Interpretation

Reading the investigation itself — the ECG from first principles through the tachycardias and conduction block, the blood count, film and coagulation screen, renal function and urinalysis, liver function tests, the chest radiograph and pulmonary function, and rheumatological serology.

Chapters 1–11 · 5,794 words

How Part III Differs

Parts I and II are about patients. **Part III is about the four or five investigations that a physician must be able to read alone, at three in the morning, with no specialist available.** These are not cases and they are not numbered as cases — they are chapters, numbered separately, and they are meant to be returned to rather than read once.

THE PRINCIPLE OF THIS PART

Every chapter gives a systematic order in which to look, and the order matters more than the list of abnormalities. Pattern recognition finds the abnormality you were expecting. **A system finds the second abnormality — the one that was not the reason the test was ordered, and the one that changes the management.**

So each chapter begins with the sequence, and only then covers what can be found and the traps that mislead.

Chapter	Tutorial it serves
1 — Reading the electrocardiogram systematically	Interpretation of the normal 12-lead electrocardiogram
2 — Ischaemia, pericarditis and the electrolytes	Ischaemic heart disease, pericarditis and electrolyte abnormalities
3 — The narrow-complex tachycardias	Supraventricular tachyarrhythmias
4 — The broad-complex tachycardias	Ventricular arrhythmias
5 — Bradycardia and conduction block	Conduction blocks and bradyarrhythmias
6 — A reading drill	Revision with practical demonstration
7 — The blood count, film, coagulation screen and marrow	Complete blood count, film interpretation, coagulation screening, normal bone marrow
8 — Renal function and urinalysis	Assessment of renal function and urinalysis
9 — Liver function tests	Assessment of liver function and its interpretation
10 — The chest radiograph and pulmonary function tests	Chest radiograph, pulmonary function tests and others
11 — Rheumatological and immunological serology	Investigations in rheumatology

Chapter 1 · Reading the Electrocardiogram Systematically

BEFORE YOU INTERPRET ANYTHING

Name, date and time · calibration (10 mm per mV) and paper speed (25 mm per second) · lead placement · and — above all — the previous tracing.

Comparing with an old electrocardiogram is often the single most useful act in the whole interpretation. A left bundle branch block that is old is a different problem from one that is new.

Two placement errors to recognise: limb lead reversal, which produces a spurious inferior or lateral pattern with an inverted P in lead I; and **chest leads placed too high, which produces false anterior T wave changes and poor R wave progression.** If the tracing does not fit the patient, look at where the electrodes are before you believe it.

The sequence — same order, every time, out loud

Step	What to establish
1. Rate	300 divided by the number of large squares between R waves. For an irregular rhythm, count the complexes in 30 large squares and multiply by 10.
2. Rhythm	Regular or irregular. Is there a P wave before every QRS, and a QRS after every P? Is the P sinus in origin — upright in II, inverted in aVR?
3. Axis	Normal −30° to +90°. Look at leads I and II: both positive is normal; I positive with II negative is left axis deviation; I negative with II positive is right axis deviation.
4. P wave	Taller than 2.5 mm — P pulmonale, right atrial enlargement. Broader than 120 ms and bifid — P mitrale, left atrial enlargement (Case 10).
5. PR interval	120–200 ms. Long — first-degree block. Short with a slurred upstroke — pre-excitation.
6. QRS	Width under 120 ms; voltage; Q waves; R wave progression across the chest leads; bundle branch block.
7. ST segment	Elevation or depression — with its shape and its distribution by territory.
8. T wave	Inversion, flattening, peaking, biphasic change.
9. QT interval	Corrected for rate. Prolonged above about 440 to 460 ms.
10. Look again	For what hides: subtle ST depression, extra P waves, delta waves, and the review of the leads you skipped.

Bundle branch block

- **Right bundle branch block:** QRS above 120 ms with an **RSR′ pattern in V1** ("M" shape) and a broad slurred S wave in leads I and V6. Causes: normal variant, pulmonary embolism, right heart strain, ischaemia, congenital disease.
- **Left bundle branch block:** QRS above 120 ms with a **broad notched R wave in V6** ("M" shape) and a dominant S in V1. **In left bundle branch block the ST segments and T waves cannot be interpreted for ischaemia** — and **a new left bundle branch block in a patient with chest pain is managed as an infarction** (Case 11).

The QT interval

- **Prolonged by:** congenital long QT syndromes; **drugs — antipsychotics, macrolides, fluoroquinolones, antiarrhythmics, methadone, ondansetron, some antifungals and antiemetics**; **electrolytes — low potassium, magnesium and calcium**; bradycardia; hypothermia; raised intracranial pressure; and hypothyroidism.

- **It matters because of torsades de pointes** (Chapter 4). **Check the corrected QT before and after starting a QT-prolonging drug**, particularly where several are combined — which happens routinely in hospital.

And then look for the things that hide

- **Posterior infarction** — tall R waves with ST depression in V1–V2 (Chapter 2). **Flutter waves** hiding within T waves. **Delta waves.** Subtle widespread ST depression with elevation in aVR. **Epsilon waves and the Brugada pattern.** Electrical alternans. And the **review leads** — aVR, and V1, which are the two most often ignored.

Chapter 2 · Ischaemia, Pericarditis and the Electrolytes

1. Ischaemia and Infarction

- **Territory and artery** — the table in Case 11. **Every inferior infarct gets right-sided leads before anyone gives a nitrate**, and tall R waves with ST depression in V1–V2 get posterior leads V7–V9.
- **Evolution:** hyperacute tall T waves → ST elevation → Q wave formation → T wave inversion → resolution with a residual Q. **A single tracing is a snapshot: repeat it if the pain continues.**
- **Reciprocal ST depression** supports a true infarction and helps distinguish it from pericarditis and from early repolarisation.

FOUR PATTERNS THAT ARE MISSED BECAUSE THEY ARE NOT ST ELEVATION

Widespread ST depression with ST elevation in aVR — suggests left main or severe proximal three-vessel disease. This is a high-risk pattern, not a "non-specific" one.

Wellens syndrome — **deep symmetrical T wave inversion, or a biphasic T wave, in V2–V3 in a patient who is now pain-free**, with preserved R waves and no Q waves. It indicates **critical proximal left anterior descending stenosis**. The patient looks well and the temptation is to discharge them; they need admission and angiography.

De Winter pattern — upsloping ST depression with tall symmetrical T waves in the precordial leads, an equivalent of proximal left anterior descending occlusion.

Posterior infarction — the "ST depression" in V1–V2 that is really elevation seen from behind.

2. Pericarditis

- **Widespread concave (saddle-shaped) ST elevation with PR segment depression, crossing territories, without reciprocal change and without Q waves** — with ST depression and PR elevation in aVR. The full comparison with infarction is in Case 17.
- **Electrical alternans, low voltage and sinus tachycardia** suggest a large effusion with tamponade.

3. The Electrolytes

Abnormality	Electrocardiographic change
Hyperkalaemia	Tall tented T waves → flattened or absent P waves with a long PR → broadening QRS → sine wave → arrest. Any change is an indication for immediate treatment (Case 28).
Hypokalaemia	Flattened T waves, ST depression, prominent U waves, prolonged QT, and ventricular arrhythmia.
Hypercalcaemia · hypocalcaemia	Short QT · long QT.
Hypomagnesaemia	Prolonged QT and torsades de pointes — and it must be corrected alongside potassium, or the potassium will not stay corrected.

4. Other Patterns Worth Recognising

Pattern	Cause
Downsloping ST with a "reverse tick"	Digoxin effect. Toxicity is a different matter: any arrhythmia, classically with bidirectional ventricular tachycardia or atrial tachycardia with block.
J waves with bradycardia and prolonged intervals	Hypothermia
Sinus tachycardia with right axis deviation, right bundle branch block and T inversion in V1–V4	Pulmonary embolism — the classical S1Q3T3 pattern is uncommon and its absence means nothing (Seminars 3 and 11)
Deep, widely splayed T wave inversion with a long QT	Subarachnoid haemorrhage and other intracranial catastrophe
Voltage criteria with lateral ST depression and T inversion	Left ventricular hypertrophy with strain (Case 14)
Deep lateral T inversion, or giant negative T waves	Hypertrophic cardiomyopathy, including the apical variant (Case 18)
Coved ST elevation with T inversion in V1–V2	Brugada pattern — associated with sudden death; refer
Concave elevation with notched J points in a young, well patient	Early repolarisation — no reciprocal change and no evolution

Chapter 3 · The Narrow-Complex Tachycardias

THE FIRST QUESTION IN ANY TACHYCARDIA

Before you classify the rhythm, decide whether the patient can wait.

Adverse features: shock · syncope · myocardial ischaemia · heart failure. Any of these in a tachyarrhythmia means **synchronised cardioversion under sedation**, not a third drug.

The rhythm diagnosis is important. It is not more important than the patient.

1. What Narrow Means

A QRS under 120 ms means the ventricles are being depolarised through the normal conducting system, so **the origin is at or above the atrioventricular node.** Then divide by regularity.

Regular narrow	Irregular narrow
Sinus tachycardia — a sign, not a diagnosis. Find the cause — pain, fever, hypovolaemia, sepsis, anaemia, thyrotoxicosis, embolism, drugs, anxiety — and treat that	Atrial fibrillation — irregularly irregular with no discernible P waves
Atrial flutter with fixed block — saw-tooth baseline; a ventricular rate close to 150 should always make you think of flutter with 2:1 conduction	Atrial flutter with variable block
Atrioventricular nodal re-entrant tachycardia — abrupt onset and offset, 140–220/min, P waves absent or retrograde	Multifocal atrial tachycardia — varying P wave morphology; think of chronic obstructive pulmonary disease and theophylline
Atrioventricular re-entrant tachycardia with an accessory pathway; atrial tachycardia; junctional tachycardia	Frequent atrial ectopy

2. Managing the Stable Regular Narrow Tachycardia

- **Vagal manoeuvres first** — the modified Valsalva with a supine reposition and passive leg raise is substantially more effective than the standard version.
- **Then adenosine, given rapidly with a continuous electrocardiographic recording running** — because **the response is diagnostic as well as therapeutic**: termination suggests a re-entrant circuit involving the node; transient block revealing flutter waves diagnoses flutter; and no effect suggests an atrial or ventricular origin. **Warn the patient about the brief and very unpleasant sensation**, and avoid it in asthma.
- Then a rate-limiting calcium channel blocker or a beta blocker; and cardioversion if drugs fail or the patient deteriorates.

THE ONE CONTRAINDICATION TO REMEMBER

In atrial fibrillation with pre-excitation — an irregular broad-complex tachycardia in a patient with a delta wave — do not give adenosine, verapamil, diltiazem, digoxin or a beta blocker.

Blocking the node diverts conduction down the accessory pathway and can precipitate **ventricular fibrillation**. Use procainamide, or cardiovert, and get expert help.

3. Atrial Fibrillation

- **Rate control or rhythm control**, according to symptoms, duration, age and structural disease; and **anticoagulation decided by the stroke risk score, independently of whether the rhythm has been controlled** — restoring sinus rhythm does not remove the need for anticoagulation.
- **Two exceptions to direct oral anticoagulants: rheumatic mitral stenosis, which requires warfarin** (Case 10), and **antiphospholipid syndrome** (Case 63).
- **Always look for the cause:** thyrotoxicosis, sepsis, alcohol, electrolyte disturbance, ischaemia, valve disease, pulmonary embolism, and obstructive sleep apnoea.
- Consider referral for ablation, and for assessment of any accessory pathway.

Chapter 4 · The Broad-Complex Tachycardias

THE RULE THAT PREVENTS DEATHS

A broad-complex tachycardia is ventricular tachycardia until proved otherwise — and overwhelmingly so in a patient with previous myocardial infarction or known structural heart disease.

Haemodynamic stability does not exclude ventricular tachycardia. A patient can sit up and talk through it, and the temptation is then to treat it as a supraventricular rhythm with a bundle branch block.

Giving verapamil to ventricular tachycardia can be fatal. If you are not certain, treat it as ventricular tachycardia — the treatment for that is safe in supraventricular tachycardia, and the reverse is not true.

1. Features Favouring Ventricular Tachycardia

- A very broad QRS; an extreme or bizarre axis; **concordance of the QRS across all the precordial leads**; **fusion beats and capture beats**; **atrioventricular dissociation**; and **a history of ischaemic heart disease or cardiomyopathy**, which alone makes ventricular tachycardia far more likely than anything else.

2. Management

- **Pulseless: defibrillate and follow the advanced life support algorithm**, seeking the reversible causes — the four Hs and four Ts.
- **Unstable with a pulse: synchronised cardioversion under sedation.**
- **Stable monomorphic ventricular tachycardia:** amiodarone or procainamide, correction of potassium and magnesium, treatment of ischaemia, and expert help. Cardiovert if drugs fail.

TORSADES DE POINTES

Polymorphic ventricular tachycardia with a prolonged QT. Often self-terminating, often recurrent, and it degenerates into ventricular fibrillation.

Treatment: intravenous magnesium sulfate · stop every QT-prolonging drug · correct potassium, magnesium and calcium · and increase the heart rate with pacing or isoprenaline if the episodes are bradycardia-dependent — because pauses precipitate it.

Amiodarone is not the answer here — it prolongs the QT further.

3. The Broad Rhythms That Are Not Ventricular Tachycardia

Rhythm	Recognition
Supraventricular tachycardia with pre-existing bundle branch block	A previous tracing showing the same QRS morphology in sinus rhythm
Pre-excited tachycardia	Irregular, very fast, with delta waves in sinus rhythm — and the drug contraindications of Chapter 3
Hyperkalaemia	A slow, broad, sine-wave rhythm with absent P waves — check the potassium in every broad-complex rhythm (Case 28)
Sodium channel blocker toxicity	Tricyclic antidepressant overdose — a wide QRS treated with sodium bicarbonate (Seminar 16)
Paced rhythm; artefact	Pacing spikes; and a "rhythm" with palpable pulses that do not match it

- **After the event:** treat the cause, correct electrolytes, revascularise where appropriate, and **assess for an implantable defibrillator** (Cases 11 and 18).

Chapter 5 · Bradycardia and Conduction Block

AGAIN, THE PATIENT BEFORE THE RHYTHM

Adverse features: shock · syncope · myocardial ischaemia · heart failure.

If present: atropine, then transcutaneous pacing or an isoprenaline or adrenaline infusion while transvenous pacing is arranged. If absent, look for the risk of progression — which is what the block type tells you.

1. The Blocks

Block	Recognition and significance
First degree	PR above 200 ms with no dropped beats. Usually benign in isolation.
Second degree, Mobitz I (Wenckebach)	Progressive PR lengthening, then a dropped beat. Usually at the node, often vagal or drug-related, and generally benign.
Second degree, Mobitz II	A constant PR interval with sudden unheralded dropped beats. Infranodal, unpredictable, and it progresses to complete block — it needs pacing. The distinction from Mobitz I is the whole point of the classification.
2:1 block	Can be either type. Needs assessment — look at the QRS width and the response to exercise or atropine.
Third degree (complete)	No relationship between P waves and QRS complexes, with a slow escape rhythm. Cannon a waves in the neck. Pacing.

2. The Causes — and the Reversible Ones First

- **Drugs, which are the commonest reversible cause: beta blockers, verapamil and diltiazem, digoxin, amiodarone, ivabradine, and cholinesterase inhibitors** — and combinations of them, especially in the elderly with declining renal function.
- **Hyperkalaemia** — check it in every bradycardia.
- **Ischaemia: inferior infarction causes atrioventricular block that is usually transient and atropine-responsive**, because the node is supplied by the right coronary artery; **anterior infarction causing block implies extensive septal damage and carries a much worse prognosis**, and generally needs pacing.
- **Metabolic and other:** hypothyroidism, hypothermia, raised intracranial pressure with the Cushing reflex, and obstructive sleep apnoea.
- **Infective and infiltrative: an aortic root abscess in infective endocarditis — a new atrioventricular block in a febrile patient with a murmur is an emergency** (Case 13); Lyme disease; diphtheria; Chagas disease; **sarcoidosis and amyloidosis** (Case 18); and rheumatic disease.
- Degenerative conduction system disease; and **high vagal tone in athletes and during sleep, which is normal.**

3. Sinus Node Disease

- **Sick sinus syndrome** — inappropriate sinus bradycardia, sinus arrest, and the **tachycardia–bradycardia syndrome**, in which treating the tachycardia unmasks the bradycardia and vice versa. Ambulatory

monitoring correlates symptoms with rhythm.

- **Before implanting a permanent pacemaker, exclude a reversible cause — almost always a drug or hyperkalaemia.** A patient paced for a bradycardia caused by their beta blocker has been given a lifelong device for a prescribing problem.

Chapter 6 · A Reading Drill

Interpretation is a skill of repetition. Work through these, saying the sequence from Chapter 1 aloud each time, and give the finding, the diagnosis and the **action**.

THE FIVE ELECTROCARDIOGRAMS YOU MUST NEVER MISS

1. ST elevation in a territory, with reciprocal depression — an infarct.

2. Complete heart block — or Mobitz II, which will become it.

3. A broad-complex tachycardia — ventricular tachycardia until proved otherwise.

4. Hyperkalaemia — tented T waves through to the sine wave.

5. A prolonged QT — the substrate for torsades.

And three more that are missed rather than mistaken: **Wellens pattern · posterior infarction · the Brugada pattern.**

The tracing	Diagnosis and action
62-year-old with chest pain: ST elevation in II, III and aVF with ST depression in I and aVL	Inferior infarct. Right-sided leads before any nitrate; reperfusion (Case 11).
58-year-old with chest pain: tall R waves and ST depression in V1–V2	Posterior infarct. Record V7–V9 and treat as an ST-elevation infarct.
Pain-free 55-year-old after an episode of chest pain: biphasic T waves in V2–V3, preserved R waves	Wellens syndrome — critical proximal left anterior descending stenosis. Admit; do not discharge.
34-year-old with positional chest pain: widespread saddle ST elevation with PR depression, no reciprocal change	Pericarditis. Anti-inflammatory drug plus colchicine; check troponin (Case 17).
Dialysis patient, missed a session: tall tented T waves, absent P waves, broad QRS	Hyperkalaemia. Calcium gluconate, insulin–dextrose, salbutamol — now (Case 28).
70-year-old, dizzy: regular P waves at 90, regular QRS at 38, no relationship between them	Complete heart block. Atropine, pacing; stop the rate-limiting drugs; check potassium.
Post-infarct patient, rate 170, broad QRS, concordant precordial leads, blood pressure 105/70	Ventricular tachycardia. Stability does not change the diagnosis. Amiodarone or cardioversion — not verapamil.
Rate exactly 150, regular, narrow, saw-tooth baseline in II	Atrial flutter with 2:1 block. Adenosine may unmask the flutter waves.
Palpitations, rate 190, narrow, regular, abrupt onset	Nodal re-entrant tachycardia. Modified Valsalva, then adenosine with the trace running.
Irregularly irregular, no P waves, rate 130	Atrial fibrillation. Rate control, look for the cause, score the stroke risk.
Young patient, syncope: short PR with a slurred upstroke, now in an irregular broad tachycardia	Pre-excited atrial fibrillation. No adenosine, verapamil, digoxin or beta blocker. Procainamide or cardioversion.
Collapsed patient, QRS 150 ms, sinus tachycardia, dilated pupils, drowsy	Tricyclic overdose with sodium channel blockade. Sodium bicarbonate (Seminar 16).

Chapter 7 · The Blood Count, Film, Coagulation Screen and Marrow

1. Reading the Blood Count

- **Haemoglobin with the mean cell volume and the reticulocyte count** — the reticulocyte count is the first branch of the whole anaemia algorithm (Case 50), and it is frequently not requested.
- **Read the white cell differential, not the total.** A normal total can conceal a neutropenia with a lymphocytosis.

Abnormality	Common causes
Neutrophilia	Infection, inflammation, tissue damage, corticosteroids, smoking, malignancy, myeloproliferative disease. A left shift and toxic granulation suggest infection rather than steroid effect.
Neutropenia	Drugs — carbimazole, clozapine, chemotherapy, co-trimoxazole — viral infection, marrow disease, hypersplenism, autoimmune, B12 and folate deficiency, and ethnic benign neutropenia
Lymphocytosis	Viral infection, pertussis, chronic lymphocytic leukaemia (Case 54), lymphoma, tuberculosis
Lymphopenia	Corticosteroids, HIV, sepsis, lymphoma, radiotherapy, malnutrition
Eosinophilia	Parasitic infestation — first on the list in this region · drug reaction and DRESS (Case 76) · atopy · eosinophilic granulomatosis with polyangiitis (Case 61) · adrenal insufficiency · malignancy
Thrombocytosis	Reactive — infection, inflammation, iron deficiency, bleeding, post-splenectomy — or clonal (Case 57)
Thrombocytopenia	Case 52 — and always look at the film first
Pancytopenia	Marrow failure or infiltration, B12 or folate deficiency, hypersplenism, drugs, and in this region visceral leishmaniasis, brucellosis and tuberculosis (Seminar 9)

2. The Film — What to Ask For and What It Shows

THE FILM FINDINGS WORTH KNOWING BY NAME

Request a film on any unexplained abnormal count, and look at the report properly. These findings are diagnostic in themselves:

Blasts and Auer rods → acute leukaemia (Case 53) · **hypersegmented neutrophils and oval macrocytes** → B12 or folate deficiency (Case 50) · **spherocytes** → hereditary spherocytosis or warm autoimmune haemolysis · **schistocytes** → microangiopathy — **with a low platelet count this is a haematological emergency** · **sickle cells** · **target cells and basophilic stippling** → thalassaemia, lead · **tear-drop poikilocytes with a leucoerythroblastic picture** → marrow infiltration or myelofibrosis (Case 57) · **rouleaux** → paraproteinaemia (Case 56) · **bite cells and Heinz bodies** → glucose-6-phosphate dehydrogenase deficiency (Case 50) · **malaria parasites** — with the species and the percentage parasitaemia (Case 42) · **smudge cells** → chronic lymphocytic leukaemia.

THE RESULTS THAT ARE NOT REAL

Pseudothrombocytopenia — platelet clumping in the EDTA tube. Not a disease; repeat in citrate (Case 52).

Spurious hyperkalaemia — haemolysis of the sample, a clenched fist, delayed transport, or a very high platelet or white cell count.

Pseudohyponatraemia — severe hyperlipidaemia or paraproteinaemia (Case 27).

A falsely normal glycated haemoglobin — haemoglobinopathy, haemolysis, recent transfusion (Case 20).

And the general rule: repeat a single surprising result before acting on it, and look at the trend rather than the value.

3. The Coagulation Screen

- **Prothrombin time and INR · activated partial thromboplastin time · fibrinogen · thrombin time · D-dimer.** The interpretation table — prolonged prothrombin time alone, prolonged partial thromboplastin time alone, both prolonged, or both normal with clear bleeding — is in Case 52, together with the **mixing study**, which separates a factor deficiency from an inhibitor.

- **Two traps:** a **lupus anticoagulant** prolongs the partial thromboplastin time in a patient who thromboses rather than bleeds (Case 63); and **the INR does not measure bleeding risk in liver disease**, where procoagulant and anticoagulant factors fall together (Case 38).

4. The Bone Marrow

- **The aspirate** gives cellular morphology, differential counts, iron stores, cytogenetics and flow cytometry. **The trephine biopsy** gives architecture, cellularity, fibrosis and infiltration — and is the part that shows a lymphoma or a granuloma.

- **Send it for culture as well as histology whenever infection is possible** — marrow culture has a good yield for tuberculosis, brucellosis and leishmaniasis (Case 41 and Seminar 9).

- Indications: unexplained cytopenias, suspected leukaemia, lymphoma or myeloma, staging, suspected infiltration, and pyrexia of unknown origin.

Chapter 8 · Renal Function and Urinalysis

THE LIMITATION OF THE NUMBER EVERYONE USES

Creatinine is a product of muscle. A frail, elderly, cachectic or amputee patient can lose most of their renal function with a creatinine that never leaves the reference range.

And the estimating equations are not valid in acute kidney injury, at extremes of body size, in pregnancy, or in amputees — exactly the patients in whom the number is most likely to be relied upon.

So interpret the creatinine against the patient's own previous values, not against the reference range (Case 28). Cystatin C where available.

1. The Numbers

- **The urea-to-creatinine relationship:** urea raised disproportionately in **gastrointestinal bleeding** (Case 38), volume depletion, a high protein load, catabolism and corticosteroids; and low in liver disease, malnutrition and pregnancy.
- **Potassium, bicarbonate, calcium, phosphate and parathyroid hormone** in chronic disease (Case 29).

2. Urinalysis, Done Properly

- **The dipstick:** protein, blood, leucocytes, nitrites, glucose, ketones, pH and specific gravity. **Two limitations to hold on to: it does not detect Bence Jones protein** (Case 56), and **it is unreliable in the elderly and in catheterised patients**, in whom bacteriuria is common and does not mean infection (Case 32).

ASK FOR THE MICROSCOPY

Microscopy is the part of urinalysis that is routinely skipped, and it is the part that localises the disease.

Dysmorphic red cells and red cell casts → glomerular bleeding, which redirects the whole investigation from urology to immunology and biopsy (Case 33).

Granular muddy-brown casts → acute tubular necrosis · white cell casts → pyelonephritis or interstitial nephritis · eosinophils → interstitial nephritis · crystals → stones, urate, oxalate or drug crystals.

3. Quantifying and Localising

- **Albumin-to-creatinine and protein-to-creatinine ratios** on an early morning sample; the thresholds of Case 29 and the nephrotic range of Seminar 2. Twenty-four-hour collections are cumbersome and frequently inaccurate.
- **In hyponatraemia: paired serum and urine osmolality with a urine sodium, taken before any fluid is given** (Case 31).
- **In metabolic alkalosis: the urine chloride**, which separates the chloride-responsive from the chloride-resistant causes. **In a normal-anion-gap acidosis: the urinary anion gap**, which separates renal from gastrointestinal bicarbonate loss (Case 30).
- Fractional excretion of sodium and of urea in distinguishing pre-renal from intrinsic injury — useful, but unreliable on diuretics.

- **Ultrasound: size, symmetry, cortical thickness, obstruction and cysts** — and remember that **small echogenic kidneys mean chronic disease whatever the history says** (Cases 28 and 29).

Chapter 9 · Liver Function Tests

THE NAME IS MISLEADING

Most of what is called a "liver function test" measures injury, not function.

The aminotransferases and alkaline phosphatase tell you that hepatocytes or bile ducts are being damaged. They do not tell you how much liver is working.

Function is measured by the albumin, the prothrombin time or INR, the bilirubin — and clinically, by the mental state. A falling aminotransferase in a deteriorating jaundiced patient means there is little liver left to leak enzymes (Case 35).

1. Read the Pattern First

- **Hepatitic** — aminotransferases raised out of proportion to alkaline phosphatase. **Cholestatic** — alkaline phosphatase and gamma-glutamyl transferase raised out of proportion. **Mixed.** This single decision narrows the differential more than anything else (Case 35).

- **An alanine aminotransferase above 1000** has a short differential: viral hepatitis, drugs and toxins (**check a paracetamol level in everyone**), ischaemic hepatitis, autoimmune hepatitis, a passing stone, acute Budd–Chiari, and Wilson disease under 40.

2. The Individual Tests

Test	What it actually means
Alanine aminotransferase	Relatively liver-specific.
Aspartate aminotransferase	Also present in muscle, heart and red cells — so check the creatine kinase before investigating a raised AST as liver disease. An AST:ALT ratio above 2 suggests alcohol; above 1 suggests cirrhosis.
Alkaline phosphatase	Liver or bone. Confirm the source with the gamma-glutamyl transferase: a raised alkaline phosphatase with a normal GGT is bone — Paget disease, metastases, osteomalacia, a healing fracture, childhood growth — or placental in pregnancy.
Gamma-glutamyl transferase	Sensitive and very non-specific. Raised in isolation by alcohol and by enzyme-inducing drugs; useful mainly to confirm that a raised alkaline phosphatase is hepatobiliary.
Bilirubin	Split it into conjugated and unconjugated (Seminar 1). An isolated unconjugated hyperbilirubinaemia with normal enzymes, a normal film and no haemolysis, provoked by fasting or illness, is Gilbert syndrome — which needs reassurance, not investigation.
Albumin	Falls in chronic liver disease — but also in inflammation, nephrotic syndrome, protein-losing enteropathy and malnutrition. It is a good acute-phase marker and a poor nutritional one.
Prothrombin time / INR	The best single marker of synthetic function — and in obstructive jaundice it corrects with vitamin K, whereas in hepatocellular failure it does not.

3. Working Up an Abnormal Result

- **Repeat it first** — transient abnormalities are common. Then take an alcohol, drug and herbal history, and calculate the body mass index and metabolic risk.

- **The non-invasive panel:** hepatitis B and C serology; autoantibodies with immunoglobulins; **ferritin and transferrin saturation**; **caeruloplasmin under the age of 40**; alpha-1 antitrypsin; coeliac serology; thyroid function; lipids and glucose; and an ultrasound.

- **Then assess fibrosis non-invasively — FIB-4 and APRI from routine bloods, or transient elastography** (Case 36).

THE RESULT THAT LOOKS REASSURING AND IS NOT

Normal liver enzymes do not exclude cirrhosis. Enzymes frequently normalise as the liver becomes fibrotic.

A falling platelet count may be the only abnormality, appearing long before ascites or varices — so a patient with a low platelet count and a risk factor for liver disease deserves a fibrosis assessment rather than a repeat count (Case 36).

Chapter 10 · The Chest Radiograph and Pulmonary Function Tests

1. Reading the Chest Radiograph

- **Details and adequacy first:** name and date; **projection** — posteroanterior or anteroposterior, since an anteroposterior film magnifies the heart and cannot be used to judge its size; erect or supine; **inspiration** (count the ribs); **penetration**; and **rotation** — the clavicles should be equidistant from the spinous process.

Step	What to inspect
A — Airway	Tracheal position and calibre, the carina, and the main bronchi.
B — Breathing	Both lung fields, zone by zone, comparing right with left; the pleura; the apices; the costophrenic angles; the horizontal fissure.
C — Circulation	Heart size (cardiothoracic ratio above 0.5 on a posteroanterior film), the cardiac and mediastinal borders, the aortic knuckle, and the pulmonary vasculature.
D — Diaphragm	Position and contour of both hemidiaphragms; free air beneath them; the gastric bubble.
E — Everything else	Bones and soft tissues; breast shadows; surgical emphysema; and every line, tube and device — including confirming the nasogastric tube position before anything is fed through it.
Review areas	The apices · behind the heart · below the diaphragm · the costophrenic angles · the periphery of the lung fields. These are where lesions hide.

- **The signs to know, with their cases:** the **silhouette sign** for localising consolidation (Case 1); the **air bronchogram**; the **meniscus** of an effusion and the tracheal rule in a white-out — **pushed away means effusion, pulled towards means collapse** (Case 6); **hyperinflation with flattened hemidiaphragms** (Case 3); **Kerley B lines, upper lobe diversion and bat's-wing shadowing** (Case 12); **cavitation** and **upper zone predilection** (Case 43); **tramline and ring shadows** (Case 4); a **widened mediastinum** (Seminar 3); and free air under the diaphragm.

2. Pulmonary Function Tests

- **The first question is obstructive or restrictive.** A **forced expiratory volume to forced vital capacity ratio below 0.7** is obstructive. A **normal or high ratio with a reduced forced vital capacity and a reduced total lung capacity** is restrictive.

- **Reversibility testing** distinguishes asthma from fixed airflow obstruction — with the caveat that a single negative test does not exclude asthma.

THE MEASUREMENT THAT DECIDES WHAT A RESTRICTIVE PATTERN MEANS

A restrictive pattern has two quite different causes, and the gas transfer separates them.

Reduced gas transfer → the lung parenchyma is diseased — interstitial lung disease, and it is also reduced in emphysema, pulmonary vascular disease and anaemia.

Normal or raised gas transfer with a restrictive pattern → the lungs are normal and the problem is the pump — chest wall deformity, obesity, pleural disease, or **neuromuscular weakness** (Case 5).

Gas transfer is raised in alveolar haemorrhage and in polycythaemia, and must be corrected for haemoglobin.

- **Flow–volume loops:** a flattened inspiratory limb indicates **extrathoracic upper airway obstruction**; a flattened expiratory limb indicates intrathoracic obstruction.
- **Peak expiratory flow** and its diurnal variation in asthma — measured before and after every intervention in an acute attack (Case 2).
- **Vital capacity in neuromuscular disease, measured serially** — and the point from Case 66: act on the falling vital capacity rather than waiting for the blood gas, because hypercapnia is a pre-terminal finding.
- **Six-minute walk distance with oximetry**, which detects the exertional desaturation that a resting saturation misses (Cases 8 and 45).

Chapter 11 · Rheumatological and Immunological Serology

THE RULE THAT GOVERNS THE WHOLE CHAPTER

These tests have poor specificity, and their usefulness depends entirely on the probability of disease before they are sent.

A positive antinuclear antibody in a patient with fatigue and nothing else is far more likely to be a false positive than lupus — and once it is in the record, the patient may spend years carrying a diagnosis that is very difficult to remove.

So order these tests to answer a specific question raised by the history and examination. Do not use them to screen an undifferentiated symptom.

1. The Tests

Test	How to interpret it
Rheumatoid factor	Poor specificity — positive in healthy older people, hepatitis C, infective endocarditis, Sjögren syndrome, sarcoidosis and chronic infection. Anti-cyclic citrullinated peptide antibody is far more specific and predicts erosive disease (Case 58).
Antinuclear antibody	Sensitive, poorly specific; positive at low titre in many healthy people. Its value lies in the negative: a negative result makes lupus very unlikely (Case 59).
The specific antinuclear antibodies	Anti-double-stranded DNA and anti-Sm — specific for lupus, and the former tracks activity. Anti-Ro and anti-La — Sjögren, and neonatal lupus with congenital heart block, so essential before pregnancy. Anti-RNP. Anti-centromere — limited systemic sclerosis; anti-topoisomerase (Scl-70) — diffuse disease with lung fibrosis. Myositis panel including anti-Jo-1. Anti-histone — drug-induced lupus.
Complement C3 and C4	Consumed in active immune complex disease. The pattern is diagnostically useful: low C3 with normal C4; low C3 and C4; or normal complement — the table in Case 33.
ANCA — proteinase-3 and myeloperoxidase	Supports but does not prove, and the titre tracks relapse unreliably. False positives in infection — including endocarditis and tuberculosis — and in drug-induced disease (Case 61).
Antiphospholipid antibodies	Lupus anticoagulant, anticardiolipin, anti-beta-2 glycoprotein I. Must be confirmed on a repeat sample at least 12 weeks later, and the assays are distorted by acute thrombosis and by anticoagulation (Case 63).

2. The Inflammatory Markers

- **C-reactive protein** rises and falls within hours to days. **The erythrocyte sedimentation rate** is slower and is confounded by **anaemia, age, sex, pregnancy and a paraprotein** — so a very high sedimentation rate with a normal C-reactive protein should prompt a myeloma screen.

- **The lupus exception, which is worth its own sentence: in active lupus the sedimentation rate rises and the C-reactive protein characteristically does not — so a high C-reactive protein in a febrile lupus patient means infection until proved otherwise** (Case 59).

- **Ferritin** is an acute-phase protein, so it is unreliable as an iron marker in inflammation (Case 49) — and **a very high ferritin in a febrile patient suggests adult-onset Still disease or haemophagocytic syndrome** (Seminar 9).

3. The Rest, and Their Practical Traps

- **HLA-B27** supports axial spondyloarthritis but does not diagnose it, and it is common in healthy people (Case 60).
- **Serum urate** — normal during an acute attack of gout and raised in many people who never get it (Case 62).
- **Creatine kinase** in suspected myositis — and remember it also explains a raised aspartate aminotransferase (Chapter 9).
- **Immunoglobulins with protein electrophoresis and serum free light chains** — for myeloma, amyloidosis and paraprotein-associated neuropathy (Cases 56 and 67).
- **Cryoglobulins must be transported to the laboratory at body temperature.** Sent in a cold tube, the test is destroyed, and a negative result means nothing. Telephone the laboratory before taking the sample.
- **Coeliac serology requires a total IgA level and a patient still eating gluten** (Seminar 13).

THE SENTENCE TO END ON

Serology supports a clinical diagnosis. It does not create one, and — with a few defined exceptions such as anti-double-stranded DNA and complement in lupus nephritis — it does not measure disease activity.

A patient improving clinically with a persistently positive antibody is improving. A patient deteriorating with a negative one is deteriorating. **Treat the patient, not the titre.**