Chapter 1

Investigations

Table 1.1 Summary of recommendations for preoperative testing

Test	Indications
No tests required for healthy adults <80 years undergoing minor surgery	
CXR	Patients >60 years, or with unexplained breathlessness, or undergoing major cardiovascular or thoracic surgery
ECG	Patients >60 years, or with respiratory, renal, or cardiovascular morbidity undergoing all except very minor surgery
FBC	Patients >60 years, or with renal failure, or undergoing major surgery, or clinical suspicion of anaemia or sepsis
U&E	Patients >60 years, or with renal dysfunction, or severe cardiovascular morbidity, or undergoing major surgery
Glucose	Patients >60 years, or suspected diabetes
LFTs	Previous or suspected liver dysfunction, ↑EtOH, malnutrition, biliary surgery
Clotting	Patients on anticoagulation, or with bleeding history, or undergoing cardiovascular surgery
Sickle	Patients with African, Afro-Caribbean, East Mediterranean, Cypriot descent
Pregnancy	♀ of child-bearing age
ABGs	Severe respiratory disease undergoing major surgery (📖 p. 172)
PFTs	Severe respiratory disease undergoing major surgery (📖 p. 176)
Echo	Ejection systolic murmur, signs of cardiac failure (📖 p. 114)

Guidelines

Key to recommendations

- Each recommendation falls into one of three categories:
  - NO: test not recommended.
  - YES: test recommended.
  - ■: the value of carrying out this test is not known, and may depend on specific patient characteristics.

Keys to surgery grades and American Society of Anesthesiologists (ASA) patient grades

Table 1.2 Surgery grades

Grade	Example
1 (minor)	Excision of skin lesion, drainage of breast abscess
2 (intermediate)	Primary repair of inguinal hernia, excision of varicose veins, tonsillectomy/adenotonsillectomy, knee arthroscopy
3 (major)	Total abdominal hysterectomy, endoscopic resection of prostate, lumbar discectomy, thyroidectomy
4 (major+)	Total joint replacement, lung operation, colonic resection, radical neck resection
Neurosurgery	Evacuation of subdural haematoma
Cardiovascular surgery	Coronary artery bypass grafting, repair of abdominal aortic aneurysm

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests*.

Table 1.3 ASA patient fitness grades

ASA grade	Description
1	'Normal healthy patient' i.e. without any clinically important comorbidity and without clinically significant past/previous medical history
2	'A patient with mild systemic disease' no functional limitation
3	'A patient with severe systemic disease' and definite functional limitation
4	'A patient with severe systemic disease that is a constant threat to life'

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests*.

Consent

- Valid consent should be obtained before ordering tests: patients should have enough information about risks, benefits, alternatives, and implications of a +ve result to be able to make an informed decision.
- Should discuss which tests are recommended, what they involve, and rationale: abnormal results should be discussed in full with patients.

Table 1.4 Examples of ASA grades 2–4 comorbidity for cardiovascular, respiratory, and renal disease

	ASA grade 2	ASA grade 3	ASA grade 4
Cardiovascular disease			
Angina	Uses GTN 2–3 times a month	Uses GTN 2–3 times a week or limiting angina	Acute MI
Exercise	Not limited	Limited activity	Very limited activity
Hypertension	Well controlled with single agent	Very symptomatic, requiring multiple antihypertensives	Systolic BP >200mmHg
Diabetes	Well controlled, no complications	Very symptomatic, complications (claudication, renal dysfunction)	DKA
Previous CABG	Not directly relevant—depends on current signs and symptoms		
Respiratory disease			
COPD	Productive cough, wheeze well controlled by inhalers, occasional URTI	Breathless on climbing stairs/ carrying shopping) wheezy much of time, several URTI per year	Acute infective exacerbation of severe COPD
Asthma	Well controlled by medication, not limiting life-style	Poorly controlled, limits lifestyle, on high dose of steroids, frequent hospital admissions	Acute asthma attack not responding to nebulizers
Renal disease			
	Cr >100μmol/L but <200μmol/L, some dietary restrictions	Cr >200μmol/L, on regular dialysis	Acute renal failure with ↑K^+, pulmonary oedema, ↓pH

COPD chronic obstructive airways disease; Cr creatinine; GTN glyceryl trinitrate, DKA diabetic ketoacidosis; MI myocardial infarction

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Routine preoperative tests

Key facts

- The aim is to identify, avoid, or plan for the adverse outcomes listed.
- Most tests are low yield in young patients, and most abnormal findings will not change management in minor surgery.
- Often little good evidence for these tests: recommendations are based on consensus statements such as NICE guidelines (📖 p. 2).
- Generally, tests required are determined by patient fitness and background, and severity of surgery. If you can think why a test is useful, order it.

Table 1.5 Summary of indications for common preoperative blood tests

Test	Indicated	Not indicated	Rationale for testing
FBC	Patients >60 years, or with renal failure, or undergoing major surgery, or clinical suspicion of anaemia or sepsis	Minor surgery	Identify anaemia (📖 p. 100), sepsis (📖 p. 90), thrombocytopaenia (📖 p. 32), neutropaenia (📖 p. 330)
U&E	Patients >60 years, or with renal dysfunction, or severe cardiovascular morbidity, or undergoing major surgery, or on cardiovascular meds/ steroids	Minor or intermediate surgery in adults <60 years	Identify renal dysfunction (📖 p. 220), ↑↓Na^+ (📖 p. 228 to p. 230), ↑↓K^+ (📖 pp. 232–234)
Glucose	Patients >60 years, or suspected diabetes	Not routinely indicated	Screen for diabetes (📖 p. 274)
LFTs	Suspected liver dysfunction, ↑EtOH, biliary surgery	Not routinely indicated	Confirm malnutrition (📖 p. 244), detect liver dysfunction (📖 p. 264) including alcoholic hepatitis (📖 p. 264)
Clotting	Patients on anticoagulation, or with bleeding history, or undergoing cardiovascular surgery, or Hx of liver disease	Not routinely indicated	Identify coagulopathy (📖 p. 68)

Table 1.5 Summary of indications for common preoperative blood tests *(continued)*

Test	Indicated	Not indicated	Rationale for testing
Sickle	Patients with African, Afro-Caribbean, East Mediterranean, Cypriot descent	Patients with documented sickle cell status, most Caucasians	Detect sickle cell disease (📖 p. 14)
Pregnancy	♀ of child-bearing age	Pre-menstrual girls, ♀ >50 years	Identify pregnancy (📖 p. 14)

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.6 Indications for other pre-op investigations and main rationale

Test	Indicated	Not indicated	Rationale for testing
ECG	Patients >60 years, or with respiratory, renal, or cardiovascular morbidity undergoing all except very minor surgery	Minor surgery, young ASA 1 patients	Identify IHD (📖 p. 118), AF (📖 p. 136), heart block (📖 p. 135) and establish a baseline for post-op comparison
CXR	Patients >60 years, or with unexplained breathlessness, or undergoing major cardiovascular or thoracic surgery	Minor surgery, young ASA 1 patients	Rule out LRTI or chest infection (📖 p. 192), screening for malignancy in elderly
ABGs	Severe respiratory disease undergoing major surgery (📖 p. 172)	Not routinely indicated	Quantify comorbidity in high risk patient
PFTs	Severe respiratory disease undergoing major surgery (📖 p. 176)	Not routinely indicated	Quantify comorbidity in high risk patient
Echo	Any new murmur, all ejection systolic unless echo within last 6/12, signs of cardiac failure (📖 p. 124)	Not routinely indicated	Identify AS (📖 p. 148), LVF (📖 p. 124)

* ABGs + PFTs do not identify the high risk patients. They are done on patients that $HxαEx^{b}$ has already identified as being high risk.

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Normal healthy adults

Table 1.7 Minor surgery* in ASA 1 adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	NO	NO	NO
ECG	NO			YES
FBC	NO	NO		
Clotting	NO	NO	NO	NO
U&E	NO	NO		
Glu	NO	NO	NO	NO
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	NO
PFTs	NO	NO	NO	NO

*E.g. excision of skin lesion, incision, and drainage

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests*.

Table 1.8 Intermediate* surgery in ASA 1 adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	NO	NO	NO
ECG	NO			YES
FBC	NO		YES	YES
Clotting	NO	NO	NO	NO
U&E	NO	NO		
Glu	NO			
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	NO
PFTs	NO	NO	NO	NO

*E.g. inguinal hernia repair, varicose veins removal

Key facts: These are adapted from the 2003 NICE publication Preoperative tests.

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Table 1.9 Major surgery* in ASA 1 adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	NO		
ECG	NO		YES	YES
FBC	YES	YES	YES	YES
Clotting	NO	NO	NO	NO
U&E			YES	YES
Glu				
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	NO
PFTs	NO	NO	NO	NO

*E.g. total abdominal hysterectomy, endoscopic resection of prostate, lumbar discectomy, thyroidectomy

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.10 Major+ surgery* in ASA 1 adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	NO		
ECG	NO		YES	YES
FBC	YES	YES	YES	YES
Clotting	NO	NO	NO	NO
U&E	YES	YES	YES	YES
Glu				
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	NO
PFTs	NO	NO	NO	NO

*E.g. total joint replacement, lung operation, colonic resection, radical neck resection

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Adults with mild comorbidity

Table 1.11 Minor surgery* in adults with mild comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	If respiratory/cardiovascular comorbidity		
ECG	YES in patients with cardiovascular comorbidity			
FBC				
Clotting	NO	NO	NO	NO
U&E	Maybe in patients with renal comorbidity Maybe indicated in patients with CVS comorbidity or >60			
Glu	NO	NO	NO	NO
LFTs	NO	NO	NO	NO
UA				
ABGs	May be indicated in patients with respiratory comorbidity			
PFTs	NO	NO	NO	NO

*E.g. excision of skin lesion, incision, and drainage

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.12 Intermediate surgery* in adults with mild comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	May be useful in patients with respiratory/cardiovascular comorbidity, otherwise not indicated if patient <60			
ECG	YES in patients with cardiovascular comorbidity, patients >60 with renal comorbidity			
FBC				
Clotting	NO	NO	NO	NO
U&E	YES in patients with renal comorbidity, or >60 with CVS comorbidity.			
Glu	NO	NO	NO	NO
LFTs	NO	NO	NO	NO
UA				
ABGs	May be useful in patients with respiratory comorbidity			
PFTs	NO	NO	NO	NO

*E.g. inguinal hernia repair, varicose veins removal

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES : test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Table 1.13 Major surgery* in adults with mild comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	May be useful in patients with respiratory/cardiovascular comorbidity, or >60 years, otherwise not indicated			
ECG	YES in patients with cardiovascular comorbidity, patients >60 with renal comorbidity			
FBC	YES	YES	YES	YES
Clotting	May be	May be	May be	May be
U&E	YES in patients with ASA 2 renal comorbidity, or >60 with ASA 2 CVS comorbidity.			
Glu	NO	NO	NO	NO
LFTs	NO	NO	NO	NO
UA				
ABGs	May be useful in patients with respiratory comorbidity			
PFTs	NO	NO	NO	NO

*E.g. total abdominal hysterectomy, endoscopic resection of prostate, lumbar discectomy, thyroidectomy

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.14 Major+ surgery* in adults with mild comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR				
ECG	YES	YES	YES	YES
FBC	YES	YES	YES	YES
Clotting				
U&E	YES	YES	YES	YES
Glu	May be useful in patients with renal comorbidity, otherwise NOT indicated			
LFTs	NO	NO	NO	NO
UA				
ABGs	May be	May be	May be	May be
PFTs	May be indicated in patients with respiratory disease, otherwise NOT indicated			

* E.g. total joint replacement, lung operation, colonic resection, radical neck resection

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Adults with major comorbidity

Table 1.15 Minor surgery* in adults with severe comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR				
ECG	YES in patients with cardiovascular comorbidity			
FBC	YES in patients with renal comorbidity			
Clotting	May be useful in patients with ASA 3 renal, otherwise NOT indicated			
U&E	YES	YES	YES	YES
Glu	May be useful in patients with ASA 3 renal, otherwise NOT indicated			
LFTs	NO	NO	NO	NO
UA				
ABGs				
PFTs	NO	NO	NO	NO

*E.g. excision of skin lesion, incision, and drainage

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.16 Intermediate surgery* in adults with severe comorbidity

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR				
ECG	YES in patients with cardiovascular comorbidity, or any patient >60			
FBC	YES in patients with renal comorbidity, or respiratory disease >80			
Clotting	Only in patients with ASA 3 renal, otherwise NOT indicated			
U&E	YES	YES	YES	YES
Glu	May be useful in patients with ASA 3 renal, otherwise NOT indicated			
LFTs	NO	NO	NO	NO
UA				
ABGs				
PFTs	May be useful in patients with ASA 3 respiratory disease, otherwise NOT indicated			

*E.g. inguinal hernia repair, varicose veins removal

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Table 1.17 Major surgery* in adults with severe comorbidity

Test	Age (years)			
	16 to <40	40 to <60	60 to <80	>80
CXR				
ECG	YES in patients with cardiovascular comorbidity, or any patient >60			
FBC	YES in patients with renal comorbidity, or respiratory disease >80			
Clotting	Only in patients with ASA 3 renal, also ASA 3 cardiovascular otherwise NOT indicated			
U&E	YES	YES	YES	YES
Glu	May be useful in patients with ASA 3 renal, also ASA 3 respiratory otherwise NOT indicated			
LFTs	NO	NO	NO	NO
UA				
ABGs				
PFTs	May be useful in patients with ASA 3 respiratory disease, otherwise NOT indicated			

*E.g. total abdominal hysterectomy, endoscopic resection of prostate, lumbar discectomy, thyroidectomy

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.18 Major+ surgery* in adults with severe comorbidity

Test	Age (years)			
	16 to <40	40 to <60	60 to <80	>80
CXR			YES if cardiovascular comorbidity	
ECG	YES	YES	YES	YES
FBC	YES	YES	YES	YES
Clotting				
U&E	YES	YES	YES	YES
Glu	May be useful in patients with ASA 2 renal or respiratory comorbidity, otherwise NOT indicated			
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	Maybe
PFTs	May be indicated in patients with ASA 3 respiratory disease, otherwise NOT indicated			

*E.g. total joint replacement, lung operation, colonic resection, radical neck resection

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Cardiovascular and neurosurgery

Table 1.19 Cardiovascular surgery* in ASA 1 children <16 years

	Age (years)			
Test	**<1**	**1 to <5**	**5 to <12**	**12 to 16**
CXR	YES	YES	YES	YES
ECG	YES	YES	YES	YES
FBC	YES	YES	YES	YES
Clotting				
U&E	YES	YES	YES	YES
Glu	NO	NO	NO	NO
UA				

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.20 Cardiovascular surgery* in adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	YES	YES	YES	YES
ECG	YES	YES	YES	YES
FBC	YES	YES	YES	YES
Clotting	May be	May be	May be	May be
U&E	YES	YES	YES	YES
Glu	May be	May be	May be	May be
LFTs	YES	YES	YES	YES
UA				
ABGs	May be useful in patients with respiratory disease, otherwise NOT indicated			
PFTs				

*E.g. CABG, AAA repair

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Table 1.21 Neurosurgery in ASA 1 children < 16 years

	Age (years)			
Test	**<1**	**1 to <5**	**5 to <12**	**12 to 16**
CXR	NO	NO	NO	NO
ECG	NO	NO	NO	NO
FBC				
Clotting				
U&E	YES	YES	YES	YES
Glu	NO	NO	NO	NO
UA				

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

Table 1.22 Neurosurgery in adults

	Age (years)			
Test	**16 to <40**	**40 to <60**	**60 to <80**	**>80**
CXR	NO	NO	May be	May be
ECG	Maybe		YES	YES
FBC	Maybe		YES	YES
Clotting	Maybe	May be	May be	May be
May be	YES	YES	YES	YES
Glu	NO			
LFTs	NO	NO	NO	NO
UA				
ABGs	NO	NO	NO	NO
PFTs	NO	NO	NO	NO

Key facts: These are adapted from the 2003 NICE publication *Preoperative tests.*

NO: test not recommended; YES: test recommended; : the value of carrying out this test is not known, and may depend on specific patient characteristic

Other preoperative tests

Sickle cell (Table 1.23)

- These patients should be tested prior to anaesthesia if there is any uncertainty about whether they have the sickle cell gene, especially:
  - Patients with no previous surgical history.
  - Patients with a +ve family history.
- Patients should ideally be offered genetic counselling before and after screening so that they can give informed consent.
- Document the result in the patient's medical record.

Table 1.23 Testing for sickle cell preoperatively

Ethnic group	Sickle cell test
African and Afro-Caribbean origin	YES
Eastern Mediterranean origin	YES
Middle East and Asian origin	YES
Cypriot origin	YES

Pregnancy test (Table 1.24)

- The need to test for pregnancy depends on the risk presented by the anaesthetic and surgery to the fetus: all ♀ of child-bearing age should be asked whether or not there is any chance that they are pregnant before surgery, or undergoing XRs or CT scans.
- ♀ should be advised of the risks of surgery or XRs to the fetus.
- If there is any doubt a pregnancy test should be carried out.

Table 1.24 Pregnancy testing

Woman of child-bearing age	Pregnancy test
With history of last menstrual period within 2 weeks	
Who says it is not possible for her to be pregnant	
Who says it is possible that she may be pregnant	YES

Echo and stress testing (Table 1.25)

Table 1.25 Indications for echo or stress testing (📖 see also p. 114)

Indication	Rationale	TTE / stress test
Dyspnoea of unknown origin	Evaluate LV function	YES for intermediate or major surgery
>3 cardiac risk factors and poor functional capacity	Evaluate LV function and identify IHD	YES for intermediate or major surgery
Symptoms and ESM	Identify critical AS	YES for intermediate or major surgery

Cross-match and group & save (Table 1.26)

Table 1.26 Suggested XM (check local protocols)

Category	Procedure	G&S/XM
G&S takes 5min, emergency XM takes 15min		
General surgery	Oesophagectomy, oesophagogastrectomy, liver resection, pancreatic surgery, rectum AP/anterior resection,	2U
	Gastrectomy, cholecystectomy, small bowel resection, colectomy, laparotomy, mastectomy, splenectomy, thyroidectomy,	G&S
Vascular surgery	Emergency aortic reconstruction	6U, FFP, plts
	Elective aortic reconstruction	2U
	Carotid endarterectomy, distal reconstruction, axillo-femoral bypass, amputation	G&S
Urology	Cystectomy	4U
	Nephrectomy	3U
	Open prostatectomy	2U
	TURP, re-implantation of ureter	G&S
Transplant	Renal	2U
Cardiothoracic	Re-op CABG/valve	4U, FFP, plts
	Thoracotomy, CABG, mitral valve replacement (MVR)/aortic valve replacement (AVR)	2U
	Mediastinoscopy	G&S
Trauma	Major RTA	4U
ENT/plastic surgery	Major head/neck reconstruction	2U
	Free flaps	2U
	Breast reduction	G&S
Orthopaedic surgery	Total hip replacement/revision	2U
	Total knee replacement	G&S
	Total shoulder replacement	G&S
	Major spinal stabilisation	2–4U
Maxillofacial	Bimaxillary osteotomy	2U

Arterial blood gases and pulmonary function tests (Table 1.27)

Table 1.27 Indications for ABGs and/or PFTs (📖 see also p. 172)

Indication	Rationale	ABG/PFTs
Lung resection	Predict post-op lung capacity	PFTs on all patients
ASA grade 3 respiratory disease (📖 p. 10)	Risk assessment, establish baseline, is ICU bed indicated?	ABG, PFTs

A–Z of laboratory investigations

A

ACTH (Table 1.28)

ACTH stimulation test: used to diagnose adrenal insufficiency (📖 p. 280). Tetracosactide® 0.25mg IM or IV given with blood collected at 0, 30min for cortisol. Normal response cortisol increase to >50mmol/L.

Table 1.28 ACTH testing 8am: < 80mg/L

Indication	Increased	Decreased
Endocrine Malignancy	Addison's disease, ecotopic ACTH e.g. small cell lung cancer, thymic tumrs	Adrenal adenoma or carcinoma, pituitary insufficiency

ALT, AST, and ALP (Table 1.29)

- INR, PT, and APTT may also be elevated in hepatic dysfunction.
- ALP can be fractionated to differentiate between bone and liver.

Table 1.29 AST (8–20U/L), ALT (8–20U/L)

Indication	Increased	Decreased
ALT: evaluate liver function	Hepatitis, liver mets, biliary obstruction, liver congestion (ALT<AST),	
AST: liver and cardiac function	AMI, hepatitis, muscle trauma, pancreatitis, intestinal injury, post CABG/cardiac cath, brain damage	Severe diabetic ketoacidosis, liver disease
ALP: liver and bone disease	Hyperparathyroidism, Paget's disease, osteoblastic bone tumours, osteomalacia, rickets, pregnancy, biliary obstruction	Malnutrition

Acid fast bacilli

Histological stain used to identify *Mycobacterium* (tuberculosis, avium much less common) in urine, sputum, pus etc.

Albumin (Table 1.30)

Table 1.30 Albumin 35–50g/L

Indication	Increased	Decreased
Nutrition Oedema		Malnutrition, (📖 p. 244) nephrotic syndrome (📖 p. 226) cystic fibrosis, multiple myeloma, Hodgkin's disease, leukaemia, protein losing enteropathy, IBD (📖 p. 270),

Acid phosphatase (Table 1.31)

- Collection of enzymes catalyzing the hydrolysis of phosphate from a variety of substrates.
- It is found in liver, erythrocytes, platelets, bone marrow, prostate.
- Today assays for acid phosphatase are rarely used. For its main indication monitoring patients with prostate cancer, it has been replaced by PSA, which is more sensitive and specific.

Table 1.31 Acid phosphatase <3.0ng/mL or <0.8IU/L

Indication	Increased	Decreased
Prostate Bone	Carcinoma of the prostate, prostatic surgery or trauma, excessive platelet destruction (ITP), rarely in bone disease	

Aldosterone (Table 1.32)

Table 1.32 Aldosterone serum (only early AM: depending on body position—supine: 3–10ng/dL, upright: 5–30ng/dL)

Indication	Increased	Decreased
Endocrine	Hyperaldosteronism (1° or 2°)	Adrenal insufficiency, panhypopituitarism

Alpha-fetoprotein (αFP) (Table 1.33)

Serum αFP serves as a screening test for neural tube defects, fetal death, or other abnormalities in pregnancy. It is usually done between 16–20 weeks of gestation.

Table 1.33 AFP <25ng/mL

Indication	Increased
Malignancy	Hepatoma, germ cell tumours of the gonads (testicular tumour, embryonal carcinoma, malignant teratoma)
Pregnancy	During pregnancy (in mother's serum): neural tube defects and other anomalies

Amylase (Table 1.34)

- Consists of pancreatic and salivary isoenzyme, small enough to pass through glomerular membrane and can be found in the urine.
- In acute pancreatitis amylase levels rise within hours after onset for 2 days, but specificity for acute pancreatitis is <50%

Table 1.34 Amylase 25–125U/L

Indication	Increased	Decreased
Pancreas	Acute pancreatitis, pancreatic duct obstruction, alcohol ingestion, mumps, parotiditis, cholecystitis, peptic ulcers, intestinal obstruction, mesenteric thrombosis, after upper abdominal surgery, renal failure,	Pancreatic destruction (chronic pancreatitis, cystic fibrosis), liver damage (hepatitis, cirrhosis)

B

B12 (vitamin) (Table 1.35)

- Use Schilling test to diagnose pernicious anemia: vitamin B12 absorption is ↓ when given without intrinsic factor (IF), whereas it is normal when administered with IF at the same time.
- The clinical triad of vitamin B12 deficiency: heamatologic-, neurologic-, GI dysfunction.
- Assuming a previously healthy diet, strict avoidance of foods containing B12 for a period of 3 years is required for complete exhaustion of B12-body-storage

Table 1.35 Vitamin B12 140–700pg/mL

Indication	Increased	Decreased
Anaemia malnutrition	Leukemia, polycythaemia vera	Inadequate intake (malnutrition) or defective absorption (pernicious anemia, after gastrectomy, malabsorption, bacterial overgrowth in blind loop syndrome)

Bilirubin (Table 1.36)

- When serum bilirubin levels exceed 30μmol/L icterus becomes evident by a yellow discoloration of the sclera. When levels rise even higher jaundice will be visible.
- Direct bilirubin is conjugated (after passage through hepatocytes), indirect bilirubin is unconjugated.
- Indirect bilirubin = total bilirubin – direct bilirubin.

Table 1.36 Total bilirubin: 3–17μmol/L; direct bilirubin: <3μmol/L; indirect bilirubin: <14μmol/L

Indication	Increased	Decreased
Total: liver and bile duct	Liver damage, biliary obstruction, haemolysis, fasting	
Direct: liver and bile duct	Billiary obstruction, drug induced cholestasis, Dubin–Johnson and Rotor's syndrome	
Indirect: liver and haemolysis	Any type of haemolytic anaemia, neonatal jaundice, Gilbert's disease, Crigler–Najjar syndrome	

Bleeding time (Table 1.37)

- Bleeding time is ↑ in disorders affecting 1° hemostasis, It is not ↑ in coagulopathies, since they usually impair 2° hemostasis only. vWD is an exception as it prolongs both 1° and 2° hemostasis.
- Several techniques have been described to determine bleeding time. Pitfalls occur in all of them and there is no role for the bleeding time as a routine preoperative screening test.

Table 1.37 Duke, Ivy <6min, template <10min

Indication	Increased	Decreased
Coagulation	Thrombocytopenia, thrombocytopathy, TTP, vascular hemorrhagic diathesis, aspirin, vWD	

Blood urea nitrogen (Table 1.38)

- Urea is an endproduct of protein metabolism.
- In order to determine renal function calculation of BUN/serum creatinine ratio can be useful. It typically is ↓ in acute tubular necrosis and low protein intake. It is ↑ due to renal hypoperfusion, glomerular disease, obstructive uropathy, or high protein intake

Table 1.38 BUN/urea 2.5–7.0 mmol/L (7–18mg/dL)*

Indication	Increased	Decreased
Kidney	Renal failure, dehydration, high protein intake, sepsis, acute MI, GI bleeding, drugs	Starvation or protein malnutrition, liver failure, pregnancy, infancy, overhydration, phenothiazines

C

Calcitonin (Table 1.39)

Calcitonin is produced in the C-cells of the thyroid. It is mainly used as a mode of recurrence of medullary carcinoma of thyroid.

Table 1.39 Calcitonin ♂: <159ng/L, ♀ <114ng/L

Indication	Increased	Decreased
Thyroid	Thyroid medullary carcinoma, paraneoplastic or reactive hypercalcaemia, CRF, Zollinger–Ellison syndrome (hypergastrinaemia), pernicious anemia	

Calcium (Table 1.40)

Serum calcium is divided into an ionized fraction (50%) and a fraction that is bound to proteins (mainly albumin). When interpreting calcium results differentiate between total calcium and ionized calcium. Values for total calcium need to be corrected according to the following equation if protein levels are not within normal limits:

$$\text{Corrected } Ca^{++} = \text{measured } Ca^{++} + (40 - \text{albumin [g/L]}) \times 0.02$$

Table 1.40 Calcium 2.12–2.65mmol/L

Indication	Increased (📖 p. 236)	Decreased (📖 p. 238)
Electrolytes	1° hyperparathyroidism, malignancy, vitamin D excess, osteoporosis, immobolization, sarcoidosis, multiple myeloma, CRF, thiazides	Hypoparathyroidism, pseudohypoparathyroidism, insufficient vitamin D, CRF (phosphate retention), renal tubular acidosis, hypoalbuanaemia

Calcium, urine (Table 1.41)

Table 1.41 Urine calcium 100–300mg/24 hours

Indication	Increased	Decreased
Urinalysis	Hyperparathyroidism, hyperthyroidism, hypervitaminosis D, distal renal tubular acidosis type I, sarcoidosis, immobilization, malignancy,	Thiazides, hypothyroidism, renal failure, steatorrhoea, rickets, osteomalacia

Carboxyhaemoglobin (Table 1.42)

Carbon monoxide (CO) binds haemoglobin 250 times more avidly compared to O_2, therefore even small amounts can result in significant levels of COHb.

Table 1.42 Carboxy-Hb—smokers: <6%; non-smokers <2%; toxic: >15%

Indication	Increased	Decreased
Haemoglobinopathies	Smokers, smoke inhalation, CO inhalation (e.g. automobile exhaust)	

Carcinoembryonic antigen (CEA) (Table 1.43)

- CEA has its main indication in monitoring colorectal carcinoma. If elevated pre-op, should normalise after radical surgery, and then be used to monitor remission.
- Pre-op CEA levels are also correlated with prognosis, 220mg/L suggesting poorer prognosis.

Table 1.43 Non-smoker: 3.0mg/L; smoker: 5.0mg/L

Indication	Increased	Decreased
Malignancy	Carcinoma (colon, lung, pancreas, stomach, breast, ovaries), non-neoplastic liver disease, IBD, smokers	

Catecholamines, serum (Table 1.44)

Ensure stress-free environment, at least 20min without physical activity. No alcohol, nicotine, tea, coffee, chocolate, citrus fruits, bananas for at least 12h.

Table 1.44 Supine: epinephrine <110 pg/mL, norepinephrine <750pg/mL, dopamine <30pg/mL

Indication	Increased	Decreased
Hypertension	Phaeochromocytoma, neural crest tumours (neuroblastoma), anxiety	

Chloride (Table 1.45)

- Chloride is quantitatively the most important extracellular anion. Although abnormalities in serum chloride itself are of little concern, both hyper- and hypochloraemia warrant investigation of the underlying disorder.

Table 1.45 Chloride 96–110mmol/L

Indication	Increased	Decreased
Electrolytes	GI bicarbonate loss with metabolic acidosis (diarrhoea), renal tubular acidosis, hypoaldosteronism, respiratory alkalosis, hyponatraemia with sodium losses in excess of chloride, bromism, administration of: ammonium chloride, amino acids (hyperalimentation), saline azetazolamides	GI chloride losses (vomiting, nasogastric suction), anion-gap metabolic acidosis, compensated respiratory acidosis, metabolic alkalosis, hyperaldosteronism, hyponatraemia

Cholesterol (Table 1.46)

Samples should be taken after a prolonged (16 h) fast.

Table 1.46 Cholesterol: <5.0 mmol/L

Indication	Increased	Decreased
Lipid status	Idiopathic hypercholesterolaemia, biliary obstruction, nephrosis, hypothyroidism, diabetes mellitus, hyperlipoproteinaemia (type IIb, III, IV), dietary intake	Liver disease, hyperthyroidism, malnutrition, cancer, chronic anaemia, steroid therapy

Cold agglutinins (Table 1.47)

- The serum cold agglutinin assay is a simple and inexpensive procedure used by some physicians for the diagnosis of *M. pneumonia* infection.
- The presence of cold agglutinins is not specific for *M. pneumonia*: Sensitivity (with titres ≥1:32) is 50–90%. The higher the cold agglutinin titre the more likely *M. pneumonia*. infection.

Table 1.47 Cold agglutinins titre of <1:32

Indication	Increased	Decreased
Pneumonia	Atypical pneumonia (mycoplasmal pneumonia), viral infections (mononucleosis, measles, mumps), cirrhosis, some parasites	

Coombs' test (Table 1.48a and b)

Direct Coombs' test

- Uses patient's erythrocytes, tests for presence of antibody on the patient's cells.

Table 1.48a Direct Coombs

Indication	Positive	Negative
haemolytic anaemia	autoimmune haemolytic anaemia (leukaemia, lymphoma, collagen–vascular diseases), haemolytic transfusion reaction, some drug sensitizations (methyldopa, levodopa, cephalothin), haemolytic disease of the newborn (erythroblastosis felalis)	normal

Indirect Coombs' test

- uses serum that contains antibody, usually from the patient.

Table 1.48b Indirect Coombs

Indication	Positive	Negative
haemolytic anaemia	immunization from previous transfusion, incompatible blood due to improper crossmatching	normal

Cortisol (Table 1.48)

In healthy individuals cortisol levels change with a circadian rhythm. These diurnal variations are blunted in conditions with sustained cortisol excess such as Cushing's disease.

Table 1.48 Cortisol 8am: 450–700mmol/L; midnight: 80–280 mmol/L

Indication	Increased	Decreased
Endocrine Malignancy	Adrenal adenoma, adrenal carcinoma, Cushing's disease, non-pituitary ACTH producing tumour, steroid therapy, oral contraceptives	Addison's disease, congenital adrenal hyperplasia, Waterhouse–Friedrichsen syndrome

Creatinine (phospho)kinase (CPK or CK) (Table 1.49)

Table 1.49 CPK 25–145mU/mL

Indication	Increased
Acute coronary syndrome	Muscle damage (acute MI, myocarditis, muscular dystrophy, muscle trauma, after surgery) brain infarction, defibrillation, cardiac catheterization, rhabdomyolysis, polymyositis

Creatinine serum (Table 1.50)

- Creatinine is a byproduct of muscle metabolism, derived from breakdown of muscle creatine and creatine phosphate
- Only when ≥50% of nephrons are destroyed does creatinine level ↑.
- In order to detect more subtle reduction in glomerular function (creatinine blind window) use either creatinine clearance or the MDRD-formula to calculate an estimated GFR

Table 1.50 Creatinine ♂: 73–126 µmol/L, ♀: 55–102 µmol/L

Indication	Increased
Kidney	Renal failure, acromegaly, ingestion of meat, aminoglycosides, and other nephrotoxic drugs

Creatinine urine

- Total creatinine ♂: 160–220 µmol/kg/24h, ♀: 110–180/kg/24h.
- For urine creatinine, 📖 see Table 1.51.

Creatinine clearance (Table 1.51)

Table 1.51 Creatinine clearance ♂: 97–137mL/min; ♀: 88–128 mL/min

Indication	Increased	Decreased
Kidney	Pregnancy	Decreases with age, see causes for increase in serum creatinine

CRP (Table 1.52)

- High sensitivity for the detection of acute and chronic inflammation.
- No organ/disease specificity.

Table 1.52 CRP <3mg/L

Indication	Increased	Decreased
Infection	Infection, acute pancreatitis, rheumatic disease (classically not SLE), chronic inflammatory disease, malignancy, acute MI, pregnant, OCP	

D

Dexamethasone suppression test

Normal cortisol: 450–700nmol/L at 8am, 80–280nmol/L at midnight (📖 see also p. 286).

Dexamethasone is given at low (1mg) and high dose (8mg), and cortisol levels are measured. A normal result is a decrease in cortisol with the low dose test.

- Cushing's syndrome due to pituitary ACTH secreting tumours is suggested by no change in cortisol with the low dose test, but a decrease with the high dose test. If there is no change in cortisol with either the low or high dose test, then other causes of Cushings syndrome, e.g. ectopic ACTH secreting tumours and adrenal Cushings are the likely causes: these can be differentiated by measuring ACTH levels.

E

Erythrocyte Sedimentation rate (ESR) (Table 1.52a)

- ESR is a very non-specific test.

Table 1.52a Westergren scale: ♂: <15–20mm/h; ♀: <25–30mm/h

Indication	Increased	Decreased
Inflammation	Infection, inflammation, rheumatic fever, endocarditis, neoplasm, acute MI	Dehydration, sickle cell anaemia, polyerthaemia, high WBC cadrexia

Ethanol (Table 1.53)

- No prior disinfection of the site of blood withdrawal.
- Determination of ethanol levels is useful only in acute alcohol consumption (for chronic alcoholism: Carbohydrate-deficient transferin CDT).
- The UK legal limit for drivers is 80gm EtOH per 100mL blood (0.08%), breath alcohol 35mcg per 100mls, or 107mg per 100mls urine.

Table 1.53 Ethanol <0.01% (<10mg of alcohol per 100mls blood) (CDT <6%)

Indication	Increased	Decreased
Alcohol	Alcohol consumption	

F

Ferritin (Table 1.54)

Ferritin is the most sensitive and earliest sign in iron deficiency before RBCs or the serum-iron itself show any change.

Table 1.54 Ferritin ♂: 15–200mcg/L, ♀: 12–150mcg/L

Indication	Increased	Decreased
Anaemia	Anaemias (haemolytic, pernicious, thalassaemia, megaloblastic), metastatic carcinoma, leukaemias, lymphomas, hepatic disease, iron overload (haemochromatosis), acute and chronic inflammation, CRF, hyperthyroidism, polycythaemia	Iron deficiency, IBD, GI surgery, pregnancy

Fibrin degradation products (FDP) (Table 1.55)

Frequently elevated after surgery (due to tissue destruction) which may mask thrombosis and its complications.

Table 1.55 FDP <10mcg/mL

Indication	Increased	Decreased
Thrombosis	Thrombosis, DVT, pulmonary embolism, MI, after surgery, DIC, liver cirrhosis, HUS	

Fibrinogen (Table 1.56)

- Fibrinogen belongs to the acute-phase proteins.
- Persistent high values (>500mg/dL) are independent risk factors for cardiovascular and cerebrovascular events.

Table 1.56 Fibrinogen 1.5–4.5g/L

Indication	Increased	Decreased
Coagulation	Infection, neoplasia, after surgery, burns, uraemia	Liver damage, DIC, surgery, neoplastic and haematological conditions with hyperfibrinolysis, acute severe bleeding, asparaginase therapy

Folic Acid (Table 1.57)

- Without exogenous intake of folic acid, stores in the liver are sufficient for a period of 3 months.
- The most common cause of folic acid deficiency is a folate-poor diet. Folic acid is found in green leafy vegetables, citrus fruits, animal products, liver.

Table 1.57 Folic Acid 2.0–21ng/mL

Indication	Increased	Decreased
Anaemia malnutrition	Folic acid administration	Inadequate intake (malnutrition, alcoholism), malabsorption (disorders involving the whole small bowel: coeliac disease, widespread Crohn's disease), requirements (haemolytic anaemias, rapidly dividing tumours), impaired folate metabolism due to chemotherapy (e.g. methotrexate)

G

Gastrin (Table 1.58)

- Gastrin levels follow a circadian rhythm, with highest values during the day and especially during meals.
- Gastrin is a hormone secreted by the G cells of the pyloric mucosa, stimulating the secretion of gastric hydrochloric acid.
- Use gastrin stimulation test to differentiate between Zollinger–Ellison syndrome and other causes of hypergastrinaemia.

Table 1.58 Gastrin ♂ <100pg/mL, ♀ <75mg/mL

Indication	Increased	Decreased
Endocrine	Zollinger–Ellison syndrome, pyloric stenosis, pernicious anaemia, atrophic gastritis, ulcerative colitis, renal insufficiency, steroid and calcium administration, insulin	Vagotomy, atropine, hypothyroidism

Glucose (Table 1.59)

Table 1.59 Glucose fasting: 3.5–5.5mmol/L

Indication	Increased	Decreased
Endocrine	Diabetes mellitus, Cushing's syndrome, acromegaly, ↑epinephrine, ACTH administration, acute pancreatitis, pancreatic glucagonoma	Exogenous insulin, oral hypoglycaemics, factitious hypoglycaemia, malnutrition, pancreatic-, hepatic-, endocrine disorders (pancreatitis, islet cell tumour, after gastrectomy

Gram stain

- Technique: spread thin layer of specimen onto glass slide, allow to dry, apply Gentian violet (15–20s), apply Iodine (15–20s), apply alcohol (few seconds only), rinse with water, counterstain with Safranin (15–20s).
- Results: Gram-+ve: dark blue; Gram-–ve: red.
- 📖 See p. 87 for influence of Gram stain on likely organism and choice of antibiotic.

Gamma-glutamyl transferase (γGT) (Table 1.60)

γGT is located in the cell membrane of nearly all cells and tissues. The γGT measured in the serum originates in large parts from the liver, but also from the prostate explaining why levels in ♂ are usually slightly higher than in ♀.

Table 1.60 γGT ♂: <28U/L; ♀: <18U/L

Indication	Increased
Liver	Cirrhosis, hepatitis, cholestasis, malignancy (liver, pancreas, prostate, kidney), renal disease, alcoholism, drugs (aminoglycosides, statins, phenytoin, phenobarbital, warfarin)

H

Haptoglobin (Table 1.61)

- Haptoglobin belongs to the acute-phase proteins and travels with the a2-fraction in electrophoresis.

Table 1.61 Haptoglobin 26–185mg/mL

Indication	Increased	Decreased
Liver Anaemia	Obstructive liver disease, acute inflammatory reactions, necrosis, tumours	Intravascular haemolysis (any type), liver damage

Haematocrit (Table 1.62)

Table 1.62 Hk ♂: 40–54%, ♀: 37–47%

Indication	Increased	Decreased
Anaemia	Polycythaemia vera, 2° polycythemia, high altitudes, vigorous exercise, smoking, haemoconcentration	Anaemia Artefact in drip arm

Haemoglobin (Table 1.63)

Table 1.63 Hb ♂: 14–18g/dL, ♀: 12–16g/dL

Indication	Increased	Decreased
Anaemia	Dehydration, polycythaemia, high altitudes, COPD, CHF	Anaemias, kidney disease, overhydration, malignancy

Hepatitis

- HBsAg: hepatitis surface antigen.
- Anti-HBc: antibody to hepatitis B core antigen; early indicator of infection.
- Anti-HBc IgM: IgM antibody to hepatitis B core antigen.
- HBeAg: hepatitis B e antigen; when present indicates high degree of infectivity.
- Anti-HBe: antibody to hepatitis B antigen; presence associated with resolution of infection.
- Anti-HBs: antibody to hepatitis B surface antigen; typically indicates immunity and clinical recovery.
- Anti-HAV: total antibody to hepatitis A virus; confirms previous exposure to hepatitis A virus.
- Anti-HAV IgM: IgM antibody to hepatitis A virus; indicative of recent infection with hepatitis A virus.

High density lipoprotein cholesterol (HDL-C) (Table 1.64)

- ↓ HDL-Cholesterol is an independent risk factor for CAD.

Table 1.64 HDL 0.9–1.9mmol/L

Indication	Increased	Decreased
Lipid status	Oestrogen (♀)	♂, obesity, diabetes mellitus, uraemia, liver disease, Tangier's disease

HIV antibody

- In a healthy person HIV antibodies are –ve. They are usually determined as a screening test for HIV infection.
- The antibody levels rise within 3–12 weeks after exposure and are detected by ELISA method. +ve tests need to be confirmed by Western immunoblot.

Human chorionic gonadotropin (HCG) (Table 1.65)

Table 1.65 β-HCG (<3mIU/mL)

Indication	Increased	Decreased
	Pregnancy, testicular tumours, throphoblastic disease (hydatidiform mole, choriocarcinoma)	

5-HIAA (5-hydroxyindoleacetic) (Table 1.66)

5-HIAA is the main serotonine metabolite (monoaminoxidase).

Table 1.66 5-HIAA 2–8mg/24h urine

Indication	Increased	Decreased
	Carcinoid tumours, epilepsy, coeliac disease	

I

Iron (Table 1.67)

- Iron levels change dramatically throughout the day due to an underlying circadian rhythm.
- ↓ iron levels alone are not helpful for the investigation of iron deficiency. Ferritin is a much more sensitive and specific parameter.

Table 1.67 ♂: 65–175mcg/dL, ♀: 50–170mcg/dL

Indication	Increased	Decreased
Anaemia	Haemochromatosis, haemosiderosis, excess destruction or ↓ production of erythrocytes, liver necrosis, porphyria	Iron deficiency anaemia, chronic blood loss (e.g. menorrhagia, GI bleeding), nephrosis with loss of iron binding protein, chronic infections or neoplastic disease

Total iron binding capacity (TIBC) (Table 1.68)

TIBC measures the maximum amount of iron that can bind to transferrin.

Table 1.68 TIBC 250–450mcg/dL

Indication	Increased	Decreased
Iron	Iron deficiency anaemia, chronic blood loss, polycythaemia	Age, haemochromatosis, renal failure, cirrhosis, rheumatoid arthritis, infections, cancer of the GI tract

L

Lactate dehydrogenase (Table 1.69)

Table 1.69 LDH 45–100U/L

Indication	Increased	Decreased
Acute coronary syndrome Skeletal muscle	Acute MI, cardiac surgery, prosthetic valve, haemolysis, hepatitis, pernicious anaemia, malignant tumours, sepsis, sarcoid, acute pancreatitis, renal infarction, CCF trauma, CPR pulmonary embolism	

Lactate (Table 1.70)

Table 1.70 Lactate 0.5–2.2mmol/L

Indication	Increased	Decreased
Acidosis	Lactic acidosis due to hypoxia, haemorrhage, circulatory collapse, sepsis, cirrhosis, exercise shock	McArdle's disease (glycogenosis type V), reduced lactate production, high LDH values

Lipase (Table 1.71)

- Lipase catalyzes the hydrolysis of trigycerides into β-monoglycerides and free fatty acids.
- Like amylase it rises within a few hours after onset of acute pancreatitis for approximately 2 days, the clinical specificity is only 60%.

Table 1.71 Lipase 10–150U/L

Indication	Increased
Pancreas	Acute pancreatitis, pancreatic duct obstruction, fat embolus syndrome

M

Magnesium (Table 1.72)

Magnesium acts as an activator in all ATP-dependent reactions and is a physiological antagonist of calcium. In hypomagnesaemia cell-membrane permeability for sodium-, potassium-, and calcium ions increase leading to an intracellular influx of calcium and hypocalcaemia.

Table 1.72 Magnesium 0.8–1.1mmol/L

Indication	Increased	Decreased
Electrolytes	Renal failure, hypothyroidism, Addison's disease, diabetic coma, severe dehydration, exogenous administration	Malabsorption, steatorrhoea, alcoholism and cirrhosis, hyperthyroidism, aldosteronism, diuretics, acute pancreatitis, hypo-, hyperparathyroidism, hyperalimentation, chronic dialysis, renal tubular acidosis

Metanephrines, urine (Table 1.73)

Urinary metanephrines can be falsely elevated due to drug-therapy with phenobarbital or hydrocortisone.

Table 1.73 Urine metanephrines 2 mg/24h urine collection

Indication	Increased	Decreased
Hypertension	Pheochromocytoma, neural crest tumours (neuroblastoma)	

Myoglobin, urine (Table 1.74)

- Myoglobin is a found in all skeletal muscle and in myocardial tissue. Both forms are indistinguishable.
- It is an O_2-binding protein that serves as a reserve for O_2 and facilitates movement of O_2 within muscle cells.
- In acute MI myoglobin has the earliest diagnostic window compared to other biochemical markers for MI.

Table 1.74 Myoglobin <0.3mg/L

Indication	Increased	Decreased
Acute coronary syndrome	Acute MI, surgery, muscle injury, delirium tremens, renal failure, seizures	

Mean cell volume (Table 1.75)

Determination of the MCV is always the first step in the evaluation of anaemia in order to classify as micro-, normo-, or macrocytic.

Table 1.75 MCV ♂: 80–94fL; ♀: 81–99fL

Indication	Increased	Decreased
Anaemia	Vitamin B12 or folic acid deficiency, alcohol excess, liver disease, reticulocytosis, cytotoxics, myelodysplastic syndromes, marrow infiltration, hypothyroidism, antifolate drugs (e.g. phenytoin)	Iron-deficiency anaemia, thalassaemia, sideroblastic anaemia chronic disease (can be monocytic)

N

Nitrogen balance

- Nitrogen balance +4 to +20g/d, urinary nitrogen 12–24g/24h.
- Nitrogen balance = 24h protein intake(g)/6.25 – 24h urine nitrogen + 4.
- Most often used in the assessment of patients on hyperalimentation, a +ve nitrogen balance is usually the goal.

O

Oestrogen receptors

- Oestrogen receptors are determined on fresh surgical specimens.
- The presence of the receptors is associated with longer disease-free interval and survival from breast cancer, and a patient is more likely to respond to endocrine therapy.

Osmolality, serum (Table 1.76)

Serum osmolality = 2 × $[Na^+]$ + [urea] +[glucose].

Table 1.76 Serum osmolality 278–298mosm/kg

Indication	Increased	Decreased
Kidney	Hyperglycaemia, alcohol, ↑sodium (water loss) nephrogenic diabetes insipidus	Low serum sodium (diuretics), Addison's disease, SIADH, iatrogenic (poor fluid balance)

Osmolality, urine

- Spot urine: 50–1400 mosm/kg, after 12h of fluid restriction: >850mosm/kg.
- The loss of the ability to concentrate urine, especially during fluid restriction, is an early indicator of impaired renal function.

P

Parathyroid hormone (Table 1.77)

Table 1.77 PTH 1–8 pmol/L

Indication	Increased	Decreased
Endocrine	Primary, secondary, tertiary hyperparathyroidism, pseudohypoparathyroidism	Hypercalcaemia not due to hyperparathyroidism, hypoparathyroidism

Partial thromboplastin time (Table 1.78)

Falsely elevated in prolonged use of tourniquet.

Table 1.78 PTT 27–38s

Indication	Increased	Decreased
Coagulation	Heparin, any defect in the intrinsic clotting system (incl. factors: I, II, V, VIII, IX, X, XI, XII)	

Phosphate (Table 1.79)

Table 1.79 Phosphorus 0.8–1.45 mmol/L

Indication	Increased	Decreased
Endocrine	Hypoparathyroidism, excess Vit. D, 2° renal failure, bone disease, Addison's disease, childhood	Hyperparathyroidism, alcoholism, diabetes, gout, salicylate poisoning, IV steroid, hypokalaemia, hypomagnesaemia, diuretics, vit. D deficiency, phosphate-binding antacids

Platelets (Table 1.80)

In conditions where platelet numbers are normal, but function is impaired, determine bleeding time, platelet function, and thromboelastograms to evaluate haemostasis.

Table 1.80 Platelets 150–450000/μL

Indication	Increased	Decreased
Coagulation	Sudden exercise, after any trauma including surgery (esp. after splenectomy), acute haemorrhage, haematological disorders, cancer	Major haemorrhage, sepsis, ITP, TTP, bone marrow suppression (chemotherapy, neoplastic infiltration, radiation), aplastic anaemia, hypersplenism, infectious mononucleosis, other viral infections, pre-eclampsia, eclampsia, HIT

Potassium (Table 1.81)

Falsely elevated in prolonged use of tourniquet.

Table 1.81 Potassium 3.5–5.0mmol/L

Indication	Increased (📖 p. 234)	Decreased (📖 p. 232)
Electrolytes	Renal failure, Addison's disease, acidosis, spironolactone, triamterene, dehydration, haemolysis, massive tissue damage, excess intake	Diuretics, vomiting, nasogastric suction, villous adenoma, diarrhoea, Zollinger–Ellison syndrome, chronic pyelonephritis, renal tubular acidosis, metabolic alkalosis, 1° aldosteronism, Cushing's syndrome

Prostatic specific antigen (Table 1.82)

- Higher in black and older men.
- PSA levels >10ng/dL almost always represent prostate carcinoma. Values between 4–10ng/dL are associated with BPH and prostate carcinoma.
- Useful parameter in the follow-up of patients after prostatectomy.

Table 1.82 PSA ♂: 4.0ng/mL; after radical prostatectomy: 0.2ng/mL

Indication	Increased	Decreased
Prostate	BPH, prostate carcinoma, prostatitis	After prostatectomy

Protein, serum (Table 1.83)

Table 1.83 Protein 60–80 g/L

Indication	Increased	Decreased
Liver Malignancy	Multiple myeloma, macroglobulinaemia, sarcoidosis	Malnutrition, IBD, leukaemia, Hodgkin's disease, any cause of ↓ albumin (📖 p. 16)

Protein, urine (Table 1.84)

- Urine protein levels can be falsely elevated in gross haematuria.

Table 1.84 Urine protein

Indication	Increased
Kidney Malignancy	Nephrotic syndrome, glomerulonephritis, lupus nephritis, amyloidosis, venous congestion of kidney (renal vein thrombosis, CHF), multiple myeloma, pre-eclampsia, interstitial renal disease, malignant hypertension

Prothrombin Time (Table 1.85)

- Falsely elevated in prolonged use of tourniquet.

Table 1.85 PT 11.5–13.5sec

Indication	Increased
Coagulation	Any defect in the extrinsic clotting system (factors: I, II, V, VII, X), Vitamin K deficiency, fat malabsorption, liver disease, DIC

R

Red blood cell count (Table 1.86)

Table 1.86 RBC ♂: 4.7–6.1 × 10^6; ♀: 4.2–5.4 × 10^6

Indication	Increased	Decreased
Anaemia	Polycythaemia vera, haemoconcentration, high altitude, cor pulmonale, cardiovascular disease	Haemorrhage, anaemia, chronic infection, leukaemia, myeloma, excessive IV fluid, chronic renal failure, pregnancy, overhydration

Red blood cell morphology

- Anisocytosis: irregular RBC size (microcytes, macrocytes).
- Burr cells (acanthocytes): severe liver disease, high levels of bile, fatty acids, or toxins.
- Helmet cells (schistocytes): microangiopathic haemolysis, haemolytic transfusion reaction, other severe anaemias.
- Howell–Jolly bodies: after splenectomy.
- Nucleated RBCs: severe bone marrow stress (haemorrhage, haemolysis, etc.), neoplastic bone marrow infiltration, extramedullary haematopoiesis.
- Poikilocytosis: irregular RBC shape (sickle, burr).
- Polychromasia: the appearance of a bluish-gray red cell on routine Wright's stain suggests reticulocytes.
- Sickling: sickle cell disease, trait.
- Spherocytes: hereditary spherocytosis, immune or microangiopathic haemolysis.
- Target cells: thalassemia, haemoglobinopathies (e.g. sickle cell disease) obstructive jaundice, any hypochromic anaemia, after splenectomy.

Reticulocyte count (Table 1.87)

If haematocrit is abnormal, correct RC

$$\text{Corrected count} = \text{RC(in \%)} \times \text{haematocrit}/45$$

Table 1.87 RC 0.5–1.5%

Indication	Increased	Decreased
Haematology Infection	Haemolysis, acute haemorrhage, therapeutic response to treatment of anaemia	Bone marrow depression (marrow aplasia, infiltration, chemotherapy, aplastic anaemia)

Rheumatoid arthritis latex test (rheumatoid factor) (Table 1.88)

- Screening test to detect antibodies found in 70–80% of patients with RA (in 70–80%).
- Low specificity: found in most patients with mixed cryoglobulinaemia (usually caused by Hep C) and other conditions (below).

Table 1.88 RA <1:40

Indication	Increased	Decreased
Rheumatoid arthritis	RA, SLE, syphilis, chronic inflammation, SBE, sarcoidosis, hepatitis, renal disease	

S

Sodium (Table 1.89)

Table 1.89 Sodium 135–145mmol/L

Indication	Increased (📖 p. 230)	Decreased (📖 p. 228)
Electrolytes	Excess water loss (sweating, diarrhoea), diuresis (diabetes mellitus, diabetes insipidus, drugs)	CHF, renal failure, cirrhosis, sodium depletion (vomiting, diarrhoea, diuretics), adrenal cortical insufficiency, SIADH, hypokalaemia

Stool for occult blood (Haemoccult test)

+ve in any GI-tract ulcerated lesion (ulcer, carcinoma, polyp), large doses of vitamin C (>500mg/d), swallowed blood (e.g. after ENT/Mac-fax/surgery), ingestion of rare meat. 📖 See differential diagnosis of GI-bleeding, p. 260.

T

T3 (triiodothyronin) and T4 (thyroxin) (Table 1.90)

- Nearly all of T3 and T4 is bound to proteins (e.g. TBG, albumin), changes in the concentrations of these proteins have a big impact on total T3 and T4 concentrations. However they do not alter free hormone concentration

Table 1.90 T3 1.6–3.0nmol/L

Indication	Increased	Decreased
Thyroid	Hyperthyroidism, thyrotoxicosis, oral oestrogen, pregnancy, exogenous T4	Malnutrition, severe illness or trauma

T4 (thyroxin) (Table 1.91)

📖 for comments see TSH, p. 37

Table 1.91 T4 65–140nmol/L

Indication	Increased	Decreased
Thyroid	Hyperthyroidism, exogenous T4, oestrogens, pregnancy	Hypothyroidism, malnutrition, anterior pituitary hypofunction, strenuous exercise, renal failure severe illness

Thyroglobulin (Table 1.92)

- Thyroglobulin is useful in the follow-up of differentiated papillary and follicular thyroid carcinoma. Persistent elevation indicates residual or recurrent disease.
- It is a protein produced exclusively in the thyroid and contains the tyrosine residues that serve as the basis for thyroid hormone production.

Table 1.92 Thyroglobulin <50ng/mL

Indication	Increased	Decreased
Thyroid	Differentiated thyroid carcinomas (papillary, follicular), Graves' disease, non-toxic goitre	Hypothyroidism, testosterone, steroids, phenytoin

Thrombin time (Table 1.93)

- TT is useful in ruling out the presence of heparin in a patient sample: a prolonged TT that corrects within addition of protamine is diagnostic of heparin.

Table 1.93 TT 10–14s

Indication	Increased
Coagulation	Heparin, DIC, fibrin-/fibrinogen degradation products, fibrinogen deficiency, dysfibrinogenemia, antithrombin–antibodies, uraemia, some patients with lupus anticoagulants

TORCH

Infections which present a prenatal danger to an unborn child are summarized as the TORCH-complex, the battery test is based on serologic evidence of exposure to toxoplasmosis, rubella, cytomegaly, and herpes virus.

- (T)oxoplasmosis.
- (O)ther infectous microorganisms: varicella, measles, mumps, coxsackie, hepatitis, HIV, parvo-virus-B19, papillomavirus, EBV, lues, syphillis, gonoccus, chlamydia, borrelia, β-haemolytic streptococci.
- (R)ubella.
- (C)ytomegalovirus.
- (H)erpes simplex.

The battery test is based on serologic evidence of exposure to toxoplasmosis, rubella, cytomegaly, and herpes virus.

Transferrin (Table 1.94)

Transferrin is an anti-acute-phase protein and is therefore reduced in any acute inflammatory process.

Table 1.94 Transferrin 2.4–4.9 g/L

Indication	Increased	Decreased
Iron	Iron deficiency, pregnancy	Acute inflammatory reaction, tumours, haemochromatosis, haemoglobinopathy

Triglycerides (Table 1.95)

Samples shouldbe taken after prolonged (16h) fast.

Table 1.95 0.5–2.0mmol/L vary with age

Indication	Increased	Decreased
Lipid status	Hyperlipoproteinaemias, hypothyroidism, liver diseases, alcoholism, pancreatitis, acute MI, nephrotic syndrome, familial increase	Malnutrition, congenital abetalipoproteinaemia

Troponin (Table 1.96)

- Troponin levels rise 3–6h after beginning of infarction. It peaks at 12–24h and is elevated for ≥1 week.
- If the troponin level is normal ≥6h after the onset of chest pain and if ECG is normal, the risk is of missing an MI is extremely low (<0.5%)

Table 1.96 Troponin <0.4mcg/L

Indication	Increased
Acute coronary syndrome	Acute or subacute MI, unstable angina (microinfarctions)

Thyroid stimulating hormone (TSH) (Table 1.97)

- TSH is a very sensitive marker for subclinical hypo-/hyperthyroidism, it remains the screening test of choice. Free thyroid hormones only need to be determined in cases when TSH is abnormal.

Table 1.97 TSH <5mU/L

Indication	Increased	Decreased
Thyroid	1° hypothyroidism, very rarely in TSH-secreting tumours of the pituitary gland	Hyperthyroidism, 2° excess exogenous T4, anterior pituary hypofunction

U

Urea

📖 See Blood Urea Nitrogen

Uric acid (Table 1.98)

Table 1.98 Uric acid ♂: 440μmol/L: ♀: 340μmol/L

Indication	Increased	Decreased
Kidney Metabolism	Gout, renal failure, destruction of large amounts of nucleoproteins (leukaemia, neoplasia, anaemia, chemotherapy, pregnancy), diuretics, hypothyroidism, parathyroid disease	Uricosuric drugs (salicylates, probenecid, allopurinol), Wilson's disease, Fanconi syndrome

Urinalysis (Table 1.99)

- Macroscopic appearance, pH, density, dipstick analysis and microscopy.
- Appearance:
  - Normal: yellow, clear, straw-coloured.
  - Pink/red: blood, haemoglobin, myoglobin, food colouring, beets.
  - Orange: pyridium, bile pigments, rifamicin
  - Brown/black: myoglobin, bile pigments, melanin, iron, sickle cell crisis.
  - Cloudy: UTI with pyuria, blood, myoglobin, chyluria, mucus, phosphate salts (in alkalic urine), urates (in acidic urine), hyperoxaluria.
  - Foamy: proteinuria, bile salts.
- Microscopy: search for RBCs, WBCs, epithelial cells, parasites, yeast, spermatozoa, crystals, contaminants, mucus, casts.

Table 1.99 Dipstick analysis, pH, and density:

pH	Acidic:	Basic:
	High protein diet, mandelamine other medications, acidosis, ketoacidosis (starvation), COPD, diarrhoea, dehydration	UTI, renal tubular acidosis, diet (high vegetable, milk), bicarbonate or acetazolamide therapy, vomiting, metabolic alkalosis, CRF

Table 1.99 Dipstick analysis, pH, and density: (*continued*)

Specific density	↑: Volume depletion, CHF, adrenal insufficiency, diabetes mellitus, inappropriate ADH, ↑proteins (nephrosis), excretion of radiographic contrast media, artifact	↓: Diabetes insipidus, pyelonephritis, glomerulonephritis, water load with normal renal function
Bilirubin	+ve dipstick: Cholestasis, hepatitis, cirrhosis, CHF with hepatic congestion, congenital hyperbilirubinaemia	–ve = normal
Haemoglobin	+ve dipstick: Stones, trauma, tumours, prostatic hypertrophy Note: a dipstick +ve for haemoglobin, in the absence of RBCs indicates free haemoglobin (trauma, transfusion reaction, haemolysis)	–ve = normal
Glucose	+ve dipstick: Diabetes mellitus, other endocrine disorders (phaeochromocytoma, hyperthyroidism, Cushing's syndrome, hyperadrenalism), stress states (burns, sepsis), pancreatitis, renal tubular disease, iatrogenic causes (steroids, thiazides), false +ve results with vitamin C ingestion	–ve = normal
Ketones	+ve dipstick: Starvation, high fat diet, DKA, vomiting, diarrhoea, hyperthyroidism, pregnancy, febrile states	–ve = normal
Nitrite	+ve dipstick: Bacterial infection Note: only +ve in infection caused by microorganism with the ability to reduce nitrate (e.g. *E. coli, Klebsiella, Proteus, Staphylococcus, Pseudomonas*)	–ve = normal
Leucocyte esterase	+ve dipstick: Bacterial infection Note: screening test for the presence of WBCs	–ve = normal
Urobilinogen`	+ve dipstick: Cholestasis, antibiotic suppression of gut flora	–ve = normal

Urinary electrolytes (Table 1.100)

Spot urines are of limited value because of large variations in daily fluid and salt intake. Results are uninterpretable if a diuretic has been given.

Table 1.100 Urinary electrolytes

Indication	Increased	Decreased
Sodium	Acute tubular necrosis, adrenal insufficiency, renal salt wasting	Volume depletion, hyponatraemia, prerenal azotaemia, hepatorenal syndrome, oedematous state
Potassium	Renal potassium wasting, diuretics, brisk urinary output	Hypokalaemia, potassium depletion, extrarenal loss
Chloride	Chloride sensitive metabolic acidosis (GI losses, diuretic induced)	Chloride resistant metabolic alkalosis (Cushing's syndrome, hyperaldosteronism, exogenous steroids, alkali ingestion)

V

Vanillylmandelic acid, urine (Table 1.101)

VMA is false +ve when administering methyldopa, chocolate or vanilla.

Table 1.101 16–48 µmol/24h

Indication	Increased	Decreased
2° HTN	Phaeochromocytoma, neural crest tumours (neuroblastoma, ganglioneuroma)	

Veneral disease research laboratory (VDRL test)

- Test searches for antilipoidal antibodies. Their presence indicates inflammatory cell destruction in the acute phase of syphilis.
- Useful test for the follow-up management after successful therapy or after spontaneous healing
- If +ve the result needs to be confirmed.

W

White blood cell count, total (Table 1.102)

The total WBC consists of neutrophils, eosinophils, basophils, lymphocytes and monocytes.

- Neutrophils: 2.0–7.5 × 10^9/L (40–70% of WBC)
- Eosinophils: 0.04–0.44 × 10^9/L (1–6% of WBC)
- Basophils: 0.0–0.1 × 10^9/L (0–1% of WBC)
- Lymphocytes: 1:3–3.5 × 10^9/L (20–45% of WBC)
- Monocytes: 0.2–0.8 × 10^9/L (2–10% of WBC)

Table 1.102 WBC 4000–11000 cells/μL

Indication	Increased	Decreased
Blood	Infections, leukaemia, leukaemoid reactions, tissue necrosis, post-splenectomy, exercise, fever, pain, anaesthesia	Overwhelming bacterial infection, certain viral infections (influenza, hepatitis, mononucleosis), aplastic anaemia, reactive arthritis, SLE, MDS, bone marrow depression (due to drugs, radiation, infiltrative tumour) pernicious anaemia, hypersplenism

Neutrophils increase in response to bacterial infection, inflammatory disease and bone marrow disorders. Eosinophils increase in response to allergic disorders, inflammation of the skin and parasitic disorders. Basophils increase in response to leukaemia, chronic inflammation, and hypersensitivity.

Lymphocytes increase in response to viral infecton, leukaemia. They are decreased in the late stages of HIV infection.

Monocytes increase in response to infection, inflammation and malignancy.