care, research and education

CONTENTS

NEWSLETTER

THE VASCULAR DIAGNOSTIC LABORATORY

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INTRODUCTION:

The inaugural issue of the Heart and Vascular Institute (HVI) quarterly newsletter is dedicated to the Vascular Laboratory. Future issues will highlight other imaging and treatment modalities, such as Electron Beam Tomography™ (EBT™) Ultrafast Heart Scan, MRI, Angiography and Enhanced External Counterpulsation (EECP). Regular features of this newsletter will include HVI News/Updates; the Heart and Vascular Research Institute activities and clinical trials updates; and publications and presentations by HVI staff. We welcome your comments and suggestions for topics to include for future issues.

A wide variety of non-invasive vascular studies are offered at HVI. The goal of the vascular laboratory is to provide excellent service to our patients and referring physicians along with complete and accurate test reports. We have already initiated a quality control program, CME credits for all involved in the vascular lab and have taken the early steps toward accreditation by the Intersocietal Commission on the Accreditation of Vascular Laboratories (ICAVL).

In this edition of the Newsletter, a brief description of several of the Vascular Lab studies currently available (with CPT codes) and a number of appropriate indications (with ICD-9 codes) are included. To facilitate patient scheduling and billing, please refer to these codes when ordering Vascular Lab examinations.

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DUPLEX ULTRASOUND

Duplex ultrasound studies combine the anatomic and morphologic information obtained with gray-scale imaging (B-mode) along with hemodynamic data (spectral and color Doppler), such as blood flow velocity and direction. The quantitative data can then be utilized for other calculations that enhance interpretation of the study results.

Carotid Duplex Ultrasound

[CPT 93880 Bilateral, 93882 Unilateral]

The most frequently performed study in the Vascular Lab, the carotid duplex ultrasound is a non-invasive means of evaluating not only the common, external, and internal carotid arteries, but also the vertebral and subclavian arteries. Typical study indications include: carotid bruit [ICD-9 785.9], TIA [435.9], and the periodic surveillance of known carotid disease [433.1-433.3].

B-mode imaging is performed to identify and characterize atherosclerotic plaque. Plaque can be characterized as one of three types on the ultrasound report: homogeneous, heterogeneous, or calcified.

Homogeneous plaque consists of calcium-free atheroma. The absence of any detectable calcification results in a hypoechoic (few echoes; dark) appearance on gray-scale imaging, rendering this form of plaque essentially indistinguishable from the normally anechoic (echo-free and dark) vessel lumen. On color Doppler images, however, areas with homogeneous plaque demonstrate no flow-related color.

Heterogeneous plaque, as its name implies, has a corresponding intermediate echotexture compared to homogeneous and calcified forms. This term can also be used when areas of both homogeneous and calcified plaque can be identified in the vessel segment. This indicates the presence of some calcification, but not to the degree where the ultrasound beam can no longer penetrate the plaque producing what is known as acoustic shadowing.

Calcified plaque appears uniformly echogenic (bright) on B-mode images, often with posterior acoustic shadowing. Shadowing potentially limits the evaluation of an affected vascular segment because sound waves are unable to penetrate that area. If a velocity measurement cannot be obtained with ultrasound in an area of stenosis, this can potentially underestimate the degree of the stenosis. This is most important in distinguishing between moderate (60-79%) and severe (80-99%) degrees of stenosis, which have differing natural histories and are managed differently.

Another scenario that presents a challenge to interpretation is the velocity elevation contralateral to a carotid occlusion. This may lead to an overestimation of the degree of stenosis or the false diagnosis of stenosis, in its absence, on the ipsilateral side.

The Vascular Lab uses a modification of the Strandness classification scheme for assigning the degree of internal carotid arterial stenosis (Table 1).[2, 3] Velocity and spectral criteria are utilized to establish a range of percent diameter stenosis for the internal carotid arteries.

No criteria have been validated for the quantitation (percent stenosis) of common carotid or external carotid disease severity. Instead, vascular disease in these locations is described as mild, moderate, or severe, based on subjective assessment of the plaque burden and peak systolic velocity. Duplex ultrasound of the carotid artery has become so accurate that most vascular surgeons are now performing a carotid endarterectomy on the basis of ultrasound alone. Since carotid angiography accounted for approximately 50% of the strokes in the Asymptomatic Carotid Atherosclerosis Study (ACAS), it should be reserved for situations where the carotid ultrasound is not clear, or technical limitations preclude an accurate examination. Most patients who have symptomatic carotid disease, however, should undergo angiography prior to percutaneous or surgical intervention.

In general, recommendations for follow-up are not included in the official report because any such recommendations only apply to asymptomatic patients. In addition, there are no rules that apply to every patient and clinical decision making is necessary for each individual case. However we have prepared general guidelines that are available to all referring physicians (Table 2).

Table 1. Internal Carotid Artery Duplex Criteria

Degree of Stenosis	Peak Systolic Velocity (PSV) cm/sec	End Diastolic Velocity (EDV) cm/sec	Spectral Broadening
0-19%	<105	...	Absent
20-39%	<105	...	Present
40-59%	105-149	...	Present
60-79%	150-240	<135	Present
80-99%	>240	≥135	Present
Occluded	No signal	No signal	No signal

References:

1. Zwibel WJ. Doppler Evaluation of Carotid Stenosis. In *Introduction to Vascular Ultrasonography*. W.B. Saunders. 1992; 9:123-132.

2. Neumyer M, et al. Validation of prescreening with duplex scanning. J. Vasc. Technology. 1987; 11:30-32.

3. Strandness DE and Taylor UW. Carotid artery duplex scanning. Clin. Ultrasound. 1987; 15:625-644.

Renal Artery Duplex Ultrasound

[CPT 93975 "RADUS"]

Since its introduction into the Vascular Lab repertoire, the volume of this study has increased enormously. This technically demanding study can identify hemodynamically significant (60-99%) renal arterial stenoses.[1, 2] The indications for this study are: hypertension not adequately controlled despite a good antihypertensive regimen [ICD-9 401.1], unexplained azotemia [539.9], a small or atrophic kidney, or recurrent congestive heart failure or flash pulmonary edema not explained by ischemic heart disease.

Unlike the carotid ultrasound study, which relies heavily on gray-scale imaging for plaque characterization along with color Doppler and spectral information, the renal arterial study relies almost entirely on the Doppler spectral waveform and turbulence demonstrated on color Doppler. The entire length of each renal artery (include accessory arteries, when present) is evaluated via two approaches: transabdominal (with the patient in the supine position) and through the flank

(with the patient in the opposite decubitus position). The presence of intestinal gas may severely limit study quality. Therefore all patients should fast (including liquids) for 12 hours prior to a renal artery duplex examination.

The abdominal aortic and renal arterial peak systolic velocities are used to calculate the renal-aortic ratio (RAR), a value used in conjunction with the absolute renal arterial peak systolic velocity to determine the severity of stenosis.

Intrarenal arterial flow velocity is also documented. The peak-systolic (PSV) and end-diastolic velocities (EDV) are used to calculate the resistive index (RI) by the formula: (PSV-EDV)/PSV. The RI value reflects the degree of resistance to flow within the kidneys. High RI values (close to 1.0) are consistent with intra-renal resistance due to parenchymal abnormalities such as nephrosclerosis and other renal pathology.

B-mode imaging is used primarily to obtain the length of each kidney. Although the ultrasound parameters are optimized for renal vascular rather than renal parenchymal evaluation, gray-scale image findings, such as cysts, masses, cortical thinning, and hydronephrosis can be detected. However, findings of uncertain significance, such as a complex renal mass, cannot be fully and properly analyzed with this technique. In such circumstances, further evaluation is advised.

The mesenteric arterial velocities are also obtained. The celiac axis and superior mesenteric artery (SMA) are routinely identified in all studies. The inferior mesenteric artery (IMA) is seen less frequently because it is often occluded in patients with abdominal aortic aneurysm and in the elderly.

References:

1. Olin JW. Role of duplex ultrasonography in screening for significant renal artery disease. Urol. Clin. of No. Amer. 1994; 21:215-226.

2. Olin JW, et al. The utility of duplex ultrasound scanning of the renal arteries for diagnosing significant renal artery stenosis. Ann. Int. Med. 1995; 122:833-838.

Mesenteric Duplex Ultrasound

[CPT 93976 RADUS-limited]

Although most mesenteric arterial stenoses are asymptomatic due to the extensive collateral network of the gastrointestinal tract, post-prandial abdominal pain and weight loss may indicate the presence of bona-fide chronic intestinal ischemia. This condition is usually associated with at least two of the three mesenteric vessels having a significant stenosis (70-99%) or occlusion. An abdominal bruit [ICD-9 789.5] may be present.

In young adults, especially females with an aesthenic body habitus, the celiac peak systolic velocity may vary widely during the respiratory cycle due to dynamic compression of the proximal celiac axis by the median arcuate ligament of the diaphragm (also know as celiac artery compression syndrome). Unlike the atherosclerotic form of mesenteric arterial disease, individuals with the median arcuate compression syndrome often do not have symptoms and are not at increased risk for bowel ischemia.

Although an obvious abdominal aortic aneurysm (AAA) will be documented by the technologist during both the renal arterial and the mesenteric arterial duplex studies, these tests are not intended as AAA examinations per se. The correct study to order for AAA detection is an abdominal aortic ultrasound.

Abdominal Aorta Duplex Ultrasound

[CPT 93978 Abdominal Duplex]

A palpable pulsatile mass [ICD-9 789.30] is the most common indication for this study request. In addition, approximately 20% of first degree offspring of an individual who had an abdominal aortic aneurysm will eventually have an AAA.

The technologist systematically interrogates the entire length of the abdominal aorta as well as the common iliac arteries for the presence of an enlargement. Multiple diameter measurements in the AP, transverse and sagittal views are obtained in the suprarenal, juxtarenal, and infrarenal aortic segments. Aortic and common iliac velocity measurements and waveforms are obtained using Doppler. The mesenteric and renal arteries are not evaluated during this study (see above for appropriate studies).

Other arterial duplex studies:

Not discussed in this issue of the newsletter, we also routinely perform arterial duplex of the lower extremities [CPT 93925 (unilateral) and 93926 (bilateral)] for indications such as graft surveillance and, in the post-catheterization patient, in the assessment of pseudoaneurysm and A-V fistula [ICD-9 447.0]. When appropriate, ultrasound-guided thrombin injection can be performed at the time of pseudoaneurysm diagnosis. Arterial duplex studies for the upper extremities [CPT 93930 (unilateral) and 93931 (bilateral)] and arterial mapping will also be available.

Note: In addition to the primary study indication, a second ICD-9 code [250.00 through 250.73] should be selected for any patient with diabetes. ("Diabetes" cannot be coded as a primary indication for any Vascular Lab study.)

Table 2. Recommendations for repeat carotid duplex scanning. These guidelines apply only to the asymptomatic patient.

Internal Carotid Artery Stenosis	Recommendation
0-19%	Only repeat if new clinical indications present
20-39%	Repeat every year
40-59%	Repeat every year
60-79%	Repeat every 6 months
80-99%	Refer for carotid endarterectomy or carotid stent
Unilateral occlusion	Repeat every year
Occlusion on one side and 60-79% on the contralateral side	Refer to a vascular specialist
Post carotid endarterectomy	Repeat in 6 months, 12 months and then yearly. If the contralateral side is 80-99%, repeat also one week after carotid endarterectomy.
Post carotid stent	Repeat at 24 hours, 6 months, 12 months and then yearly

PVR

[CPT 93923 PVR, 93924 PVR with exercise, 93922 ABI]

The PVR (pulse-volume recording) with segmental pressures is an excellent diagnostic tool in patients suspected of having peripheral arterial disease (PAD). The information that one can get from PVRs is:

1. *Confirm or rule out (PVR with exercise) the presence of peripheral arterial disease.*
2. *Determine the level of vascular disease.*
3. *Determine the severity of vascular disease.*
4. *Quantify functional impairment (treadmill test)*
5. *Predict the level of amputation in those patients without other options.*
6. *Provide objective evidence of improvement or worsening after a percutaneous or surgical intervention.*

Blood pressure measurements are first obtained from each upper extremity (brachial). (Discrepancy between the arm pressures usually indicates subclavian or innominate stenosis.) Blood pressure cuffs are then applied to the thigh, calf, ankle, metatarsal region of the foot, and great toe. Pressure measurements obtained at the thigh, calf, and ankle are compared with the upper extremity (the higher of the two brachial measurements). At the level of the ankle, this ratio is known as the ABI (ankle-brachial index). Gradients (segmental pressure drops) along the extremity help to localize the general level of arterial disease and provide a clue to the vessel or vessels affected. In addition, the overall severity of PAD in an affected limb is assessed at the level of the ankle via the ABI (see Table 3).

Analysis of the waveform morphology and relative amplitude is especially important in the presence of arterial calcification, which can falsely elevate pressure readings (resulting in false negative studies). In fact, calcification can render the arteries "non-compressible", i.e. pressures registering above the scale of the equipment (over 255 mmHg).

If the study is normal at rest, an exercise study should be performed. The patient is asked to walk on the treadmill at 2.5 mph and 12% grade in an attempt to reproduce the patient's chief complaint (usually pain or discomfort in the buttocks, hip, thigh, calf, etc.).

At the end of the treadmill portion, the patient is quickly re-evaluated at the level of the ankle bilaterally with both pressure measurements and waveform analysis. A significant drop in pressure from the rest portion is consistent with PAD. However, as only the ankle measurement is obtained, the exact site of arterial narrowing in the corresponding lower extremity cannot be determined.

PVR's can also be obtained in the upper extremities in patients with arm claudication or ulcerations on the fingers. In patients with symptoms suggestive of thoracic outlet syndrome, a specific thoracic outlet study should be obtained.

Lower Extremity Venous Duplex Ultrasound

[CPT 93970 Bilateral, 93971 Unilateral]

These studies are almost always ordered to confirm or exclude the presence of a clinically suspected deep venous thrombosis (DVT) in patients with lower extremity pain [ICD-9 729.5] and/or swelling [729.81]. The lower extremity venous tree is evaluated using Doppler maneuvers, B-mode imaging to visualize thrombus and by using compression. Features of an acute DVT ultrasonographically are:

1. *A dilated vein segment.*
2. *Inability to compress the vein (cannot get the walls to coapt).*
3. *May or may not visualize thrombus in the acute stage since it is less echogenic than subacute or chronic thrombus.*

If the vein is not dilated, or highly echo-genic thrombus is visualized, the report may read either "DVT, age indeterminate" or "remote DVT". In this situation, clinical judgement will be necessary to determine how the patient should be treated. Once a patient is started on anti-thrombotic therapy, there is no need to repeat the duplex venous study unless new symptoms occur.

A lower extremity duplex study for acute DVT will be performed the same day it is ordered. If you have difficulty obtaining this study, call one of us immediately. We will also be performing venous insufficiency studies and upper extremity duplex studies.

Table 3. Ankle-brachial index versus severity of PAD

ABI	Severity of Disease
0.9-1.1	Normal
0.7-0.89	Mild
0.4-0.69	Moderate
<0.4	Severe

** NOTE: In the presence of calcified arteries, the severity of disease is determined by waveform analysis*

ACCREDITATION

The Intersocietal Commission for the Accreditation of Vascular Laboratories (ICAVL) is formed by representatives from multiple organizations which include, among others, the American College of Cardiology (ACC), the American Institute of Ultrasound in Medicine (AIUM), the Society of Cardiovascular and Interventional Radiology (SCVIR), the Society for Vascular Medicine and Biology (SVMB), the Society for Vascular Surgery (SVS), and the Society of Vascular Technology (SVT). Personnel, instrumentation, components of study performance, reporting, correlation with other imaging studies, quality assurance, and procedure volume are some of the Vascular Lab features which are examined. For greater detail, a copy of the ICAVL's "Standards 2000" is available at each Vascular Lab location.

THE SOCIETY OF VASCULAR MEDICINE AND BIOLOGY

Founded in 1989, SVMB fosters the integration of vascular biological advances into clinical practice and promotes an interactive collegial approach for delivering the highest quality care to patients with vascular disorders. The mission of the Society also includes the formation of formal research and educational opportunities for doctors-in-training as well as continuing medical education for practicing physicians.

If you are interested in becoming a member or learning more about the Society, please contact Dr. Jeffrey Olin, the Society's current president, or visit the Society's website at **www.svmb.org**.

APPROPRIATE ICD-9 CODES

Carotid duplex [CPT 93880, 92882]

ICD-9	Description
342.00-342.92	Hemplegia and hemiparesis
344.00-344.9	Other paralytic syndromes
362.30-362.37	Retinal vascular occlusion
362.84	Retinal ischemia
368.10	Subjective visual disturbance, unspecified
368.11	Sudden visual loss
368.12	Transient visual loss
368.40-368.47	Visual field defects
433.00-433.91	Occlusion and stenosis of precerebral arteries
433.1 *	Occlusion and stenosis of carotid
433.2 *	Occlusion and stenosis of vertebral
433.3 *	Occlusion and stenosis of multiple (bilateral)
434.00-434.91	Occlusion of cerebral arteries
434.11	Cerebral embolism
435.00-435.9	Transient cerebral ischemia
435.0	Vertebral syndrome
435.1	Basilar syndrome
435.2	Subclavian steal
435.9	TIA
436	CVA; Acute, but ill-defined, cerebrovascular disease
437.0	Cerebral atherosclerosis
437.3	Cerebral aneurysm, nonruptured
437.4	Cerebral arteritis
437.7	Transient global ischemia
442.81	Aneurysm, artery of neck
442.82	Aneurysm, subclavian artery
446.0-446.7	Polyarteritis nodosa and allied conditions
446.5	Giant cell arteritis
446.7	Takayasu's disease
780.2	Syncope
780.3	Dizziness and giddiness (NOT PAYABLE ALONE)
781.2	Abnormality of gait
781.3	Lack of coordination
781.4	Transient paralysis of limb
782.0	Disturbance of skin sensation
784.3	Aphasia
784.4	Other speech disturbance
785.9	Arterial bruit/weak pulse; Other symptoms involving cardiovascular system
900.0-900.9	Injury to blood vessels of head and neck
900.01	Injury to common carotid artery
900.02	Injury to external carotid artery
900.03	Injury to internal carotid artery
901.1	Injury to innominate and subclavian arteries
996.1	Mechanical complication of vascular device, implant, graft
996.70-996.79	Other complication of prosthetic device, implant, graft
996.73	Complications due to renal dialysis device, implant, graft
998.0-998.9	Other complications of procedures not elsewhere classified
998.11	Hemorrhage, hematoma, seroma complicating procedure
998.2	Accidental puncture during procedure
V 58.49	Other specified aftercare following surgery

* *Occlusion and stenosis require a 5th digit: 0 = without infarction; 1 = with infarction*

Arterial duplex [lower extremity 93925 (bilateral) and 93926 (unilateral), upper extremity bilateral (93930) and unilateral (93931)] and PVR [at rest only 93923, with exercise 93924, ABI 93922]

ICD-9	Description
440.0	Atherosclerosis of aorta
440.21-440.24	Atherosclerosis of native arteries of the extremities
440.21	Atherosclerosis of native arteries of the extremities, with claudication
440.22	Atherosclerosis of native arteries of the extremities, with rest pain
440.23	Atherosclerosis of native arteries of the extremities, with ulceration
440.24	Atherosclerosis of native arteries of the extremities, with gangrene
440.30-440.32	Atherosclerosis of bypass graft of extremities
440.30	Atherosclerosis of bypass graft of extremities: unspecified graft
440.31	Atherosclerosis of bypass graft of extremities: autologous vein graft
440.32	Atherosclerosis of bypass graft of extremities: nonautologous vein graft
441.00-441.9	Aortic aneurysm and dissection
441.01	Dissecting thoracic aortic aneurysm
441.02	Dissecting abdominal aortic aneurysm
441.03	Dissecting thoracoabdominal aortic aneurysm
441.2	Thoracic aortic aneurysm
441.4	Abdominal aortic aneurysm
442.0	Other aneurysm of artery of upper extremity
442.3	Other aneurysm of artery of lower extremity: femoral
443.0-443.9	Other peripheral vascular disease
443.0	Raynaud's disease
443.9	Peripheral vascular disease, unspecified
444.0-444.9	Arterial embolism and thrombosis
444.22	Embolism - lower extremity
447.0	Arteriovenous fistula, acquired
447.1	Stricture of artery
447.2	Rupture of artery
707.1	Ulcer of skin of lower extremity, except decubitus
707.8	Chronic ulcer of other specified sites
785.4	Gangrene
903.00-903.9	Injury to blood vessels of upper extremity
903.1	Injury to brachial blood vessel
903.2	Injury to radial blood vessel
903.3	Injury to ulnar blood vessel
903.4	Injury to palmar artery
904.0-904.9	Injury to blood vessels of lower extremity, and unspecified sites
904.0	Injury to common femoral artery
904.1	Injury to superficial femoral artery
904.2	Injury to femoral veins
904.3	Injury to saphenous veins
996.1	Mechanical complication of other vascular device, implant, and graft
996.70-996.79	Other complication of internal prosthetic device, implant, and graft
996.73	Complication due to renal dialysis device, implant, graft
998.1	Hemorrhage or hematoma complicating a procedure
998.11	Hemorrhage, hematoma, seroma complicating procedure
998.2	Accidental puncture or laceration during a procedure
V 58.49	Other specified aftercare following surgery

APPROPRIATE ICD-9 CODES

Venous duplex [CPT 93970 (bilateral) and 93971 (unilateral)]

ICD-9	Description
415.11-415.19	Pulmonary embolism and infarction
451.0-451.9	Phlebitis and thrombophlebitis
451.0	Phlebitis and thrombophlebitis: superficial lower extremity
451.11	Phlebitis and thrombophlebitis: femoral
451.19	Phlebitis and thrombophlebitis: popliteal
451.81	Phlebitis and thrombophlebitis: iliac
451.82	Phlebitis and thrombophlebitis: superficial upper extremity
451.83	Phlebitis and thrombophlebitis: deep veins upper extremity
454.0	Varicose veins of lower extremities with ulcer
454.2	Varicose veins of lower extremities with inflammation and ulcer
459.1	Postphlebitic syndrome
459.2	Compression of vein
671.20-671.24	Superficial thrombophlebitis in pregnancy and puerperium
671.30-671.33	Deep thrombophlebitis, antepartum
671.40-671.44	Deep thrombophlebitis, postpartum
695.9	Unspecified erythematous condition
707.1	Ulcer of lower limbs except decubitus
729.5	Pain in limb
729.81	Swelling of limb
747.60-747.69	Other anomalies of peripheral vascular system
782.2	Localized superficial swelling, mass, or lump
782.3	Edema
785.4	Gangrene
785.4	Gangrene
786.00	Respiratory abnormality, unspecified
786.03	Apnea
786.04	Cheyne-Stokes respiration
786.05	Shortness of breath
786.06	Tachypnea
786.07	Wheezing
786.09	Other respiratory abnormality
786.3	Hemoptysis
786.52	Painful respiration
786.59	Other discomfort, pressure, or tightness in chest
794.2	Nonspecific abnormal results of pulmonary function study
903.00-903.9	Injury to blood vessels of upper extremity
903.1	Injury to brachial blood vessel
903.2	Injury to radial blood vessel
903.3	Injury to ulnar blood vessel
903.4	Injury to palmar artery
904.0-904.9	Injury to vessels of lower extremity and unspecified sites
904.0	Injury to common femoral artery
904.1	Injury to superficial femoral artery
904.2	Injury to femoral veins
904.3	Injury to saphenous veins
996.1	Mechanical complication of other vascular device, implant, or graft
996.70-996.79	Other complications of internal prosthetic device, implant, or graft
996.73	Complications due to renal dialysis device, implant, graft
997.2	Peripheral vascular complications
998.2	Accidental puncture or laceration during procedure
999.2	Other vascular complication of medical care (NEC)
V 45.81	Post aortocoronary bypass status

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