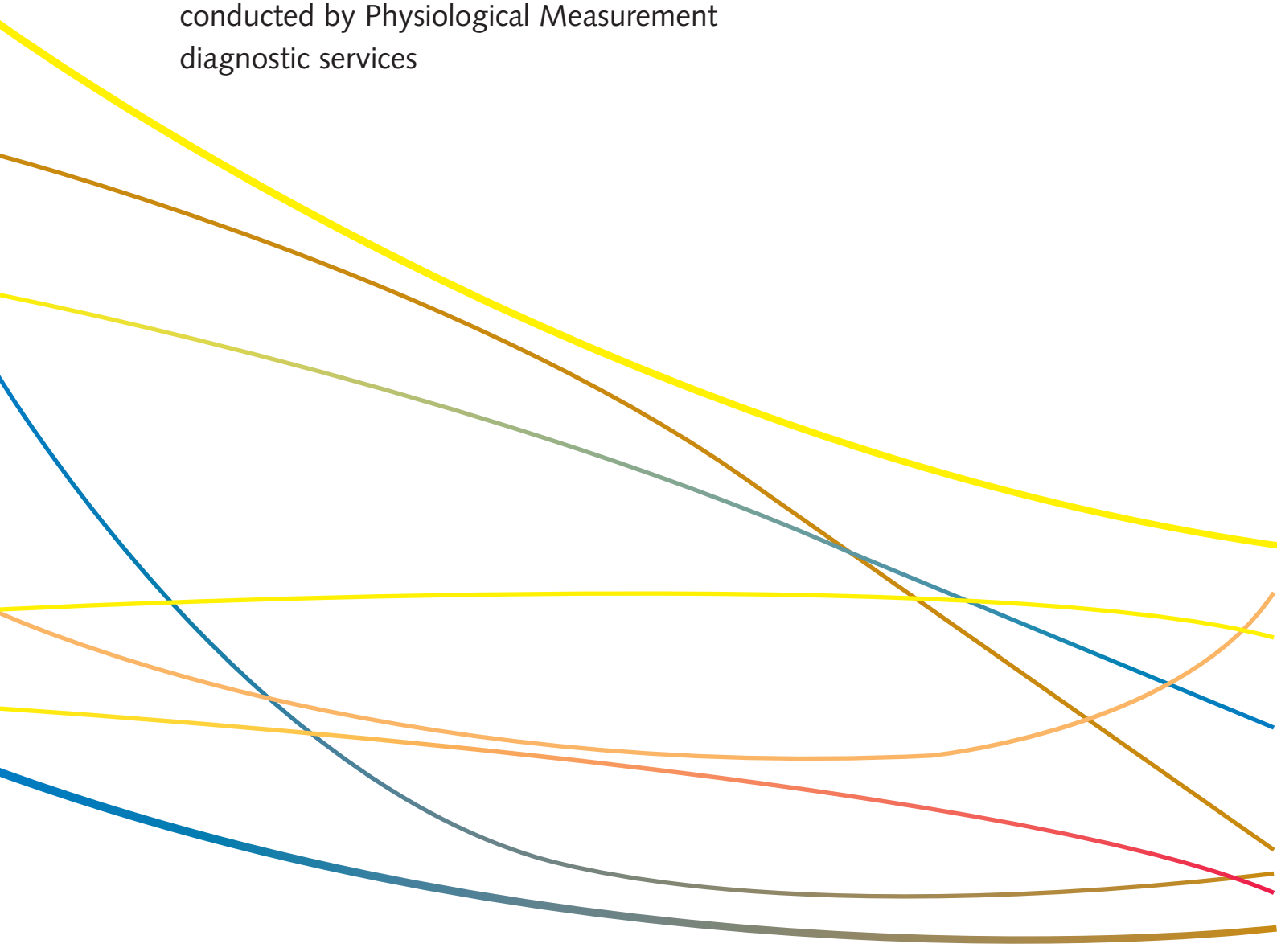
DH Department of Health

What is Physiological Measurement?

A guide to the tests and procedures conducted by Physiological Measurement diagnostic services



NHS

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Foreword

Professor Sue Hill – CBiol, FIBiol, Hon MRCP, OBE: Chief Scientific Officer & National Clinical Lead for Physiological Measurement, Department of Health

Physiological Measurement is one of four diagnostic programmes at the Department of Health, central to the delivery of the 18 weeks implementation programme. The term 'Physiological Measurement' has been adopted to reflect those services that predominantly focus on assessing the function of major organ systems (e.g. neurophysiology involves investigating the function of the central and peripheral nervous system and the impact of different pathologies). In some instances, these services may also restore function through a range of therapeutic intervention strategies. Locally, the clinical services that are included within this term may be dispersed across provider organisations and are not usually part of a distinct physiological measurement department or unit.

Access to diagnostic services is recognised as a major rate-limiting step in achieving the 18 week patient pathway by December 2008, which encompasses all stages that lead up to treatment, including outpatient consultations and diagnostics tests/procedures. Significant focus has now been given to resolving bottlenecks caused by long waits for diagnostics, including Physiological Measurement services. These services have traditionally had a low profile and been poorly understood, often embedded within block contract arrangements and not recognised as an integral service entity. However, Physiological Measurement is a major area of the diagnostic service portfolio, providing a wide range of specialist investigations and elements in the care pathway that are essential in achieving more rapid treatment for patients.

This document provides a comprehensive overview of the tests and procedures conducted by Physiological Measurement diagnostic services. It has been developed to provide information about these services for providers, commissioners and for those individuals who have ultimate strategic and operational management responsibility for delivery. Crucial to the development of these services is a clear understanding of demand for and capacity of current services and an exploration of how services can be delivered differently. Service transformation involves synchronising technology, processes and the skills and competences of the workforce, all working together to deliver efficient and effective services for the patient. It also means considering the broader agenda for delivering services closer to patients, as outlined in 'Our health, Our care, Our say' (2005), and finding longer term, sustainable solutions.

As the National Clinical Lead for Physiological Measurement, I am delighted that NHS commissioners and providers of NHS services are now giving attention to Physiological Measurement services, which have perhaps been neglected in the past. I hope that this document receives the wide circulation that it deserves and that it helps people to understand this complex area, which is crucial to improving the services we deliver to patients.

Foreword

Professor Dame Carol Black – FMedSci, FRCP, DBE: Chair of the Academy of Medical Royal Colleges and former President of the Royal College of Physicians. Co-chair of the Physiological Measurement Strategy Group, DH.

Clinicians and patients will surely welcome this determined approach to bringing Physiological Measurement forward into the thinking of everyone who has a part in improving service delivery and outcome. They will be glad to find a clear definition of the term. Measuring the blood pressure, body temperature, or the levels of components of the blood are, of course, Physiological Measurements too but the term as used here means *assessment of function of major organ systems*. No less than the more familiar tests that are part of normal clinical care, physiological measures are integral to the processes of diagnosis and therapeutic intervention, and to the experience of millions of patients. It is time to give closer attention to their key place in service improvement.

It is a common experience that bottlenecks or rate-limiting steps (to adopt the term long used to describe the brake in biological pathways) are found in the patient journey through diagnosis, or interpretation of the patient's problem, to the point where the patient and the doctor can make a properly informed decision on treatment. Frequently, not only are there long waits but patients must return for physiological investigations often at a time and place inconvenient to them.

Where the health benefits of Physiological Measurements can be foreseen there should be no difficulty in principle in incorporating them within a regular planned clinical pathway, as is already expected and done during pregnancy, for example. Similar planning should become the norm in the range of disorders referred to in this document.

We do not suggest that a complete investigative sequence can be arranged from the early stages when a patient presents with a problem or seeks advice, but there is a rational sequence of steps, informed by clinical judgement. Increasingly the adoption of agreed clinical protocols or algorithms will allow the forward planning necessary to give the unimpeded care pathways sought by patients and their doctors.

The document brings out more fully than hitherto the complexity and sophistication of physiological measurement services and their essential place in the patient pathway. It gives new emphasis to the range of skills needed across the healthcare team, and to the clinical standards and clinical governance procedures against which performance should be assessed; and it points once more to the functions and support structures necessary for efficient clinical networks that work collaboratively to serve patients well.

The statement brings yet new challenges to commissioners and providers, to the Healthcare Scientists who deliver many of these services and the clinicians who request them.

I. Introduction

I. Introduction

i. Physiological Measurement and 18 Weeks

1. Reducing waiting times for diagnostics is central to delivering shorter, overall access times for the benefit of patients. A combination of record investment, the hard work of NHS staff and reform has brought waiting lists down to a record low.

2. By 2008, the NHS will introduce a maximum wait for patients of 18 weeks from GP referral to hospital treatment, including any diagnostics. This is one of the most significant reforms in the history of the NHS, ensuring all local health providers move patients as quickly as possible through the different stages of a clinical pathway towards initiation of treatment (www.18weeks.nhs.uk).

3. Physiological Measurement diagnostic services face some of the biggest challenges in delivering the 18 weeks patient pathway, having some of the longest waiting times and/or the largest number of people waiting. Despite the fact that these services are less well known and have not featured explicitly in public service agreements to date, they have an important role to play in the NHS to deliver key access targets, National Service Frameworks (NSFs) and the wider modernisation agenda, which is briefly outlined in Table 1. Physiological Measurement diagnostics are an intrinsic part of many care pathways and reducing waits for these tests will contribute to the total 18 weeks waiting time commitment.

4. A number of symptom-based commissioning pathways have been developed for each of the highest volume clinical specialties to challenge existing practice, utilise service improvement tools and techniques, and maximise opportunities for transformational change, in order to deliver 18 week pathways. The pathways are high-level service focused pathways to help support and enable commissioners. More information on commissioning pathways and the role of Physiological Measurement diagnostics in these to help achieve 18 weeks can be found at, http://www.18weeks.nhs.uk/public/default.aspx?load=ArticleViewer&ArticleId=645.

ii. Physiological Measurement Services

5. Physiological Measurement services measure and monitor a range of physiological parameters usually in major organ systems, providing information on the extent of disease or disability and the provision and/or response to therapeutic interventions, which may be an integral part of the service provided. There are around 300 specialist Physiological Measurement tests and approximately 10 million procedures are carried out per year.

Table 1: High-level overview of the eight Physiological Measurement diagnostic areas:

Discipline	Indication of tests & services provided	Key drivers	Key issues
Audiology	A wide range of hearing and balance assessments to determine functional ability, possible pathologies and impact on related daily activities.	• 18 Weeks Public Service Agreement (PSA)*; • 'Improving Access to Audiology Services in England' (DH, March 2007); • National Service Frameworks (NSFs) – Older People, Children; • Modernising Hearing Aid Services; • Newborn Hearing Screening Programme (NHSP) / Early Support.	• Growing demand; • Introduction of digital hearing aids; • Phasing out old analogue hearing aids; • Extending provision of cochlear implants.
Cardiac Physiology	Diagnosis and management of patients with known or suspected cardiovascular disease incorporating invasive, non invasive and interventional procedures	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Coronary Heart Disease (CHD), Older People, Children; • Range of National Institute for Clinical Excellence (NICE) guidelines.	• Increasing demand and prevalence of some conditions e.g. heart failure; • Impact of guidelines.
Gastrointestinal (GI) Physiology	Functional assessment of the upper / lower GI tract and the management of patients with pelvic floor dysfunction.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Cancer, Older People, Children; • National Institute for Clinical Excellence (NICE) guidelines – faecal incontinence, dyspepsia.	• Growing demand and increase in prevalence of some conditions; • Unsustainable service provision models.
Neurophysiology	Diagnosis of a wide range of conditions affecting the central and peripheral nervous systems.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Long Term Conditions (LTC), Neurology; Older People, Mental Health; • Forthcoming DH National Stroke Strategy (to be published later in 2007)	• Increased demand for peripheral neurophysiology investigations.
Ophthalmic and Vision Science	Investigations of the disorders of vision, and diseases of the eye and the visual pathway.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Long Term Conditions (LTC), Diabetes, Older People, Children; • National Institute for Clinical Excellence (NICE) guidelines – photodynamic therapy and other treatments for macular degeneration, diabetic retinopathy, laser refractive surgery.	• Increased demand for specialist tests and follow-up work; • Crossover between NHS and independent sector provision.
Respiratory Physiology and Sleep Physiology	A wide range of diagnostic testing and therapeutic services to patients with suspected and/or confirmed respiratory disease and/or sleep related breathing problems.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Long Term Conditions (LTC), Older People, Children; Chronic obstructive pulmonary disease; • National Institute for Clinical Excellence (NICE) guidelines – Oxygen therapy.	• Increasing demand for some specialist respiratory tests and sleep investigations; • Provision of nasal ventilation, with potentially large, yet unrecognised, demand.
Urodynamics	Assessments that investigate bladder and lower urinary tract function.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Long Term Conditions (LTC), Older People.	• Increased demand; • Unsustainable service provision models.
Vascular Technology	Investigation and monitoring of diseases of the arteries and veins.	• 18 Weeks Public Service Agreement (PSA)*; • National Service Frameworks (NSFs) – Long Term Conditions (LTC), Diabetes, Older People, Coronary Heart Disease (CHD); • Forthcoming DH National Stroke Strategy (to be published later in 2007).	• Increased demand for some emergency services e.g. Deep Vein Thromboses (DVT); • Increase in renal workload for fistula access; • Increased demand for faster Transient Ischaemic Attacks (TIA or 'mini strokes') referrals.

* Public Service Agreement (PSA): NHS objectives agreed with the Treasury.

6. Within the national work programme for Physiological Measurement, eight different disciplines or areas are recognised that provide services to almost all clinical specialities – Table 1 provides a high-level overview of these eight Physiological Measurement diagnostic areas and outlines some of the key issues these services are currently facing.

7. The tests and investigations undertaken in the eight areas of Physiological Measurement comprise of a number of different processes that may be delivered by a range of professionals within the healthcare team. Many of the processes are embedded within complex care pathways. Understanding the component parts is critical to the efficient and effective delivery of the service and in identifying the workforce delivering each activity and function. Appropriately matching the skills and competences of the workforce to the service needs, including conducting each diagnostic test component, is critical for the delivery of 18 weeks, as outlined below in Table 2.

Table 2: Diagnostic Test Components:

DECISION TO INVESTIGATE	• Information it will provide; • How it will influence patient management; • Requirement of evidence based care pathway.
PATIENT ASSESSMENT (pre-testing)	• Contra-indications to test investigation being performed; • Identification of pre-test requirements; • Appropriateness of referral related to presenting symptoms; • Information for the patient about test(s); • Assessment of clinical status immediately prior to investigation.
EQUIPMENT	• Preparation (can include environments); • Calibration/verification and QA; • Maintenance/repair; • Operating safety (& impact on environments).
PERFORMANCE OF DIAGNOSTIC 'TEST' (Simple, Routine, Specialist, Complex)	• Protocols/standards; • 'Patient' specific modifications; • Technical acceptability; • QA of 'test' performance/procedure; • Technical acceptability (limitations).
RESULTS INTERPRETATION & REPORTING	• Selection of result; • Linked to presenting symptoms/provisional diagnosis; • Pattern recognition; • Comparison with internal QA within 'sets' of results.
CLINICAL ADVICE & MANAGEMENT	• Support differential diagnosis; • Directs treatment options and further investigations.

8. Currently, most Physiological Measurement services are located in acute Trusts with limited direct access to diagnostic provision for primary care (with some notable exceptions, such as Adult Hearing Services). Although innovation is starting to occur, secondary care generally still acts as a gatekeeper with diagnostic tests often only accessed as part of a linear patient pathway and after an outpatient attendance. There are many opportunities to deliver Physiological Measurement services and tests differently, in particular by locating services in primary care settings, or as one-stop services within outpatients, or exploring the provision of e-diagnostic resources for primary and secondary care. These opportunities need to be explored in the context of the care pathway and in achieving the 18 week access target.

iii. Physiological Measurement Workforce

9. Physiological Measurement tests are mainly carried out by healthcare scientists (HCS) (Clinical Scientists, Clinical Physiologists and associate/assistant practitioners), with medical staff involved in delivery of some elements of the diagnostic test components (e.g. decision to investigate, or in more complex testing, or in reporting and interpreting). In some areas, a multi-disciplinary approach is taken (e.g. in Urology where specialist nurses, scientists and medics may be involved in different parts of the diagnostic pathway). The development of new roles to match the functions that need to be delivered and the high volume of bundled test requirements is a key part of the solution to address waits for many physiological measurement diagnostic services. New roles for scientific staff are being tested at sites across the NHS through other national programmes, such as DH/Skills for Health, Healthcare Science Programme. Further information related to Physiological Measurement workforce solutions will be found at regular intervals on the 18 week website at www.18weeks.nhs.uk.

10. Currently, only Clinical Scientists are regulated under statute by the Health Professions Council (HPC). Voluntary regulation arrangements are in place for Clinical Physiologists through The Registration Council for Clinical Physiologists (RCCP) (http://fp.clinphys.f9.co.uk) with a move to statutory regulation of practice anticipated in the future. It is important that staff are registered appropriately, either as part of statutory or voluntary arrangements.

iv. Physiological Measurement and Children

11. In many of the Physiological Measurement areas, some services will be set up specifically for children and younger people. These services may differ from the way diagnostic testing is carried out for adults by having specially skilled staff, specialist equipment and/or a specialist environment. Children will often undergo measurement in areas dealing predominantly with an adult population. Clinics or part of clinics specifically for children should be developed if possible and the advice of paediatric staff including play therapists sought to develop a child friendly atmosphere .There is often greater sensitivity required when dealing with children, which in turn may require longer timescales to conduct particular diagnostic tests, or may require repeated tests. Children may also be on different care pathways to adults or be referred from different sources, such as social services or education. Many children will have long-term conditions where repeated diagnostic testing will be part of an ongoing cycle of care.

12. It is important to consider all the above points when referring to each of the eight Physiological Measurement areas in this document and particularly for each set of test summaries.

v. 'What is Physiological Measurement?'

13. This document is a guide for a range of audiences, including those providing the service, managers and healthcare scientists (HCS). A range of specialties within Trusts and primary care providers could benefit from this document as could those who are commissioning services in Primary Care Trusts (PCTs), Strategic Health Authorities (SHAs) and through practice-based commissioning. It provides a high level overview, which may be helpful for Board members and senior management teams. It may also be used for communications in raising the profile of Physiological Measurement.

14. This document has been developed in partnership with medical staff, healthcare scientists and other members of the multi-disciplinary team who are involved in the delivery of Physiological Measurement services. It is designed to promote understanding of the diagnostic tests and procedures that are offered and we have tried to ensure that the information provided is as accurate as possible. However, it is an explanatory document and not intended to provide a comprehensive list of all tests that may be performed, nor to dictate clinical practice.

15. The subsequent chapters of this document cover each of the eight areas of Physiological Measurement in more detail and provide the following information:

- Where the service is located;
- What services they provide;
- Where referrals come from and who takes the decision to refer;
- Who currently delivers the service;
- A comprehensive summary of tests that includes information about the nature of the tests involved (e.g. invasive or non-invasive), location (e.g. in-patient or out-patient), average time taken for the test to be performed (including equipment preparation time), patient contact time (including any history taking), any explanation needed at the end of the test, the actual test, interpreting/analysing/reporting time (if this is not an integral part of the overall testing time), and finally – a summary of the function and indication of the test.

16. The NHS has been set the following milestones for achievement in relation to 18 weeks by March 2008:

- 85% of admitted pathways, and 90% of non-admitted pathways to reach clock stop within 18 weeks;
- All diagnostic tests including Physiological Measurement tests to be carried out within a maximum of 6 weeks.

17. The Physiological Measurement tests that are collected in the monthly national diagnostic data collection and the quarterly diagnostic census, to monitor delivery of these milestones, have been based on the test summary details within 'What is Physiological Measurement?'. This document should therefore act as a useful guide for those involved in collecting such data. For further information on waiting times data, the monthly data collection and diagnostic census, visit http://www.performance.doh.gov.uk. (Current data collection guidance is posted on UNIFY system news and tools: http://nww.steis.doh.nhs.uk/steis/steis.nsf/steismain?readform&login=1).

18. The vision for the future of Physiological Measurement diagnostic services is that they should:

- Be patient centred;
- Realise the benefits of new technology;
- Be streamlined and efficient within Referral to Treatment (RTT) pathways of 18 weeks by Dec 2008;
- Be delivered closer to home;
- Provide excellent patient information;
- Be accessible from primary as well as secondary care.

19. This document is one in a series of products that either have been, or are in the process of being developed by the national Physiological Measurement Programme as aids for the NHS and other providers of NHS services in delivering this vision. For further information and regular updating, visit www.18weeks.nhs.uk.

20. The immediate priority is 18 weeks, which will in turn drive other elements of the vision set out above. In 2007/08, the focus will therefore be on what the DH can do to help front line staff involved in the delivery of Physiological Measurement services to achieve 18 weeks. The biggest challenges for 18 weeks relate to audiology, cardiac physiology, neurophysiology and respiratory/sleep physiology and materials will be produced setting out good practice in these areas. The commitments set out in Improving Access to Audiology Services in England (DH, March 2007) will be taken forward. Information will be provided on workforce and leadership, which are crucial to delivery of 18 weeks and a series of case studies across all physiological measurement disciplines will be made available. A capacity tool will be placed on the 18 weeks website for use by Physiological Measurement services/departments to review their productivity and model the potential that they could gain by working in different ways.

II. The Eight Areas of Physiological Measurement

1. Audiology

Audiology involves a wide range of hearing and balance assessments. These assessments determine functional ability, possible pathologies and impact on related daily activities. Following assessment, an appropriate care pathway is selected for treatment (e.g. surgery for cochlear implant) and support, but more often for rehabilitative support strategies (e.g. programmed digital signal processing (DSP or 'digital') hearing aids, counselling, assistive listening devices) to improve the ability to participate in daily activities.

Where is the service located?

21. The majority of acute Hospital Trusts are supported by an on site audiology department. However, audiology is a community-facing service with a high number of adult and paediatric outreach sites, some GP based services and an increasing number of private sector providers. There is the potential for more services to be provided directly in primary care settings. Paediatric audiology services work in partnership with local authority services who provide the major ongoing rehabilitative support for parents and their children.

22. The majority of audiology tests need to be undertaken in quiet clinical rooms (background noise <35dBA), sound proofed rooms or electrically shielded and sound proofed rooms.

What services do they provide?

23. The major elements of audiology services include:

- Assessment of patient needs and selection of appropriate care pathways;
- Hearing function (including pure tone audiometry – see below) and tinnitus assessments;
- Diagnostic audio vestibular function tests (i.e. balance tests and electrophysiological tests of hearing and balance);
- Assessment for implantable devices that aid hearing and communication (e.g. bone anchored hearing aids and cochlear implants) and for patients with central auditory processing disorders (provided by a small number of centres, up to 20).
- Fitting of digital hearing aids to new and existing patients;
- Hearing and tinnitus patient management and follow-up;
- **Pure Tone Audiometry** is a behavioural assessment that determines the threshold for hearing at a number of pure tone frequencies and maps them onto an audiogram in a standard manner. It requires active cooperation from the patient. Sound may be applied monaurally by means of an earphone (air conduction audiometry), or vibrations may be applied to the skull by a bone vibrator (bone-conduction audiometry).

Where do referrals come from and who takes the decision to refer?

24. The majority of referrals to audiology come directly from GPs, self referrals from existing hearing aid patients, with the remainder from ear, nose and throat departments (ENT) and other internal departmental referrals i.e. from audiologist to hearing therapist, or from 'repair clinic' to hearing aid assessment clinic. Children may also be referred to paediatric audiology services through the Newborn Hearing Screening Programme (NHSP), a health visitor or school nurse.

25. Referrals from specialties other than ENT have a significant impact on the total patient journey. These referrals particularly impact on some of the lower volume tests provided by audiology services. For example, many patients that require vestibular/balance assessment and rehabilitation associated with dizziness or falls may be referred from a range of specialties, but often do not reach audiology until quite late in the patient pathway.

26. Audiology services work closely with a range of agencies, including Education & Social Services, and voluntary sector providers to support the provision of NHSP and services for children and adults with learning disabilities, dual sensory impairments and complex needs.

Who delivers the service at the moment?

27. There are 166 hearing aid departments in England, based upon Modernising Hearing Aid Services (MHAS) sites, 124 consortia for New Born Hearing Screening Programmes (NHSP) and there is access to around 18 cochlear implant services. Skill mix and number of staff varies between organisations. The bulk of the service is delivered by healthcare scientists (clinical scientists and audiologists). In paediatric audiology in particular, a proportion of staff are audiological physicians, who may undertake some assessments. In general practice, some GPs may undertake baseline hearing assessments and arrange for hearing aid services to be delivered within their practices. In paediatric audiology, the service is often led by a consultant clinical scientist. There is scope for new roles to be developed and for skill mix to be reviewed to match the workforce to the main functions delivered.

Improving Access to Audiology Services in England…

28. …was published on 6 March 2007. This sets out the aspiration to transform the patient experience of audiology services with a series of actions that the NHS will take to help make this happen. It sets out how health reform levers can improve quality, efficiency and access to audiology services.

Audiology Tests Summary

ADULT AUDIOLOGY

Standards and Guidelines: British Academy of Audiology (BAA) and British Society of Audiology (BSA) guidelines; Modernising Hearing Aid Services (MHAS) guidelines; Do Once and Share (DOAS) care pathways; Technicians, Therapists and Scientists in Audiology (TTSA) criteria for direct referral; RNID best practice guidelines for adult audiology.

Referral for hearing aid assessment (new patients)/Re-referral for hearing aid assessment (existing patients)

Test	Test Time				Function	Indication
	Procedure					
Technicians, Therapists and Scientists in Audiology (TTSA) criteria (or locally developed referral criteria).	NI	D	OP/DV	B	Suitability criteria for direct referral to audiology or ENT.	Hearing Impairment.
Otoscopy.	NI	D	OP/DV	A	Clinical examination of external auditory meatus, ear drum and gross structures of middle ear.	Outer / middle ear pathologies.
Pure Tone Audiometry.	NI	D	OP/DV	C	Behavioural assessment of frequency specific hearing thresholds and requires active cooperation from the patient. Sound may be applied monaurally by means of an earphone (air conduction audiometry), or vibrations may be applied to the skull by a bone vibrator (bone-conduction audiometry).	Conductive or sensorineural hearing loss.
Tympanometry & Reflexes.	NI	D	OP	B	Functional analysis of outer ear, eardrum and middle ear	Outer / middle ear pathologies and VII & VIII cranial nerve function.
Loudness Discomfort Level test.	NI	D	OP/DV	A	Behavioural assessment for sound levels at which patients experience discomfort as a function of frequency.	Enables calculation of effective Dynamic Range of hearing and also indicates whether loud sounds are experienced as excessively loud compared to normal hearing listeners (this recruitment is often experienced with sensorineural pathologies).
Glasgow Hearing Aid Benefit Profile (GHABP) – part I.	NI	D	OP/DV	B	Assess initial disability & handicap of hearing impairment.	Needs assessment – disability & handicap.
Impression taking.	I/NI	T	OP/DV	B	Taking impressions for manufacture of patient specific ear mould.	Ear mould for hearing aid.

KEY:

Procedure – NI: Non-invasive; I: Invasive; D: Diagnostic; T: Therapeutic; OP: Outpatient; DV: Domiciliary Visit; DC: Day case; IP: Inpatient.
Test Time – A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

Referral for complex needs hearing aid assessment, fitting and follow-up – Learning disability hearing assessment. New & Re-assessment adult patients with learning disability follow generic adult hearing aid pathway (as above), but require additional considerations as highlighted in 'Do Once & Share LD auditory assessment' care pathway and the following:

Test	Test Time				Function	Indication
	Procedure					
Threshold Auditory Brainstem Response – tone pip ABR (air conduction).	NI	D	OP/DV	F	To determine frequency specific air conducted hearing thresholds – recommended procedure (if required).	Hearing impairment.
Threshold Auditory Brainstem Response – bone conduction ABR*.	NI	D	OP/DV	F	Usually performed when the person cant make a response off their own accord, e.g. for a person who is a slow developer, or has learning difficulties, or cannot speak or move, or has cognitive impairment. Also used as a follow-up assessment following referral from NHSP to determine bone conducted hearing thresholds – recommended to be performed when elevated air conduction levels recorded (if required).	Hearing impairment.
Transient Evoked Oto-acoustic Emissions.	NI	D	OP/DV	D	Assesses outer hair cell function – objective test of inner ear function (if required).	Conductive or sensorineural hearing loss.

Bone Anchored Hearing Aid (BAHA) assessment (new & existing patients) Otoscopy, Pure Tone Audiometry, Tympanometry & Reflexes, Loudness Discomfort Level test, Threshold Auditory Brainstem Response – tone pip ABR (air conduction), Threshold Auditory Brainstem Response – bone conduction ABR , Transient Oto-acoustic Emissions, Unaided & Aided Soundfield Thresholds. New patients – Glasgow Hearing Aid Benefit Profile (GHABP) – part I. Existing patients – Glasgow Hearing Aid Difference Profile (GHADP) – part I.

Test	Test Time				Function	Indication
	Procedure					
Referral suitability criteria completed.	NI	D	OP	C	Suitability criteria against agreed referral guidelines.	Severe to profound hearing impairment.
AB word lists.	NI	D	OP	C	Speech discrimination tests.	Speech & lip-reading ability (aided & unaided).

KEY:

Procedure – NI: Non-invasive; I: Invasive; D: Diagnostic; T: Therapeutic; OP: Outpatient; DV: Domiciliary Visit; DC: Day case; IP: Inpatient.
Test Time – A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

Hearing aid fitting and follow up

Test	Test Time				Function	Indication
	Procedure					
Real ear measurements.	NI	D/T	OP/DV	C	Objective measurement of sound-pressure level in patient's ear once hearing aid has been fitted to enable accurate programming of hearing aid to a target.	Fitting and evaluation of hearing aids.
Hearing Direct Referral or local tele-audiology service.	NI	T	OP/DV	B	Referral for follow-up in audiology department or by telephone.	Referral for local / central telephone follow-up appointment.
Counselling & instruction.	NI	T	OP/DV	D	Counselling and instructing the patient in the use of the hearing aid.	Hearing difficulty.
Glasgow Hearing Aid Benefit Profile (GHABP) – part II.	NI	D/T	OP/DV	C	Outcome measure to assess use, benefit & satisfaction and residual disability with device.	Outcome measure – use disability & handicap, benefit & satisfaction.
Hearing aid repairs.	NI	T	OP/DV	B	Hearing aid repair service. Wide ranging chronic and transitory faults in hearing aids diagnosed & rectified.	Maintenance of existing hearing aid systems.

Hearing aid re-assessment referral (DSP) – Assessment, fitting, follow-up using appropriate combination of tests included above

BAHA fitting

Test	Test Time				Function	Indication
	Procedure					
Unaided & aided soundfield thresholds	NI	D	OP	C	Soundfield measurement of unaided & aided hearing levels.	Unaided & aided hearing levels.
Follow-up questionnaire.	NI	T	OP/DV	C	Determine appropriateness of fitting.	All BAHA patients.

KEY:

Procedure – NI: Non-invasive; I: Invasive; D: Diagnostic; T: Therapeutic; OP: Outpatient; DV: Domiciliary Visit; DC: Day case; IP: Inpatient.
Test Time – A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

Referral for Cochlear implant candidacy assessment (adult) – As generic adult hearing pathway (as above), additionally Threshold Auditory Brainstem Response – tone pip ABR (air conduction), Threshold Auditory Brainstem Response – bone conduction ABR, Transient Evoked Oto-acoustic Emissions (as above) and:

Test	Test Time				Function	Indication
	Procedure					
Unaided & aided soundfield thresholds.	NI	D	OP	C	Soundfield measurement of unaided & aided hearing levels.	Unaided & aided hearing levels.
BKB sentences or other speech material.	NI	D	OP	C	Assess speech in noise.	Speech & lip-reading ability (aided & unaided).

Device implanted – there will be device specific diagnostic test to ensure appropriate implantation and functionality.
Tuning of cochlear implant – device specific diagnostic test to ensure functionality and mapping of electrodes.
Follow-up of cochlear implant patients makes extensive use of diagnostics tests to measure outcome and guide rehabilitation (depending on age and ability of patient).

Hearing Therapy

Test	Test Time				Function	Indication
	Procedure					
Range of rehabilitative assessments undertaken: hearing aid rehabilitation, balance rehabilitation, mapping of cochlear damaged / dead region(*), central auditory processing disorders / obscure auditory dysfunction, lip-reading, sudden hearing loss support; Assessment of need for assistive listening devices, their provision and use, etc.	NI	(*D)T	OP/DV	F	Rehabilitation for patients with hearing & balance impairments. Psychological support, formulation, delivery & review of complex management programmes (for both patient and family). Discharge, review or onward referral as required.	Need for and success of adult audio-vestibular rehabilitation.

KEY:

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Test Time – A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

Adult Audio-Vestibular Diagnostic Services (Tests will also include: Otoscopy, Pure Tone Audiometry, Tympanometry & Reflexes)

Test	Test Time				Function	Indication
	Procedure					
Cortical Electric Response Audiometry (ERA).	I/NI	D	OP/DV	F	To determine frequency specific air conducted cortical hearing thresholds – recommended.	Undertaken to determine hearing thresholds at specific frequencies when either patient is unable to respond or malingering is suspected.
Electrocochleography.	I/NI	D	OP/IP	F	To determine potential differences within cochlear.	Performed when patient is suspected of having endolymphatic hydrops or 'Menieres' type symptoms.
Neuro-otological Auditory Brainstem Response (air conduction).	I/NI	D	OP	F	To determine functionality and integrity of cranial nerve VIII. Identifies retro-cochlear lesions, such as demyelisation and lesions.	Retro-cochlear lesions.
Middle ear analysis.	NI	D	OP/IP	D	Otoscopy, Tympanometry & Reflexes.	
Transient Evoked Oto-acoustic Emissions (OAE). Distortion Product Oto-acoustic Emissions. Spontaneous Oto-acoustic Emissions.	NI	D	OP/DV	D	Diagnostic assessment of outer hair cell function – objective test of inner ear function.	Hearing impairment pathology including potential inner hair cell impairment.
Pure tone audiometry (as above).						

Speech Audiometry – Otoscopy, BKB sentences, AB word lists etc.

Steady state evoked potentials (Tests will also include Otoscopy)

Test	Test Time				Function	Indication
	Procedure					
Steady state evoked potential (SSEP).	NI	D	OP/IP	E	To determine frequency specific air conducted hearing thresholds.	Hearing impairment.

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Tinnitus assessment (Tests will include Otoscopy, Pure Tone Audiometry, Tympanometry & Reflexes and standard blood tests (VDRL, FBC, TFT, Glucose, Electrolytes)).

Tinnitus rehabilitation

Test	Test Time – Procedure				Function	Indication
Tinnitus Handicap Inventory. Hearing Handicap Inventory. Hyperacusis Questionnaire.	NI	T	OP/DV	E	History and Questionnaires (as required) including: digital sound generators, reading, self help groups, sound enrichment, relaxation therapy, counselling, sleep management, tinnitus retraining therapy (as required).	Tinnitus.

Balance assessment (Balance investigation tests will include Otoscopy, Pure Tone Audiometry, Tympanometry & Reflexes)

Test	Test Time – Procedure				Function	Indication
Caloric irrigation test.	NI	D	OP/DV	E	Using water or air irrigations, function and impairments of vestibular organs of inner ears can be assessed.	Balance disorders.
Electronystagmography.	NI	D	OP/DV	E	Using surface mounted skin electrodes, nystagmus can be recorded.	Balance disorders.
Videonystagmography.	NI	D	OP/DV	E	Using video goggles nystagmus can be recorded.	Balance disorders.
Benign Paroxysmal Positional Vertigo (BPPV).	NI	D/T	OP/DV	D	Using a series tests and if positive a range of particle repositioning manoeuvres, free floating otoconia can be repositioned to treat affects of BPPV (Hallpike / positional assessment, Side lying test, Epley repositioning manoeuvre assessment, Semont manoeuvre, Brandt Daroff, Bar-B-Que role).	Benign Paroxysmal Positional Vertigo (BPPV).
Posturography.	NI	D	OP	E	Dynamic Force plate – Functional assessment of 3 dynamics within balance function – visual, proprioceptive and vestibular.	Balance disorders.
Vestibular rehabilitation.	NI	T	OP	E	Vestibular Ocular Reflex exercises, dynamic gait exercises, eye control tasks, counselling, relaxation, referral to physiotherapy, use of questionnaires (dizziness handicap inventory, etc). Cawthorne Cooksey exercises.	Balance disorders – Once balance assessment has been undertaken and diagnosis established, most balance patients require this specialist therapy/rehabilitation.

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PAEDIATRIC AUDIOLOGY

Standards and Guidelines: Newborn Hearing Screening Programme (NHSP) guidelines and standards, BAA/BSA recommended procedures, Modernising Children Hearing Aid Services (MCHAS) protocols and NDCS quality standards.

Paediatric hearing services following newborn screening

Test	Test Time				Function	Indication
	Procedure					
Newborn Hearing Screening.	NI	D	IP/OP/	DV	CNeonatal screen to assess outer hair cell function – used to identify congenital hearing impairment.	Congenital hearing impairment.
Automated Auditory Brainstem Response (AABR).	NI	D	IP/OP/DV	D	Automated Auditory Evoked potential test – used to assess function of VII cranial nerve and determine hearing levels at a predetermined pass level.	Congenital hearing impairment.

Newborn Hearing Screening (Onward referral):

Assess threshold ABR after NHSP referral. Tests include: Threshold Auditory Brainstem Response – tone pip ABR (air conduction), Threshold Auditory Brainstem Response – click ABR (air conduction), Threshold Auditory Brainstem Response – bone conduction ABR (refer to 'Referral for complex needs hearing aid assessment, fitting and follow-up' in Adult Audiology section above).

Otoscopy, Tympanometry & High Frequency Reflexes (refer to 'Referral for hearing aid assessment (new patients) / Re-referral for hearing aid assessment (existing patients)' in Adult Audiology section above).

Assess thresholds using Steady State Evoked Potentials. Tests include: Steady State Evoked Potential (SSEP), Threshold Auditory Brainstem Response – bone conduction ABR, Otoscopy, Tympanometry & High Frequency Reflexes (refer to Adult Audiology section above).

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Paediatric Hearing Services

Audiological assessment at 2nd tier clinic (pre-school). Screening clinic, which assess hearing thresholds, middle ear function and speech discrimination ability of pre-school children. Discharges, reviews or refers onward to 3rd tier consultant led clinics as required

Test	Test Time				Function	Indication
	Procedure					
Distraction Test.	NI	D	OP	C	Behavioural assessment of frequency specific hearing thresholds. Suitable for children with developmental level of 6-10 months.	Conductive or sensorineural hearing loss.
Visual Reinforcement Audiometry.	NI	D	OP	C	Behavioural assessment of frequency specific hearing thresholds. Suitable for children with developmental level of 6-30 months.	Conductive or sensorineural hearing loss.
Performance Test.	NI	D	OP	C	Behavioural assessment of frequency specific hearing thresholds. Suitable for children with developmental level of 30-42 months.	Conductive or sensorineural hearing loss.
Co-operative speech test.	NI	D	OP	B	Speech discrimination test – used to assess receptive and expressive language development and to cross check behaviourally acquired hearing thresholds. Age range 18-24 months.	Conductive or sensorineural hearing loss.
McCormick Toy Test.	NI	D	OP	B	Speech discrimination test – used to assess receptive and expressive language development and to cross check behaviourally acquired hearing thresholds. Age range 24-42 months.	Conductive or sensorineural hearing loss.

Tests also include: Otoscopy, Tympanometry & High Frequency Reflexes for outer / middle ear pathologies

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Audiological assessment at 2nd tier clinic (school-age)

Tests include: McCormick Toy Test, Pure Tone Audiometry, Otoscopy, Tympanometry & High Frequency Reflexes.

Test	Test Time				Function	Indication
	Procedure					
Play Audiometry.	NI	D	OP	C	Behavioural assessment of frequency specific hearing thresholds. Suitable for children with developmental level of 42+ months.	Conductive or sensorineural hearing loss.
Manchester Picture Test.	NI	D	OP	B	Speech discrimination test – used to assess receptive and expressive language development and to cross check behaviourally acquired hearing thresholds. Age range 42-72 months.	Conductive or sensorineural hearing loss.

Audiological assessment at 3rd tier clinic (pre-school)

Diagnostic audiological assessment clinic. To provide assessment and diagnostic results. Review, discharge, refer for medical intervention and other onward referral. Confirmation of hearing loss undertaken and informed options as part of habilitation initiated. Tests include: Distraction Test, Visual Reinforcement Audiometry, Performance Test, McCormick Toy Test, Otoscopy, Tympanometry & High Frequency Reflexes.

Test	Test Time				Function	Indication
	Procedure					
Transient Oto-acoustic Emissions.	NI	D	OP	C	Assesses outer hair cell function – objective test of inner ear function.	Conductive or sensorineural hearing loss.
Co-operative speech test.	NI	D	OP	B	Speech discrimination test – used to assess receptive and expressive language development and to cross check behaviourally acquired hearing thresholds. Age range 18-24 months.	Conductive or sensorineural hearing loss.

Audiological assessment at 3rd tier clinic (school-age)

Tests include: Performance Test, Play Audiometry, Pure Tone Audiometry, Transient Oto-acoustic Emissions, McCormick Toy Test, Manchester Picture Test, AB Word lists, Otoscopy, Tympanometry & High Frequency Reflexes.

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Test Time – A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

Paediatric Hearing Aid Services

Tests include: Distraction Test, Visual Reinforcement Audiometry, Performance Test, Play Audiometry, Pure Tone Audiometry, Transient Oto-acoustic Emissions, Co-operative speech test, McCormick Toy Test, Manchester Picture Test, AB Word lists, Otoscopy, Tympanometry & High Frequency Reflexes.

Test	Test Time				Function	Indication
	Procedure					
Tympanometry & reflexes.	NI	D	OP	B	Functional analysis of outer ear, eardrum and middle ear.	Outer/middle ear pathologies and VII & VIII cranial nerve function.
Unaided & aided soundfield thresholds.	NI	T	OP	D	Soundfield measurement of unaided & aided hearing levels.	Unaided & aided hearing levels.
Real ear to coupler differences.	NI	T	OP	C	Objective measurement of sound-pressure level in child's ear canal – used to set up & configure hearing aid prior to fitting	Setting up hearing aids.
Real ear measurements.	NI	T	OP	C	Objective measurement of sound-pressure level in child's ear once hearing aid has been fitted to enable accurate programming of hearing aid to a target.	Fitting and evaluation of hearing aids.
PEACH Questionnaire.	NI	T	OP	D	Outcome measure – used to measure performance, benefit & satisfaction with hearing aid(s).	Verification of amplification.
Listening Situations Questionnaire.	NI	T	OP	D	Outcome measure – used to measure performance, benefit & satisfaction with hearing aid(s).	Verification of amplification.

Child hearing aid reassessment

Assessments undertaken to assess auditory function, hearing aid evaluation & verification, including outcome measures of benefit and satisfaction. Tests as above.

Assessment for BAHA

Fitting and follow-up. Tests as above modified if necessary for age and ability of child.

Referral for Cochlear Implant Candidacy assessment

Fitting, tuning and follow-up. Tests as above and also Threshold Auditory Brainstem Response – click ABR (air conduction), Threshold Auditory Brainstem Response – bone conduction ABR. Age appropriate developmental follow-up.

Assessment for central auditory processing problems

Tests as above, which maybe modified according to age and ability of child.

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2. Cardiac Physiology

Cardiac physiology services involve the diagnosis and management of patients with known or suspected cardiovascular disease. An extensive range of both invasive and non-invasive diagnostic and interventional procedures are carried out.

Where is the service located?

29. Cardiac Physiology services are usually based in acute Hospital Trusts, linked to cardiology departments, providing both invasive and non-invasive diagnostic and therapeutic procedures. There are some services provided in primary care, either by clinical physiologists undertaking complex measurements in outreach clinics, or by GPs/nurse practitioners providing some diagnostics such as electrocardiogram (ECG) and 24-hour blood pressure recordings. More services could be provided directly in primary care, taking advantage of modern portable equipment and making available current diagnostic resources, including reporting and interpretation, for both primary and secondary care. Provision of cardiac physiology is a key factor in the delivery of care pathways across the primary and secondary care sectors, including critical care, transplantation and surgery to support the successful delivery of the National Service Framework (NSF) for coronary heart disease (CHD).

What services do they provide?

30. Services will usually include:

- Echocardiography (Echo);
- Electrophysiology studies (EPS);
- Electrocardiogram (ECG) and blood pressure recording;
- Exercise Stress Testing;
- Diagnostic and interventional angiography;
- Pacemaker implantation and follow-up;
- Implantation of cardioverter defibrillators (ICD) and other devices and subsequent follow-up.

31. Echocardiography and Electrophysiology Studies are the two of the major tests performed in Cardiac Physiology:

- **Echocardiography (Echo)** is a technique that uses ultrasound to produce images of the heart to detect structural and/or functional abnormalities.
  - Transthoracic echocardiography (TTE) is performed by putting a probe on the chest.
  - Transoesophageal echocardiography (TOE) is a more invasive procedure where the probe is passed into the oesophagus. As the oesophagus lies directly behind the heart, the pictures obtained using this approach are usually of

superior quality and are particularly valuable in patients who have had valve replacements, those with a suspected blood clot or infection in the heart and in patients where inadequate images have been obtained using the transthoracic approach.

- Both techniques provide visual information regarding the function of the heart, enable inspection of the heart valves to check whether they are opening and closing properly and allow for measurement of the heart's chambers, major blood vessels and the thickness of the heart walls.
- Doppler ultrasound studies give information about the direction and velocity of blood flow within the heart. The studies require high specification ultrasound scanners with appropriate colour and pulsed Doppler facilities. Lower specification and hence cheaper scanners can be used for less complex investigations. Investigations are performed and reported by a range of specialised practitioners.

Currently, nearly all echocardiograms are performed in hospitals, but some scans are now being provided in primary care, for example by GPs with a special interest in Cardiology, or by cardiac physiologists.

- **Electrophysiology studies (EPS)** involves an invasive procedure (carried out as an in-patient and undertaken in the cardiac catheterisation laboratory). It involves placing catheters with multiple recording electrodes at specific sites within the heart, using x-ray and/or electromagnetic imaging techniques to correctly position them. The procedure uses complex equipment to collect multiple recordings from the heart, then monitor, record and store them. An EPS procedure provides a detailed analysis of the heart's electrical conduction system to assess whether it functions correctly, to locate the site of abnormalities and inform treatment. During the EPS procedure, the cardiologist will use electrical stimuli to deliberately induce rhythm disturbances in order to establish a diagnosis. The cardiologist, in conjunction with other members of the team, will usually interpret the results at the time and treatment, in the form of ablation or insertion of a device (for example an implantable cardiovertor defibrillator (ICD) or pacemaker), may also be undertaken at the same time.

Where do referrals come from and who takes the decision to refer?

32. Patients are referred through a range of different routes. Anecdotal evidence suggests 50% of referrals into cardiac physiology services come from cardiology

and cardiac surgery departments and the remaining 50% from a combination of GP direct access and internal Trust referrals from a wide range of clinical specialties including neurology, oncology and general medicine.

Who delivers the service at the moment?

33. Clinical physiologists (cardiac) make up a large part of the workforce carrying out these investigations:

- **Invasive procedures** will normally involve medical staff (cardiologists) who are responsible for insertion and manipulation of catheters, exposure of X-Rays and interpretation of the results. In these procedures, the responsibilities of the clinical physiologist (cardiac) would include setting up equipment, monitoring and recording measurements and their interpretation.
- **Echocardiography (Echo)** is undertaken by a range of practitioners:
  - cardiac physiologists who specialise in echocardiography;
  - Specialist registrars (SpR's) and consultant cardiologists;
  - Individuals brought into the service to specifically deliver echo;
  - A small number of nurses or GP's with special interest trained in simple screening echocardiography.

  Complex or invasive echocardiography usually involves medical and clinical physiologists (cardiac).
- **Electrophysiology Studies (EPS)** is delivered by a multi-professional team. Trained medical staff are required to insert catheters. Clinical physiologists (cardiac) set up and calibrate both the measuring and therapeutic equipment. They monitor, record and interpret measurements, recording any therapeutic part of the procedure.
- **Basic Electrocardiogram (ECG)** recordings are often made by cardiographers, but are interpreted and reported by clinical physiologists (cardiac) or medical staff.
- **Exercise Stress Tests** are usually undertaken by cardiac physiologists. The test may be supervised by medical staff.

34. New roles are being explored to introduce greater skill mix into the cardiac physiology workforce, particularly at associate level to undertake the high volume / lower clinical risk investigations, but also at advanced levels to provide more specialist interpretation, particularly in echocardiography.

Cardiac Physiology Tests Summary

ECHOCARDIOGRAPHY

Standards: Guidance as set out by the British Society of Echocardiography Education Committee "Minimum dataset for adult Transthoracic echocardiography" Recommended views for a standard adult Transthoracic echocardiography (www.bsecho.org).
Note: test times include reporting.

Test	Test Time				Function	Indication
	Procedure					
Echocardiograms TTE.	NI	D	OP/IP	D/E	To assess structure and function of the heart.	Heart failure, valve disease, congenital heart disease, cardiomyopathy, pericardial effusion, to detect the presence of thrombus, infective vegetatitions, tumours.
Echocardiograms Bubble Contrast.	I	D	OP/IP	D/E	As above, but an injection of microbubble contrast is given intravenously	ASD (atrial septum defect) or VSD (ventricular septum defect).
Echocardiograms Dobutamine Stress Echo.	I	D	OP/IP	F	Assessment after the heart has been put under stress (using an infusion of dobutamine).	To assess LV function, allows detailed studies of regional wall movement – coronary heart disease, myocardial viability.
Echocardiograms GUCH.	NI	D	OP/IP	D/E	Complex, specialist knowledge of the congenital cardiac conditions is needed.	
Echocardiograms TOE.	I	D	DC/IP	D/E	To assess the structure and function of the heart but where more detailed pictures are required or where images from TTE were not adequate.	Valve replacements, suspected blood clot or infection in the heart or where inadequate images have been obtained using the transthoracic approach.
Intraoperative TOE.	I	D	DC/IP	D/E	As above, but in theatre for monitoring during a surgical procedure.	Intraoperative monitoring e.g. to assess valvular incompetence following repair.

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ELECTROPHYSIOLOGY

Test	Test Time				Function	Indication
	Procedure					
Electrophysiological Study (EPS).	I	D	DC/IP	G/I	To assess the electrical conduction system within the heart.	Abnormal heart rhythm or arrhythmia. Diagnosing Wolff Parkinson White Syndrome.
EPS + Ablation.	I	T	DC/IP	G/I	To destroy (ablate) abnormal electrical circuits / foci for the treatment of arrhythmias.	To treat the above.
EPS + Carto Mapping +/- Ablation.	I	D/T	DC/IP	G/I	As above – but instead of using X-rays for positioning, a Carto Mapping system is used.	As above – normally used for AF ablation.
VT Stim.	I	T	DC/IP	G/I	To induce and attempt to terminate Ventricular Tachycardia.	Life threatening arrhythmias (VT). As a guide to treatment with an AICD.

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ECG & BLOOD PRESSURE RECORDING AND MONITORING

Standards:

1 The Society for Cardiological Science and Technology; Clinical Guidelines by Consensus, Number 1 Recording A Standard 12-Lead Electrocardiogram, April 2005.
2 Guidelines for Ambulatory Electrocardiography (Circulation 1999: 886-893).
3 The Use and Interpretation of Ambulatory Blood Pressure Monitoring: Recommendations of the British Hypertension Society BMJ 2000;320;1128-1134.
4 Practice Guidelines of the European Society of Hypertension for Clinic Ambulatory and Self Blood Pressure Measurement. Journal of Hypertension 2005, 23:697–701.
5 The British Cardiac Society Protocol For Cardiac Physiologists Managed Exercise Stress Testing (2003).

Test	Test Time				Function	Indication
	Procedure					
Electrocardiograms: Standard and 12 lead ECGs[1].	NI	D	OP/IP	B	To record the rhythm and electrical activity of the heart.	Suspected heart disease / heart condition. Widespread screening investigation. Pre operative assessment.
Ambulatory ECG monitoring: Application (Holter monitoring)[2]	NI	D	OP/IP	B	To monitor the ECG over an extended period, normally 24 hours.	When an ECG does not show the arrhythmia and it is still suspected to be the cause of symptoms.
Ambulatory ECG Monitoring: Analysis.	NI	D	OP/IP	D/E	To analyse and report the 24 hour recording.	
Patient activated ECG monitoring / event recorder: Application.	NI	D	OP/IP	B	To monitor over a longer period to try and detect infrequent rhythm events.	When symptoms are infrequent and have not been detected by ambulatory ECG monitoring.
Patient activated ECG monitoring: Analysis.	NI	D	OP/IP	C/D	To analyse and report the 24 hour recording.	
Ambulatory BP Monitoring: Application[3, 4].	NI	D	OP/IP	C	To monitor the BP over an extended period, normally 24 hours.	To assess if the patient has true hypertension / monitor of treatment.
Ambulatory BP Monitoring: Analysis.	NI	D	OP/IP	B	As Ambulatory ECG monitoring analysis.	
Exercise tolerance testing[5].	NI	D	OP/IP	D/E	To make a graphical recording of the heart's rhythm and electrical activity during exertion.	Assessment of chest pain during exercise. Measure outcome of treatment. Arrhythmias / cardiomyopathy.
Metabolic exercise testing (or Cardio-respiratory Exercise Testing).	NI	D	OP/IP	D/E	To measure maximum O2 uptake whilst monitoring ECG, blood pressure and respiratory gases.	Assessment of heart failure for cardiac transplantation.
Tilt testing and Autonomic Function.	NI	D	OP/IP	D/E	To induce the symptoms of syncope while ECG, heart rate and BP are monitored.	Syncope / falls.
Stress thallium / radionucleide scans. (Also relevant under Catheter Lab / Other Imaging Procedures)	I	D	OP/IP	D/E	To assess heart function and myocardial perfusion during exertion, but where more detailed information is required.	Assessment of ischaemic heart disease.
Pharmacological challenge.	I	D	OP	D/E	To record ECG changes with drug challenge.	To assess arrhythmias / conduction pathways.

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CATHETER LABORATORY/OTHER IMAGING PRODEDURES

Standards: guidelines produced by the British Cardiovascular Intervention society and the British Cardiac Society Percutaneous coronary intervention: recommendations for good practice and training) Heart 2005 (www.bcis.org.uk).

Implantable Devices:

Test	Test Time				Function	Indication
	Procedure					
Implantable devices: Pacemaker, Bi-ventricular pacemaker.	I	T	IP/DC	F/G	To restore electrical activity and hence improve pumping action of heart. Syncope.	Bradycardias and complete heart block etc.
Implantable devices: Defibrillator.	I	T	IP/DC	F/G	To terminate life threatening arrhythmias.	Dangerous arrhythmias.
Implantable ECG recorder.	I	D	IP/DC	D/E	To record ECG over extended time period (>1 weekk	To detect arrhythmia when symptoms occur very infrequently.
Pacemaker, Bi ventricular pacemaker: Follow-up.	NI	D/T	OP	D/E	To monitor pacemaker's function.	
Implantable Defibrillator: Follow--up	NI	D	OP	D/E	To monitor defibrillator function.	
Implantable ECG recorder: Follow-up.	NI	D	OP	D/E	As above.	

Diagnostic Catheters:

Test	Test Time				Function	Indication
	Procedure					
Cardiac Biopsy +/- Right Heart Catheters.	I	D	IP/DC	*	To obtain detailed information about the functioning of the heart and condition of the coronary arteries. Right heart catheter – to measure right heart / pulmonary pressures and the oxygen saturations of the blood.	Diagnosis of cardiomyopathies / monitoring for rejection post cardiac transplantation etc. Right heart catheter- Severity of congenital heart disease (e.g. Atrial septal Defect ASD, ventricular Septal Defect VSD, and valvular heart disease, etc.).
Cardiac Catheterisation: Diagnostic.	I	D	IP/DC	D/E	To obtain detailed information about the functioning of the heart and condition of the coronary arteries.	Diagnosis and stratification of treatment for coronary artery disease. Diagnosis of structural heart disease.
Cardiac Catheterisation: GUCH/neonatal/paediatric/congenital	I	D	IP/DC	D/E	As above, but more complexity involved.	As above, but congenital heart disease.
Invasive Cardiac Output Measurement.	I	D	IP/DC	D/E	To measure the cardiac output – invasive method.	

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Other Coronary Interventions:

Test	Test Time				Function	Indication
	Procedure					
Coronary Angioplasty / Other Coronary Interventions – includes: - Balloon / Stent. - Atherectomy. - Flow wire. - Pressure wire. - Distal protection device. - IVUS. - Laser. - Alcohol mediated septal ablation^. - Thombectomy. - Brachytherapy.	I	T T D D T D T T T T	IP/DC	D/E (^F/G)	To widen / stent areas of coronary artery narrowing. (^ To reduce obstruction to left ventricular outflow.)	Treatment of coronary artery disease. (^ Treatment of hypertrophic obstructive cardiomyopathy.)
Valvuloplasty – includes: - Mitral Balloon. - Tricuspid Balloon. - Pulmonary Balloon. - Aortic Balloon.	I	T	DC/IP	E/F/G	To widen valve using balloon valvuloplasty.	Treatment of valvular heart disease.
Great Vessel Intervention (Coarc / Recoarc Aortic Valve). Aortic Dilatation other than Coarc. Pulmonary Artery Dilatation. SVC / other large vein intervention. Carotid Intervention/Scanning. Balloon pericardiotomy.	I	T	DC/IP	E/F/G	To dilate areas of vascular narrowing.	Percutaneous treatment of cardiovascular (non valvular) lesions.
Closures: (ASD, VSD, PFO, PDA).	I	T	DC/IP	E/F/G	To close cardiovascular defects.	Treatment of cardiovascular defects.

Other Imaging:

Test	Test Time				Function	Indication
	Procedure					
Cardiac Magnetic Resonance Imaging (MRI).	O	D	OP	D/E	To obtain additional information regarding anatomical/structural cardiac function.	

*Usually carried out during another diagnostic procedure.
Stress thallium / radionucleide scans (see ECG and Blood Pressure Recording and Monitoring, above) also relevant in this section.

KEY:

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3. Gastrointestinal (GI) Physiology

Gastrointestinal (GI) diagnostic investigations are carried out to assess the function of the whole of the GI tract, from the process of swallowing to evaluation of and therapy for disorders of defaecation in patients with pelvic floor disorders.
Some investigations measure muscle activity and sphincter function; others investigate the effect of enzymes; and by analyzing the gaseous by-products of bacteria, it is possible to establish the cause of food intolerance, malabsorption and gastric duodenal ulcers.

Where is the service located?

35. At present, GI physiology investigations are carried out in designated diagnostic units in acute Hospital Trusts. Some of these units are embedded in endoscopy units and others are part of cardio-respiratory units, or are combined with urodynamic measurement units for sustainable approaches to provision.

36. More services could be provided in primary care (e.g. Helicobacter breath tests), with early triage and procedures bundled earlier in the patient pathway, either at a one-stop clinic or before outpatient appointment.

What services do they provide?

37. The most common diagnostic investigations are:

- Invasive manometric techniques in the evaluation of the motility and function of the GI tract;
- Assessment of gastro-oesophageal reflux, duodeno-gastro-oesophageal reflux and laryngo-pharyngeal reflux using invasive naso-gastric sensors to measure pH and bile and also implantable oesophageal pH capsules;
- Non-invasive breath tests for confirmation of small bowel overgrowth, lactose intolerance, oro-caecal transit disturbance and Helicobacter pylori;
- Non-invasive bio-chemical tests to evaluate pancreatic function;
- Non-invasive evaluation of gastric electromyographic signals using electrogastrography for example in patients with diabetic neuropathy;
- Radio-opaque marker studies to evaluate colonic transit time;
- Invasive neural pathway stimulation of the anal canal;
- Sacral nerve stimulation using implantable devices;
- Biofeedback retraining in patients with pelvic floor dysfunction using pressure or myographic sensors.

38. The workload is divided between upper and lower GI investigations. Patients with dyspepsia, where it cannot be managed in primary care, form a large part of the upper GI workload. NICE guidelines report that 40% of the adult population suffer

dyspeptic symptoms. However, only 10% of patients attending their general practitioner with dyspepsia will be referred for hospital consultation or investigation. Patients with faecal incontinence (chronic diarrhoea affects 7-14% of the elderly population1) and chronic constipation make up the majority of the lower GI workload.

Where do referrals come from and who takes the decision to refer?

39. Patients referred for GI diagnostics range from neonates through adulthood to the elderly. They are referred for a range of conditions including symptoms affecting the throat (inflammation caused by acid reflux or dysphagia caused by a stroke) patients with non-cardiac chest pain and patients suffering from faecal incontinence. Referrals are accepted from a range of sources:

- Paediatricians;
- Gynaecologists (ano rectal manometry and biofeedback);
- Geriatricians;
- Stroke Specialists;
- Respiratory Physicians;
- Otolaryngologists;
- Endocrinologists;
- Gastroenterologists;
- Upper GI surgeons;
- Colo-rectal surgeons;
- Cardiologists;
- ENT departments;
- GPs.

40. Increasingly referrals are received from respiratory physicians and otolaryngologists for assessment of patients with persistent cough and exacerbations of asthma and cystic fibrosis. There is some direct access service provision to GPs. Specialist units with expertise and facilities also receive tertiary referrals from other Trusts where some tests are not generally available.

Who delivers the service at the moment?

41. GI physiology services are delivered by a multidisciplinary workforce of clinical physiologists, clinical scientists, specialist nurse practitioners and medical staff with a specialist knowledge of GI procedures. GI physiologists work closely with gastroenterologists and upper and lower GI surgeons to provide this service. Units are usually operated by small numbers of staff, often single-handed, which creates problems for sustainable provision.

1 Talley et al 'Prevalence of GI symptoms in the elderly: a population based study' Gastroenterology 1992 895-901

42. The independent practitioner, from whichever background, undergoes specialist training covering the anatomy and physiology of the GI tract and the equipment and techniques used to perform these diagnostic tests. Also, using the same equipment, they will undertake therapy for patients with pelvic floor dysfunction. All practitioners, when fully trained, can carry out both non-invasive and invasive procedures and those who receive further training as specialist and advanced practitioners will be working at a level that demands expert clinical knowledge and responsibility.

43. There is potential for clinical physiologists to provide a larger proportion of the service in many departments and to streamline procedures across the whole of the multi-disciplinary team.

Gastrointestinal (GI) Physiology Tests Summary

Note: Prior to test, all patients will need to be assessed and consented in accordance with national protocols.

UPPER GI

Standards: Guidelines for Oesophageal Manometry and pH Monitoring British Society for Gastroenterology (BSG)1996 (updated version pending) (www.bsg.org.uk/clinical_prac/guidelines/oes_man.htm). Guidelines for the diagnosis and management of Barrett's columnar-lined oesophagus. A Report of the Working Party of BSG 2005 A Watson, RC Heading, NA Shepherd.

Test	Test Time				Function	Indication
	Procedure					
Static oesphageal manometry.	I	D	OP/DC/	IP	EMeasurement of sphincter function and gastric, oesophageal and oropharyngeal motility.	Evaluation of primary / secondary oesophageal motility disorders, preoperative evaluation, non-cardiac chest pain, pre-determination of LOS location prior to pH monitoring, dysphagia.
Ambulatory pH monitoring.	I	D	OP/DC/	IP	G*Detection of gastroesophageal reflux.	Evaluation of gastro-oesophageal reflux, non-cardiac chest pain, atypical cardiac, respiratory and dental symptoms. Evaluation of medical and surgical therapy.
Ambulatory oesophageal manometry.	I	D	OP/DC/IP	G*	Prolonged measurement of oesophageal peristalsis.	Non-cardiac chest pain e.g. diffuse oesophageal spasm, hypercontracting oesophagus, intermittent dysphagia.
Ambulatory combined manometry and pH.	I	D	OP/DC/IP	G*	Prolonged measurement of peristalsis and acid reflux in the oesophagus.	Non-cardiac chest pain e.g. diffuse oesophageal spasm, 'reflux induced spasm'.
Ambulatory bile +/- pH studies.	I	D	OP/DC/IP	G*	Detection of oesophageal bilirubin.	Evaluation of duodeno-gastric reflux e.g. patients with Barrett's Oesophagus.
Biliary manometry.	I	D	OP/DC/IP	E	Measurement of biliary and pancreatic pressures.	Patients with biliary pain, evaluation of Sphincter of Oddi dysfunction, recurrent pancreatitis.
Breath tests: ^{13}C Urea Breath Test. Hydrogen Breath Test.	NI	D	OP	 E G	 Measurement of 13C in expired breath. Measurement of H2 in expired breath.	Detection of H.pylori in peptic ulcer disease. Investigation of patients with suspected bacterial overgrowth, malabsorption, lactose intolerance.
Electrogastrography.	NI	D	OP	G	Detection of abnormal gastric myoelectrical rhythms.	Evaluation of patients with gastroparesis.
Fluoromanometry.	I	D	OP/DC	E	Combined measurement of oesophageal peristalsis.	Evaluation of dysphagia in patients where previous standard tests are equivocal.
Pain provocation tests.	I	D	OP/DC	G	Provocation of patients symptoms.	To induce typical symptoms in patients with non-cardiac chest pain, to assess gastric acid output on stimulation, to assess abnormal colonic motility.
Telemetric pH monitoring.	I	D	OP/DC/IP	G*	Attachment of a tubeless pH electrode (capsule) to the oesophageal wall.	Assessment of gastro-oesophageal reflux in patients intolerant to standard pH measurement – used where patient is unable to tolerate more invasive test.

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Test	Test Time				Function	Indication
	Procedure					
Intubation under sedation.	I	D	OP/DC	E	Introduction of manometry systems or pH catheters while sedated.	Assessment of swallow function in patients who cannot tolerate intubation procedure.
Oesophageal impedance +/- pH and manometry.	I	D	OP/DC	G*	Introduction of impedance catheter into oesophagus (+/- manometry and or pH catheters).	To assess non-acidic reflux, gastro-oesophageal reflux and oesophageal transit in patients with persistent cough, laryngopharyngeal reflux, aerophagia.
Small bowel manometry	I	D	OP/DC	G*	Prolonged measurement of motility and migrating motor complexes.	Patient with slow transit constipation. Suspected intestinal failure.

LOWER GI

Guidelines: PD Thomas et al Guidelines for the management of chronic diarrhoea. Gut 2003 52 (suppl v) v1-v15.
NICE Guidelines: Faecal incontinence: the management of faecal incontinence (In progress, Expected date of issue: June 2007).

Test	Test Time				Function	Indication
	Procedure					
Ano rectal manometry +/- balloon expulsion.	I	D	OP/DC	E	Measurement of anal canal and rectal pressures.	Faecal incontinence, constipation, pre and post-operative evaluation.
Ano rectal ultrasound.	I	D	OP/DC	C	360 degree, 2D and 3D imaging of anal canal.	Faecal incontinence, constipation, anal pain, anal fissures, abscess, tumours.
Barostat.	I	D	OP/DC	E	Balloon / air bag catheter introduced into oesophagus, stomach, colon or rectum.	Test of visceral compliance, sensory thresholds and GI muscle tone.
Biofeedback.	I	T	OP/DC/IP	E	Measurement of anal canal pressures combined with exercises and dietary and pharmaceutical manipulation.	Pelvic floor dysfunction (faecal incontinence, constipation).
Colonic manometry (+/- ambulatory).	I	D	OP/DC	G*	Colonic intubation with solid state / water perfused catheters.	Differentiation between neuropthic or myopathic disorders, prior to colectomy exclude pseudoobstruction or stoma reversal.
Colonic transit marker study.	NI	D	OP	C	Ingestion of radio-opaque capsules.	Evaluation of colonic transit in patients with obstructive defaecation, slow transit constipation.
Lower GI ambulatory ano-rectal / rectal manometry.	I	D	OP/DC	G*	Prolonged measurement of peristalsis and sphincter function by intubation with intraluminal microtransducer catheter.	Evaluation of reported intermittent spasm or pain in patients where previous standard tests are equivocal.
Pudendal nerve stimulation. (Usually undertaken with anorectal manometry and ultrasound).	I	D	OP/DC	C	Combined nerve stimulating and recording electrode introduced into anorectum to location of pudendal nerve.	Investigate pudendal nerve neuropathy in faecal incontinence, perineal descent syndrome, pre and post operative assessment, prior to rectal resection in constipation and straining.
Sacral nerve stimulation.	I	T	DC/IP**	D/E	Low-level electrical stimulation applied via electrodes through the sacral foramina to the sacral nerve.	Patients with a weak but structurally intact sphincter to alter sphincter and proximal bowel behaviour using the surrounding nerves and muscles.

* Time given does not include the full monitoring period when the patient will normally go home or back to a ward, but if problems arose, staff would intervene. ** Outpatient (OP) – as follow-up.
Note: All manometry and relux tests require intubation (insertion of instrument into gastro intestinal tract). Test times allow for the intubation part of the procedure and time for assessment and consent.

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4. Neurophysiology

Neurophysiology involves the diagnosis of a wide range of conditions affecting the central and peripheral nervous systems. It is concerned with testing the electrical function of the brain, spinal cord and nerves in the limbs and muscles. It is principally diagnostic.

Where is the service located?

44. Clinical Neurophysiology services are usually based in acute Hospital Trusts and often linked to neurological centres. It is a fast growing area of development where high technology and computerisation are increasingly being employed. The service has recently been given a greater focus through the National Service Framework for Long-Term Neurological Conditions. Investigations are usually carried out in dedicated environments, but can be performed in clinical areas such as intensive care units and operating theatres. There are also some community-based centres that undertake certain, simple tests, for example, to help in the detection of carpal tunnel syndrome.

45. More services could be provided directly in primary care or through direct access. However, there is a need for patients to be triaged early and for diagnostics to be bundled where appropriate and provided much earlier in the care pathway, either before outpatient appointment at a one-stop clinic, or other community settings. There are also opportunities to consider pre-referral assessment by GPs with a special interest.

What services do they provide?

46. Peripheral Neurophysiology is concerned with the peripheral nervous system only. The core tests provided by neurophysiology departments in peripheral neurophysiology are:

- Nerve Conduction Studies (NCS);
- Electromyography (EMG).

47. The other key group of tests provided by a neurophysiology department are:

- Electroencephalography (EEG);
- Evoked Potentials (EP).

48. Some of the more specialised techniques that may be carried out in some units include long-term ambulatory EEG monitoring, telemetry, sleep studies and monitoring during surgical procedures.

- **Nerve Conduction Studies (NCS)** involve electrical stimulation of peripheral nerves with recording of responses from nerves or muscles. It is used to investigate a range of peripheral nerve disorders. The most common is carpal tunnel syndrome, which is the entrapment of the median nerve as it passes through the carpal tunnel in the wrist. The higher end of estimation is that it is a problem affecting up to 3.5% of the general population[1].

1 Author: Patrick Browning, MD, Consulting Staff, Redwood Regional Medical Group, Santa Rosa Memorial Hospital (http://www.emedicine.com/radio/topic135.htm)

- **Electromyography (EMG)** is an invasive procedure, involving insertion of a needle into muscle, which investigates the causes of muscle weakness and a variety of disorders affecting the peripheral nervous system.
- **Electroencephalography (EEG)** is used to investigate the electrical activity of the brain using either scalp surface electrodes or more invasive direct brain recording electrodes.
- **Evoked Potentials (EP)** is used to record electrical signals produced naturally by the spinal cord and brain following repeated stimulation of the visual, auditory or somatosensory (sensation) pathways.

Where do referrals come from and who takes the decision to refer?

49. Services are provided to a wide range of specialities including:

- Neurology;
- Orthopaedics;
- Paediatrics;
- Rheumatology;
- General medicine;
- Mental health.

50. Most neurophysiology referrals come from secondary care, although a proportion of referrals are direct from primary care.

Who delivers the service at the moment?

51. The workforce may include: consultant clinical neurophysiologists, clinical neurologists, or doctors training in neurology and neurophysiology, consultants in allied specialties with appropriate training, clinical physiologists (neurophysiology) or other healthcare scientists with appropriate training. The workforce is involved in setting up equipment, taking an appropriate clinical history, making and recording the measurements and reporting the results.

- **Nerve Conduction Studies (NCS)** are primarily a consultant-led service, but in some centres, for pure carpal tunnel nerve conduction studies, more extensive NCS are delivered by clinical physiologists who make an initial report. Consultants in allied specialties with appropriate training, or other healthcare scientists with appropriate training, frequently perform nerve conduction studies to protocol, with a consultant usually reporting the investigation results.
- **Electromyography (EMG)** tests are usually delivered and reported by the consultant neurophysiologist.
- **Electroencephalography (EEG)** services tend to be delivered by clinical physiologists, but are generally reported by consultant neurophysiologists. In

some departments, a very experienced clinical physiologist with further specialist training may report these tests and some departments are looking at introducing an extended role of consultant clinical physiologist to take on the reporting of routine EEGs with normal and abnormal results.

- **Evoked Potentials (EP)** tests are normally carried out by clinical physiologists and reported by consultants.

52. New advanced roles for clinical physiologists are being explored in order to increase skill mix and provide greater capacity to undertake the increased demand for peripheral neurophysiology services.

Neurophysiology Tests Summary

PERIPHERAL NEUROPHYSIOLOGY

The choice of the appropriate test is from a large battery of tests available and is variable, dependent both on the clinical situation and the results of the investigation as it evolves.

Standards: Guidance is laid down by the IFCN Section 4 relating to terminology, standards of instrumentation of EMG and standards of quantification of EMG and Neurography. EPTA has set guidelines for checking EMG equipment October 2004. The British Society of Neurophysiologists (BSN) and EPTA have produced standards for EMG and nerve conduction studies (2006).

Test	Test Time				Function	Indication
	Procedure					
Carpal tunnel screening testing.	NI	D	OP/DC/IP	D	A standard test to diagnose nerve damage.	Carpal tunnel syndrome – nerve lesion, irritation or entrapment of the median nerve at the wrist.
Nerve Conduction Studies (NCS) (non-medic and medic).	NI	D	OP/DC/ IP	F	To measure the function of the peripheral nervous system, i.e. nerves and muscles.	Carpal tunnel syndrome, entrapment neuropathies, peripheral neuropathy.
Electromyography (EMG).	I	D	OP/DC/ IP	D/F	To measure the electrical activity of the muscle in order to gather information about muscular system.	Muscular weakness, spinal problems, disorders affecting the peripheral nervous system: entrapment neuropathy, peripheral neuropathy, radiculopathy, motor neurone disease, neuromuscular junction disorders, myopathy, plexopathy.

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ELECTROENCEPHALOGRAPHY (EEG)

Standards: Guidance is specified by the International Federation of Clinical Neurophysiology (IFCN): EEG-IFCN Standards for digital recording of Clinical EEG at EEG and Clinical Neurophysiology 106 (1998) 259-261; and the IFCN Recommendations for the Practice of Clinical Neurophysiology 2001, which includes: (i) EEG Technical standards, (ii) The 'ten-twenty' electrode system as set out by the IFCN, (iii) EEG Instrumentation; IFCN Standards for digital recording of clinical EEG, (iv) IFCN guidelines for topographic, (v) frequency analysis of EEGs or EPs (evoked potentials) and (vi) how to report the EEG findings using a glossary of terms most commonly used by clinical electroencephalographers.

The Electrophysiological Technologist's Association (EPTA) produced guidelines for checking Digital EEG machines (October 1994).

Test	Test Time				Function	Indication
	Procedure					
Standard recording.	NI	D	OP/DC/ IP	F		Epilepsy, altered consciousness, coma, developmental problems, dementia.
Complex recording.	NI	D	OP/DC/IP	G/I		Developmental problems, epilepsy (Paediatric / neonatal, off site status epilepticus).
Ambulatory recording.	NI	D	OP/IP	H/I*		To characterize clinical attacks (epileptic / non-epileptic). To monitor anticonvulsant effect on epilepsy syndrome.
Sleep recording (sleep deprived or drug induced).	NI	D	OP/IP	F/H	The electrical activity of the brain is recorded using either scalp surface electrodes or more invasive direct brain recording electrodes.	Increases the chance of detecting interictal (and less commonly ictal) discharges and so helps definition of epilepsy syndrome.
Video telemetry (long term recording over 5-7 days).	NI	D	OP/IP	H*		More detailed analysis of recorded events. Demonstration of non-epileptic patients where attacks not thought to be epilepsy has important implications for patient management.
Video EEG.	NI	D	OP/IP	I		Definition of epilepsy syndrome. Localisation of epileptic focus. Types of non-epileptic attacks, movement disorders, sleep disorders.
Depth Recordings.	I	D	OP/IP	I		In a very small selected group of patients being considered for epilepsy surgery, this may be used to map the distribution and spread of seizure activity.

* Per 24 hour recording.

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EVOKED POTENTIALS

These are recordings of electrical signals produced naturally by the spinal cord and brain following repeated stimulation of the visual, auditory or somatosensory (sensation) pathways.

Standards: The International Society for Clinical Electrophysiology of Vision (ISCEV) has set standards (www.iscev.org/standards/index.html) for visual evoked potentials.

Test	Test Time				Function	Indication
	Procedure					
Visual evoked potentials (VEPs): Flash VEP. Pattern VEP.	NI	D	OP/DC/ IP	F	Tests of the pathway between the eye and the back of the brain using flash or pattern stimuli.	Multiple sclerosis. Other causes of visual pathway damage.
Electroretinogram (ERG).	NI	D	OP/DC/ IP	E/G	Records the electrical activity from the retina. The response to flashing lights of different colours, brightness or patterns are recorded.	Hereditary and acquired retinal degeneration.
Somatosensory evoked potentials (SEPs).	NI (NI/I	D D	OP/DC/ IP IP	E I)	Tests of the sensation pathways from the arm or leg through the spinal cord to the brain using electrical stimulation of skin or peripheral nerve.	Multiple sclerosis. Spinal cord or nerve root disease. (Monitoring of spinal cord or brain function during surgical procedures.)
Brain stem auditory evoked potentials (BSAEPs).	NI (NI/I	D D	OP/DC/ IP IP	E I)	Investigate the pathways from the ears to the brain. Clicks or pure tone sounds are delivered using headphones.	Damage to brainstem pathways with tumours or in multiple sclerosis. Used in audiology to study peripheral hearing apparatus. (Monitoring of auditory pathway/brainstem during surgical procedures.)

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5. Ophthalmic and Vision Science

Ophthalmic and vision science is primarily concerned with the clinical assessment of the structure and function of the visual system. The information is used by ophthalmologists, optometrists and other clinical professionals to aid the clinical management process.

Where is the service located?

53. The majority of the service is located in acute Hospital Trusts in ophthalmology outpatient departments, but is also provided in primary care using local clinical facilities, community optometric practices, or mobile services such as some diabetic retinopathy screening services.

54. There is scope for more tests and procedures to be carried out in primary care settings, with early triage and procedures bundled earlier in the patient pathway, either at a one-stop clinic or before outpatient appointment. Most ophthalmologists work in hospitals rather than in community practices, but this may change with the current restructuring of the NHS. There is scope for interventions such as laser, surgery, prescription of medical treatment, orthoptic treatment to be carried out in primary care settings.

What services do they provide?

55. The visual system is highly complex and a large number of different techniques are used to evaluate it. The parameters that can be measured include:

- Visual acuity, refractive error and the determination of optical requirements;
- Field of vision;
- Ocular motility, binocular vision and stereopsis;
- Anatomical changes, often linked to pathological change;
- Temporal properties of vision and motion perception;
- Colour vision.

56. The use of ophthalmic imaging to examine and record the structures of the eye has increased significantly over the past few years. It is vital in cases where laser treatment is being applied to the retina. The various forms of imaging are tasks that can be undertaken by a number of ophthalmic-related health professionals and particularly clinical scientists and ophthalmic science practitioners.

57. There are five key areas of work:

- Glaucoma;
- Diabetic retinopathy;
- Cataract;
- Age-related macular degeneration (ARMD);
- Children (ocular motility and binocular vision).

58. Each area will require defined tests to be undertaken, with some patients requiring auxiliary tests. Virtually all patients will have visual acuity, slit lamp examination and fundoscopy at each visit and many will also have tonometry. Refraction may be performed if this has not been undertaken recently (usually within the last two years), or there is evidence of uncorrected or undercorrected refractive error. Most patients with vision impairment from any form of ocular disease would be referred for low vision assessment.

- **Glaucoma:** Visual acuity, visual fields, slit-lamp examination, tonometry with corneal Pachymetry, gonioscopy, fundus examination and photography (preferably stereo) of the optic disc. Auxiliary tests could include retinal nerve fibre layer analysis, optic disc imaging with optical coherence tomography (OCT) and scanning laser ophthalmoscopy (HRT), and imaging of the anterior segment of the eye with optical coherence tomography and ultrasound biomicroscopy.
- **Diabetic retinopathy:** Visual acuity, slit-lamp examination and fundoscopy, retinal imaging/photography. Auxiliary tests could include fluorescein angiography and optical coherence tomography of the retina.
- **Cataract:** Visual acuity, slit-lamp examination, fundoscopy and tonometry, focimetry (measurement of the power of the current spectacles), keratometry (measurement of the corneal curvature), and biometry of the eye using optical coherence interferometry and A-scan ultrasound (to measure the axial length of the eye and the position of its optical components). From these results, the power of the intraocular lens to be implanted can be calculated. Auxiliary tests could include contrast and glare sensitivity testing, B-scan biometry and A- and B-scan diagnostic ultrasonography.
- **Age-related macular degeneration (ARMD) Dry Type:** Visual acuity and ophthalmic examination. Auxiliary tests could include photography and low vision assessment.
- **Age-related macular degeneration (ARMD) Wet Type:** Visual acuity, slit-lamp examination and fundoscopy, photography and fluorescein angiography (if treatment is possible). Auxiliary tests could include optical coherence tomography (OCT), ICG angiography and low vision assessment. If treatment were to be undertaken, visual acuity, slit-lamp examination and fundoscopy, and fluorescein angiography would be mandatory at each visit.

- **Children:** Visual acuity, binocular vision (orthoptic) examination, refraction and ophthalmic examination with fundoscopy. For follow-up appointments, refraction and ophthalmic examination would be auxiliary.

59. Diseases of the visual system, in particular cataract, glaucoma, diabetic eye disease and age-related macular degeneration (ARMD) disproportionately affect elderly people. Glaucoma affects approximately 2% of the population aged over 40, but is more prevalent in those aged over 70. Sight-threatening diabetic retinopathy affects 10-13% of all those with diagnosed diabetes.

60. Age-related macular degeneration is, as its name suggests, a disease of older people. About 2.2% of those aged 65 and over will display signs of ARMD, of which there are two main types. 'Dry' ARMD tends to cause a slow deterioration of vision and is, in general terms, untreatable. 'Wet' ARMD is often more aggressive than the 'dry' form and can lead to serious loss of vision within a few weeks or months. Some 'wet' forms are treatable by photodynamic therapy (PDT) if it is provided early enough. Follow-up visits requiring a range of tests are required every three months. New therapies for the treatment of 'wet' ARMD are being evaluated. If they prove to be successful, the demand for treatment is likely to increase.

Where do referrals come from and who takes the decision to refer?

61. Most referrals to ophthalmic units are made by optometrists and GPs working in primary care. A small number of referrals come from within a hospital, and tertiary referrals are usually only made to the larger centres, often based in teaching hospitals. Diabetologists, rheumatologists, neurologists and paediatricians refer significant numbers of patients.

Who delivers the service at the moment?

62. Physiological testing and measurement may be undertaken by a number of ophthalmic-related professionals including ophthalmologists, optometrists, orthoptists, nurses, vision scientists and ophthalmic science practitioners (formally ophthalmic photographers and technicians). There may be no clear-cut distinctions about who undertakes a wide range of tests, but some are restricted to ophthalmologists, ophthalmic medical practitioners, optometrists and some orthoptists (e.g. refraction with provision of an optical prescription (sight tests)). Other tests, especially electro-physiological tests, are only interpreted by healthcare scientists and ophthalmologists with special training, but the results might be obtained by technologists working under their supervision, or to a protocol.

63. The workforce delivering this service is complex and diverse with a number of scientific disciplines and professions involved in these investigations. Patients may receive a battery of tests delivered by different personnel when they attend hospital appointments. These include: ophthalmologists, optometrists, orthoptists, dispensing opticians, vision scientists, medical and ophthalmic photographers, ophthalmic science practitioners and nurses. Ophthalmic science practitioners undertake routine clinical history taking and examination of ophthalmic patients, ophthalmic imaging and angiography, visual field testing and tonometry. They may also undertake screening for diabetic retinopathy. Vision scientists investigate and diagnose diseases or process problems of the visual system, which may include investigations of the electrophysiological aspects of vision and how visual information is processed.

64. New roles are being developed such as Ophthalmic Science Practitioners and extending the roles of existing practitioners. A Foundation Degree, BSc Honours and Masters in Ophthalmic Science and Technology commenced in September 2006.

Ophthalmic and Vision Science Tests Summary

Standards: The Royal College of Ophthalmology has developed guidelines (www.rcophth.ac.uk/standards).

CLINICAL HISTORY, EXAMINATION AND ROUTINE / ADJUNCTIVE TESTS (routinely carried out for each patient)

Test	Test Time				Function	Indication
	Procedure					
Ophthalmic patient history.	NI	D	OP/IP/DC	B	To take a history of presenting complaint, current and past ocular history, general medical history, directed systems review, family and social history, current medications and allergies.	Part of routine clinical assessment of all patients.
Slit-lamp examination.	NI	D	OP/IP/DC	B	To examine for presence of disease or abnormality of the eyelids and anterior segment of the eye.	Part of routine clinical examination.
Pupil responses.	NI	D	OP/IP/DC	A	To assess pupil responses to light, accommodation and swinging torch.	Part of routine clinical examination.
Confrontation visual fields.	NI	D	OP/IP/DC	A	To determine visual field is full to confrontation.	Routine screen for gross visual field defect.
Intra-ocular pressure (IOP) measurement (tonometry): - Goldmann. - Perkins. - Tonopen. - Pascal.	I/NI	D	OP/IP/DC	A	To measure intra-ocular pressure by determining the resistance of the cornea to applanation (flattening) or indentation.	Screening, diagnosis and management of glaucoma, part of routine clinical assessment.
Ocular alignment and motility and binocular vision.	NI	D	OP/IP/DC	C	To determine if the eyes are aligned and that the ocular movements are full and to test for fusion and stereopsis.	Disorders of ocular motility and binocular vision.
Ophthalmoscopy: - Ophthalmoscope. - Slit-lamp and condensing lens. - Indirect ophthalmoscope.	NI	D	OP/IP/DC	B	To examine for presence of disease or abnormality of the posterior segment of the eye.	Part of routine clinical assessment of all patients.
Tear production (Schirmer test).	I/NI	D	OP/IP/DC	A	To assess tear production.	Symptoms or signs of dry eye or watering eyes.
Drainage of tears (syringing of nasolacrimal passage).	I	T	OP/IP/DC	B	To assess tear drainage.	Symptoms or signs of watering eyes.
Exophthalmometry.	NI	D	OP/IP/DC	A	To measure protrusion of the eyes.	Thyroid eye disease. Orbital tumours.
Pupillometry: - Manual. - Automated.	NI	D	OP/IP/DC	A	To measure pupil diameter in standard light conditions.	Prior to some PM tests e.g. visual field. Prior to corneal laser surgery.

KEY:

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Test Time - A: 10 mins; B: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5hrs; G: 1.5-3 hrs; H: 3-4 hrs; I: >4 hrs; (Average times only. Complex cases may take longer.)

PSYCHOPHYSICAL TESTS (what the person can see)

Test	Test Time				Function	Indication
	Procedure					
Visual acuity: - Snellen. - logMAR. - Near vision tests.	NI	D	OP/IP/DC	B	To measure the ability to detect a separation between discrete elements of an object.	All ophthalmic diseases and disorders.
Glare testing: - Brightness acuity. - Contrast sensitivity.	NI	D	OP/IP/DC	A	To measure the effects of glare on visual acuity.	Media opacities, including cataract.
Contrast sensitivity: - Contrast sensitivity gratings. - Pelli-Robson chart.	NI	D	OP/IP/DC	B	To measure the ability to detect objects of varying contrast (P-R chart) and spatial frequency.	Cataract. Diseases of optic nerve and visual pathway.
Visual Fields: - Standard Automated Perimetry (SAP).	NI	D	OP/IP/DC	C	To measure light sensitivity at multiple locations across the retina.	Glaucoma – screening, diagnosis & monitoring. Other optic nerve and neurological disease. Driving license requirement (usually Esterman programme).
Visual Fields: – Kinetic Perimetry.	NI	D	OP/IP/DC	C	To determine different isopters in visual field with targets of varying size and brightness.	As for automated perimetry, but more often used for advanced field loss in glaucoma. It is also the preferred method of testing for optic nerve and neurological diseases. Functional field loss.
Visual Fields: - Frequency Doubling Technology (FDT). - Motion perimetry. - Flicker perimetry.	NI	D	OP/IP/DC	C	To screen and monitor for field loss with temporal and motion processing properties of vision.	Glaucoma – screening, diagnosis & monitoring. Other optic nerve and neurological disease.
Visual Fields: – Central (Amsler).	NI	D	OP/IP/DC	A	To determine the presence, size and nature of a central visual field defect.	Macular disease e.g. ARMD. Drug toxicities.
Microperimetry.	NI	D	OP/IP/DC	C	To detect and measure the size and depth of scotomas in the visual field and map these to the fundus image.	Retinal disease and dystrophies. Neurological defects.
Dark adaptometry.	NI	D	OP/IP/DC	C	To measure increase in cone and rod light sensitivity during dark adaptation.	Retinal disease / dystrophy.
Colour Vision Tests: - Ishihara plates. - D15. - 100 Hue. - Anomaloscope.	NI	D	OP/IP/DC	B B D/E C	To detect the presence of a colour vision defect.	Inherited colour deficiencies. Optic nerve disease. Drug toxicities.

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REFRACTIVE MEASUREMENTS

Test	Test Time				Function	Indication
	Procedure					
Refraction.	NI	D/T	OP/IP/DC	C	To measure the refractive error of the eye by objective and subjective means to determine its extent and its effect upon vision.	Reduced vision, which might be due to a refractive error, or a change in an existing refractive error. A prescription for an optical appliance is required. Required for performance of a range of tests, e.g. visual fields, HRT II, biometry with intraocular lens calculation. When there is a presence of squint / diplopia.
Autorefraction.	NI	D	OP/IP/DC	A	To measure the refractive error of the eye with an autorefractor.	Suspected refractive error.
Keratometry.	NI	D	OP/IP/DC	A	To measure the curvature of the central cornea and refractive power for diagnosis, treatment planning and management.	Essential measurement for biometry prior to intra-ocular lens implantation. Diagnostic procedure for some corneal diseases e.g. keratoconus. Prior to contact lens fitting.
Corneal topography.	NI	D	OP/IP	A	To investigate and measure the contour of the anterior and posterior surface of the cornea for diagnosis, treatment planning and management.	Prior to corneal laser refractive surgery and to investigate any problems post surgery. Corneal diseases. Prior to contact lens fitting and assessment of contact lens associated problems.
Focimetry: - Manual Focimetry. - Automated Focimetry.	NI	D	OP/IP/DC	B	To measure the optical power of glasses and contact lenses.	Patients wearing spectacles or contact lenses of unknown prescription.
Contact lens assessment.	I	D/T	OP/IP	D/E	To investigate the effect upon vision of a contact lens as an alternative to spectacles.	To achieve better quality of vision than can be obtained with glasses e.g. for corneal diseases, high refractive errors. To treat ocular disease e.g. corneal ulcers. To relieve ocular pain. To improve cosmesis of a disfigured eye.
Low vision assessment.	NI	D/T	OP/IP/DC	D/E	To assess the potential benefit of optical and electronic aids, illumination and contrast in people with vision loss.	Inability to see well enough with glasses and/or contact lenses to undertake everyday tasks.

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BIOMETRY

Test	Test Time				Function	Indication
	Procedure					
Biometry / Axial Length Measurement: - IOLMaster (optical coherence interferometry). - A-scan biometry. - B-scan biometry.	NI	D	OP/IP	C	To measure the axial length of the eye and, with keratometry and other measurements, to calculate the power of intraocular lens inserted with cataract surgery.	An essential procedure prior to cataract surgery May be used for diagnosis e.g. of shallow anterior chamber, microphthalmos etc.

OPHTHALMIC IMAGING

Ultrasonography: Ultrasound can image opaque structures, and this is a major advantage over imaging with light / lasers. For example, it can be used to image the retina in the presence of vitreous haemorrhage, and can image the internal structures of tumours that aid the differential diagnosis of the tumour. It can also demonstrate the movement of ocular structures that can help to distinguish (for example) retina from vitreous detachment.

Test	Test Time				Function	Indication
	Procedure					
Diagnostic B-scan ultrasonography. Standardised echography.	NI	D	OP/IP	D	To image and measure posterior segment and orbital structures for diagnosis, monitoring and treatment planning. A- and B-scan ultrasonography is used.	Posterior segment disease and abnormality. Diseases of the orbit, including tumours and inflammation of the extraocular muscles e.g. dysthyroid eye disease. Investigation for intraocular foreign bodies. Used to monitor the response to treatments such as radiotherapy.
Pachymetry.	NI	D	OP/IP/DC	A	To measure corneal thickness. Uses A-scan ultrasonography.	Prior to corneal laser surgery. Diagnosis of corneal disease. Adjunct to tonometry (tonometry results are modified according to corneal thickness).
Ultrasound Biomicroscopy (UBM).	NI	D	OP/IP/DC	C	To image and measure structures of anterior segment of the eye for diagnosis and treatment planning. High frequency B-scan ultrasonography is used.	Corneal diseases, corneal laser treatment. Glaucoma: investigation angle structures, drainage blebs Tumours of anterior segment. Trauma of anterior segment. Lens and intraocular lens displacement.

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Ocular imaging with light and lasers:

Test	Test Time				Function	Indication
	Procedure					
(Anterior segment of the eye):						
Photography / imaging of anterior segment with slit lamp camera, including anterior chamber angle with additional contact lenses (goniophotography).	I/NI	D	OP/IP	C	To document and monitor abnormalities of the anterior segment of the eye.	A range of pathological conditions e.g. corneal conditions, tumours such as iris naevi and melanomas.
Optical Coherence Tomography (OCT).	NI	D	OP/IP/DC	C	To document, measure and monitor abnormalities of anterior segment.	A range of pathological conditions e.g. corneal conditions, tumours such as iris naevi and melanomas, narrow angle glaucoma.
Corneal endothelium specular microscopy.	NI	D	OP/IP/DC	C	To measure the density of corneal endothelial cells.	Corneal endothelial dystrophies and disease. Assessment of donor corneas prior to corneal transplantation.
(Posterior segment of the eye):						
Photography / imaging of posterior segment (including stereo-imaging): - Fundus camera. - Simultaneous stereo fundus camera. - Scanning laser ophthalmoscope (SLO). - Hand-held camera. - Extreme wide-angle.	NI	D	OP/IP	C	To screen, document and monitor diseases and abnormalities of the posterior segment of the eye with a fundus camera. The pupil must be dilated with drops for standard fundus cameras but not SLOs.	A wide range of diseases of retina, vitreous, choroid and optic nerve.
Non-mydriatic fundus photography / imaging.	NI	D	OP/IP/DC	B	To screen, document and monitor diseases and abnormalities of the posterior segment of the eye with a non-mydriatic fundus camera.	Diseases and abnormalities of the posterior segment of the eye. The primary use is diabetic retinopathy screening.
Confocal scanning laser tomography (Heidelberg Retinal Tomograph II, HRT II).	NI	D	OP/IP/DC	B	To image and measure the optic nerve head and macula diagnose and monitor optic disc cupping.	Glaucoma (imaging and measurement of optic nerve head and NFL). Diabetic and other macular oedema and disease (by measuring retinal thickness).
Optical Coherence Tomography (OCT).	NI	D	OP/IP	C	To provide high resolution images of the layers of the retina and choroid and structure of optic nerve. The OCT is a scanning laser that utilised the principle of optical coherence interferometry.	Diabetic and other macular oedema. Macular Holes. Age-Related Macular Degeneration. Glaucoma (nerve fibre layer).
Retinal nerve fibre layer analysis (GDx-NFA).	NI	D	OP/IP	C	To image and measure the thickness of the retinal nerve layer for diagnosis and monitoring. This is a scanning laser that utilizes the birefringence properties of the retinal nerve fibre layer.	Glaucoma and suspected glaucoma. Other diseases of the optic nerve and retinal nerve fibre layer.
Retinal thickness analyzer (RTA).	NI	D	OP/IP/DC	C	To image and measure the thickness of the retina at the macular and optic disc. This is a scanning laser that measures the distance between reflected images from the internal limiting membrane and the RPE.	Diabetic and other macular oedema. Age-Related Macular Degeneration. Glaucoma (nerve fibre layer).

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Ocular imaging with light and lasers: (Cont)

Test	Test Time				Function	Indication
	Procedure					
(Posterior segment of the eye): (Cont)						
Stereoscopic photography of the optic nerve head (Discam).	NI	D	OP/IP	B	To provide stereoscopic images / photographs of the optic nerve head. This is a modified fundus camera.	Glaucoma and suspected glaucoma. Other diseases of the optic nerve.
Fundus autofluorescence (AF) with confocal scanning laser ophthalmoscope (Heidelberg Retina Angiograph HRA).	NI	D	OP/IP/DC	C	To image the lipofuschin pigment in the retinal pigment epithelium for diagnosis and monitoring of retinal dystrophies and degenerations.	Retinal dystrophies Age-related macular degeneration.

Ocular angiography:

Test	Test Time				Function	Indication
	Procedure					
Fluorescein Angiography of anterior segment	I	D	OP/IP/DC	C	To investigate blood circulation to the anterior segment of the eye. A yellow dye, fluorescein sodium, is injected intravenously and images are taken with a slit lamp camera as the dye circulates through the anterior segment.	Anterior segment ishcaemia and inflammation, corneal neovascularisation.
Fundus Fluorescein Angiography.	I	D	OP/IP/DC	E	To investigate blood flow to the retina, choroid, and optic nerve for diagnosis, and, as appropriate, the treatment planning and monitoring. The pupil is dilated. Fluorescein sodium is injected intravenously or administered orally. A sequence of images are taken by a fundus camera or Heidelberg Retinal Angiograph (HRA) as the dye is circulates through the retinal and choroidal vessels.	Wet age-related macular degeneration and monitoring of treatment with photodynamic therapy. Diabetic retinopathy. Ocular tumours. Hereditary retinal dystrophies. Other macular / retinal disease. Optic nerve abnormalities.
Indocyanine green (ICG) Angiography.	I	D	OP/IP/DC	E	As above, to investigate blood flow to the choroid, retina and optic nerve, but indocyanine green dye provides a better demonstration of the choroidal circulation.	Diagnosis of vascular abnormalities of the choroid.

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ELECTROPHYSIOLOGICAL TESTS (the electrical transmission of the visual system)

Test	Test Time				Function	Indication
	Procedure					
Electro-oculogram (EOG).	NI	D	OP/IP	E	To record the electrical potential between the front and back of the eye with standardized eye movements during light and dark adaptation.	Diseases of the retinal pigment epithelium, including: Inherited retinal dystrophies. Toxic and nutritional eye disease.
Electroretinogram (ERG): - Standardised ERG. - Bright Flash ERG. - Macula or focal ERG. - Pattern ERG. - Multifocal ERG	NI	D	OP/IP	E	To record the electrical activity of the retina in response to light stimulus.	Diseases of retina including inherited retinal dystrophies, vascular disease, nutritional and toxic conditions. Opaque media. Retinal ganglion cell and optic nerve disease e.g. glaucoma, retrobulbar neuritis. Investigation of unexplained visual loss. Investigation of infants with poor vision.
Visually evoked potential (VEP): - Flash VEP. - Pattern VEP. - Special VEP.	NI	D	OP/IP	E	To record the electrical activity of the brain in response to a light stimulus.	Diseases of retina including vascular disease, nutritional and toxic conditions. Opaque media. Retinal ganglion cell and optic nerve disease e.g. retrobulbar neuritis. Investigation of unexplained visual loss. Investigation of infants with poor vision.
Electromyogram (EMG).	NI	D	OP/IP	D/E	Records the electrical activity of muscles.	Muscle weakness, e.g. myasthenia gravis. Muscle over-action, e.g. blepharospasm. According to muscle activity during the injection of botulinum toxin.
Electro-nystagmography.	NI	D	OP/IP	D/E	For measurement of nystagmus and eye movements.	Nystagmus. Dizziness, vertigo or balance problems.

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6. Respiratory Physiology (including Sleep Physiology)

Respiratory Physiology involves a wide range of diagnostic testing and therapeutic services for patients with suspected respiratory disease or conditions that affect the functioning of the respiratory system. Sleep Physiology investigations are included in this area and conducted to identify abnormal sleep patterns and pathologies, and to assess and provide therapeutic intervention.

Where is the service located?

65. The majority of services are located in dedicated respiratory or lung function laboratories in acute Hospital Trusts. However, many departments offer services including spirometry, oxygen assessments and blood gases for primary care in a variety of delivery packages (e.g. direct access or services in the community), or training to other health professionals who wish to measure spirometry and blood gasses. Sleep physiology services are predominantly associated with respiratory laboratories, but there are some dedicated units around the country. Provision of therapy for home ventilation and sleep apnoea treatment are based in secondary care and provide an on-going follow-up service for these patients. The proportion of primary care based investigations could be increased and include specialist reporting and interpretation of tests.

66. There is great scope for all types of respiratory tests, including those to detect sleep related breathing disorders to be provided much earlier in the care pathway associated with early triage, and bundled diagnostics offered either prior to an outpatient appointment or in a one-stop approach.

What services do they provide?

67. Lung function services include routine testing of airways (spirometry for COPD, asthma, screening for lung disease), lung size and gas transfer to classify the major respiratory disease types (known as "full tests"). Other routine tests include blood gases; assessment of response to bronchodilator drugs, respiratory muscle assessment, skin prick allergy testing and a variety of up to 20 other specific respiratory tests. There are a number of field exercise tests together with advanced full exercise tests that investigate the overall physiological responses of the patient.

68. The demand for sleep physiology is increasing significantly. Sleep disorders are very common and can vary from mild to life-threatening. There are more than 80 recognised sleep disorders, which may affect the timing, quality and quantity of sleep. The most common are insomnia, sleep apnoea, restless leg syndrome, narcolepsy and sleep problems associated with Parkinson's disease, autism and many other conditions. Sleep apnoea probably constitutes over 75% of sleep workload.

69. Sleep investigations are often conducted in a sleep laboratory where sensors and monitors are applied to the patient to record various physiological parameters during sleep. They may also be carried out on the ward or in the

patients home (domiciliary studies) in order to capture 'sleep' in the normal environment or for prolonged monitoring periods. Patients are referred for sleep studies by their GP or by physicians from other specialities such as ear nose and throat (ENT), thoracic medicine, paediatrics, neurology and psychiatry etc. The majority of tests will involve a respiratory physiologist, although respiratory physicians and scientists may be involved in the reporting and interpretation, particularly of the more complex investigations.

70. Estimates of the prevalence of sleep disorders vary, but a figure of 4% of middle-aged men and 2% of middle-aged women has been reported[1]. More men than women suffer (2-3:1).

71. A survey conducted by the Association of Respiratory Technology and Physiology (ARTP) in 2005 provides detailed information on the availability of tests (and therefore the likely workload) nationally. The survey report can be found at www.artp.org.uk.

Where do referrals come from and who takes the decision to refer?

72. Patients of all ages might be referred for respiratory physiology investigations, with conditions that include:

- Chronic Obstructive Pulmonary Disease (COPD);
- Sarcoidosis;
- Interstitial lung fibrosis;
- Myopathies;
- Cystic fibrosis;
- Emphysema (included in COPD);
- Asthma;
- Extrinsic allergic alveolitis;
- Pre-operative screening;
- Allergy;
- Sleep breathing disorders;
- Unexplained breathlessness or a reduction in exercise tolerance;
- Pulmonary manifestations of other systemic conditions or as a result of other drug therapy.

Referrals may also come from tertiary centres for oncology and cardiology.

73. Secondary care referral for respiratory physiology investigations comes (approximately) from:

- Respiratory physicians (routine and specialist tests) – 40%;
- Other consultants (mainly ENT for sleep, routine tests for pre-operative assessments, cardiology, oncology, rheumatology) – 60%;

1 Young, T. and Laurel, F. (1998) Thorax 53 (supp 3) S16-19

In departments where a primary care based service for simple screening is offered this workload may constitute 25 to 35% of the overall tests performed.

Who delivers the service at the moment?

74. The majority of this service is delivered by clinical physiologists (respiratory) who will work with highly specialised equipment to perform basic and complex lung function tests. All these tests whether basic or complex require total patient co-operation in order to produce reliable and accurate results. A major necessity of the clinical respiratory physiologist's role is the ability to encourage the patient to perform the test to the best of their ability, with the correct technique to produce a successful respiratory test with valid results. There are about 30-40 clinical scientists (nationally) who support respiratory medicine services, especially in sleep and ventilation, exercise physiology and more specialist investigations, and in reporting and clinically interpreting the results of respiratory investigations.

75. The respiratory physiologists role could be extended, for example, in primary care and the assistant practitioner role further developed.

Respiratory Physiology (including Sleep Physiology) Tests Summary

SLEEP PHYSIOLOGY (Diagnostic)

Standards: AASM. International Classification of Sleep Disorders: Diagnostic and Coding Manual. 2nd Ed, 2005.
Chesson AL et al. Practice Parameters for the Use of Portable Monitoring Devices in the Investigation of Suspected Obstructive Sleep Apnoea in Adults SLEEP, Vol. 26, No. 7, 2003.
Kushida, CA et al. Practice Parameters for the Indications for Polysomnography and Related Procedures: An Update for 2005 SLEEP, Vol. 28, No. 4, 2005.
Littner MR et al. Practice Parameters for Clinical Use of the Multiple Sleep Latency Test and the Maintenance of Wakefulness Test. SLEEP, Vol. 28, No. 1, 2005.
Littner MR et al. Practice Parameters for the Role of Actigraphy in the Study of Sleep and Circadian Rhythms: An Update for 2002. SLEEP, Vol. 26, No. 3, 2003.
McNicholas WT, Krieger J. Public health and medico-legal implications of sleep apnoea. Eur Respir J 2002; 20: 1594–1609.
Scottish Intercollegiate Guidelines Network (SIGN) – Management of Obstructive Sleep Apnoea/Hypnopnoea in Syndrome in Adults, 2003 and endorsed by the British Thoracic Society.

Test	Test Time				Function	Indication
	Procedure					
Basic tests:						
Oximetry.	NI	D	OP/IP	D/E	Basic assessment of overnight oxygen levels.	Detection of sleep apnoea and respiratory failure (including Narcolepsy, Obstructive Sleep Apnoea, Insomnia, Patients with sleep disordered breathing).
Actigraphy.	NI	D	OP/IP	D/E	Basic assessment of nocturnal limb movements.	Detection of periodic limb movement disorder or sleep / wake patterns in problems of sleep hygiene / circadian rhythm disorders.
More complex tests:						
Cardiopulmonary Sleep Studies (Non-EEG). (or Semi-polysomnography)	NI	D	OP/IP	F/G	Complex multi-channel recording of breathing patterns, oxygen levels and sound to determine degree of suspected sleep disordered breathing.	In-depth investigations of breathing patterns during sleep, but do not require the assessment of sleep patterns (Obstructive Sleep Apnoea, respiratory failure, pre-surgical assessment for palatal surgery).
Full polysomnography (EEG, EOG, EMG).	NI	D	OP/IP	F/G	Highly complex assessment of sleep pattern, coupled with data obtained from semi-polysomnographic studies.	More in-depth, highly complex investigations of breathing and sleep patterns, or where there is a need to assess sleep patterns to determine the potential diagnosis of non-respiratory sleep disorders (Narcolepsy, Periodic Leg Movement Syndrome, Sleep Apnoea, Insomnia, Nocturnal Epilepsy, Sleep Walking and the effects or drugs (legal or otherwise)).
Multiple sleep latency test / maintenance of wakefulness test (MWT).	NI	D	IP	H	Determination of the drive to sleep or the ability to remain awake by studying sleep onset during the day after full polysomnography.	To determine if an individual is excessively sleepy and has characteristic features found in narcolepsy or if the individual can remain awake following treatment.
Osler test.	NI	D	IP	H	A non-EEG method of the multiple sleep latency test / maintenance of wakefulness test (MWT).	To determine if an individual is excessively sleepy and has characteristic features found in narcolepsy or if the individual can remain awake following treatment.
Nasal CPAP provision. (Follow-up at a later date)	NI	D/T	OP/Dom	D/E	Assessment of patients with obstructive sleep apnoea and subsequent follow-up in the domiciliary setting.	Sleep apnoea, Upper airways resistance syndrome – where long-term monitoring is required.

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ACUTE & DOMICILIARY SERVICES & SUPPORT

Standards: British Guideline on the Management of Asthma. BTS 7 SIGN 2003.
BTS. Current best practice for nebuliser treatment. 1997.
BTS. NIPPV Non-Invasive Ventilation in Acute Respiratory Failure. Thorax 2002; 57:192-211.
Chronic obstructive pulmonary disease – Management of chronic obstructive pulmonary disease in adults in primary and secondary care. NICE 2004.
ERS Monograph No 16 – Non-Invasive Ventilation, 2001.
Scottish Intercollegiate Guidelines Network (SIGN) – Management of Obstructive Sleep Apnoea/Hypnopnoea
Domiciliary Oxygen Service for England and Wales – Clinical Component www.brit-thoracic.org.uk.

Test	Test Time				Function	Indication
	Procedure					
Nebuliser provision.	NI	D/T	OP/Dom	D/E	Provision of home nebuliser service.	Patients requiring long-term drug delivery, where alternative methods of delivery are unsuitable.
NIV provision (Non-Invasive Ventilation). (Follow-up at a later date)	NI	D/T	OP/Dom	F/G	Provision of home service of patients.	Conditions where respiratory failure has occurred e.g. Gross Obesity, COPD, Kyphoscoliosis.
Oxygen provision: Long-term therapy assessment. (Follow-up at a later date)	NI	D/T	OP/Dom	F/G	Supplemental oxygen therapy – to help raise the arterial oxygen tension in patients with hypoxaemia.	Many different lung conditions (primarily, but not exclusively COPD).
Oxygen provision: Short burst therapy assessment. (Follow-up at a later date)	NI	D/T	OP/Dom	F/G	Supplemental oxygen therapy – to help raise the arterial oxygen tension in patients with hypoxaemia.	Many different lung conditions (primarily, but not exclusively COPD).
Ambulatory oxygen assessmen	NI	D/T	OP/Dom	F/G	Supplemental oxygen therapy – to help raise the arterial oxygen tension in patients with hypoxaemia.	Many different lung conditions (primarily, but not exclusively COPD).

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GAS EXCHANGE (Rest and Exercise)

Standards: ATS/ACCP Statement on Cardiopulmonary Exercise Testing. Am J Respir Crit Care Med. Vol 167. pp 211-277, 2003.
Brusasco V et al. Standardization of the singler-breath determination of carbon monoxide uptake in the lung – "ATS/ERS Task Force: Standardisation of Lung Function Testing". Eur Respir J 2005; 26; 720 -735.
BTS/ARTP. Guidelines for the measurement of respiratory function: Recommendations of the British Thoracic Society and the Association of Respiratory Technicians and Physiologists. Respir Med 1994; 88; 165-194.
BTS Guidelines – fitness to fly. Thorax 2002: 57: Suppl. 2 (revised 2004).
BTS Guidelines for Prescription of Home Oxygen, in preparation 2006.
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Gosselink R, Stam H. Lung Function Testing. Eur Respir Monograph 2005; 10: No 31.
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Kendrick AH. Non-invasive Blood Gas Measurements I – Pulse Oximetry. Eur Respir Buyers 2000; 3: 15–24.
Kendrick AH. Non-invasive Blood Gas Measurements III – Practical Applications. Eur Respir Buyers 2000; 3: 30–36.
Lumb AB. Nunn's Applied Respiratory Physiology. 5th edition. Butterworth Heinemann Ltd, 2000.
Pitkin AD et al. Arterialised earlobe blood gas analysis. Thorax 1994; 49:364-366.
Royal College of Physicians. Domiciliary Oxygen Therapy Services, 1999.
Wasserman K et al. Principles of Exercise Testing and Interpretation. 4th Ed, Lippincott Williams & Wilkins, 2005.

Test	Test Time				Function	Indication
	Procedure					
Blood Gas Analysis (invasive): PO2, PCO2, pH, haemoglobin.	I	D	OP/Dom	C	Assessment of acid-base status using invasive sampling of blood from artery or from arterialized sample at rest and during exercise.	Shortness of breath. To determine any hypoxaemia (?PO2) and hypercapnia (?PCO2) present. Effectiveness of supplementary oxygen (LTOT) or CPAP or NIV treatment.
Blood Gas Analysis (non-invasive): pulse oximetry, transcutaneous measurements.	NI	D	OP/Dom	C	Assessment of gas exchange function non-invasively at rest and during exercise.	Shortness of breath, desaturation on exercise, to look at trends in the estimates of oxygen / carbon dioxide and oxygen saturation, to assess the effectiveness of supplementary oxygen (as above), assessment of patients with chronic lung disease who wish to fly (see Assessment for fitness to fly (Hypoxic Challenge –
Physiological and anatomical shunts.	I	D	OP	D/E	Assessment of shunts, where blood does not pass through the lungs and hence gas exchange function may be compromised.	Patients with known aterio-venous malformations, ventilation / perfusion mismatch and including patients from Cardiology.
Transfer factor and components	NI	D	OP	B/C	Assessment of gas exchange using carbon monoxide (CO) to assess gas exchange function of the lungs.	Patients with restrictive and obstructive spirometry.
Distribution of blood flow and ventilation.	I	D	OP	D/E	Assessment of the distribution of ventilation and perfusion (blood supply) relative to each other.	Most often performed to detect pulmonary embolus or other aspects of maldistribution of ventilation or perfusion.

KEY:

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LUNG MECHANICS

Standards: ATS/ERS Statement on Respiratory Muscle Testing. Am J Respir Crit Care Med 2002; 166: 518 – 624.
Benditt JO. Esophageal and Gastric Pressure Measurements. Respir Care. 2005; 50: 68 – 77.
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Miller M et al. Standardisation of Spirometry – "ATS/ERS Task Force: Standardisation of Lung Function Testing". Eur Respir J 2005; 26; 319-338.
NICE/BTS. Chronic Obstructive Pulmonary Disease: National clinical guideline for management of chronic obstructive pulmonary disease in adults in primary and secondary care. Thorax 2004; 59; (suppl 1); 1-232.
Quanjer Ph. Standardised Lung Function Testing. European Community for Coal and Steel. Bull Physiopathol Resp 1993; 19: Supp 15.
Oostveen E et al. The forced oscillation technique in clinical practice: methodology, recommendations and future developments. Eur Respir J 2003; 22: 1026-1041.
Uldry C, Fitting JW. Maximal values of sniff nasal inspiratory pressure in healthy subjects. Thorax 1995; 50: 371 – 375.

Test	Test Time				Function	Indication
	Procedure					
Peak expiratory flow (PEF).	NI	D	OP/ IP	B/C	To measure the maximal expiratory flow rate that can be achieved when expiring following a full inspiration.	
Spirometry.	NI	D	OP/ IP	C/D	To measure airway function and dynamic lung volumes during either forced or relaxed inspiratory and expiratory manoeuvres.	Screening / diagnosis of suspected lung disease, assessment of therapy (bronchodilators) / effects of therapy (cancer drugs), pre-operative assessment. Disorders include Asthma, Chronic Obstructive Pulmonary Disease (COPD), Respiratory Muscle Weakness, Cystic Fibrosis, Asbestosis and other industrial lung diseases.
Flow volume curves.	NI	D	OP/ IP	C/D	A graphical representation of a flow and volume signal recorded during a maximal forced expiration or inspiration.	
Static lung volumes.	NI	D	OP/ IP	C/D	To measure total lung capacity (TLC) and its sub divisions including residual volume (RV).	Diagnosis / monitoring effectiveness of therapy / monitoring of disease.
Airways resistance	NI	D	OP/ IP	B/D	Resistance is the pressure required to produce a flow of air into or out of the lung and provides information on narrowing of the airways.	Assessment of pharmacological intervention in those unable to perform spirometry; assessment of asthma, bronchial hyper-reactivity, upper airway function and for monitoring disease and response to treatment.
Respiratory Muscle Assessment – Basic (non-invasive).	NI	D	OP/ IP	C/D	To measure maximum expiratory and inspiratory pressure generated by the respiratory muscles during a forced expiratory or inspiratory manoeuvre.	Respiratory muscle and chest wall disease, and alveolar disease may have a significant affect of the ability of the subject to ventilate.
Respiratory Muscle Assessment: – Complex (Pdi / Snip / Sniff).	NI	D	OP/ IP	F/G	Assessment of inspiratory and diaphragmatic respiratory muscle function, with or without stimulation.	

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PHYSIOLOGICAL RESPONSES TO EXERCISE

Standards: Clinical exercise testing with reference to lung diseases: Indications, standardization and interpretation strategies: ERS Taskforce on the Standardization of Clinical Exercise Testing: Eur Respir J; 1997:2662-2689.
ACC/AHA 2002 Guideline update for Exercise Testing: Circulation 2002; 106:1883-1892.
The endurance shuttle walk test: a new field test for the assessment of endurance capacity in chronic obstructive pulmonary disease: Thorax 1999;54: 213-222.
Field Tests in Pulmonary Disease: Editorial Thorax 1999; 54: 191-193.
Development of a shuttle walking test of disability in patients with chronic airflow obstruction. Thorax 1992;47:1019-1024.
The importance of exercise in pulmonary rehabilitation. Clin Chest Med 1994;15:327-336.
A Qualitative Systematic Overview of the Measurement Properties of Functional Walk Tests Used in the Cardiorespiratory Domain. Chest 2001; 119(1): 256 – 270.

Test	Test Time				Function	Indication
	Procedure					
Gas analysis: O2 uptake, CO2 output.	NI	D	OP	F/G	Assessment of the ability of the respiratory system (lungs, circulation and cells) to take up oxygen (O_2) and release carbon dioxide (CO_2).	Shortness of breath associated with exercise. Assessing why patients continue to present with SOB yet complex pulmonary function tests, field exercise tests and cardiac exercise tests are all normal.
Exercise induced asthma. (also included in Systemic & Airway Responsiveness tests below)	NI	D	OP	D/E	An exercise and breathing test to assess if the cause of a subjects respiratory symptoms are caused or exacerbated by exercise (the symptoms are usually caused be breathing cold, dry air).	
Field walking tests: 6 / 12 minute walk tests.	NI	D	OP	D/E	Timed walking test to measure exercise capacity.	Assessment of impairment / disability, monitoring response to therapeutic interventions, assessment for ambulatory oxygen and investigation of exercise induced bronchospasm.
Field walking tests: Shuttle walk tests (incremental & endurance).	NI	D	OP	F/G	Timed walking test to measure exercise capacity.	Assessment of impairment / disability, monitoring response to therapeutic interventions, assessment for ambulatory oxygen and investigation of exercise induced bronchospasm.
Cardio-respiratory Exercise Testing (or Metabolic Exercise Testing):						
Gas exchange, ventilation and work rate.	NI	D	OP	F/G	Quantitative estimation of functional status and impairment.	Evaluation of unexplained breathlessness, determination of functional (aerobic) capacity, determination of factors limiting exercise in pulmonary, cardiovascular disease and combined cardio-pulmonary disease, pre-operative risk assessment, evaluation of impairment / disability monitoring disease progress (e.g. Interstitial lung disease / cystic fibrosis / cardiovascular disease), monitoring response to therapeutic interventions (e.g. heart and lung transplantation / interstitial lung disease / cystic fibrosis / bronchodilator therapy in COPD / cardiovascular disease), development of exercise prescriptions for pulmonary and cardiac rehabilitation
Cardiac responses: Cardiac frequency, 12 lead ECG, blood pressure, cardiac output.	NI	D	OP	F/G	Quantitative estimation of functional status and impairment.	
Disability assessment.	NI	D	OP	D/E	Assessment of the impact of cardio-respiratory disease on the ability of a patient to undertake their current job.	

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RESPONSES TO THERAPEUTIC INTERVENTIONS

Standards: Domiciliary Oxygen Therapy service. Clinical Guidelines and advice for Prescribers. A report of the Royal College of Physicians 1999.
Clinical component for the Home Oxygen Service in England and Wales. BTS Working Group on Home Oxygen Services 2004.
Chronic obstructive pulmonary disease – Management of chronic obstructive pulmonary disease in adults in primary and secondary care. NICE 2004.
British Guideline on the Management of Asthma. BTS 7 SIGN 2003.
Current best practice for nebuliser treatment. The nebuliser project group of the British Thoracic Society Standards of Care Committee 1997.
BTS. NIPPV Non-Invasive Ventilation in Acute Respiratory Failure. Thorax 2002; 57:192-211.
BTS Statement on Pulmonary Rehabilitation. Thorax 2001; 56; 827 – 834.
Chronic obstructive pulmonary disease – Management of chronic obstructive pulmonary disease in adults in primary and secondary care. NICE 2004.
ERS Monograph No 16 – Non-Invasive Ventilation, 2001.
Scottish Intercollegiate Guidelines Network (SIGN) – Management of Obstructive Sleep Apnoea/Hypnopnoea in Syndrome in Adults, 2003 and endorsed by the British Thoracic Society.

Test	Test Time				Function	Indication
	Procedure					
Pharmacological Interventions:						
Assessment for long-term oxygen therapy.	NI	D/T	OP	F/G	Formal assessment of requirements for regular oxygen therapy (>15 hours / day) in the home.	Patients with chronic hypoxaemia e.g. COPD, severe chronic asthma, interstitial lung disease, pulmonary malignancy etc. Patients with nocturnal hypoventilation e.g. obesity, neuromuscular disease etc. Palliative use e.g. terminal lung cancer.
Nebuliser assessment.	NI	D/T	OP	C/D	Formal assessment of requirement for inhaled drug therapy delivered by nebulisation.	Conditions where large doses of drug are required e.g. acute severe asthma, brittle asthma. Cystic Fibrosis.
Supplemental oxygen (rest and exercise).	NI	D/T	OP	F/G	Formal assessment of requirements for additional oxygen during exercise and / or at rest used on a PRN basis.	Rest – Episodic breathlessness, not relieved by other treatments e.g. severe COPD, heart failure etc. Exercise – severe hypoxaemia, on LTOT and who wish to leave the home e.g. severe COPD / Patients on LTOT who are mobile and could leave the home on a regular basis e.g. severe chronic asthma / Patients not on LTOT, but who desaturate on exercise e.g. severe interstitial lung disease.
Non-pharmacological interventions:						
Monitoring and response to Nasal CPAP.	NI	D/T	OP	D/E	Assessment and follow-up of the response to nasal CPAP for the treatment of Obstructive Sleep Apnoea Undertaken on the basis of looking at the chart review / downloads from equipment and/or further blood gases and/or oximetry.	Conditions such as obstructive sleep apnoea, Upper airways resistance syndrome.
Monitoring and response to NIV.	NI	D/T	OP	F/G	Assessment and follow-up of the response to NIV for the treatment and management of Respiratory Failure. Undertaken on the basis of looking at the chart review/downloads from equipment and/or further blood gases and/or oximetry.	Conditions where respiratory failure has occurred – Gross Obesity, COPD, Kyphoscoliosis, Neuromuscular disease etc.
Pulmonary rehabilitation including exercise retraining, inspiratory muscle training.	NI	D	OP	F/G	A multi-disciplinary programme of care for patients with chronic respiratory impairment. This is not a one off episode, with a number of sessions required to obtain pulmonary rehabilitation.	Mainly COPD where patients would benefit from input from a pulmonary rehabilitation programme.

SYSTEMIC & AIRWAY RESPONSIVENESS

Standards: ERS – Airways Responsiveness: Standardization Statement. Eur Respir J 1993; 6: Suppl 16, 53 – 83.
ATS – Guidelines for Methacholine and Exercise Testing. Am J Crit Care Med 2000: 161: 309 – 329.

Test	Test Time				Function	Indication
	Procedure					
Bronchial challenge testing: Allergens.	NI	D	OP	F/G	To assess if the cause of a subjects respiratory symptoms are caused or made worse by a specific substance i.e. cat hair or occupational exposure.	This group of tests is fundamental to diagnosis and establishing causation of asthma if they are used in conjunction with other tests. To exclude / elucidate a diagnosis of increased or altered airways reactivity i.e. asthma. To assess the severity of any increased reactivity i.e. is the response mild, moderate or severe. To determine the relative risk of developing asthma. To assess response to treatment and help establish appropriate treatment regimes.
Bronchial challenge testing: Histamine / Methacholine.	NI	D	OP	F/G	To assess if the subjects respiratory symptoms are caused by the airways being over sensitive when exposed to substances found in the normal environment.	
Bronchodilator response.	NI	D/T	OP	C	When breathing tests show that a subjects airways are 'tighter' than they should be and therefore has airways obstruction. A bronchodilator is given and the response measured to see if the obstruction can be eliminated or reduced by treatment.	
Exercise induced asthma. (also included in Physiological Responses to Exercise tests above)	NI	D	OP	D/E	An exercise and breathing test to assess if the cause of a subjects respiratory symptoms are caused or exacerbated by exercise (the symptoms are usually caused be breathing cold, dry air).	
Skin allergen testing.	NI	D	OP	C	A skin test to assess if a subject is allergic (type 1 allergy) to specific substances, i.e. house dust mite.	
Cold air challenge	NI	D	OP	C	To assess if the subjects respiratory symptoms are caused by exposure to cold air.	

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VENTILATORY CONTROL AT REST

Standards: BTS Managing Passengers with Respiratory Disease Planning Air Travel. Updated 2005.
Cramer D, Ward S, Geddes D. Assessment of oxygen supplementation during air travel. Thorax. 1996; 51: 202 – 203.
Folgering H. The pathophysiology of hyperventilation syndrome. Monaldi Arch Chest Dis. 1999; 54: 365 – 372.
Stocks J, Gerritsen J (Eds). Tidal breath analysis for infant pulmonary function testing. Eur Respir J 2000; 16: 1180 – 1192.

Test	Test Time				Function	Indication
	Procedure					
Exhaled breath tests: (Nitric Oxide), (Breath condensates).	NI	D	OP	C	Evolving technology to determine presence of airway inflammation.	Asthma / inflammatory lung conditions.
Assessment for fitness to fly (Hypoxic Challenge).	NI	D	OP	D/E	To assess patients with respiratory disease planning to travel by air ability to maintain safe levels of oxygenation while at altitude.	Patients with severe respiratory disease / moderate respiratory disease with other coexisting problems e.g. coronary disease. Patients can then be advised that they are fit to fly / will require supplemental oxygen during the flight / are unfit to fly.
Hyperventilation responses, hypoxic and hypercapnic challenge, pressure output.	NI	D	OP	F/G	To assess hyperventilation response to determine if there is an underlying physiological explanation or a psychological problem, often referred to as Hyperventilation Syndrome.	Patients that experience unexplained periods of excessive breathlessness that may be associated with symptoms of hyperventilation.
Tidal breathing pattern and minute ventilation.	NI	D	OP	C/D	To assess the possible increased work of breathing in – for patients with respiratory disease.	Patients with respiratory disease where the normal breath rate or depth has increased to maintain adequate ventilation of the lung alveolar to maintain as close to normal blood levels of oxygen and carbon dioxide as possible. Usually performed as part of a cardio-respiratory exercise test.

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7. Urodynamics

Urodynamics is a series of measurements, which investigate how the lower urinary tract functions.

Where is the service located?

76. Urodynamics tests are generally carried out in a urological or gynaecological department within an acute Hospital Trust. A minority of other specialties may also have some urodynamic facilities. Flow rate tests are sometimes carried out in primary care, as are filling cystometry and pressure-flow studies. Specialist community continence teams could provide more investigations directly in primary care.

What services do they provide?

77. The lower urinary tract comprises the bladder (a reservoir for the storage and expulsion of urine) and the urethra (which acts as a valve to contain urine within the bladder during urine storage and acts as a conduit to convey urine away from the body during voiding). Urodynamics is an umbrella term describing Physiological Measurements of the bladder and urethra's abilities to fulfil these functions and predominantly involves the measurement of pressure and flow. It allows the clinician to determine what physical factors are involved in bladder disorders. This is important, for example, in the diagnosis of different types of incontinence for which there are different indicated treatments. This allows the patient to be offered the optimal therapy.

78. The groups of patients that urodynamics tests are carried out on is usually subdivided into the following five categories:

- Adult men;
- Adult women;
- Children;
- Patients with neurogenic dysfunction;
- The frail elderly.

79. Symptoms will include incontinence, frequent urination, sudden and/or strong urges to urinate, problems starting or maintaining a urine stream, painful urination, problems emptying the bladder completely and recurrent urinary tract infections.

80. In the United Kingdom, it is estimated that at least 6 million adults cannot control their bladders as they would wish, with about 500,000 children over the age of five having similar problems, especially with bedwetting. An estimate of how many people are affected was made in 1995 by the Royal College of Physicians?.[1]

1 Royal College of Physicians of London (1995): Incontinence: causes, management and provision of services. Royal College of Physicians, London. ISBN 1 873240 97 X.

They looked at 24 different studies for bladder leakage (urinary incontinence) and collated their results. Figures suggested 13.8% of the population, aged over 40, experience some incontinence problems and for 6.6% the problem is severe enough for treatment to be sought. Other studies have reported much higher figures. The Medical Research Council team in Leicester found in adults aged over 40 that more than one in three had clinically significant symptoms of bladder problems[2].

81. There is a need to focus on streamlining services, for example, by bundling tests as early as possible in the patient pathway and in the most appropriate unit.

Where do referrals come from and who takes the decision to refer?

82. A wide range of clinical specialties refer for urodynamic studies, with referrals received from the following:

- Urologists;
- Gynaecologists;
- Paediatricians;
- Spinal injuries specialists;
- Physicians;
- Surgeons;
- GPs;
- Nurses (continence advisors/continence nurse specialists);
- Physiotherapists.

Who delivers the service at the moment?

83. The main healthcare professionals who carry out urodynamics are doctors (principally urologists), gynaecologists and nurses. Physiotherapists, clinical scientists and clinical physiologists also carry out urodynamics, with some additional support provided by medical or nursing staff. The majority of tests are invasive and are an 'intimate examination' involving the placement of devices in the urethra, vagina and rectum and potential adjustment of these throughout the investigation. Therefore, invasive urodynamic tests require the presence of a chaperone and a minimum of two personnel to carry out the investigation, one of whom must be capable of interpreting the recordings. All healthcare professionals (urodynamacists) who carry out these investigations should have received appropriate training.

84. The urodynamacist is responsible for taking a clinical history, ensuring equipment is correctly set up, recording

2 Perry S et al (2000): An epidemiological study to establish the prevalence of urinary symptoms and felt need in the community: the Leicestershire MRC Incontinence Study: Journal of Public Health Medicine 22: 3: 427-434.

appropriately and interpreting the recordings. The report is written by the urodynamacist or by the responsible clinician, especially in cases where advice regarding the clinical management of the patient is also required in addition to a factual report of lower urinary tract function. It is important to ensure that appropriate scientific support is given to departments where healthcare scientists are not directly involved in service delivery particularly related to equipment calibration and the accuracy and reliability of the measurements being obtained.

85. Through improved productivity and considering a joint role with GI Physiology these two services could be made more sustainable, particularly since some of the skill sets are similar.

Urodynamics Tests Summary

Standards:

1. Abrams P, Cardozo L,Fall M, Griffiths D, Rosier P, Ulmsten U, van Kerrebroeck P, Victor A, Wein A 'The Standardisation of Terminology of Lower Urinary Tract Function' Neurourology and Urodynamics 2002 (pp. 167-178).
2. Schafer W, Abrams P, Liao L, Mattiasson A, Pesce F, Spangberg A, Sterling AM, Zinner NR, van Kerrebroeck P. 'Good Urodynamic Practices: Uroflowmetry, Filling Cystometry, and Pressure-Flow Studies' Neurourology and Urodynamics 2002 (pp. 261-274).
3. van Waalwijk, van Doorn E, Anders K, Khullar V, Kulseng Hansen S, Pesce F, Robertson A, Rosario D, Schafer W. 'Ambulatory Urodynamic Monitoring.' Neurourol.Urodyn 19:113-125 (2000).
4. Lose G Griffiths D Hosker G Kulseng-Hansen S Perucchini D Schafer W Thind P Versi E 'Standardisation of Urethral Pressure Measurement' Neurourology and Urodynamics 2002 (pp. 258-260).

Test	Test Time				Function	Indication
	Procedure					
Free flow rate (uroflowmetry).	NI	D	OP	B	To assess if there is a general problem with the lower urinary tract's ability to expel urine.	One of the main test in urodynamics and is carried out throughout the different categories.
Cystometry (filling and/or voiding).	I	D	OP	D/E	To monitor the pressure inside the bladder as it fills and / or as the patient empties their bladder with simultaneous measurement of the urinary flow rate.	As above, although used selectively in children and the frail elderly.
Video-urodynamics (videocystourethrography).	I	D	OP	D/E	To provide simultaneous imaging of the lower urinary tract whilst filling cystometry and a pressure-flow study are carried out.	This test is often used as the primary urodynamic investigation in patients with neurogenic dysfunction / young men with voiding dysfunction / urinary problems following surgery of the lower urinary tract.
Ambulatory urodynamics.	I	D	OP	H*	To monitor bladder and lower urinary tract function over a longer period of time (typically 3-4 hours).	Usually employed when conventional urodynamics have failed to demonstrate the cause of a patients urinary symptoms.
Non-invasive pressure/flow (penile cuff test etc).	NI	D	OP	D/E	To monitor bladder pressure during voiding with simultaneous measurement of flow rate	Adult males with suspected bladder outlet obstruction.

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Test	Test Time				Function	Indication
	Procedure					
Urethral function tests.	I	D	OP	C	To assess the urethra's ability to act as a valve to contain urine within the bladder.	Adult women – in the routine clinical situation, they have little proven utility so are usually only carried out in a minority of centres on selected patients.
Residual urine assessment by ultrasound.	NI	D	OP	(C/D)**	To measure the amount of residual urine after the bladder has been voided, usually performed by ultrasound (recommended).	One of the main test in urodynamics and is carried out throughout the different categories.
	I	D	OP	C (D/E)	To measure the amount of residual urine after the bladder has been voided, occasionally performed by catheterisation measurement (if ultrasound unavailable).	
Pad tests.	NI	D	OP	C	To assess the degree of leakage.	Predominantly used in adult women. Quantifying the degree of urine loss helps counselling a patient regarding the improvement she might expect to see following therapy. Assessing the results of therapy.

* Patient returns normally after 3-4 hours, but may return earlier or several times requiring attention from urodynamacist.

** Test time B is the performance of a single test. However, if the patient has recently emptied their bladder before attending for the test then there is a period of waiting whilst the bladder fills to a reasonable amount before the patient can empty it again and then have the scan – this is more likely to be test time C. Additionally, this assessment is often conducted with two or three tests performed at the same visit, to ensure a representative value of residual urine is obtained, rather than a one-off measurement. If the procedure includes the possibility of repeating the assessment two or three times at one attendance and then also taking into consideration any time spent waiting for the bladder to refill, this is more likely to be time D or E.

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8. Vascular Technology

Vascular Technology involves the investigation and monitoring of diseases of the arteries and veins. It primarily uses ultrasound to image blood vessels and assess the blood flow within them. Investigations are principally diagnostic.

Where is the service located?

86. Vascular laboratories or vascular studies units are usually based in acute Hospital Trusts. The majority are in stand-alone units. However, in some Trusts this work is carried out in the main radiology department. This tends to be the case in smaller district general hospitals, which do not have a specialist vascular surgery unit. A small proportion are based in shared units, often with cardiology. Investigations are usually carried out in dedicated rooms. Some investigations are carried out at the patient's bedside, or in intensive care units and coronary care units. Intra-operative monitoring in theatre and one-stop clinics in outpatient departments is also provided by many vascular laboratories, for example neurovascular clinics for Transient Ischaemic Attacks (TIA or 'mini strokes'). Some simpler investigations may be carried out in primary care, such as abdominal aortic aneurysm screening services for the over 65s or ankle pressure indices. Direct GP access for some investigations such as deep vein thrombosis (DVT) scanning and carotid screening is available in some units.

87. There are opportunities for services to be delivered differently and to provide improved support for primary care. For example, models are emerging that are associated with DVT Screening.

What services do they provide?

88. The majority of vascular investigations are performed using colour duplex ultrasonography. This combines conventional ultrasound imaging with Doppler ultrasound, allowing simultaneous visualisation of blood vessels and of the way blood is flowing. Other non-invasive techniques include continuous wave Doppler ultrasound, which is often used as a screening tool or to make pre and post exercise measurements, and plethysmography, which detects volume changes from blood flowing into and out of different parts of the body. There is growing interest in carotid angioplasty and stenting with volumes anticipated to rise in the future as more sophisticated, safer equipment becomes available.

89. Services normally provided include:

- Carotid scans for patients suspected of having a TIA or stroke;
- Peripheral arterial scans for patients with conditions such as intermittent claudication or critical limb ischaemia;
- Peripheral venous scans for patients with suspected DVT or varicose veins.

90. Some units will also provide abdominal scanning to assess visceral blood vessels, such as renal blood flow to investigate for renal vascular disease. An increasing area of work is the assessment of renal patients, prior to arterio-venous fistula surgery and then follow-up of arterio-venous fistulas. This usually takes place in acute Trusts that have a renal unit.

Where do referrals come from and who takes the decision to refer?

91. Vascular laboratories receive referrals from almost all specialties. However, surgery (vascular), medicine and elderly services provide the highest number of referrals. The majority of vascular labs provide DVT scanning and increasing demands for this emergency service has an impact on the delivery of other vascular laboratory services. In some acute Trusts, DVT scanning is carried out separately in radiology.

Who delivers the service at the moment?

92. The main healthcare professionals who carry out these scans in dedicated vascular technology units are vascular scientists who enter this area from a range of backgrounds including nursing, radiography, science graduates and medical physics. A number of clinical scientists are also involved in the delivery of this service, who will mainly have come from a medical physics background. The service is healthcare scientist led with the vascular scientist being responsible for managing the service, setting up equipment, carrying out the scan, recording and interpreting results, producing a report and ensuring any necessary action is taken. As well as scientists, nurses, radiographers (sonographers), radiologists and other doctors also contribute to vascular technology services dependant on where the service is located. Some vascular surgeons have also had training to undertake some of the less complex studies and vascular scanning is planned to form part of Specialist Registrar training in this area.

93. Vascular labs tend to have two to three specialists delivering these services, larger units will need more, but some units are operated by a single member of staff. Hence, services are very vulnerable due to the major impact that sickness or a member of staff leaving would have. Due to the nature of the work, vascular scientists are at risk of work-related musculo-skeletal problems.

1 The provision of vascular services 2004: Vascular Surgical Society of Great Britain and Ireland: can be found at the following website: http://www.vascularsociety.org.uk/Docs.

94. There is potential to review roles and, for example, for nurses to lead some clinics, or for an associate practitioner role to be developed, as well as opportunities for combining with cardiology, especially echo services, where similar skill sets are employed in order to help create sustainable services for the future.

Vascular Technology Tests Summary

Standards: Vascular Laboratory Practice Parts 1 – V1 is a series of publications produced by the Society for Vascular Technology of Great Britain and Ireland in collaboration with the Institute of Medical Physics and Engineering in Medicine. These provide a set of national guidelines for the recommended working practice in vascular laboratories.

ARTERIA

Test	Test Time				Function	Indication
	Procedure					
Ankle & Brachial Pressure Index measurement (ABPI).	NI	D	OP/IP	B	Indication of degree of arterial insufficiency affecting the lower limbs.	Intermittent Claudication, limb ischaemia, leg ulcers, graft surveillance.
Pre & Post exercise ABPI (treadmill testing).	NI	D	OP/IP	C	To provide an indicator of the degree of arterial insufficiency after the patient has exercised.	Normally carried out when the resting pressures are within normal limits.
Continuous wave Doppler assessments.	NI	D	OP/IP	C	Collection of flow patterns (Doppler waveforms) from arteries normally at several sites from the leg.	Simple screening tool for Intermittent Claudication, limb ischaemia, leg ulcers.
Arterial Duplex (lower limb).	NI	D	OP/IP	D/E	To assess the condition of the major leg arteries and flow within them.	As above.
Arterial Duplex (upper limb).	NI	D	OP/IP	C	To assess the condition of the major arm arteries and flow within them.	Upper limb ischaemia, thoracic outlet syndrome.
Aortic Aneurysm Surveillance.	NI	D	OP	B	To screen the aorta for aneurysmal disease.	Screening for this disease has been shown to significantly reduce the risk of death.
Visceral Assessment.	NI	D	OP/IP	C/D	To assess the visceral vessels, such as superior and inferior mesenteric arteries, looking for a wide range of abnormalities.	Mesenteric ischaemia, renal artery stenosis, visceral artery aneurysm, renal / liver transplants and other conditions.
Pre Arterial Fistula Assessment.	NI	D	OP/IP	C	To assess condition / size of arteries and veins and flow, prior to creation of access fistula for renal dialysis.	Prior to patients to creation of access fistula for dialysis.
Arterial Fistula Surveillance (exc. planned).	NI	D	OP/IP	C/D	To assess flow through an arterio venous access fistula.	Patients on or requiring renal dialysis.
Assessment of graft patency (graft surveillance exc. planned).	NI	D	OP/IP	C	To assess / monitor the flow and function of a leg arterial bypass graft.	Surveillance of bypass graft – for improved graft patency and limb salvage.
EVAR Surveillance (exc. planned).	NI	D	OP/IP	C	To assess the function and flow of endovascular aortic repair (EVAR) for aortic aneurysm.	Surveillance so that any necessary remedial intervention can be undertaken.
Carotid Duplex.	NI	D	OP/IP	C	To assess the condition of the extra cranial part of the carotid arteries and the flow within them.	Transient Ischaemic attacks (TIAs), Stroke, Amaurosis fugax.
Transcranial Doppler.	NI	D	OP/IP	F/G*	To assess the intracranial arterial flow.	Often used to monitor cerebral blood flow during carotid endarterectomy surgery.

*If post-operative monitoring is required, then the overall test time may be I.

KEY:

Procedure – NI: Non-invasive; I: Invasive; D: Diagnostic; T: Therapeutic; OP: Outpatient; DV: Domiciliary Visit; DC: Day case; IP: Inpatient.
Test Time – A: 10 mins; B: 15 mins; C: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5 hours; G: 1.5-3 hours; H: 3-4 hours; I: >4 hours. (Average times only. Complex cases may take longer.)

VENOUS

Test	Test Time				Function	Indication
	Procedure					
Deep Vein Thrombosis (DVT).	NI	D	OP/IP	C	To detect thrombus in the deep veins (normally of the legs, but sometimes arms).	Suspected DVT, also chronic leg swelling/deep venous insufficiency.
Assessment of venous reflux.	NI	D	OP/IP	D/E	To detect reflux in the superficial and deep venous system, providing detailed information for surgeon.	Complex primary varicose veins, secondary varicose veins. Leg ulcers, Chronic leg swelling.
Vein mapping.	NI	D	OP/IP	C	To assess the suitability of a superficial vein for use as a conduit for a bypass graft, marking out on limb.	Patients who are being considered for lower limb arterial bypass surgery.
Vein marking.	NI	D	OP/IP	B	To mark on patients leg site of sapheno popliteal junction and / or perforators prior to surgery.	Carried out prior to varicose vein surgery.

THERAPEUTIC PROCESSES

Test	Test Time				Function	Indication
	Procedure					
Psuedoaneuyryms	NI	D	OP/IP	B	To detect the presence of a false aneurysm.	The most common cause of false aneurysms is a rupture in the arterial wall after catheterization.
Compression of false aneurysms.	NI	D/T	OP/IP	D/E	To compress the neck of the false aneurysm to induce thrombosis, stopping further flow into false aneurysm.	As above.
Ultrasound guidance of thrombin injection of false aneurysms.	I	T	IP	E/F	To inject thrombin into the false aneurysm to produce thrombus and stop further flow into aneurysm.	As above.
Ultrasound guided venous ablation (VNUS, EVLT, etc).	I	T	DC	E/F	To provide ultrasound guidance of probes during these procedures in which the vein is destroyed.	Treatment of appropriate thigh varicose veins.

Arterio-Venous Malformation (AVM) assessments are rarely performed and would be conducted as a one off procedure, usually with direct consultation with the referrer about each particular assessment – i.e. no fixed protocol.

TCD Imaging. This is not a routine investigation in vascular labs. It is used, though very rarely and mainly as part of research studies in specialist units (sickle cell work, but also in some neurology units).

KEY:

Procedure - NI: Non-invasive; I: Invasive; D: Diagnostic; T: Therapeutic; OP: Outpatient; DV: Domiciliary Visit; DC: Day case; IP: Inpatient.
Test Time - A: 10 mins; B: 15 mins; C: 15-30 mins; D: 30-45 mins; E: 45-60 mins; F: 1-1.5 hours; G: 1.5-3 hours; H: 3-4 hours; I: >4 hours. (Average times only. Complex cases may take longer.)

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