

Chapter 1

NORMAL RANGES

Notes

1 All are serum values (unless otherwise stated).

2 'Normal range' values differ between individual laboratories and normal healthy individuals, as well as different ages and sexes. Furthermore, disease processes beyond those commonly associated with a particular 'abnormality' may be associated with variations in individual measurements.

For example, elevated ESR levels may be found in heart failure (even in the absence of the presence of any of the common 'normal' causes of elevated ESR). Quoted reference intervals should therefore be considered as guides rather than absolute values, and should always be considered in the clinical context.

3 All values are for adults unless otherwise stated.

Haematology

Full blood count (FBC)

Haemoglobin (Hb)	13.0–18.0 g/dL (males), 11.5–16.5 g/dL (females)
Mean cellular volume (MCV)	80–96 fL
Packed cell volume (PCV)/Haematocrit (Hct)	40–50% (males), 36–45% (females)
Mean corpuscular haemoglobin (MCH)	28–32 pg
Mean cell haemoglobin concentration (MCHC)	32–35 g/dL
Reticulocytes	25–85 × 10 ⁹ /L or 0.5–2.4%
Platelets	150–400 × 10 ⁹ /L
White cell count (WCC)	4–11 × 10 ⁹ /L
Differential WCC:	
Neutrophils	2.5–7.5 × 10 ⁹ /L
Lymphocytes	1.5–4.0 × 10 ⁹ /L
Monocytes	0.2–0.8 × 10 ⁹ /L
Eosinophils	0.04–0.44 × 10 ⁹ /L
Basophils	0.0–0.1 × 10 ⁹ /L

Others

Erythrocyte sedimentation rate (ESR)	0–15 mm/1st hour (males), 0–30 mm/1st hour (females)
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Coagulation screen

Prothrombin time (PT)	12–15 s
Activated partial thromboplastin time (APTT)	40–50 s
Bleeding time	3–8 min
International normalised ratio (INR)	<0.9–1.2
Fibrinogen	1.8–5.4 g/L
D-Dimer	<0.5 mg/L (varies with assay used, e.g. ELISA/latex agglutination, etc.)

Haematinics

Iron	12–30 $\mu\text{mol/L}$
Total iron-binding capacity (TIBC)	45–75 $\mu\text{mol/L}$
Ferritin	15–300 $\mu\text{g/L}$
Transferrin	2.0–4.0 g/L
B12	160–760 ng/L
Folate	2.0–11.0 $\mu\text{g/L}$
Red cell folate	160–640 $\mu\text{g/L}$
Haptoglobins	0.13–1.63 g/L

Haemoglobin electrophoresis (normal adults)

Haemoglobin A	>95%
Haemoglobin A2	2–3%
Haemoglobin F	<2%

Chemistry

Ions	
Sodium (Na^+)	137–144 mmol/L
Potassium (K^+)	3.5–5.0 mmol/L
Chloride (Cl^-)	95–107 mmol/L
Bicarbonate (HCO_3^-)	20–28 mmol/L
Corrected calcium (Ca^{2+})	2.2–2.6 mmol/L
Phosphate (PO_4^{4-})	0.8–1.4 mmol/L
Copper (Cu^{2+})	12–26 $\mu\text{mol/L}$
Caeruloplasmin	200–350 mg/L
Magnesium (Mg^{2+})	0.75–1.05 mmol/L
Anion gap	12–16 mmol/L Calculated by: $([\text{Na}^+] + [\text{K}^+]) - ([\text{Cl}^-] + [\text{HCO}_3^-])$
Renal	
Urea	2.5–7.5 mmol/L
Creatinine	60–110 $\mu\text{mol/L}$
Urate	0.23–0.46 mmol/L (males), 0.19–0.36 mmol/L (females)
Plasma osmolality	278–305 mosmol/kg

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Hepatic	
Total protein	61–76 g/L
Albumin	37–49 g/L
Total bilirubin	1–22 μ mol/L
Conjugated bilirubin	0–3.4 μ mol/L
Alanine aminotransferase (ALT)	5–35 U/L
Aspartate aminotransferase (AST)	1–31 U/L
Alkaline phosphatase (ALP)	45–105 U/L (over 14 years)
Gamma glutamyl transferase (GGT)	4–35 U/L (<50 U/L in males)
Lactate dehydrogenase (LDH)	10–250 U/L
Cardiac	
Creatine kinase MB fraction	<5%
Troponin I	0–0.4 μ g/L
Troponin T	0–0.1 μ g/L
Others	
Creatine kinase (CK)	24–195 U/L (males), 24–170 U/L (females)
Plasma lactate	0.6–1.8 mmol/L
Fasting plasma glucose	3.0–6.0 mmol/L
Haemoglobin A _{1c} (HbA _{1c})	3.8–6.4%
Fructosamine	<285 μ mo/L
Serum amylase	60–180 U/L

Lipids and lipoproteins

NB: These target levels vary depending on the patient's overall cardiovascular risk assessment.

Cholesterol	<5.2 mmol/L
LDL (low density lipoprotein) cholesterol	<3.36 mmol/L
HDL (high density lipoprotein) cholesterol	>1.55 mmol/L
Fasting serum triglyceride	0.45–1.69 mmol/L

Blood gases

(See Chapter 3 for further information)

H ⁺	35–45 nmol/L
pH	7.35–7.45
PaO ₂	10.6–12.6 kPa
PaCO ₂	4.7–6.0 kPa
Base excess	±2 mmol/L

NB: 1 kPa = 7.6 mmHg. Atmospheric pressure approximately 100 kPa.

Hormones

Adrenal

Serum aldosterone (normal diet)	Upright (4 h): 330–830 pmol/L Supine (30 min): 135–400 pmol/L
Serum cortisol	09.00: 200–700 nmol/L 22.00: 50–200 nmol/L
Urinary cortisol	<280 nmol/24 h
Dexamethasone suppression test	Overnight (after 1 mg dexamethasone): cortisol <50 nmol/l Low dose test (2 mg/day for 48 h): cortisol <50 nmol/L
Serum oestradiol	
Males	<180 pmol/L
Females	Post-menopausal: <100 pmol/L Follicular: 200–400 pmol/L Mid-cycle: 400–1 200 pmol/L Luteal: 400–1 000 pmol/L
Serum progesterone	
Males (very rarely undertaken)	<6 nmol/L
Females:	Follicular <10 nmol/L Luteal >30 nmol/L (should be checked on day 21 of 28-day menstrual cycle)
Serum testosterone	
Males	9–35 nmol/L
Females	0.5–3 nmol/L

Anterior pituitary

Plasma adrenocorticotrophic hormone (ACTH)	09.00: <18 pmol/L
Plasma follicle stimulating hormone (FSH)	
Males	1–7 U/L
Females	Follicular: 2.5–10 U/L Mid-cycle: 25–70 U/L Luteal: 0.32–2.1 U/L Post-menopausal: >30 U/L
Plasma growth hormone (GH)	
Basal, fasting and between pulses:	<1 mU/L
After hypoglycaemia	>40 mU/L (many centres accept values >20 mU/L)

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Plasma luteinising hormone (LH)	
Males	1–10 U/L
Females	Follicular: 2.5–10 U/L Mid-cycle: 25–70 U/L Luteal: 1–13 U/L Post-menopausal: >30 U/L
Plasma prolactin (PL)	65–490 mIU/L (females), 55–340 mIU/L (males) or 1–25 ng/mL (females), 1–20 ng/mL (males)

Posterior pituitary

Plasma antidiuretic hormone (ADH)	0.9–4.6 pmol/L (NB: random values can be meaningless – need to measure this in the context of hydration status and should ideally be measured only in the specialist context of a controlled hypertonic saline infusion test)
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Thyroid

Plasma thyroid binding globulin (TBG)	13–28 mg/L (not routinely measured in clinical practice)
Plasma thyroid stimulating hormone (TSH)	0.4–5 mU/L
Total plasma thyroxine (T4)	58–174 nmol/L
Free T4	10–22 pmol/L
Total tri-iodothyronine (T3)	1.07–3.18 nmol/L
Free T3	5–10 pmol/L
Serum TSH receptor antibodies	<7 U/L
Serum antithyroid peroxidase	<50 IU/mL

Others

Plasma parathyroid hormone (PTH)	0.9–5.4 pmol/L
Plasma calcitonin	<27 pmol/L (should be measured in fasting state)
Serum cholecalciferol (vitamin D3)	60–105 nmol/L
Serum 25-OH-cholecalciferol	45–90 nmol/L

Tumour markers

NB: These values can be meaningless when interpreted outside the appropriate clinical context. Tumour markers are

best used for monitoring treatment response and tumour recurrence, as well as for diagnosis when considered alongside relevant clinical and other investigative findings.

Alpha-fetoprotein (AFP)	<10 kU/L
Carcinoembryonic antigen (CEA)	<10 µg/L
Neurone specific enolase	<12 µg/L
Prostate specific antigen (PSA)	<4 µg/L (males >40 years) / <2 µg/L (males <40 years)
Human chorionic gonadotrophin (B-HCG)	<5 U/L
CA 125	<35 U/mL
CA 19-9	<33 U/mL

Cerebrospinal fluid

Opening pressure	50–200 mm H ₂ O
Protein	0.15–0.45 g/L
Albumin	0.066–0.442 g/L
Chloride	116–122 mmol/L
Glucose	2.2–4.4 mmol/L (>50% plasma glucose)
Lactate	1–2 mmol/L
Red cell count	0/mm ³
White cell count	≤5/mm ³
<i>Differential</i>	
Lymphocytes	60–70% (<5/mm ³)
Monocytes	30–50%
Neutrophils	None

Sweat

Chloride	60 mmol/L (higher values are consistent with a diagnosis of cystic fibrosis) <i>NB:</i> Some sources use higher values for the diagnosis of CF
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Immunoglobulins

IgM	0.45–2.0 g/L
IgG	7.0–14.5 g/L
IgA	0.8–4.0 g/L

Urine

Glomerular filtration rate (GFR)	70–140 mL/min
Creatinine clearance (an estimate of GFR)	75–115 mL/min (females), 82–125 mL/min (males)
Total protein	<150 mg/24 h
Albumin	<30 mg/24 h
Albumin/creatinine ratio	<3.5 mg/mmol (males), <2.5 mg/mmol (females)
Sodium	100–250 mmol/24 h
Potassium	14–120 mmol/24 h
Phosphate (inorganic)	15–50 mmol/24 h
Calcium	2.5–7.5 mmol/24 h
Urobilinogen	1.7–5.9 μ mol/24 h
Osmolality	350–1000 mosmol/kg
5-HT metabolite	
5-Hydroxyindole acetic acid (HIAA)	16–73 μ mol/24 h
Catecholamine and metabolites	
Noradrenaline	60–660 nmol/24 h
Adrenaline	15–160 nmol/24 h
Metanephrines	0.03–0.695 μ mol/mmol creatinine or <5.5 μ mol/24 h
Hydroxymethylmandelic acid (HMMA)/ vanillylmandelic acid (VMA)	16–48 μ mol/24 h

NB: Most centres are moving away from the measurement of VMA due to its poor relative sensitivity as compared to catecholamines and metanephrines.

Units and conversion tables

■ Always write out the abbreviation in full when documenting in notes or charts (especially drug prescription charts) – for example, write ‘milligrams’ rather than ‘mg’) to avoid confusion.

■ Errors cost lives: a slight misinterpretation of what unit is written (for example, if ‘ μ g’ looks like ‘mg’) could lead to a 1,000-fold increase in the dose administered. These errors happen but can be prevented.

Length

1 centimetre (cm)	10 millimetres (mm)
1 metre (m)	100 centimetres (cm) = 1000 millimetres (mm)
1 inch	25.4 millimetres (mm)
1 foot	12 inches = 304.8 millimetres (cm)

Mass

1 nanogram (ng)	1 000 picograms (pg)
1 microgram (μg)	1 000 nanograms (ng)
1 milligram (mg)	1 000 micrograms (μg)
1 gram (g)	1 000 milligrams (mg)
1 kilogram (kg)	1 000 grams (g)
1 pound (lb)	0.45 kilograms (kg)

Volume

1 millilitre (mL)	1 000 microlitres (μL)
1 litre (L)	1 000 millilitres (mL)
1 pint	Approximately 568 mL
1 decilitre (dL)	100 millilitres (mL)
1 fluid ounce (fl oz)	Approximately 29.6 mL
1 unit per litre (U/L)	Also written as IU/L (international units/litre)
milliunits per litre (mU/L)	10^{-3} units/litre
kilounits pre litre (kU/L)	10^3 units/litre

Concentration

mole (mol)	SI base unit of the amount of a substance – amount of substance of a system that contains an equivalent number of elementary entities (e.g. atoms, molecules, electrons, etc.) as there are atoms in 12g of carbon-12 (^{12}C)
millimole (mmol)	10^{-3} mol
micromole (μmol)	10^{-6} mol
picomole (pmol)	10^{-12} mol
osmole (osmol)	1 osmole is one gram molecular weight (1 mole) of any non-dissociable substance, and contains 6.02×10^{23} particles
milliosmole (mosmol)	10^{-3} osmol

Pressure

pascal (Pa)	measure of force per unit area (one newton per square metre)
kilopascal	1 000 Pa