NONINVASIVE INVESTIGATIONS IN

VASCULAR DISEASE

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NONINVASIVE INVESTIGATIONS IN VASCULAR DISEASE

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Preface

Evaluation of patients with vascular disorders used to be a qualitative assessment based upon a medical history and a physical examination. Finally, when indicated, invasive angiography was added. No part of this diagnostic triad provided accurate quantitative data until the introduction of noninvasive investigation. The laboratory at St. Mary's Hospital became a pioneering resource in this new technology as well as a magnet that attracted the best and the brightest physicians and surgeons from around the world who wished to develop an expertise in this new field. Indeed, a review of the list of fellows, beginning in 1962, became a virtual "Who's Who" in worldwide angiology as these individuals returned to their home countries to set up their own noninvasive laboratories for both continued research as well as the opportunity to put into practice the experience gained during their fellowship.

Over the last four decades, the sophistication and technological advances in the field of noninvasive diagnosis for patients with vascular disorders have, in many instances, made invasive investigation unnecessary or obsolete. In the instance of arterial occlusive disease, it is well recognized that an angiogram is, at best, a static approximation of the location of occlusive lesions in the distribution of the arteries being studied. Since the examination is a two-dimensional approximation of a three-dimensional vessel, frequently it will lead to an under-appreciation of the magnitude of the lesion that is present. Finally, an invasive arteriogram provides no information concerning the quantitative effect of the specific lesion, nor the adequacy with which collateral blood flow has compensated for the area of obstruction. In

contrast, noninvasive assessment can provide both imaging as well as quantitative of the pathologic effect of a specific area of obstruction.

As the field of noninvasive investigation has grown, the medical practitioner is presented with a confusing number of test options. These tests require an increasing sophistication in order to interpret results. Selection of a specific investigation must include the knowledge of test accuracy, variability, as well as reliability of performing the individual examination in a specific laboratory.

The indiscriminate ordering of investigations is not cost effective and will often lead to confusing and possibly conflicting results.

This book provides a guide that on one hand is encyclopedic, but on the other is both practical and readable. Thus, a practitioner faced with a patient suffering from a particular vascular disorder can review the investigative options and select those tests that will answer the clinical question that is posed in both an accurate and cost effective manner. The text represents the most up-to-date treatise on the subject and will remain current for years to come.

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ISVI (Italian Society for Vascular Investigations)

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Past Research Fellows

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F. W. Taylor (UK)	1976–1977
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T. Sonecha (UK)	1978–1998
C. Miles (Australia)	1978–1979
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J. James (UK)	1979–1981
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M. Hoare (Australia)	1980–1981
R. Girvan (UK)	1980–1981
J. Ramsden (UK)	1980–1981
B. Pardy (UK)	1980–1982
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M. Melville (Australia)	1981–1982
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A. Lamerton (UK)	1981–1984
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C. Hammond (Nigeria)	1981–1982
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T. Riepel (Chile)	1981–1982
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Introduction

Noninvasive diagnostic vascular tests have been developed for screening, detection and quantification of vascular disorders. They are now a fundamental part of the management of vascular disease. Experience and competence in noninvasive vascular investigations are required in all centres dealing with medical or surgical vascular problems. General practitioners, physicians and specialists must know, with different degrees of competence, the meaning of the several available vascular tests, their indications and limitations.

The aim of this book is to give indications to different kinds of medical and non-medical operators which may lead to selective, cost-effective use of noninvasive vascular tests eliminating as far as possible, useless, more invasive or more expensive tests.

Noninvasive Vascular Laboratories

Noninvasive vascular laboratories have been mainly created and developed in the last two to three decades. The detection of vascular disease, the precise quantification and localisation of the vascular problem and the assessment of its severity may be usually rapidly defined by a standardised set of noninvasive tests in most vascular laboratories.

From a technical point of view four major types of noninvasive vascular tests may be considered:

1. flow parameters (including velocity) measurements
2. pressure measurements

3. microcirculatory studies
4. imaging.

While the first three types are almost always quantitative, objective and may be standardised, imaging is mainly a qualitative type of evaluation and is therefore very operator- dependent.

At present, most noninvasive assessments are based on ultrasound (Doppler and B-mode ultrasound) or more commonly on the combination of the two (colour duplex scanning or colour flow imaging).

The Initial Noninvasive Assessment

In the outpatient clinic a simple (low cost) hand-held, continuous wave (CW) Doppler may give, in experienced hands and in association with careful clinical evaluation, significant information which may generally define the initial management of most vascular problems. The accurate use of a pocket Doppler may rapidly rule out the need for further elaborate and expensive investigations and tests.

The **preliminary examination** mainly answers to the question: **Is there a disease?**

The Choice of the Most Useful Test

The necessity of more complex, time-consuming and expensive noninvasive or invasive vascular investigations (duplex, colour flow imaging, treadmill tests etc.) is usually defined in most vascular patients (>80%) by an expert vascular physician or surgeon or by a vascular technologist on the basis of the initial CW Doppler screening test.

Usually the **second noninvasive step** is **duplex ultrasound and/or colour flow imaging (CFI)**. Detailed morphological (B-mode imaging) and dynamic (flow velocity and flow imaging) may be rapidly obtained.

The localisation of the vascular problem is easily achieved with colour flow imaging in most patients and in many cases may give a direct indication for invasive treatment such as angioplasty and even vascular surgery or endovascular procedures.

Noninvasive Tests in Asymptomatic Subjects

Ultrasound-based noninvasive tests are also important screening techniques for high risk subjects (e.g. patients undergoing coronary revascularisation may be screened for carotid artery disease). Aortic or other aneurysms, venous thrombosis, venous insufficiency and peripheral vascular disease can be screened for and detected by noninvasive investigations in a matter of minutes.

Levels of Testing

The most common noninvasive tests available in most vascular laboratories are listed in Table I.1.

Table I.1. The Range of Common Noninvasive Tests.

NONINVASIVE INVESTIGATIONS IN VASCULAR DISEASE

A: ULTRASOUND

1. Doppler
2. B-Mode ultrasound
3. Duplex
4. Colour Duplex
5. Power Doppler
6. 3-D and evolution of ultrasound-based methods

B: VOLUMETRIC TESTS

1. Straingauge plethysmography
2. Air-plethysmography
3. Pulse volume recording
3. Other tests

C. TESTS BASED ON LIGHT TRANSMISSION METHODS

1. Photoplethysmography
2. Light Reflection Rheography
3. Laser Doppler Flowmetry

D. OTHER NONINVASIVE METHODS

1. Capillaroscopy/Videocapillaroscopy
 2. Transcutaneous PO₂ and PCO₂ Measurements
 3. Isotopic and Radioactivity-Based Methods
-

Table I.2. Levels of Noninvasive Investigations

Equipment	Staff
LEVEL 1: Basic screening tests: pocket Doppler; LRR/PPG	Non-specialised* or specialised
LEVEL 2: Vascular Laboratory: duplex and B-mode; PPG/LRR, impedance or other plethysmography. Treadmill/effort tests etc.	Specialised i.e. technologist; vascular surgeon or angiologist or vascular imaging specialist in charge
LEVEL 3: Specialised Vascular Laboratory: high resolution B-mode, duplex; colour flow imaging, power-Doppler; plethysmography; microcirculation (i.e. Laser Doppler Flowmetry (LDF)); contrast ultrasound studies. Treadmill/effort tests etc.	As for level 2: both technicians and specialised physicians in charge.
Note: At this level: more than one duplex available	More than one technician and/or vascular specialist available

Table I.2 shows the levels of complexity and organisation of noninvasive vascular investigations and different types of vascular laboratories.

At the higher level, to provide a large number and range of vascular investigations, a number of dedicated, well trained and experienced medical and nonmedical operators should be always available together with the instruments.

The cost and availability of highly specialised personnel is the essential factor in maintaining efficiency and costs in parallel in vascular laboratories.