

Overview of tests

Part 1

Chapters

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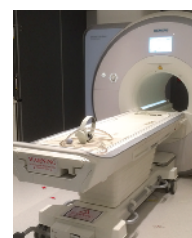
Investigations and interpreting tests

Box 1.1 What is the reason for investigations?

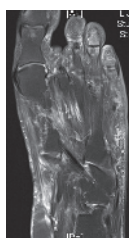
- To confirm the diagnosis or to exclude other diagnoses
- To obtain detailed information for a particular diagnosis
- To investigate the complication of disease
- To monitor the progress of disease and the results of treatment
- To detect evidence of disease before clinical manifestation

Remember:

- Patient's identity
- Accurate request form
- What is the purpose of this test?
- Any risks
- Any alternative investigations
- Confidentiality
- How you and patient will receive the results

Figure 1.1 Blood tests**Figure 1.2** Imaging

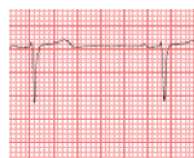
(a) MRI scan



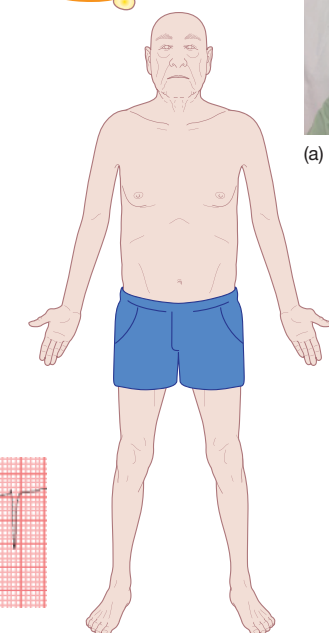
(b) MRI of the right foot

Figure 1.3 Tests utilising electrical activity

(a) ECG machine



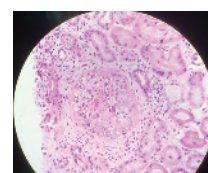
(b) ECG

**Figure 1.4** Biopsies

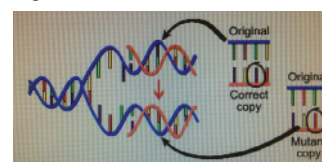
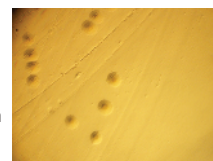
(a) Biopsy gun



(b) USS guided renal biopsy



(c) Renal biopsy H&E histopathology examination

Figure 1.5 Urine analysis**Figure 1.6** Genetic tests**Figure 1.7** Joint aspiration culture grew mycoplasma

	Use	Definition	Formula
Accuracy	Ability of a test to correctly detect the presence or absence of a disease		
Sensitivity	Ability of a test to correctly detect the presence of a condition	Sensitivity is the probability that a test will indicate 'disease' among those with the disease	$\text{Sensitivity} = A/(A+C) \times 100$
Specificity	Ability of a test to correctly detect the absence of a condition	Specificity is the fraction of those without disease who will have a negative test result	$\text{Specificity} = D/(D+B) \times 100$
Positive predictive value	Frequency of positive initial diagnosis confirmed by gold standard test	Positive predictive value is the proportion of patients with positive test results who are correctly diagnosed	$\text{Positive Predictive Value} = A/(A+B) \times 100$
Negative predictive value	Frequency of negative initial diagnosis confirmed by gold standard test	Negative predictive value is the proportion of patients with negative test results who are correctly diagnosed	$\text{Negative Predictive Value} = D/(D+C) \times 100$

	Disease	Non disease	Total number
Positive test	A (True positive)	B (false positive)	Total number of test positive
Negative test	C (False negative)	D (True negative)	Total number of test negative
Total number	Total number of subjects with disease	Total number of subjects without disease	Total

The perfect investigation:

- 100% specificity
- 100% sensitivity
- No risks, adverse effects
- Cheap and easy to perform
- Provides definite information about patients' diagnosis, prognosis and management

Investigations are tests to determine more about a person's health, illness or prognosis. A variety of types of investigations can be undertaken, including: blood tests (e.g. biochemistry, haematology, immunology – Figure 1.1), radiology (e.g. plain X-rays, CT scans, ultrasounds, nuclear medicine tests, MRI scans – Figure 1.2), tests utilising electrical activity (e.g. ECG, EEG or nerve conduction – Figure 1.3), biopsies (tissue obtained for histological and cytological analysis – Figure 1.4), analysis of other biological fluids/specimens (e.g. urine, stool, cerebrospinal fluid – Figure 1.5), genetic testing (e.g. analysing for a DNA mutation that might cause disease – Figure 1.6) and tests for infection (e.g. attempts to culture an organism, detect DNA or an antibody response – Figure 1.7).

Investigations may be undertaken during an acute illness to contribute to making a diagnosis (e.g. a CT scan of the head in someone who is unconscious) or as a screening test in a well individual (e.g. a mammogram) to look for asymptomatic disease. Sometimes tests are undertaken to exclude particular diagnoses, especially if symptoms or signs of that illness can be subtle or nonspecific.

Prior to undertaking investigations in non-emergency settings, a detailed history and physical examination should be performed. Information obtained will often lead to selecting the most appropriate investigations.

When undertaking an investigation it is essential to ensure that it is done on the right person. Identification can be helped by accurate completion of request forms, verification of identity with questions about name, address, date of birth and examination of wrist bands. The use of sticky labels can improve the amount of information on a tube or a request form, but it is easy to mistakenly stick the wrong label on the wrong tube.

The person should have an appropriate understanding of the reason for the test, with consent that includes potential risks and consequences, the possible outcomes of the test and its implications.

The result

When requesting a test, consider how you (or other health professionals) will receive/check/chase the result and how the result will be communicated to the patient (and other relevant health professionals involved in care).

Confidentiality

Remember that all test results (and, indeed, even the fact that a patient is undergoing a test) should be regarded as confidential, restricted to the patient or professionals directly involved in their care and only shared with relatives and friends with the patient's explicit permission and understanding. Similarly, test results and images should be stored in a confidential manner.

Repeating tests

In some situations it may be helpful to repeat a test; for example, when following change in an incidentally noted pulmonary nodule on CT scanning or repeating urea, creatinine and electrolytes to monitor response to rehydration. However, be wary of repeating tests too frequently or at too short an interval. Recognise that some abnormalities may take days or weeks to resolve following treatment and that the levels of some blood tests have prolonged half-lives. It is important to recognise that there will be variation in any test because of inter-individual variation and analytical variation.

Specificity and sensitivity

A perfect diagnostic test would be positive in every patient who has the disease (i.e. have no false negatives). This is the sensitivity of the test. The ideal test would also not be positive in any patient without the disease (i.e. have no false positives). This is the specificity. Diagnostic sensitivity is the proportion of individuals with disease who have a positive test associated with that disease. Diagnostic specificity refers to the proportion of individuals without disease who yield a negative test. A 'perfect' test would have both 100% diagnostic sensitivity and specificity. A test with 50% sensitivity and specificity is no better than tossing a coin.

For any test result one can compare the probability of getting that result if the patient truly had the condition with the probability if they were healthy. The ratio of these probabilities is the likelihood ratio (LR), calculated as sensitivity/(1 – specificity).

Receiver operator characteristic curves

A receiver operator characteristic curve plots the false-positive rate (FPR = 1 – specificity) versus the true-positive rate (TPR = sensitivity). They assess the diagnostic accuracy of any test. The area under the curve (range: 0.5–1.0) is a quantitative representation of test accuracy, where values from 0.5 to 0.7 represent low accuracy, from 0.7 to 0.9 represent tests that are useful for some purposes, and >0.9 represent tests with high accuracy.

Measures of disease probability

No test is perfect, and after every test the true disease state of the patient remains uncertain. Quantitating this residual uncertainty can be done with Bayes' theorem. This provides a mathematical way to calculate the post-test probability of disease from three parameters: the pre-test probability of the disease, the test sensitivity and test specificity. Pre-test probability: can be estimated using population prevalence of disease or more patient-specific data.

$$\text{Post-test probability} = \frac{\text{Pre-test probability} \times \text{test sensitivity}}{\text{Pre-test probability} \times \text{test sensitivity} + (1 - \text{disease prevalence}) \times \text{test false-positive rate}}$$

Normal range

When interpreting tests it is important to examine the test value with the normal range for that patient. These reference ranges are often derived from a population of 'normal' individuals and reflect the prediction interval within which 95% of values fall such that 2.5% of values will be less than the lower limit of this interval and 2.5% of the time it will be greater. However, this assumes a normal distribution of values and may not account for changes with age, gender and other physiological or pathological changes, such as impaired renal function. For some tests, because a large proportion of the 'normal' population have values associated with disease risk, a healthy or recommended range is quoted (e.g. vitamin D or cholesterol).

Incidental findings: none of us are 'normal'

Incidental findings are results that you were not looking for. With increasingly sophisticated testing, very large number of healthy individuals can be found to have 'abnormalities' detected. Examples include benign cysts in the liver, detected with CT scans or ultrasounds, and small pulmonary nodules. The interpretation of such incidental findings can be difficult but should be grounded in the pre-test probability, any symptoms or signs and the incidence of such findings in healthy individuals.