Acetaminophen Level
Therapeutic level: Varies according to use [1]
Toxic level: >25 mcg/mL
Acetoacetate
Reference Range
The normal reference range for quantitative acetoacetate assays measured by gas chromatography is:
Normal range (plasma/serum): 5-30 µg/mL (conventional units)
Semiquantitative methods, although nonspecific for acetoacetate, are frequently used to determine the presence of ketone bodies (acetone and acetoacetate) in urine and blood and are discussed in Ketones.
Acetylcholine Receptor Antibody
Reference Range
Normally, no acetylcholine receptor (AChR) antibody exists in the bloodstream. Binding antibody is the most common antibody found in myasthenia gravis (MG) patients. As binding and blocking antibody together have high sensitivity and specificity (99.6%) for MG patients and chances to find a positive modulating antibodies in patients negative for above antibodies is less than 0.4%. [1] Therefore the reflex panel detects anti-acetylcholine receptor (blocking and binding) antibodies in the serum, if antibody level is greater than 0.4nmol/L, or antibody level is greater than 15% then modulating antibody is added. [1, 2]
Normal findings [3] :

- AChR (muscle) binding antibodies: ≤ 0.02 nmol/L
- AChR (muscle) modulating antibodies: 0-20% (reported as percentage loss of AChR)
- Striational (striated muscle) antibodies: < 1:60

Acid Phosphatase
Reference Range
In adults and elderly persons, the normal findings for acid phosphatase are 0.13-0.63 U/L (Roy, Brower, Hayden; 37°C) or 2.2-10.5 U/L (SI units). [1]
Normal findings in children are 8.6-12.6 U/mL (30°C), while normal findings in newborns are 10.4-16.4 U/mL
Acid-Base Interpretation
Reference Range
Serum bicarbonate
Normal findings [1] :

- Adult/child: 21-28 mEq/L
- Newborn/infant: 16-24 mEq/L

Arterial blood pH
Normal findings [1] :

- Adult/child: 7.35-7.45
- Newborn: 7.32-7.49
- 2 months-2 years: 7.34-7.46
- pH (venous): 7.31-7.41

Arterial blood partial pressure of carbon dioxide
Normal findings [1] :

- Adult/child: 35-45 mm Hg
- Child < 2 years: 26-41 mm Hg
- pCO_2 (venous): 40-50 mm Hg

Activated Clotting Time

Reference Range

The normal range for ACT is 70-120 sec, with the therapeutic range for anticoagulation being 150-600 sec. (However, these ranges vary according to the test device used and the therapy employed.)

Activated Protein C Resistance (Factor V Leiden) Assay

Reference Range

The normal reference value for the activated protein C resistance (APCR) ratio is greater than 2.1.

Adrenocorticotropin (ACTH)

Reference Range

Adrenocorticotropin (ACTH) is a polypeptide hormone composed of 39 amino acids that is secreted by corticotroph cells in the anterior pituitary gland.

Each laboratory has its own reference range for ACTH depending on the assay used.

ACTH levels are higher in men and during pregnancy.

Normal findings

Adult/elderly [1]

Female (19 years or older): 6-58 pg/mL

Male (19 years or older): 7-69 pg/mL

Children [1]

Male and female (10-18 years): 6-55 pg/mL

Male and female (1 week-9 years): 5-46 pg/mL

Alanine Aminotransferase

Alanine aminotransferase (ALT) is an enzyme found primarily in the liver and kidney. It was originally referred to as serum glutamic pyruvic transaminase (SGPT). Normally, a low level of ALT exists in the serum. ALT is increased with liver damage and is used to screen for and/or monitor liver disease. Alanine aminotransferase (ALT) is usually measured concurrently with AST as part of a liver function panel to determine the source of organ damage. [1]

Normal findings

Adult/child: 4-36 units/L at 37°C, or 4-36 units/L (SI units) [2]

Elderly: May be slightly higher than an adult [2]

Infant: May be twofold the level of an adult [2]

Albumin

Reference Range

The reference range for albumin testing is as follows: [1, 2]

- The normal range is 3.5 to 5.5 g/dL or 35-55 g/liter. This range may vary slightly in different laboratories.
- Albumin composes 50%-60% of blood plasma proteins.

Aldolase

Reference Range

Aldolase is an enzyme involved in synthesizing glucose and breaking it down into products of energy. Elevated serum aldolase levels may indicate damage to different organ systems.

Reference ranges for aldolase are as follows [1]:

- Adult: 3-8.2 Sibley-Lehninger units/dL or 22-59 mU/L at 37°C (SI units)
- Child: Approximately two times the adult values
- Newborn: Approximately four times the adult values

Amikacin Level

Reference Range

Peak serum levels correspond to efficacy of the drug. Trough serum levels correspond to toxicity.

Therapeutic levels
Amikacin, like other aminoglycosides, can be given in multiple daily doses (conventional) or once-daily dose (pulse).

Indication	Peak Serum Levels/Efficacy	Trough Serum Levels/Toxicity
Multiple daily dose regimen		
Nonbacteremic gram-negative infection (UTI, synergism with beta-lactams)	15-30 mcg/mL	1-4 mcg/mL
Serious gram-negative infection (bacteremia, pneumonia, sepsis)	25-40 mcg/mL	4-8 mcg/mL
Once daily dosing		
Critically ill patients with gram-negative infection	55-64 mcg/mL	< 1 mcg/mL

Ammonia
Reference Range
Adult: 10-80 mcg/dL or 6-47 μmol/L (SI units)
Child: 40-80 mcg/dL
Newborn: 90-150 mcg/dL
Ammonia: < 50 mcg/dL paracentesis fluid
Ammonia cerebrospinal fluid (CSF) level: 10-35 mg/dL (5.87-20.5 mmol/L) [1]
Amylase
Reference Range
Normal findings
Blood [1]
Adult: 60-120 Somogyi units/dL or 30-220 units/L (SI units)
A slight increase in values may seen during normal pregnancy and in the elderly.
Newborn: 6-65 units/L
Urine (24-hour) [1]
Up to 5000 Somogyi units/24 hr or 6.5-48.1 units/hr (SI units)
Possible critical values [1]
Blood: Over threefold the upper limit of normal (depending on the method)
Androstenedione
Reference Range
Androstenedione is a C-19 (19 carbon atoms) steroid hormone found in men as well as in premenopausal women. Androstenedione originates in the gonads, with minor contribution from the adrenal glands (1.5-3 mg/day); in postmenopausal women, the adrenal gland constitutes the major source of this hormone.
Androstenedione production in the adrenal glands is under effect of the adrenocorticotropic hormone (ATCH), whereas in the gonads it is controlled by the luteinizing hormone/follicle-

stimulating hormone (LH/FSH). Each laboratory has its own reference range for androstenedione, depending on the assay. The tables below show the reference ranges.

Table 1. Androstenedione Reference Ranges [1] (Open Table in a new window)

	Conventional Units	SI Units
Men		
18-30 y	50-220 ng/dL	1.74-7.63 nmol/L
31-50 y	40-190 ng/dL	1.39-6.59 nmol/L
51-60 y	50-220 ng/dL	1.74-7.63 nmol/L
Women		
Follicular	35-250 ng/dL	1.21-8.68 nmol/L
Midcycle	60-285 ng/dL	2.08-9.89 nmol/L
Luteal	30-235 ng/dL	1.04-8.15 nmol/L
Postmenopausal	20-75 ng/dL	0.69-2.60 nmol/L
Children		
1-12 mo	6-78 ng/dL	0.21-2.71 nmol/L
1-4 y	5-51 ng/dL	0.17-1.77 nmol/L
5-9 y	6-115 ng/dL	0.21-3.99 nmol/L
10-13 y	12-221 ng/dL	0.42-7.67 nmol/L
14-17 y	22-225 ng/dL	0.76-7.81 nmol/L

Table 2. Tanner Stage Reference Ranges [2] (Open Table in a new window)

Tanner stage I	
Male	0.04-0.32 ng/mL

Female	0.05-0.51 ng/mL
Tanner stage II	
Male	0.08-0.48 ng/mL
Female	0.15-1.37 ng/mL
Tanner stage III	
Male	0.14-0.87 ng/mL
Female	0.37-2.24 ng/mL
Tanner stage IV-V	
Male	0.27-1.07 ng/mL
Female	0.35-2.05 ng/mL

Anion Gap

Reference Range

The anion gap is the difference between primary measured cations (sodium Na^+ and potassium K^+) and the primary measured anions (chloride Cl^- and bicarbonate $HCO3^-$) in serum. This test is most commonly performed in patients who present with altered mental status, unknown exposures, acute renal failure, and acute illnesses. [1] See the Anion Gap calculator.

The reference range for the anion gap is as follows: [2]

- 16 ± 4 mEq/L (if the calculation employs potassium)
- 12 ± 4 mEq/L (if the calculation does not employ potassium)

For the urine anion gap, the most prominently unmeasured cation is $NH4^+$. Healthy subjects typically have a gap of 0 to slightly normal (< 10 mEq/L). A urine anion gap of more than 20 mEq/L is seen in metabolic acidosis when the kidneys are unable to excrete $NH4^+$ (such as in renal tubular acidosis). If the urine anion gap is zero or negative but the serum AG is positive, the source is most likely gastrointestinal (diarrhea or vomiting).

Androstenedione

Reference Range

Androstenedione is a C-19 (19 carbon atoms) steroid hormone found in men as well as in premenopausal women. Androstenedione originates in the gonads, with minor contribution from the adrenal glands (1.5-3 mg/day); in postmenopausal women, the adrenal gland constitutes the major source of this hormone.

Androstenedione production in the adrenal glands is under effect of the adrenocorticotropic hormone (ATCH), whereas in the gonads it is controlled by the luteinizing hormone/follicle-stimulating hormone (LH/FSH). Each laboratory has its own reference range for androstenedione, depending on the assay. The tables below show the reference ranges.

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Children		
1-12 mo	6-78 ng/dL	0.21-2.71 nmol/L
1-4 y	5-51 ng/dL	0.17-1.77 nmol/L
5-9 y	6-115 ng/dL	0.21-3.99 nmol/L
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Tanner stage II	
Male	0.08-0.48 ng/mL
Female	0.15-1.37 ng/mL
Tanner stage III	
Male	0.14-0.87 ng/mL
Female	0.37-2.24 ng/mL
Tanner stage IV-V	
Male	0.27-1.07 ng/mL
Female	0.35-2.05 ng/mL

Anti-Cyclic Citrullinated Peptide Antibody
Reference Range
Citrullination is a normal physiologic process that occurs in many dying cells. [1] Citrulline is a nonstandard amino acid that is produced by diminution of arginine residue present on certain human proteins by the peptidyl arginine-deiminase (PAD) enzyme. The PAD enzyme has several isoforms, of which PAD2 and PAD4 are expressed in inflammatory leukocytes. [2] The release of PAD from dying cells citrullinates extracellular proteins that contain arginine. Production of anti–citrullinated protein antibody (ACPA) depends on the genetic background of the patient.

- < 20 EU/mL - Negative
- 20-39 EU/mL - Weakly positive
- 40-59 EU/mL - Moderately positive
- >60 EU/mL - Strongly positive
- Normal value - < 20 EU/mL

Anti-RA33 Antibody
Reference Range
The cutoff point is as recommended by the manufacturers of the ELISA kit using the technique discussed in Collection Panel for anti-RA33. Results are considered positive at 25 U/mL or higher.
Anti-RNP Antibody
Reference Range
Because normal and abnormal ranges depend on the laboratory used, it is important to analyze results according to guidelines established by the laboratory running the sample. For example, according to one laboratory, the following parameters are accepted:
A negative antinuclear ribonucleoprotein (anti-RNP) antibody result is defined as less than 20 U based on enzyme-linked immunoassay (ELISA).

A borderline result is defined as 20-25 U.
A positive result is defined as more than 26 U.
Anti-Ro Antibody
Reference Range
Anti-Ro antibodies, also known as anti-SSA antibodies, are associated with Sjögren syndrome.
Anti-Ro antibodies, immunoglobulin G (IgG) [1] :

- < 1 U (negative)
- ≥ 1 U (positive)

Anti-Smith Antibody
Reference Range
Anti-Smith antibodies are present in some cases of systemic lupus erythematosus (SLE) and mixed connective-tissue disease (MCTD).
Normal findings [1] : Negative
Anti-Smooth-Muscle Antibody
Reference Range
In normal findings, there are no anti–smooth-muscle antibodies (ASMAs) at titers >1:20. [1] There are no differences in race or sex with regard to titer results.
Anti-Xa Assay (Heparin Assay)
Reference Range
The anti–factor Xa assay is designed to measure plasma heparin (unfractionated heparin [UH] and low–molecular weight heparin [LMWH]) levels and to monitor anticoagulant therapy.
Therapeutic ranges of heparin are as follows:

- LMWH: 0.5-1.2 IU/mL [1, 2]
- UH: 0.3-0.7 IU/mL [3, 2]

Prophylactic ranges of heparin are as follows:

- LMWH: 0.2-0.5 IU/mL [1, 2]
- UH: 0.1-0.4 IU/mL [4, 2]

In children under age 8 weeks, the therapeutic ranges of heparin are as follows [2] :

- Standard heparin (UH): 0.3-0.7 IU/mL
- LMWH: 0.5-1 IU/mL (for specimens drawn 4-6 hours subsequent to the heparin's subcutaneous injection)

In children under age 8 weeks, the prophylactic range of heparin is as follows [2] :

- LMWH: 0.1-0.3 IU/mL

Antiadrenal Antibody
Reference Range
The reference range for this assay is < 1 U/mL.
Anticardiolipin Antibody
Reference Range
The quantitative measurement of anticardiolipin (aCL) antibody is important in diagnosing antiphospholipid syndrome (APS).
Normal findings
Negative [1] :

- < 23 GPL (immunoglobulin G [IgG] phospholipid units)
- < 11 MPL (IgM phospholipid units)

Antimicrobial Susceptibility
Antimicrobial susceptibility tests are used to determine which specific antibiotics a particular bacteria or fungus is sensitive to. Most often, this testing complements a Gram stain and culture, the results of which are obtained much sooner. Antimicrobial susceptibility tests can guide the physician in drug choice and dosage for difficult-to-treat infections. [1]

Results are commonly reported as the minimal inhibitory concentration (MIC), which is the lowest concentration of drug that inhibits the growth of the organism. Reports typically contain a quantitative result in µg/mL and a qualitative interpretation. The interpretation usually categorizes each result as susceptible (S), intermediate (I), resistant (R), sensitive-dose dependent (SD), or no interpretation (NI).

Antimitochondrial Antibody

Reference Range

The presence of serum antimitochondrial antibodies (AMA) is a highly specific indication of primary biliary cirrhosis (PBC).

Normal findings [1] : No AMAs at titers > 1:5 or < 0.1 units

Antineutrophil Cytoplasmic Autoantibody, Cytoplasmic (c-ANCA)

Antineutrophil cytoplasmic antibodies (ANCA) are found in several vasculitic conditions, including granulomatosis with polyangiitis, microscopic polyangiitis, and Churg-Strauss syndrome. Cytoplasmic ANCA (c-ANCA) represents a subset of these antibodies, in which the primary molecular target is proteinase-3 within the cytoplasm of neutrophils and monocytes. The role of c-ANCA in Wegener granulomatosis (WG) is unclear and unlikely to be pathogenic, as high titers do not correlate well with disease severity and may remain positive even with treatment and remission. [1]

Reference ranges according to the components of ANCA are as follows. [2]

ANCA, immunoglobulin G (IgG): < 1:20 (not significant)

Myeloperoxidase antibody:

- Negative: ≤19 AU/mL
- Equivocal: 20-25 AU/mL
- Positive: ≥26 AU/mL

Serine protease 3 antibody:

- Negative: ≤19 AU/mL
- Equivocal: 20-25 AU/mL
- Positive: ≥26 AU/mL

Antinuclear Antibody

Antinuclear antibody (ANA) tests identify antibodies present in serum that bind to autoantigens present in the nuclei of mammalian cells. Most of these antibodies are IgG, but IgM and IgA have also been detected. The enzyme-linked immunosorbent assay (ELISA) method involves the interaction of these antibodies present in the serum sample with a preprepared antigen and the addition of an antibody that adheres to this complex and induces a color change; the result is an optical density value (a photometric scale) that is read as positive, negative, or equivocal. [1]

The reference range for antinuclear antibody is negative by ELISA.

If the ELISA method results in an abnormal or equivocal finding, the sample is titered using indirect immunofluorescence (IFA) assays on Hep-2 cells, and any value less than or equal to 1:40 dilution (or < 1.0 IU) is negative. [2]

The frequency of positivity on ANA screening test (on Hep-2 cells) is as follows:

- Mixed connective tissue disease: 100%
- Drug-induced lupus erythematosus: 100%
- Systemic lupus erythematosus: 95%-100%
- Sjögren syndrome: 80%
- Scleroderma: 60%-95%
- Polymyositis-dermatomyositis: 49%-74%
- Rheumatoid arthritis: 40%-60%
- Normal: Less than 4%

Antiphospholipid Antibodies

Antiphospholipid (APL) antibodies are group of antibodies directed against epitopes on plasma proteins that are uncovered by binding of these proteins to anionic phospholipids on plasma membranes. The most commonly used tests to detect APL include lupus anticoagulant (LAC), anticardiolipin (ACL) antibodies, and anti-β_2-glycoprotein I antibodies.

Lupus anticoagulant

The International Society of Thrombosis and Haemostasis (ISTH) criteria for lupus anticoagulant detection include 4 mandatory steps, in the following sequence: [1]

1. Prolongation of a phospholipid-dependent clotting assay (activated partial thromboplastin time [aPTT], kaolin clotting time [KCT], diluted Russell's viper venom test [dRVVT], diluted prothrombin time [dPT]); two tests that have different assay principles should be used, usually the dRVVT and aPTT; this is the screening step
2. Mixing study with 1:1 proportion of patient's plasma and a normal pooled plasma without preincubation and reassessment of the clotting assay used in step one; if it remains prolonged, an inhibitor is present, either LAC or a specific factor inhibitor; if it corrects, then LAC is excluded and the cause is likely a specific factor deficiency
3. Confirmation that the inhibitory activity is phospholipid-dependent by relative correction of the abnormal clotting time when the concentration of phospholipid is increased in the screening test(s) that yielded abnormal results; this step confirms that the cause of abnormal mixing study is LAC (phospholipid-dependent inhibitor), not a specific factor inhibitor; knowing the clinical history helps in diagnosis—thrombosis in case of LAC or hemorrhage in the case of factor deficiency
4. Exclusion of other coagulopathies that may yield similar results or accompany the LAC presence; specific factor assay might be necessary

The results from the above tests are considered positive when they are above the local cutoff value. For tests in steps 1 and 2, the cutoff value is the 99th percentile of the distribution of the tests performed on plasmas from at least 40 healthy donors younger than 50 years. In the confirmatory tests in step 3, the cutoff value is equal to the mean of the individual percentage of corrections, calculated with the following equation:

$[(\text{Screen} - \text{confirm})/\text{screen}] \times 100^{\dagger}$

Anticardiolipin antibodies

Enzyme-linked immunoassay (ELISA) is currently the test of choice. The reference range findings are as follows: [2]

- Less than 15 immunoglobulin G (IgG) phospholipids units (GPL): Absent or none detected
- Less than 12 immunoglobulin M (IgM) phospholipids units (MPL): Absent or none detected
- Less than 12 immunoglobulin A (IgA) phospholipids units (APL): Absent or none detected

If the test is obtained to diagnose antiphospholipid syndrome, only medium to high titers of IgG or IgM antibodies (defined as >40 GPL or MPL, or >99th percentile [3]) are considered a positive test result.

Anti-β2 glycoprotein I

ELISA is the test used to detect these antibodies, IgM and IgG isotypes. Per antiphospholipid syndrome diagnostic criteria, these anti-β_2 -glycoprotein I antibodies of IgG and/or IgM isotype should be present in the in plasma, in a titer greater than the 99th percentile to be considered a positive test result.

Antistreptolysin O Titer

Reference Range

The antistreptolysin O titer measures the level of antistreptolysin O antibodies in the blood plasma.

Normal findings for antistreptolysin O titers
Adult/elderly: ≤160 Todd units/mL [1]
Child [1]:

- Newborn: Similar to mother's value
- 6 months-2 years: ≤50 Todd units/mL
- 2-4 years: ≤160 Todd units/mL
- 5-12 years: 170-330 Todd units/mL

Antithrombin III
Reference Range
Antithrombin is a natural anticoagulant that inhibits the activated coagulation factors thrombin (factor IIa), factor Xa, and, to a lesser extent, factor XIa and factor IXa.
Normal findings
Antithrombin activity [1]:

- Newborn: 35-40%
- Older than 6 months to adult: 80-130%

Antithrombin antigen assay [1]:

- Plasma: > 50% of control value
- Serum: 15-34% lower than plasma value
- Immunologic: 17-30 mg/dL
- Functional: 80-120%

Variation in values occurs according to the laboratory methods employed.
Aspartate Aminotransferase
Reference Range
Normal findings
The reference ranges for aspartate aminotransferase (AST) are as follows.
Adults: 0-35 units/L or 0-0.58 μKat/L (SI units) (Values tend to be slightly lower in females than males.) [1]
Elderly: Values are slightly higher than those of other adults. [1]
Children [1]:

- 0-5 days: 35-140 units/L
- < 3 years: 15-60 units/L
- 3-6 years: 15-50 units/L
- 6-12 years: 10-50 units/L
- 12-18 years: 10-40 units/L

Antithyroglobulin
Reference Range
Thyroglobulin is a protein found in thyroid cells. Antithyroglobulin antibody testing is used in the evaluation for thyroid problems.
Antithyroglobulin is not normally found in the blood stream. However, 10-20% of healthy individuals have detectable antithyroglobulin levels.
The reference range value for antithyroglobulin is less than 116 IU/mL.
Antithyroid Antibody
Antithyroid antibody studies are used to evaluate for autoimmune thyroid problems.
The reference ranges for antithyroid antibodies are as follows:

- Thyroid peroxidase antibody (TPOAb): Titer less than 9 IU/mLco [1]
- Thyroglobulin antibody (TgAb): Less than 116 IU/mL [1]
- Thyroid-stimulating immunoglobulin antibody (TSI): Less than 130% of basal activity [1]
- Thyroid-stimulating hormone (TSH) receptor binding inhibitor immunoglobulin (TBII)/TRAb: 1.75 IU/L or less

Apolipoprotein A-I

Apolipoprotein A-I (Apo-A1) is a structural and functional protein that constitutes approximately 70% of the protein in high density lipoprotein (HDL).

The reference ranges of Apo-A1 are as follows [1]:

- Adult males: 75-160 mg/dL
- Adult females: 80-175 mg/dL
- Male newborns: 41-93 mg/dL
- Female newborns: 38-106 mg/dL
- Males (aged 6 months-4 years): 67-167 mg/dL
- Females (aged 6 months-4 years): 60-148 mg/dL
- Children aged 5-17 years: 83-151 mg/dL

Apolipoprotein B

Apolipoprotein B (apoB) levels are used to evaluate the risk for cardiovascular disease. [1]

The reference range of apoB levels in adults is less than 130 mg/dL (1.3 g/L).

ApoB levels are higher in males than in females and tend to increase with age.

It has been suggested the range be adjusted according to the risk factor stratification, [2] similar to low-density lipoprotein cholesterol (LDL-C).

Table 1. Treatment Goals for Total ApoB Relative to LDL-C Levels (Open Table in a new window)

Risk	ApoB	LDL-C
High risk: CHD or CHD risk equivalent	< 90 mg/dL	< 100 mg/dL
Moderate risk: ≥2 risk factors	< 110 mg/dL	< 130 mg/dL
Low risk: 0-1 risk factors	< 130 mg/dL	< 160 mg/dL
CHD, coronary heart disease		

Table 2. ADA/ACC Consensus Report Treatment Goals in Patients with Cardiometabolic Risk and Lipoprotein Abnormalities [3] (Open Table in a new window)

Risk	ApoB	LDL-C	Non-HDL-C
Highest-risk patients: Known CVD or DM plus ≥1 additional major CVD risk factor	< 80 mg/dL	< 70 mg/dL	< 100 mg/dL
High-risk patients: ≥2 CVD risk factors but no DM or known CVD or DM but no other major risk factors	< 90 mg/dL	< 100 mg/dL	< 130 mg/dL
CVD, cardiovascular disease; DM, diabetes mellitus; non-HDL-C, non–high-density lipoprotein cholesterol			

BRAF Gene Mutation Tests

BRAF gene mutation testing has emerged as an important tool for diagnosis, prognosis, treatment, and predicting patient outcome in response to targeted therapy for multiple cancer types.

The *BRAF* gene mutation test result is positive (ie, a mutation is present) if V600E is found in the *BRAF* gene. V600E is the most common gene mutation for the *BRAF* gene and is the most common mutation tested for in clinical laboratories.

Bacterial Wound Culture

Bacterial wound cultures, together with clinical examination, are used to determine the presence of infection in wounds.

The reference range for a negative bacterial wound culture result depends on the method, as follows: [1]

- Qualitative wound culture: No growth of any pathogenic organism or growth of normal skin flora
- Semiquantitative wound culture: Less than 4+ growth
- Quantitative wound culture: Less than 100,000 organisms per gram (if tissue specimen is used), per milliliter (if fluid collection is used), or per swab (if swab is used).

Barbiturate Levels

Barbiturates are sedatives/hypnotics used mainly for anesthesia and epilepsy treatment. They affect the gamma-aminobutyric acid (GABA) system and cause a CNS suppressive effect, which ranges from anxiolysis, sedation, and coma to fatal cardiovascular and respiratory arrest upon overdose. [1, 2] They are classified as short-acting, intermediate-acting, and long-acting. See Table 1 for classification and properties.

Drug	Half-life (h)	Duration of Effect (h)	Hypnotic Dose, mg	Minimum Toxic level, mg/L
Ultra–short-acting				
Methohexital	3-5	< 0.5	50-120	>5
Thiopental	8-10	< 0.5	50-75	>5
Short-acting				
Secobarbital	15-40	>3-4	100-200	>10
Intermediate-acting				
Amobarbital	10-40	>4-6	65-200	>10
Butabarbital	35-50	>4-6	100-200	>10
Long-acting				

Mephobarbital	10-70	>6-12	50-100	>30
Phenobarbital	80-120	>6-12	100-320	>30

Beta-Hydroxybutyrate

The reference range is less than 0.4-0.5 mmol/L. [1, 2, 3] Levels of more than 1 mmol/L require further action, whereas levels of more than 3 mmol/L require immediate medical review.

Beta2 Microglobulin

Serum and plasma beta$_2$ microglobulin values have emerged as markers for the activation of the cellular immune system, as well as a tumor marker in certain hematologic malignancies. Urine beta$_2$ microglobulin values indicate renal filtration disorders. Measurement of values in both serum and urine can help distinguish a problem of cellular activation from a renal disorder. [1]

Normal findings [2]:

- Blood: 0.70-1.80 mcg/mL
- Urine: ≤300 mcg/L
- Cerebrospinal fluid (CSF): 0-2.4 mg/L

Bilirubin

Bilirubin is a tetrapyrrole and a breakdown product of heme catabolism. Most bilirubin (70%-90%) is derived from hemoglobin degradation and, to a lesser extent, from other hemo proteins. In the serum, bilirubin is usually measured as both direct bilirubin (DBil) and total-value bilirubin (TBil). [1]

Direct bilirubin correlates with conjugated bilirubin but tends to overestimate actual conjugated bilirubin, as it includes both the conjugated bilirubin and bilirubin covalently bound to albumin (delta-bilirubin). Indirect bilirubin correlates with unconjugated bilirubin but tends to underestimate unconjugated bilirubin, as a portion of the unconjugated bilirubin reacts with diazosulfanilic acid, producing azobilirubin, which is measured as direct bilirubin.

Normal findings

Adult/elderly/child [2]:

- Total bilirubin: 0.3-1.0 mg/dL or 5.1-17 µmol/L (SI units)
- Indirect bilirubin: 0.2-0.8 mg/dL or 3.4-12.0 µmol/L (SI units)
- Direct bilirubin: 0.1-0.3 mg/dL or 1.7-5.1 µmol/L (SI units)

Newborn [2]:

- Total bilirubin: 1.0-12.0 mg/dL or 17.1-205 µmol/L (SI units)

Possible critical values

Total bilirubin [2]:

- Adult: >12 mg/dL
- Newborn: >15 mg/dL

Bleeding Time

Bleeding time is a laboratory test to assess platelet function and the body’s ability to form a clot. The test involves making a puncture wound in a superficial area of the skin and monitoring the time needed for bleeding to stop (ie, bleeding site turns "glassy").

Normal findings

Bleeding time (blood): 1-9 minutes (Ivy method) [1]

Special note: The bleeding time is a historical footnote in the archives of laboratory medicine. At the current time, it has been largely discredited and, in part, replaced by other testing. It is included in this collection of other laboratory tests for the convenience of our readers, who may see a reference to the bleeding time in older medical literature.

Blood Culture

The reference range for blood culture is no growth.

Blood Urea Nitrogen (BUN)

Blood urea nitrogen (BUN) testing is commonly part of the basic metabolic panel (BMP) or comprehensive metabolic panel (CMP), which is commonly obtained as part of a routine medical examination. It is also obtained in patients in emergency or urgent care settings, as it can provide valuable information that may provide clues to various clinical presentations that may be caused by chemical imbalances in the body that require prompt and immediate attention.

Urea production occurs primarily in the liver (urea cycle, also referred to as the ornithine cycle) and is regulated by N-acetylglutamate. Urea is found dissolved in blood and is excreted by the renal tubules. In addition, a small amount of urea is also excreted in sweat. Therefore, the BUN level may reflect functioning of the liver and/or kidneys.

The reference ranges for the BUN levels are as follows [1]:

- Adult: 10-20 mg/dL or 3.6-7.1 mmol/L (SI units)
- Elderly: May be slightly raised beyond adult levels
- Child: 5-18 mg/dL
- Infant: 5-18 mg/dL
- Newborn: 3-12 mg/dL
- Cord: 21-40 mg/dL

Possible critical value [1]:

- >100 mg/dL (indicates seriously impaired renal function)

Brain-Type Natriuretic Peptide (BNP)

The most important use of natriuretic peptides is in helping to establish the diagnosis of heart failure (HF) in a patient in the urgent care setting in whom the diagnosis is uncertain.

The reference values of brain-type natriuretic peptide (BNP) and N-terminal (NT) proBNP are different to exclude or confirm a diagnosis of heart failure. These values also depend on age and gender and are higher in elderly persons and women.

Normal findings are as follows [1]:

- BNP: < 100 pg/mL
- NT-proBNP: < 300 pg/mL

Critical value [1]:

- BNP: >400 pg/mL (heart failure likely)

In patients with a prior diagnosis of heart failure, knowledge of optivolemic natriuretic peptide values is important when interpreting elevated levels of these molecules.

C-Peptide

C-peptide is a peptide composed of 31 amino acids. It is released from the pancreatic beta cells during cleavage of insulin from proinsulin. It is mainly excreted by the kidney, and its half-life is 3-4 times longer than that of insulin.

The reference ranges for C-peptide are as follows [1]:

- Fasting: 0.78-1.89 ng/mL or 0.26-0.62 nmol/L (SI units)
- 1 hour after glucose load: 5-12 ng/mL

C-Reactive Protein

The normal finding for C-reactive protein (CRP) is < 1.0 mg/dL or < 10.0 mg/L (SI units) (< 3 mg/L for high-sensitivity CRP [hs-CRP]). [1]

Cardiac risks associated with C-reactive protein levels are as follows [1]:

- Low: < 1.0 mg/dL
- Average: 1.0-3.0 mg/dL
- High: >3.0 mg/dL

C-Terminal Telopeptide

The reference ranges for C-terminal telopeptide in urine are as follows [1]:

- Adults: 1.03 ± 0.41 ng/mL
- Children: 8.00 ± 3.37 ng/mL

The reference ranges for C-terminal telopeptide in serum are as follows [1]:

- Female (premenopausal): 40-465 pg/mL
- Female (postmenopausal): 104-1008 pg/mL
- Male: 60-700 pg/mL

CA 125

Cancer antigen 125 (CA 125) is the only tumor marker recommended for clinical use in the diagnosis and management of ovarian cancer.

The reference range of CA 125 is 0-35 units/mL (0-35 kU/L).

The cutoff of 35 kU/L for CA 125 was determined from the distribution of values in healthy individuals to include 99% of the normal population. [1] The lack of an international standard for CA 125 hampers comparability among laboratories, and values derived from different methods are not interchangeable. As such, baseline levels in patients who undergo serial CA 125 monitoring should be redetermined if the methodology in the assay is changed. [2]

Serum CA 125 values tend to decline with age and the onset of menopause. Levels also vary by race; concentrations tend to be lower in postmenopausal Asian and African women than in their white counterparts.

CA 15-3

Cancer antigen 15-3 (CA 15-3) is used to monitor response to breast cancer treatment and disease recurrence.

The reference range of serum CA 15-3 is less than 30 U/mL. The upper limit of the range varies depending on the laboratory and kit used for the test. Values obtained with different assay kits, methods, or laboratories cannot be used interchangeably.

CA 19-9

Cancer antigen 19-9 (CA 19-9; also known as carbohydrate antigen 19-9) is used to help differentiate between cancer of the pancreas and other conditions, as well as to monitor treatment response and recurrence.

The reference range of serum CA 19-9 is less than 37 U/mL.

CA 27-29

Cancer antigen 27-29 (CA 27-29) is used to predict early recurrence of disease in women with treated carcinoma of the breast.

The reference range of serum CA 27-29 is less than 38 U/mL. The upper limit of the range may vary depending on the laboratory and testing kit used for the test. Values obtained with different assay kits, methods, or laboratories cannot be used interchangeably.

Calcitonin

Calcitonin reference ranges are dependent on the method used for assessment.

Basal (plasma) [1]:

- Males: ≤19 pg/mL or ≤19 ng/L (SI units)
- Females: ≤14 pg/mL or ≤14 ng/L (SI units)

Calcium infusion (2.4 mg/kg) [1]:

- Males: ≤190 pg/mL or ≤190 ng/L
- Females: ≤ 130 pg/mL or ≤ 130 ng/L

Pentagastrin injection (0.5 mcg/kg) [1]:

- Males: ≤ 110 pg/mL or ≤ 110 ng/L
- Females: ≤ 30 pg/mL or ≤ 30 ng/L

Age, pregnancy, lactation, and ingestion of food have been reported to influence calcitonin concentration in healthy individuals, but specific reference intervals have not been established.

Calcium, Ionized

Ionized calcium binds to negatively charged sites on protein molecules, competing with hydrogen ions for the same binding sites on albumin and other calcium-binding proteins. This binding is pH dependent and alters the level of ionized calcium in the blood. An increase in pH, alkalosis, promotes increased protein binding, which decreases free calcium levels. Acidosis, on the other hand, decreases protein binding, resulting in increased free calcium levels.

The reference ranges for ionized calcium are as follows [1]:

- Newborn: 4.2-5.58 mg/dL or 1.05-1.37 mmol/L
- 2 months-18 years: 4.8-5.52 mg/dL or 1.2-1.38 mmol/L
- Adult: 4.5-5.6 mg/dL or 1.05-1.3 mmol/L

Critical values are as follows [2]:

- Less than 2 mg/dL (< 0.5 mmol/L) may produce tetany or life-threatening complications.
- In patients with multiple blood transfusions, 2-3 mg/dL (< 0.5-0.75 mmol/L) may require calcium administration.
- More than 7 mg/dL (>1.75 mmol/L) may cause coma.

Carbamazepine Level

Carbamazepine (Tegretol) is an iminostilbene that has been used as a first-line medication for both generalized and partial complex seizure disorders.

The therapeutic reference range of carbamazepine is 4-12 mg/L.

The minimum toxic level is 10 mg/kg.

The toxic concentration/critical laboratory value is greater than 30-40 mg/L.

The terminal elimination half-life of carbamazepine is 18-55 hours for initial/short-term use and 5-26 hours for long-term use (3-5 weeks of continuous drug therapy). The terminal elimination half-life of 10,11-epoxide (carbamazepine metabolite) is 5-10 hours.

The volume of distribution is 1.4 L/kg (up to 3 L/kg in cases of overdose).

Carboxyhemoglobin

Carboxyhemoglobin (COHb) is a stable complex of carbon monoxide that forms in red blood cells when carbon monoxide is inhaled. COHb should be measured if carbon monoxide or methylene chloride poisoning is suspected. COHb is also useful in monitoring the treatment of carbon monoxide poisoning.

Normal findings for saturation of hemoglobin differ among smokers, nonsmokers, and newborns, as follows [1]:

- Nonsmokers: < 3%
- Smokers: ≤12%
- Newborns: ≥12%

Possible critical value is >20%

Cerebrospinal Fluid Analysis

Characteristics of normal spinal fluid are below: [1, 2, 3, 4]

- Total volume: 150 mL
- Color: Colorless, clear, like water
- Pressure: < 20 cm H_2O
- Osmolarity at 37°C: 281 mOsm/L
- Specific gravity: 1.006 to 1.008
- Acid-base balance:
    - pH: 7.28-7.32
    - Pco_2: 47.9 mm Hg
    - HCO_3-: 22.9 mEq/L
- Sodium: 135-150 mmol/L
- Potassium: 2.7-3.9 mmol/L

- Chloride: 700-750 mg/dL
- Calcium: 2.0-2.5 mEq/L (4.0 to 5.0 mg/dL)
- Magnesium: 2.0-2.5 mEq/L (2.4 to 3.1 mg/dL)
- Lactic acid: 10-25 mg/dL
- Lactate dehydrogenase: 40 U/L or less (adults); 70 U/L or less (neonates)
- Glucose: 50-75 mg/dL in cerebrospinal fluid (CSF) or 60-70% of blood glucose concentration
- Glutamine: 6-15 mg/dL
- Proteins: 20-40 mg/dL
    - At different levels of spinal tap:
        - Lumbar: 20-40 mg/dL
        - Cisternal: 15-25 mg/dL
        - Ventricular: 15-45 mg/dL
    - Normal CSF proteins concentration in children:
        - Up to 6 days of age: 70 mg/dL
        - Up to 4 years of age: 24 mg/dL
- Electrophoretic separation of spinal fluid proteins (% of total protein concentrations)
    - Prealbumin: 2-7%
    - Albumin: 56-76%
    - Alpha1-globulin: 2-7%
    - Alpha2-globulin: 4-12%
    - Beta-globulin: 8-18%
    - Gamma-globulin: 3-12%
- Oligoclonal bands - absent
- Immunoglobulins
    - IgG: 10-40 mg/L
    - IgA: 0-0.2 mg/L
    - IgM: 0-0.6 mg/L
    - k/l ratio: 1
- Erythrocyte count:
    - Newborn: 0-675/mm^3
    - Adult: 0-10/mm^3
- Leukocyte count:
- Children:
    - Younger than 1 year: 0-30/mm^3
    - Age 1-4 years: 0-20/mm^3
    - Age 5 years to puberty: 0-10/mm^3
- Adult: 0-5/mm^3
- Antibodies, viral DNA: None
- Bacteria (Gram stain, culture, VDRL): Negative
- Cancerous cells: None
- Cryptococcal antigen: None

Chlamydia Trachomatis Culture

Old Content

Chlamydia trachomatis is a gram-negative, obligate intracellular parasite that is linked to several diseases. A properly obtained negative *C trachomatis* culture indicates the absence of infection with 100% specificity. [1, 2]

New Content

Chlamydia trachomatis is a gram-negative, obligate intracellular parasite that is linked to several diseases. A properly obtained negative *C trachomatis* culture indicates the absence of infection with 100% specificity. [1, 2]
Normal findings include a negative culture and the following antibody values. [3]
Chlamydophila pneumoniae

- IgG: < 1:64
- IgM: < 1:10

Chlamydophila psittaci

- IgG: < 1:64
- IgM: < 1:10

Chlamydia trachomatis

- IgG: < 1:64
- IgM: < 1:10

Normal findings also include negative nucleic acid detection results
Chloride
Chloride is the predominant anion that exists in the extracellular space. It maintains cellular integrity via its effects on osmotic pressure and water balance, in addition to maintaining acid-base balance. [1] Chloride daily requirements for adults are 80-120 mEq/d as sodium chloride (NaCL). [2]
Normal findings [3] :

- Adult/elderly: 98-106 mEq/L or 98-106 mmol/L (SI units)
- Child: 90-110 mEq/L
- Newborn: 96-106 mEq/L
- Premature infant: 95-110 mEq/L

Possible critical values: < 80 or > 115 mEq/L
Chromogranin A
Chromogranin A is a secretory protein, composed of 439 amino acids, found in the large dense-core vesicles of the neuroendocrine cells. It belongs to the family of granins that includes chromogranin B, chromogranin C, and secretogranin II.
Chromogranin A can be either measured in the serum or detected by immunohistochemistry in a tissue specimen.
Normal findings
Chromogranin A (blood test): ≤225 ng/mL [1]
However, the reference ranges for serum chromogranin A vary widely with the techniques used.
Clot Retraction
Normal clot retraction time is 0-2 hours. If the weight of the clot or the percent of extruded serum is used as the end measure, the result depends on the volume of the specimen used, which varies from laboratory to laboratory. [1]
The coagulation cascade is complex. Platelets play a major role to initiate the process and regulate it through biochemical and mechanical interactions. The 3 steps of this process for platelets are adhesion, aggregation, and finally, retraction. [2, 3] The clot retraction study measures the time taken for a platelet plug to undergo this last step, which indicates overall platelet function.
Complement
The complement system consists of a complex network of several plasma proteins that interact with each other and cell surface proteins. Upon proteolytic activation, an enzymatic cascade is propagated, resulting in recruitment of inflammatory cells, amplification of their phagocytic capacity, and formation of membrane attack complexes that promote lysis of microbes. [1, 2]

The reference ranges for total complement (total hemolytic complement: CH_{50} [CH_{100}]), complement C3, and complement C4 are listed below.

Normal findings

Total complement: 30-75 units/mL [3]

C3: 75-175 mg/dL [3]

C4: 22-45 units/mL

Copper

Copper levels can be evaluated to help diagnose several disease processes. These conditions may be monitored by looking at the total copper, the free serum copper, 24-hour urine copper, and liver biopsy copper concentrations. Serum ceruloplasmin is also a valuable test and can be used to determine the free serum copper.

Copper reference ranges are as follows:

- Free serum copper: 1.6-2.4 µmol/L or 10-15µg/dL [1]
- Total copper: 10-22 µmol/L or 63.7-140.12 µg/dL [2]
- Serum ceruloplasmin: 2.83-5.50 µmol/L or 18-35 µg/dL [1]
- 24-hour urine copper 0.3-0.8 µmol or 20-50 µg [1]
- Liver copper 0.3-0.8 µmol/g of tissue or 20-50 µg/g of tissue

Creatine Kinase

Total creatine phosophokinase (CPK) [1] :

Adult/elderly:

- Male: 55-170 units/L or 55-170 units/L (SI units)
- Female: 30-135 units/L or 30-135 units/L (SI units)

(Values are higher following exercise.)

Newborn: 68-580 units/L (SI units) [1]

Isoenzymes [1] :

- Creatine kinase-MM (CK-MM): 100%
- CK-MB: 0%
- CK-BB: 0%

However, serum CK levels can vary among healthy subjects, even when correcting for muscle mass. Age, gender, race, and, as stated, physical activity can affect CK. CK is higher among black males, as well as newborns. [2] Moreover, CK reference ranges are varied with different assays and reference temperatures.

Creatinine

Creatinine is critically important in assessing renal function because it has several interesting properties. In blood, it is a marker of glomerular filtration rate; in urine, it can remove the need for 24-hour collections for many analytes or be used as a quality assurance tool to assess the accuracy of a 24-hour collection.

The reference ranges for serum creatinine are listed below. [1]

Adult:

- Female: 0.5-1.1 mg/dL or 44-97 µmol/L (SI units)
- Male: 0.6-1.2 mg/dL or 53-106 µmol/L (SI units)
- Elderly: Reduced muscle mass may lead to lower values

Adolescent: 0.5-1.0 mg/dL

Child: 0.3-0.7 mg/dL

Infant: 0.2-0.4 mg/dL

Newborn: 0.3-1.2 mg/dL

Possible critical values: >4 mg/dL (indicates seriously impaired renal function)

The reference interval varies with race, ethnicity, and gender. As a result, one should look at the calculated eGFR (estimated glomerular filtration rate), as reported from the measured

serum creatinine, to assess renal function. [2] The GFR can also be calculated from the creatinine clearance (see below).
Note that urine creatinine concentrations (mg/dL) vary depending on water intake (hydration status) and, therefore, are not very meaningful by themselves.
Table 1. Glomerular Filtration Rate [3] (Open Table in a new window)

Age (Years)	Mean GFR (mL/min/1.73 m^2)
20-29	116
30-39	107
40-49	99
50-59	93
60-69	85
70+	75

Creatinine Clearance
Adult (< 40 years) reference ranges for creatinine clearance are as follows [1]:

- Male: 107-139 mL/min or 1.78-2.32 mL/s (SI units)
- Female: 87-107 mL/min or 1.45-1.78 mL/s (SI units)

The reference range in newborns is 40-65 mL/min. [1]
Owing to declines in the glomerular filtration rate (GFR), values fall 6.5 mL/min/decade of life. [1]
The normal range for a 24-hour urine creatinine level is 500-2000 mg/day.
Cryoproteins
Cryoglobulins do not have a consensus reference range. [1] Serum cryoglobulins in most individuals are in low concentrations (100-300 mg/L) among the high concentrations (60,000-80,000 mg/L) of normal serum proteins.
The cryocrit (percentage of packed cryoglobulins referred to total serum after centrifugation at 4°C [2]) is the most practical and clinically useful parameter to predict a patient's clinical outcome; 1% or more of cryocrit is abnormal.
D-Dimer
D-dimer is the degradation product of crosslinked (by factor XIII) fibrin. It reflects ongoing activation of the hemostatic system. The reference concentration of D-dimer is < 250 ng/mL, or < 0.4 µ/mL. [1]
The reference range/cutoff value for D-dimer is ideally established by the performing laboratory, or, if a cutoff value published in the literature is used, the value has to be determined with the same methodology, preferably from the same manufacturer.
Point-of-care testing is available to determine the D-dimer amount semiquantitatively (latex agglutination–based). This test has high interobserver variability, making it less clinically valuable.

A quantitative, automated point-of-care D-dimer test has been developed, providing an excellent, cost-effective, and rapid tool, especially in the setting of ruling out pulmonary embolism among patients with a low probability of the condition.

Dehydroepiandrosterone (DHEA)

Dehydroepiandrosterone (DHEA) can be measured with radioimmunoassay, liquid chromatography–mass spectrometry (LC-MS), or chemiluminescent techniques, and the reference range varies by the technique used.

The reference ranges for DHEA concentrations measured with LC-MS are listed in Table 1.

Table 1. Reference Ranges of DHEA Concentrations by Tanner Stage, Age, and Sex as Measured With LC-MS (Open Table in a new window)

Tanner Stage	Male	Female
Stage I [1]	0.11-2.37 ng/mL	0.14-2.76 ng/mL
Stage II [1]	0.37-3.66 ng/mL	0.83-4.87 ng/mL
Stage III [1]	0.75-5.24 ng/mL	1.08-7.56 ng/mL
Stage IV and V [1]	1.22-6.73 ng/mL	1.24-7.88 ng/mL
Age	Male	Female
6-24 months	< 2500 ng/L	< 1990 ng/L
2-3 years	< 630 ng/L	< 850 ng/L
4-5 years	< 950 ng/L	< 1030 ng/L
6-7 years	60-1930 ng/L	< 1790 ng/L
7-9 years	100-2080 ng/L	140-2350 ng/L
10-11 years	320-3080 ng/L	430-3780 ng/L
12-13 years	570-4100 ng/L	890-6210 ng/L
14-15 years	930-6040 ng/L	1220-7010 ng/L
16-17 years	1170-6520 ng/L	1420-9000 ng/L

18-40 years	1330-7780 ng/L	1330-7780 ng/L
40-67 years	630-4700 ng/L	630-4700 ng/L

Dehydroepiandrosterone (DHEA) Sulfate

Serum dehydroepiandrosterone sulfate (DHEA-S) peaks around the third decade and then drop with age.

DHEA-S can be measured by radioimmunoassay, liquid chromatography-mass spectrometry, or chemiluminescent techniques, and the reference range varies with the technique used.

Normal findings

Tanner stage	Male	Female
Stage I	7-126 mcg/dL	7-209 mcg/dL
Stage II	13-241 mcg/dL	28-260 mcg/dL
Stage III	32-446 mcg/dL	39-390 mcg/dL
Stage IV-V	65-371 mcg/dL	81-488 mcg/dL

Desipramine Level

Antidepressants are multicyclic compounds that increase the concentration of monoamines in the synapse by inhibiting the metabolism of neurotransmitters or preventing their uptake. [1] Because of the high risk of suicidality in depressed patients, the safety of antidepressants after an overdose is of critical importance. Desipramine is a tricyclic antidepressant (TCA). Being the most potent sodium channel blocker among its group, it causes severe cardiotoxicity (eg, wide QRS complex, hypotension) without producing significant antimuscarinic symptoms.

The reference range for desipramine is as follows:

- Normal range: 100-300 ng/mL
- Potentially toxic level: >500 ng/mL

Deoxycorticosterone (DOC)

Deoxycorticosterone (DOC) is a C-21 (21 carbon atoms) steroid hormone synthesized in the zona fasciculata (ZF) and zona glomerulosa (ZG) of the adrenal gland and is a precursor for the synthesis of cortisol and aldosterone (see the image below).

The reference range for DOC can be seen in the table below.

Table 1. Deoxycorticosterone Reference Range

	Conventional units	SI units
Male	3.5-11.5 ng/dL	106-333 pmol/L
Female		

Follicular phase	1.5-8.5 ng/dL	45-257 pmol/L
Luteal phase	3.5-13 ng/dL	91-393 pmol/L
Pregnancy		
1st trimester	5-25 ng/dL	151-757 pmol/L
2nd trimester	10-75 ng/dL	303-2270 pmol/L
3rd trimester	30-110 ng/dL	908-3329 pmol/L
Children		
< 1 y	7-57 ng/dL	212-1725 pmol/L
1-5 y	4-49 ng/dL	121-1483 pmol/L
6-12 y		
Male	9-34 ng/dL	272-1029 pmol/L
Female	2-13 ng/dL	61-393 pmol/L

Dexamethasone Suppression Test

Types of dexamethasone suppression tests include high-dose suppression and low-dose suppression tests. Normal findings in prolonged testing include the following [1]:

- Low dose: >50% reduction of plasma cortisol
- High dose: >50% reduction of plasma cortisol
- Urinary free cortisol: < 20 mcg/24 hr (< 50 nmol/24 hr)

In the rapid (overnight) test, normal results find plasma cortisol levels suppressed to < 2 mcg/dL.

Dexamethasone/Corticotropin-Releasing Hormone Test

Testing corticotropin-releasing hormone (CRH) levels involves measuring the response to an intravenous bolus injection of synthetic ovine CRH at doses of 1 mcg (200 nmol) per kg of body weight (or total dose of 100 mcg) pushed over 30 seconds. [1]

Table 1. Serum Corticotropin [2, 3] (Open Table in a new window)

Plasma Concentration	Peak Level	Increase From Baseline	Time to Peak Level
Corticotropin	10-120 pg/mL (2.2-24 pmol)	35-900%	10-30 min postinjection

Cortisol	13-36 mcg/dL (360-1000 nmol/L)	20-600%	30-60 min postinjection

Diagnostic Influenza Tests

Diagnostic influenza tests aid with identification of influenza types A and B and influenza A subtypes 2009 H1N1, H1, H3, H5, N1, and N2. Variation exists among diagnostic methods for identification of types and subtypes of influenza (see Tables 1, 2, 3, and 4).

These tests can be used for any age or sex.

Qualitative: Positive or negative.

Differential Blood Count

A differential blood count gives the relative percentage of each type of white blood cell and also helps to reveal abnormal white blood cell populations (eg, blasts, immature granulocytes, and circulating lymphoma cells in the peripheral blood).

Reference ranges for differential white blood cell counts are as follows [1]:

- Neutrophils - 2500-8000 per mm^3 (55-70%)
- Lymphocytes - 1000-4000 per mm^3 (20–40%)
- Monocytes - 100-700 per mm^3 (2–8%)
- Eosinophils - 50-500 per mm^3 (1–4%)
- Basophils - 25-100 per mm^3 (0.5-1%)

Digoxin Level

Folk healers and physicians have used digitalis preparations for over 200 years to treat various illnesses. Like many other medications, digitalis was originally derived from a plant (foxglove). Digitalis strengthens the force of contractions of weakened hearts, but it is not a cardiac vitamin that can make a strong heart stronger. Digoxin and digitoxin are the main digitalis products. [1] Digoxin is absorbed quickly from the gastrointestinal tract with a bioavailability of between 75% and 95%. It is eliminated primarily through kidneys; therefore, it has a half-life of 36-48 hours in patients who have normal kidney function and 3.5-5 days in patients who are anuric. [2]

Therapeutic levels of digoxin are 0.8-2.0 ng/mL. The toxic level is >2.4 ng/mL.

Direct Antiglobulin Test

Direct antiglobulin test is used to demonstrate in vivo coating of red blood cells with IgG antibodies and complement (C3d). The assay uses Coombs reagent incubated with the patient's washed red blood cells. [1]

Normal findings: Negative; no agglutination

Diuretic Screening

Diuretic medications are used to artificially elevate the urination rate. Several types of diuretics can be used increase water excretion through distinct mechanisms.

The reference range value for urine diuretic screening is a negative test result.

The following are sought in a qualitative diuretic screening: metolazone, hydroflumethiazide, hydrochlorothiazide, furosemide, chlorthalidone, chlorothiazide, bumetanide, and benzthiazide.

Dopamine

Dopamine is a monoamine neurotransmitter that belongs to the catecholamine family; the catecholamine family includes dopamine, norepinephrine, and epinephrine. Dopamine is mainly produced in the nervous system and adrenal medulla; it plays a role in many brain functions like behavior and cognition.

The plasma reference ranges for dopamine are as follows [1]:

- Supine adults: < 10 ng/ml (conventional units); < 0.065 nmol/L (SI units)
- Ambulatory adults: < 20 ng/mL (conventional units); < 0.13 nmol/L (SI units)
- Age 3-15 years: < 60 pg/mL (conventional units); < 0.39 nmol/L (SI units)

The urinary reference range for dopamine in adults and elderly persons is 65-400 mcg/24 hr. [2]
The urinary reference ranges for dopamine in children are as follows [2]:

- 0-1 year: 0-85 mcg/24 hr
- 1-2 years: 10-140 mcg/24 hr
- 2-4 years: 40-260 mcg/24 hr
- >4 years: 65-400 mcg/24 hr

Eosinophils
Normal findings
Eosinophils (differential count): 1-4% [1]
Eosinophil blood count (absolute): 50-500/mm^3
Epinephrine
Epinephrine, a catecholamine secreted by the adrenal gland, is an important central nervous system (CNS) neurotransmitter and has a central role in autonomic regulation including intestinal and bronchial smooth muscle tone, vascular tone, glucose metabolism, and cardiac rate and contractility. Endogenous plasma concentrations in resting adults are normally small, less than 30 pg/mL, but may increase by markedly during stress. Traditionally urinary catecholamines, including epinephrine, are usually measured to diagnose disease states and not serum levels. However, some authors advocate for serum measurements.
The reference range of urinary epinephrine excretion varies by age, as follows.
Adult/elderly: < 20 mcg/24 hr or < 109 nmol/day (SI units) [1]
Child [1]:

- 0-1 year: 0-2.5 mcg/24 hr
- 1-2 years: 0-3.5 mcg/24 hr
- 2-4 years: 0-6 mcg/24 hr
- 4-7 years: 0.2-10 mcg/24 hr
- 7-10 years: 0.5-14 mcg/24 hr

Erythrocyte Count (RBC)
Normal red blood cell (RBC) findings
(RBC × 10^6/μL or RBC × 10^{12}/L [SI units]) [1]
Adult/elderly [1]:

- Male: 4.7-6.1
- Female: 4.2-5.4

Children [1]:

- Newborn: 4.8-7.1
- 2-8 weeks: 4-6
- 2-6 months: 3.5-5.5
- 6 months-1 year: 3.5-5.2
- 1-6 years: 4-5.5
- 6-18 years: 4-5.5

Erythrocyte Sedimentation Rate
Normal values for the erthyrocyte sedimentation rate (ESR), as derived using the Westergren method, are as follows [1]:

- Male: ≤15 mm/hr
- Female: ≤ 20 mm/hr
- Child: ≤10 mm/hr
- Newborn: 0-2 mm/hr

Erythropoietin

Erythropoietin testing, in combination with other tests, can be used to differentiate polycythemia vera from secondary polycythemia. It can also help differentiate between appropriate and inappropriate secondary polycythemia.
Normal findings [1] : 5-35 IU/L
Estradiol
Depending on the method of evaluation, reference intervals can vary from one clinical lab to another. In addition, the reference range of estradiol (E2) varies by age and sex.
The conversion factor is shown below.
Estradiol: pg/mL x 3.676 = pmol/L (molecular weight = 272)
Reference ranges for serum estradiol
Child < 10 years old: < 15 pg/mL [1]
Adult male: 10-50 pg/mL [1]
Adult female [1] :

- Follicular phase: 20-350 pg/mL
- Midcycle peak: 150-750 pg/mL
- Luteal phase: 30-450 pg/mL
- Postmenopause: ≤ 20 pg/mL

Reference ranges for urine estradiol (mcg/24 hours)
Child < 10 years old: 0-6 [1]
Adult male: 0-6 [1]
Adult female [1] :

- Follicular phase: 0-13
- Midcycle peak: 4-14
- Luteal phase: 4-10
- Postmenopause: 0-4

Ethanol Level
Ethanol level can be measured by blood, urine, saliva, or breath tests. Toxic concentration is dependent on individual tolerance and usage although levels greater than 300-400 mg/dL can be fatal due to respiratory depression. Conversion unit: one millimole of ethanol per liter of blood is equal to 4.61 milligrams of ethanol per 100 milliliters of blood. [1]
To convert serum ethanol level to BAC, move the decimal point 3 places to the left. Example, a 100 mg/dL serum ethanol level is equivalent to a 0.10 (g/dL) BAC, or 0.10% (weight/volume). This means that one tenth of a percent of a person's blood volume is alcohol or that a person has 1 part alcohol per 1000 parts blood. [2, 3]
At a blood ethanol level of less than 50 mg/dL, or 0.05% concentration, an individual is not considered to be intoxicated. The possible critical value for blood ethanol is >300 mg/dL. [4]
Urine ethanol levels vary widely and do not correlate well with blood alcohol level (and according to Wallach cannot be used to determine level of intoxication; see more below).
Factor II, Prothrombin Assay
Prothrombin is the precursor of thrombin in the coagulation pathway; it is synthesized in the liver, much as other vitamin K – dependent proteins are, and has a molecular weight of 72 kd. The plasma half-life of prothrombin is approximately 60 hours. [1]
Normal findings: The reference range is between 80% and 120% of normal values
Factor IX Assay
Factor IX (plasma thromboplastin component [PTC]) is produced in the liver. It is a single-chain zymogen with a molecular weight of 57 kd and a plasma half-life of 18-24 hours. It binds effectively to collagen not only in vitro [1] but also, apparently, in vivo, and this may account for the finding that when factor IX is infused into hemophilia B patients, recovery is only 50% of what was expected.
The reference range for factor IX is between 60% and 140% of normal values.

Factor V Assay

Factor V is a large glycoprotein with a molecular weight of 330,000 daltons and a plasma half-life of about 12 hours, with some reports of a half-life of up to 36 hours. [1] It functions as a cofactor in converting factor II to active factor II. It is proteolyzed by protein C/S complex. [2]

The reference range for factor V is as follows:

- 50-150% of normal

Factor VII Assay

Factor VII circulates as a single-chain zymogen with a molecular weight of about 50,000 daltons. It has the shortest half-life of the procoagulant factors, approximately 3-6 hours. [1] The human factor VII gene is located on chromosome 13, very close to the gene for factor X. [1] Research indicates that embryos deficient in factor VII develop normally, without evidence of hemorrhage. Nevertheless, factor VII–deficient newborns sometimes develop fatal intra-abdominal or intracranial hemorrhage. [2, 3]

The reference range for factor VII is 65-140% of normal.

Factor VIII Assay

Factor VIII (antihemophilic factor) is a key factor of the intrinsic clotting cascade. Normal hemostasis requires at least a quarter (25%) of factor VIII activity.

Symptomatic hemophiliacs usually have levels 5% of normal level. Disease is categorized as severe if the level is less than 1%, moderate if it is 1-5%, and mild if the level is more than 5%.

The reference range for factor VIII is 55-145% of normal.

Factor X Assay

Factor X is synthesized in the liver, and vitamin K is required for its production. The reference range of factor X is 45-155% of normal.

Factor XI Assay

The so-called contact factors include factor XI, factor XII, high-molecular-weight kininogen (HK), and prekallikrein (PK). Factor XI is synthesized in the liver and megakaryocytes and is an 80-kd zymogen precursor of a serine protease. It circulates in complex with the nonenzymatic cofactor HK [1] and has a mean plasma half-life of about 52 hours.

The reference range for factor XI is between 65% and 135% of normal values

Factor XII Assay

Factor XII, also known as Hageman factor, is indicated when factor XII deficiency is suspected.

Normal findings: 50-150% of normal

Factor XIII Assay

Factor XIII, an enzyme that cross-links fibrin, belongs to the blood coagulation system. [1, 2] Screening for factor XIII, also known as fibrin-stabilizing factor, is performed when its absence is suspected. [3]

Qualitatively, factor XIII levels are referred to as decreased or normal. [4] Quantitation of the enzyme's levels is carried out in research laboratories.

Factor-Inhibitor Assay

If, after an adequate infusion of factors VII, VIII, IX, XI, and V, bleeding continues, a factor-inhibitor assay is indicated. Although nearly all procoagulants have an inhibitor, the inhibitor to factor VIII is the most common.

Under normal circumstances, no factor inhibitors are present.

Ferritin

Ferritin is the cellular storage protein for iron. It is present in small concentrations in blood, and the serum ferritin concentration normally correlates well with total-body iron stores, making its measurement important in the diagnosis of disorders of iron metabolism. [1]

Reference ranges

Male: 12-300 ng/mL [2]

Female: 10-150 ng/mL{ref}

Children [2]:

- Newborn: 25-200 ng/mL
- ≤1 month: 200-600 ng/mL
- 2-5 months: 50-200 ng/mL
- 6 months-15 years: 7-142 ng/mL

Fibrin and Fibrinogen-Degradation Products

Fibrin and fibrinogen-degradation product (FDP) testing is commonly used to diagnose disseminated intravascular coagulation (DIC).

Normal findings

FDP: < 10 mcg/mL or < 10 mg/L (SI units) [1]

Possible critical values

FDP: > 40 mcg/mL [1]

Fibrinogen

Fibrinogen is a soluble protein in the plasma that is broken down to fibrin by the enzyme thrombin to form clots.

Fibrinogen reference ranges are as follows [1]:

- Adult: 200-400 mg/dL or 2-4 g/L (SI units)
- Newborn: 125-300 mg/dL

Possible critical value: < 100 mg/dL

Flecainide Level

Flecainide is used mainly for treatment and prevention of ventricular arrhythmia, paroxysmal supraventricular tachycardia, paroxysmal atrial fibrillation, and paroxysmal atrial flutter.

In adults, the reference range of the therapeutic trough of flecainide is 0.2-1 µg/mL. [1]

In children, the reference range of the therapeutic trough is 200-800 ng/mL, although concentrations of up to 800 ng/mL may be required for adequate control in some children.

Folate (Folic Acid)

Folate measurements are used in the diagnosis and management of megaloblastic anemia. The reference range of the plasma folate level varies by age, as follows [1]:

- Adults - 2-20 ng/mL, 2-20 µg/L, or 4.5-45.3 nmol/L
- Children - 5-21 ng/mL, 5-21 µg/L, or 11.3-47.6 nmol/L
- Infants - 14-51 ng/mL, 14-51 µg/L, or 31.7-115.5 nmol/L

The reference range of the red blood cell (RBC) folate level also varies by age, as follows [1]:

- Adults: 140-628 ng/mL or 317-1422 nmol/L
- Children: Over 160 ng/mL or over 362 nmol/L

However, since the United States instituted mandatory fortification of cereal grain products with folic acid, new adult reference values of 5.8-32.8 ng/mL (13.1-74.3 nmol/L) for serum folate and 153-515 ng/mL (347-1167 nmol/L) for erythrocyte folate have been proposed, demonstrating the importance of establishing regional and national reference values. [2]

Biochemical deficiency has been defined as a concentration of less than 3 ng/mL (< 6.7 nmol/L) for serum folate and less than 140 ng/ml (< 322 nmol/L) for erythrocyte folate.

Follicle-Stimulating Hormone (FSH)

Age-specific, gender-specific, and, for women, menstrual cycle phase–specific reference intervals have been established for follicle-stimulating hormone (FSH). (However, depending on the laboratory method used, variations in values can occur.)

Normal findings for FSH (IU/L)

Adult [1]

Male: 1.42-15.4

Female:

- Follicular phase: 1.37-9.9
- Ovulatory peak: 6.17-17.2

- Luteal phase: 1.09-9.2
- Postmenopause: 19.3-100.6

Child (age 1-10 years) [1]
Male: 0.3-4.6
Female: 0.68-6.7
Free and Total Carnitine
Carnitine is a quaternary, water-soluble ammonia compound biosynthesized from lysine and arginine. It serves as a mechanism for transport of long-chain fatty acids from the cytoplasm across the inner mitochondrial membrane and into the mitochondrial matrix, the site of b-oxidation of fatty acids for energy generation.
The reference range of carnitine depends on the laboratory being used; various ranges have been reported in the literature. [1]
The following table of values is derived from Belay et al 2006. [2] These examples do not imply endorsement of the laboratories cited, but instead are used for reference only.
Table. Reference Range of Carnitine at a Single Laboratory [2] (Open Table in a new window)

Age Range	Serum Free Carnitine (µmol/L)	Serum Total Carnitine (µmol/L)
Neonate	26-76	35-102
Child	41.4±10.4*	56.2±11.4*
Adolescent female	39.3±8.1*	53.2±8.9*
Adolescent male	39.6±9.3*	53.5±10.5*
Adult female	19.3-53.9**	28.1-66.4**
Adult male	38.8-69.5	44.2-79.3

*Mean ± standard deviation (SD)
**95% confidence interval (CI)

Quest Laboratories reports the reference range of total carnitine as follows [3]:

- Men: 30-70 µmol/L
- Women: 25-58 µmol/L
- Male children (age ≤17 years): 32-62 µmol/L
- Female children (age ≤17 years): 28-59 µmol/L

Quest Laboratories reports the reference range of free carnitine as follows [3]:

- Men: 23-59 µmol/L
- Women: 19-48 µmol/L
- Male children (age ≤17 years): 25-54 µmol/L
- Female children (age ≤17 years): 19-51 µmol/L

The University of California San Francisco Laboratory reports the normal values of free and total carnitine in adults as 18-69 µmol/L and 20-71 µmol/L, respectively. [4]

Chace et al (2003) examined free and total carnitine levels in newborns. The reference ranges depended both on technique used (radioenzyme vs tandem mass spectroscopy) and the sample type (whole blood vs serum). [5]
Variations in the ratio of free to total carnitine may also be important; typically, normal is reported as 0.1-0.4.
Fructosamine
A serum fructosamine (a glycated protein) level, similar to a hemoglobin A1c (HbA1c) level, enables assessment of long-term glycemic control in patients with diabetes mellitus. [1, 2, 3, 4, 5]
Normal values vary in relation to the serum albumin concentration and are 200-285 µmol/L when the serum albumin concentration level is 5 g/dL. [4] Reduction in serum albumin lowers the serum fructosamine value.
Fungal Culture
Fungal cultures are used to evaluate for suspected fungal disease (eg, candidiasis).
Normal findings: No growth in 24 days
Gamma Glutamyl Transferase
Gamma glutamyl transferase (GGT) is an enzyme found in cell membranes of many tissues mainly in the liver, kidney, and pancreas. [1] It is also found in other tissues including intestine, spleen, heart, brain, and seminal vesicles. The highest concentration is in the kidney, but the liver is considered the source of normal enzyme activity. [1]
The reference ranges for GGT are as follows [2] :

- Male and female age 45 years and older: 8-38 units/L or 8-38 international units (IU)/L (SI units)
- Female younger than age 45 years: 5-27 units/L or 5-27 IU/L (SI units)
- Elderly: Slightly higher than adult level
- Child: Similar to adult level
- Newborn: Five times higher than adult level

Gastrin
Tests for the hormone gastrin, which is secreted by G cells of the gastric antrum and the pancreatic islets of Langerhans, are used to investigate pernicious anemia and achlorhydria and to diagnose gastrinoma that is or is not associated Zollinger-Ellison syndrome.
Normal findings
Adult: 0-180 pg/mL or 0-180 ng/L (SI units) [1]
Elderly patients have higher gastrin levels. [1]
Child: 0-125 pg/mL
Genital Human Papillomavirus
Human papillomavirus (HPV) is a nonenveloped double-stranded DNA virus and member of the Papovaviridae family. HPV has a predilection for differentiating squamous epithelium, where it infects and transforms host cells. HPV-related cellular aberrancies in females are concentrated in the squamocolumnar region of the ectocervix, making this region ideal site for diagnostic sampling. Although over 100 strands of HPV have been identified, 35 have been shown to infect the genital epithelium.
Reference ranges, based on the test, are listed below.
Signal amplification DNA-based assays
Results show the ratio of the specimen reactivity to the positive control mean. A result is considered to be positive if its reactivity is at least that of the positive control. [1, 2]
Polymerase chain reaction
Amplified DNA from cells harboring human papillomavirus are used as positive controls. Tested samples are compared to the positive controls to determine positivity.
Gentamicin Level

Gentamicin is an antibiotic administered to treat severe blood infections caused by gram-negative bacilli.

Table 1. Optimal and Toxic Gentamicin levels [1] (Open Table in a new window)

Trough Gentamicin levels	Peak Gentamicin levels
Optimal: 0.5-2 µg/mL	Optimal: 5-10 µg/mL
Toxic: >2 µg/mL	Toxic: >12 µg/mL

Glucagon

Glucagon consists of 29 amino acids in a single-chain polypeptide with a molecular weight of 3485. It is produced by the alpha cells of the exocrine part of the pancreas and is removed by the liver and kidneys. Because glucagon has a half-life of just 3-6 minutes, collection of serum glucagon needs to occur in a chilled collecting tube with the immediate addition of a proteolytic enzyme inhibitor.

The reference ranges for glucagon can be found in the table below. [1]

Table 1. Glucagon Reference Ranges

Table. (Open Table in a new window)

Test	Source	Ages, conditions, etc.	Conventional Units	Conversion Factor	SI Units	Comments
Glucagon	Plasma	Adult	≤ 60 pg/mL	0.287	≤17.2 pmol/L	Centrifuge immediately under refrigeration. Store in plastic vial with 0.5 ml aprotinin (10,000KIU/mL) at -20°C. An overnight fast is required.
		Children				
		Cord blood	≤ 215 pg/mL		≤ 62 pmol/L	
		Day 1	≤ 240 pg/mL		≤ 69 pmol/L	
		Day 2	≤ 400 pg/mL		≤ 115 pmol/L	
		Day 3	≤ 420 pg/mL		≤ 121	

					pmol /L	
		Day 4-14	≤ 148pg/ mL		≤ 42 pmol /L	

Additional information on glucagon and glucose levels is as follows:

- For basic reference, the interval for glucagon is 50-100 pg/mL or 50-100 ng/L (SI units) [2]
- Blood glucose levels are measured in mg/dL
- Hypoglycemia is considered when the glucose value is less than 70 mg/dL
- The normal glucose range is 80-100 mg/dL
- The glucose range for prediabetes is 100-125 mg/dL

Glucose

The normal glucose reference ranges are as below [1]:

- Cord - 45-96 mg/dL or 2.5-5.3 mmol/L (SI units)
- Premature infant - 20-60 mg/dL or 1.1-3.3 mmol/L
- Neonate - 30-60 mg/dL or 1.7-3.3 mmol/L
- Infant - 40-90 mg/dL or 2.2-5.0 mmol/L
- Child < 2 years - 60-100 mg/dL or 3.3-5.5 mmol/L
- Adult - 74-106 mg/dL or 4.1-5.9 mmol/L

For children over age 2 years to adult, the normal reference ranges are as follows [1]:

- Fasting (ie, no caloric intake for at least 8 hours) - 70-100 mg/dL or < 5.5 mmol/L
- Casual or random (ie, any time of day, with no regard to food intake) - ≤200 mg/dL (< 11.1 mmol/L)

For elderly patients, the normal reference ranges are as follows [1]:

- 60-90 years - 82-115 mg/dL or 4.6-6.4 mmol/L
- >90 years - 75-121 mg/dL or 4.2-6.7 mmol/L

Possible critical values

These are as follows [1]:

- Adult male - < 50 and >400 mg/dL
- Adult female - < 40 and >400 mg/dL
- Infant - < 40 mg/dL
- Newborn - < 30 and >300 mg/dL

Two-hour postprandial glucose

Normal values are as follows [1]:

- 0-50 years - < 140 mg/dL or < 7.8 mmol/L (SI units)
- 50-60 years - < 150 mg/dL
- 60 years and older - < 160 mg/dL

Gram Stain

Gram stain is the most common stain used in microbiology to identify bacteria. It is named after Christian Gram, who first developed the technique to identify the organism responsible for pneumonia.

A normal value is defined as no pathologic organism seen in the smear.

Normal findings: Normal upper respiratory tract

Growth Hormone

Random growth hormone (GH) levels in a healthy person range as follows [1]:

- Men - < 5 ng/mL (mcg/L [SI units])

- Women - < 10 ng/mL (mcg/L [SI units])
- Newborns - 5-23 ng/mL (mcg/L [SI units])
- 1 week - 2-27 ng/mL (mcg/L [SI units])
- 1-12 mos - 2-10 ng/mL (mcg/L [SI units])
- 1 year (female) - 0-10 g/mL (mcg/L [SI units])
- 1 year (male) - 0-6 ng/mL (mcg/L [SI units])

GH suppression test value (using 100 g glucose) in a healthy person is as follows [1]:

- < 2 ng/mL

GH stimulation test values (normal) [1]:

- GH - > 10 mg/mL (mcg/L [SI units])
- Insulin-like growth factor 1 (IGF-1) - > 80 ng/mL

Obesity impairs GH release, so the GH levels required to diagnose deficiency should be lower in persons with obesity.

A study by Lee et al indicated that in patients with GH deficiency undergoing a GH stimulation test using dopamine, insulin, or arginine, a negative association exists between the individual's body mass index standard deviation score (BMI SDS) and the peak serum GH level derived through the test. Thus, according to the investigators, BMI factors should be taken into account in the interpretation of GH stimulation testing results. [2]

SI Units = Conventional Units X 1 (mcg/L = ng/mL X 1)

HDL Cholesterol

High-density lipoprotein cholesterol (HDL-C) is used in the assessment of coronary or other vascular pathology risk. [1]

Normal findings for HDL-C are as follows [2]:

- Male: >45 mg/dL or >0.75 mmol/L (SI units)
- Female: >55 mg/dL or >0.91 mmol/L (SI units)

Haptoglobin

Haptoglobin is an acute-phase reactant whose principal clinical utility is in defining conditions of hemolysis. levels can also become elevated in infection and inflammation.

The reference ranges for haptoglobin are as follows [1]:

- Adult: 50-220 mg/dL or 0.5-2.2 g/L (SI units)
- Newborn: 0-10 mg/dL or 0-0.1 g/L (SI units)

Possible critical value: < 40 mg/dL

Helicobacter Pylori Antigen Test

Helicobacter pylori antigen testing is approved by the US Food and Drug Administration (FDA) for use as a noninvasive diagnostic test for *H pylori* infection and as a test to determine eradication after treatment.

H pylori antigen testing has 3 distinct forms.

The first developed was an enzyme immunoassay (EIA), which uses polyclonal anti–*H pylori* capture antibody absorbed to microwells. This qualitative test results in a color change that indicates a positive or negative result. There are specific cutoff values of certain optical density, read by spectrophotometry, that are set by manufacturers for positive, negative, and equivocal results.

An EIA utilizing a monoclonal antibody was then developed that eliminated equivocal readings, creating better differentiation between results. [1] Possible results are as follows:

- Positive: *H pylori* antigen detected
- Equivocal: See Interpretation
- Negative: *H pylori* antigen not detected

Lastly, there is an immunochromatographic test with a monoclonal antibody. It has a positive line to indicate a positive reading accompanied by a control line. [1] Possible results are as follows:

- Both positive and control lines present: *H pylori* antigen detected
- Control line only present: *H pylori* antigen not detected

Blood test (normal findings)

Immunoglobulin M (IgM) [2]:

- ≤30 U/mL: Negative
- 30.01-39.99 U/mL: Equivocal
- ≥40 U/mL: Positive

IgG [2]:

- < 0.75: Negative)
- 0.75-0.99: Equivocal
- ≥1: Positive

Breath test (normal findings)

No evidence of *H pylori*. [2]

Stool test (normal findings)

No evidence of *H pylori*.

Hematocrit

The reference range varies depending on the methodology used. Normal ranges should be validated by individual clinical laboratories.

Reference ranges (SI units/conventional units) are as follows:

- Males - 0.40-0.54/40-54%
- Females - 0.36-0.46/36-46%
- Newborns - 0.53-0.69/53-69%

Hemoglobin A1c Testing

The reference interval for hemoglobin A1c is 4.0-5.6% (20-38 mmol/mol) [1]:

The decision limits for nonpregnant adults, according to the American Diabetes Association, are as follows [1]:

- The diagnostic criterion for diabetes is a hemoglobin A1c level greater than or equal to 6.5% (48 mmol/mol)
- For patients with diabetes mellitus, the goal of therapy, in general, is a level below 7.0% (53 mmol/mol)
- A goal of less than 6.5% (48 mmol/mol) may be appropriate for some patients who can achieve this without significant episodes of hypoglycemia (eg, persons newly diagnosed with diabetes, individuals with diabetes who are managed with diet and exercise alone)
- For elderly patients, patients with a short life expectancy, and patients with frequent/severe episodes of hypoglycemia, a less strict goal of below 8% (64 mmol/mol) may be more appropriate and must be determined on an individualized basis

Note: Different associations may have different hemoglobin A1c treatment goals; for example, the American Association of Clinical Endocrinologists recommends a treatment goal of less than 6.5% (48 mmol/mol) for most patients.

Hemoglobin Concentration (Hb)

The reference ranges for hemoglobin (Hb) concentrations in adults are as follows [1]:

- Male: 14-18 g/dL or 8.7-11.2 mmol/L (SI units)
- Female: 12-16 g/dL or 7.4-9.9 mmol/L (SI units)
- Pregnant female: >11 g/dL
- Elderly: Slight decrease in values

The reference ranges for Hb concentrations in children are as follows [1]:

- Newborn: 14-24 g/dL
- 0-2 weeks: 12-20 g/dL

- 2-6 months: 10-17 g/dL
- 6 months-1 year: 9.5-14 g/dL
- 1-6 years: 9.5-14 g/dL
- 6-18 years: 10-15.5 g/dL

Possible critical values [1]:

- < 5.0 g/dL or >20 g/dL

Hemoglobin Electrophoresis

Hemoglobin electrophoresis is used as a screening test to identify normal and abnormal hemoglobins and assess their quantity. Hemoglobin types include hemoglobin A_1 (HbA_1), hemoglobin A_2 (HbA_2), hemoglobin F (HbF; fetal hemoglobin), hemoglobin C (HbC), and hemoglobin S (HbS). Hemoglobin reference ranges are as follows.

Adult/elderly: Percentage of total Hb [1]:

- HbA_1: 95-98%
- HbA_2: 2-3%
- HbF: 0.8-2%
- HbS: 0%
- HbC: 0%
- HbE: 0%

Children: HbF [1]:

- Newborn: 50-80%
- < 6 months: < 8%
- >6 months: 1-2%

Hepatitis B Test

Hepatitis B virus (HBV) testing plays an important role in detection, classification, and management of HBV disease.

Results of HBV serologic markers can be reported qualitatively or quantitatively as international units (IU) or signal per cutoff (s/c) value. For example, a hepatitis B surface antigen (HBsAg) level of less than 1 s/c is considered negative, while a level of more than 5 s/c is considered positive. Any value between 1 and 5 s/c is indeterminate and should be repeated. For hepatitis B surface antibody (anti-HBs), a level less than 5 mIU is considered negative, while a level more than 12 mIU is considered protective. Any value between 5 and 12 mIU is indeterminate and should be repeated.

There is no standardization between laboratories, and these cutoff values tend to vary between manufacturers. Therefore, results are usually reported as “negative” or “positive.” The laboratory or manufacturer’s insert should be referenced for quantitative measurement, if required.

These following reference ranges are based on qualitative measurement of serologic markers in an asymptomatic, nonimmunized population.

- HBsAg: Negative
- Anti-HBs: Negative; a level of greater than 10-12 mIU/mL is protective
- Immunoglobulin M (IgM) hepatitis B core antibody (anti-HBc): Negative
- Immunoglobulin G (IgG) anti-HBc: Negative
- Hepatitis B e-antigen (HBeAg): Negative
- Hepatitis B e-antibody (anti-HBe): Negative
- HBV DNA: Negative

Hepatitis C Test

The following assays are used for diagnosing and managing hepatitis C (HCV) infection:

- Serologic assays - These detect a specific antibody to the hepatitis C virus (anti-HCV) in the serum or plasma and are reported as a positive or a negative value

- Molecular assays - These detect viral nucleic acid and can be qualitative or quantitative. Quantification of the virus is reported using international units per milliliter (IU/mL).
- Genotyping assays - These are most useful in epidemiological studies and are clinically used to predict the likelihood of response and duration of therapy; they help to classify the virus into the 6 major genotypes.

Herpes Simplex Viral Culture

Normal findings in herpes simplex viral culture [1]:

- No virus present
- No herpes simplex virus (HSV) antibodies present

High-Sensitivity C-Reactive Protein

The reference ranges for C-reactive protein (CRP) and high-sensitivity CRP (hs-CRP) are as follows. [1]

Normal findings: < 1.0 mg/dL or < 10.0 mg/L (SI units)

Cardiac risk:

- Low: < 1.0 mg/dL
- Average: 1.0-3.0 mg/dL
- High: > 3.0 mg/dL

Homocysteine

Plasma and urine homocysteine tests are indicated in the screening and diagnosis of different types of homocystinuria.

Normal findings: 4-14 µmol/L (Levels may rise with age.)

Human Chorionic Gonadotropin (hCG)

Human chorionic gonadotropin (hCG) is produced during pregnancy. It can support pregnancy by allowing for the production of progesterone, which can help to prepare the lining of the uterus for implantation. It consists of cells that ultimately form the placenta, which provides nutrition to the egg after it has been fertilized and connects to the uterine wall. [1, 2]

hCG is a dimer consisting of a 145 amino acid beta-subunit that is unique to hCG and a 92 amino acid alpha-subunit. The alpha-subunit is identical to that for luteinizing hormone (LH), follicle-stimulating hormone (FSH), and thyroid-stimulating hormone (TSH). The alpha and beta-subunits have separate genes on separate chromosomes (chromosomes 6 and 19, respectively). After synthesis, the alpha and beta-subunits are bonded with a noncovalent bond before being released into the circulation.

For males and nonpregnant females, the normal level for hCG is < 2 IU/L. With regard to the detection of pregnancy in females, hCG values represent the following [3]:

- Negative: < 5 IU/L
- Indeterminate: 5-25 IU/L
- Positive: >25 IU/L

Hydroxyproline

As a major part of collagen, hydroxyproline has an essential role in collagen stability. Testing hydroxyproline in the serum and in the urine is common.

The reference range of hydroxyproline is as follows: [1]

- Total hydroxyproline in the urine among those aged 18-21 years - 13-28 mg/24/m^2
- Total hydroxyproline in the urine among those aged 22-55 years - 8.5-23.5 mg/24/m^2
- Free hydroxyproline in the serum of males - 0.7-1.55 µg/mL
- Free hydroxyproline in the serum of females - 0.7-1.40 µg/mL

Imipramine Level

Imipramine (Tofranil) is a tricyclic antidepressant that has been used for the treatment of not only depression, but also panic attacks, enuresis, and chronic pain syndromes.

The therapeutic levels of the imipramine and desimpramine concentration are 150-350 ng/mL. Other important laboratory values associated with imipramine include the following:

- Minimum toxic level: 300 ng/mL
- Toxic concentration/critical laboratory value: 1000 ng/mL
- Lethal dose: 2 g
- Terminal elimination half-life of imipramine (parent drug): 10-16 hours
- Terminal elimination half-life of desimpramine (active metabolite): 12-30 hours
- Volume of distribution: 10-30 L/kg

Immunofixation

Immunofixation consists of an electrophoresis phase and a fixation phase.[1] Serum or urine immunofixation negative for a monoclonal protein or a polyclonal pattern is considered to be normal. Cerebral spinal fluid (CSF) immunofixation that does not reveal oligoclonal bands is also considered normal. A polyclonal immunoglobulin pattern in the serum or urine immunofixation is considered to be nonspecific.

Immunoglobulins

Immunoglobulins are glycoprotein molecules that are produced by plasma cells in response to an immunogen. Indications for serum immunoglobulin testing include diagnosis and monitoring of monoclonal gammopathies and immune deficiencies.

Reference ranges of immunoglobulins may vary based on sex and factors such as alcohol use, smoking status, and chronic conditions (eg, diabetes/metabolic syndrome) (see Considerations).

Normal findings

Age and methods impact results.[1]

Immunoglobulin G (IgG) (mg/dL)[1]

- Adults: 565-1765
- Children: 250-1600

IgA (mg/dL)[1]

- Adults: 85-385
- Children: 1-350

IgM (mg/dL)[1]

- Adults: 55-375
- Children: 20-200

IgD and IgE[1]

- Minimal

Insulin

Insulin is an anabolic hormone that promotes glucose uptake, glycogenesis, lipogenesis, and protein synthesis of skeletal muscle and fat tissue through the tyrosine kinase receptor pathway. In addition, insulin is the most important factor in the regulation of plasma glucose homeostasis, as it counteracts glucagon and other catabolic hormones—epinephrine, glucocorticoid, and growth hormone.

Table 1. Reference Range of Insulin Levels[1] (Open Table in a new window)

	Insulin Level	Insulin Level (SI Units*)
Fasting	< 25 mIU/L	< 174 pmol/L
30 minutes after glucose administration	30-230 mIU/L	208-1597 pmol/L

1 hour after glucose administration	18-276 mIU/L	125-1917 pmol/L
2 hour after glucose administration	16-166 mIU/L	111-1153 pmol/L
≥3 hours after glucose administration	< 25 mIU/L	< 174 pmol/L
*SI unit: conversional units x 6.945		

Iron

The amount of circulating iron bound to transferrin is reflected by the serum iron level.

The serum iron reference ranges are as follows [1]:

- Male: 80-180 mcg/dL or 14-32 μmol/L (SI units)
- Female: 60-160 mcg/dL or 11-29 μmol/L (SI units)
- Newborn: 100-250 mcg/dL
- Child: 50-120 mcg/dL

Iron-Binding Capacity

The index of transferrin present in circulating blood is the iron-binding capacity. Transferrin can be nearly one-third saturated with iron. The unsaturated iron-binding capacity (UIBC) is measured using radioactive iron or spectrophotometric approaches. The sum of the UIBC and the plasma iron is the total iron-binding capacity (TIBC). [1] Direct measurement of the TIBC may also be performed. [2]

The iron-binding capacity reference range is 255-450 μg/dL.

Joint-Fluid Crystal

Gout and pseudogout are the 2 most common crystalline arthropathies and are caused by deposition of monosodium urate (MSU) and calcium pyrophosphate dihydrate (CPPD) crystals, respectively. This causes inflammation, pain, and destruction of the joint. These 2 pathologies are often diagnosed clinically but can only be done so with certainty by microscopic analysis of synovial fluid.

A normal joint-fluid aspirate is negative for any crystals.

Some other parameters for joint-fluid reference ranges are as follows [1]:

- Synovial appearance - Clear
- Synovial color - Pale yellow
- Synovial red blood cell (RBC) count - 0
- Synovial white blood cell (WBC) count - 0-150/mm ^{3}
- Synovial neutrophils - 7%
- Synovial lymphocytes - 24%
- Synovial monocytes - 48%
- Synovial macrophages - 10%
- Glucose - Same as fasting blood glucose
- Protein - 1-3 dL
- Lactic acid dehydrogenase - < 25 mg/dL
- Uric acid - 6-8 mg/dL
- Gram stain - Negative

Note that the exact ranges can vary per lab.

Ketones

Acetoacetate, beta-hydroxybutyrate, and acetone are ketone bodies. In carbohydrate-deficient states, fatty-acid metabolism spurs acetoacetate accumulation. The reduction of acetoacetate in the mitochondria results in beta-hydroxybutyrate production. Beta-hydroxybutyrate and

acetoacetate, the predominant ketone bodies, are rich in energy. Beta-hydroxybutyrate and acetoacetate transport energy from the liver to other tissues.
Acetone forms from the spontaneous decarboxylation of acetoacetate. Acetone is the cause of the sweet odor on the breath in persons with ketoacidosis. [1, 2, 3] Ketone bodies fuel the brain with an alternative source of energy (close to two thirds of its needs) during periods of prolonged fasting or starvation, when the brain cannot use fatty acids for energy.
The reference range for ketone is a negative value, at less than 1 mg/dL (< 0.1 mmol/L).
LDL Cholesterol
Normal blood test findings for low-density lipoprotein cholesterol (LDL-C) are as follows [1] :

- Adult - < 130 mg/dL
- Children - < 110 mg/dL

Laboratory Diagnostics and Testing Guidance for COVID-19
Because the signs and symptoms of coronavirus disease 2019 (COVID-19) may overlap with those of other respiratory pathogens, it is important to perform laboratory testing to specifically identify symptomatic individuals infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Moreover, it is estimated that up to 40% of people with SARS-CoV-2 infection may be asymptomatic (subclinical infection) or presymptomatic, and still potentially capable of transmitting the virus to others. [1, 2] Therefore, in certain cases, individuals without obvious signs or symptoms of SARS-CoV-2 infection also require testing.
Currently, there are three basic types of tests to determine if an individual has been infected with SARS-CoV-2: viral nucleic acid (RNA) detection, viral antigen detection, and detection of antibodies to the virus. Viral tests (nucleic acid or antigen detection tests) are used to assess acute infection, whereas antibody tests provide evidence of prior infection with SARS-CoV-2. (The US Food and Drug Administration [FDA] has not authorized the use of antibody tests for the diagnosis of acute infection.)
Cell culture isolation of SARS-CoV-2 is possible, but the Centers for Disease Control and Prevention (CDC) recommends that clinical laboratories not attempt this unless it is performed in a biosafety level 3 (BSL-3)–certified laboratory.
With any type of laboratory test, the clinical accuracy or reliability depends on performance characteristics such as sensitivity and specificity, as well as the pretest probability that a person has SARS-CoV-2 infection and the prevalence of COVID-19 in the local community. Taken together, these parameters determine whether a positive or negative result should be interpreted as correct.
Lead
Lead is a heavy metal that is mostly found as a compound in the Earth’s crust. The largest use of lead in the present day and age is in batteries of cars.
The reference ranges for lead are as follows:

- Normal levels in children: < 10 µg/dL (If screening test at 6 months shows more than 2 µg/dL, repeat testing is warranted in 1 year and exposure prevention strategies should be initiated.)
- Normal levels in adult: < 25 µg/dL

Leukocyte Count (WBC)
The reference range for adults (males and females) is as follows [1] :

- Total leukocytes (adults and children >2 years) - 5000-10,000/mm^3
- Total leukocytes (children aged 2 years or below) - 6200-17,000/mm^3
- Total leukocytes (neonates) - 9000-30,000/mm^3
- Neutrophils - 2500-8000/mm^3
- Lymphocytes - 1000-4000/mm^3
- Monocytes - 100-700/mm^3
- Eosinophils - 50-500/mm^3

- Basophils - 25-100/mm^3

Lidocaine Level

Lidocaine is an amide-type local anesthetic available as a crystalline powder soluble in alcohol and normal saline. It suppresses ventricular ectopy in the setting of myocardial infarction and increases the ventricular fibrillation threshold. These actions prevent PVCs from inducing ventricular fibrillation.

Lidocaine is a class IB antiarrhythmic used as a second-line agent and after myocardial infarction in certain groups of patients to treat premature ventricular contractions, ventricular tachycardia, and fibrillation. [1]

Normal findings [2]:

- Lidocaine has a therapeutic drug range of 1.5-5.0 mcg/mL
- For lidocaine, the toxic drug range is > 5 mcg/mL

Lipase

Lipase is produced by the pancreas, liver, intestine, tongue, stomach, and many other cells. Lipase testing is indicated in acute pancreatitis, as well as in the diagnosis of peritonitis, strangulated or infarcted bowel, and pancreatic cyst. [1]

The reference range for lipase is 0-160 U/L or 0-160 U/L (SI units), although values depend on method.

Lipid Profile (Triglycerides)

Triglycerides are lipid compounds composed of a glycerol esterified to 3 fatty acid chains of varying length and composition. These fatty acid chains can be saturated or unsaturated, and the chemical composition of each chain is different. Each chain consists of carbon and hydrogen atoms with varying single or double-bonded chains, depending on the degree of saturation or unsaturation. Triglycerides are formed of mixed chains, and the structural comparison between the chains is heterogenous in nature.

Adult/elderly

Normal findings in adult and elderly individuals are as follows [1]:

- Male - 40-160 mg/dL or 0.45-1.81 mmol/L (SI units)
- Female - 35-135 mg/dL or 0.40-1.52 mmol/L (SI units)

Child/adolescent

Normal findings in children aged 0-5 years are as follows [1]:

- Male - 30-86 mg/dL
- Female - 32-99 mg/dL

Normal findings in children aged 6-11 years are as follows [1]:

- Male - 31-108 mg/dL
- Female - 35-114 mg/dL

Normal findings in children and adolescents aged 12-15 years are as follows [1]:

- Male - 36-138 mg/dL
- Female - 41-138 mg/dL

Normal findings in young people aged 16-19 years are as follows [1]:

- Male - 40-163 mg/dL
- Female - 40-128 mg/dL

Values of possible medical urgency

A fasting triglyceride level of over 400 mg/dL may indicate medical urgency.

Lipoprotein (a)

Reference ranges for lipoprotein (a) (Lp[a]), a type of low-density lipoprotein (LDL), vary, being dependent on assay and reporting laboratories. They also differ by population and may vary regionally worldwide. Nonetheless, many US lipidologists generally consider an Lp(a) level of less than 10 mg/dL to indicate a lower cardiovascular risk. Levels higher than 10 mg/dL are associated with an increase in cardiovascular risk (see Interpretation).

The apolipoproteins have a primary responsibility for the transport of lipids and cholesterol. Apolipoprotein B (apoB) is a nonexchangeable lipoprotein that exists in two forms in humans, apoB-100 and apoB-48.

Lithium Level

Lithium is used in the treatment of both manic and depressive phases of bipolar disorder, as well as in unipolar depressive disorder to prevent future depressive episodes. Patients refractory to antidepressants may be treated with lithium as an adjunct to other drugs. [1, 2, 3]

Depending on the indication for lithium treatment, target serum concentrations vary.

The reference range for therapeutic levels of lithium is 0.8-1.2 mEq/L.

However, a study by Hsu et al indicated that in patients with euthymic bipolar disorder, lithium serum levels of 0.4-0.8 mmol/L significantly inhibit the recurrence of major mood episodes, although this effect was found only in patients aged 40-60 years. The adjusted hazard ratio (aHR) was 0.75, compared with 0.77 for levels of 0.8-1.2 mmol/L, with the aHR for levels below 0.4 mmol/L being used as reference. [4]

The toxic lithium level is >2 mEq/L.

Lupus Erythematosus (LE) Cell Test

Lupus erythematosus (LE) cell testing was once performed to diagnose systemic lupus erythematous but has been replaced for this purpose by antinuclear antibody (ANA) testing.

Negative findings on LE cell testing exclude a diagnosis of systemic lupus erythematosus (SLE).

The presence of LE cells indicates lupus.

A smear is considered positive when 10 or more characteristic LE cells are seen during a 15-minute search, associated with the presence of extracellular, amorphous, nuclear masses. The presence of LE cells in bone marrow or body fluids is also a clue leading to the diagnosis of SLE.

Luteinizing Hormone

The reference range for luteinizing hormone (LH) is as follows:

Normal findings for luteinizing hormone (LH)

Adult [1]

Male: 1.24-7.8 IU/L

Female:

- Follicular phase: 1.68-15 IU/L
- Ovulatory peak : 21.9-56.6 IU/L
- Luteal phase: 0.61-16.3 IU/L
- Postmenopause: 14.2-52.3 IU/L

Child (age 1-10 years) [1] :

- Male: 0.04-3.6 IU/L
- Female: 0.03-3.9 IU/L

Lyme Disease Serology

Because of the significant false positivity associated with test results, even among healthy populations from nonendemic regions, serologic testing for Lyme disease should only be performed if the clinician estimates the chance is at least 20% chance that the patient has active Lyme disease.

Normal levels vary depending on the laboratory assay performed, as follows.

Borrelia burgdorferi antibody enzyme immunoassay (Lyme index value) [1] :

- < 0.9 = negative
- 0.91-1.09 = equivocal
- >1.1 = positive

Western blot [1] :

- ≥5 different immunoglobulin G (IgG) antibodies reactive = positive

- ≥2 different IgM antibodies reactive = positive

See Lyme Disease and 4 Emerging Tick-Borne Illnesses, a Critical Images slideshow, to help identify and treat several tick-borne conditions.

Magnesium

Magnesium is one of the major intracellular cations. For normal neuromuscular activity, humans need normal concentration of extracellular calcium and magnesium. Intracellular magnesium is an important cofactor for various enzymes, transporters, and nucleic acids that are essential for normal cellular function, replication, and energy metabolism. [1]

Normal findings [2]:

- Adult: 1.3-2.1 mEq/L or 0.65-1.05 mmol/L (SI units)
- Child: 1.4-1.7 mEq/L
- Newborn: 1.4-2 mEq/L

Possible critical values [2]:

- < 0.5 mEq/L or >3 mEq/L

Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC)

The reference ranges for mean corpuscular hemoglobin (MCH) are as follows [1]:

- Adult/elderly/child: 27-31 pg
- Newborn: 32-34 pg

The reference ranges for mean corpuscular hemoglobin concentration (MCHC) are as follows [1]:

- Adult/elderly/child: 32-36 g/dL (or 32-36%)
- Newborn: 32-33 g/dL (or 32-33%)

Mean Corpuscular Volume (MCV)

Mean corpuscular volume (MCV) is the average volume of red cells in a specimen. MCV is elevated or decreased in accordance with average red cell size; ie, low MCV indicates microcytic (small average RBC size), normal MCV indicates normocytic (normal average RBC size), and high MCV indicates macrocytic (large average RBC size).

The reference ranges for MCV are as follows [1]:

- Adult/elderly/child: 80-95 fL
- Newborn: 96-108 fL

Methemoglobin

An assessment of methemoglobin levels is indicated as part of numerous tests used when methemoglobinemia is clinically suspected.

Normal findings [1]:

- 0.06-0.24 g/dL or 9.3-37.2 µmol/L (SI units)
- 0.4-1.5% of total hemoglobin

Possible critical values > 40% of total hemoglobin

Methylmalonic Acid

Methylmalonic acid (MMA) levels are commonly used to evaluate for vitamin B-12 deficiency. The normal value for MMA is < 3.6 µmol/mmol creatinine.

Microalbumin

Microalbuminuria is defined as excretion of 30-300 mg of albumin per 24 hours (or 20-200 mcg/min or 30-300 mcg/mg creatinine) on 2 of 3 urine collections. [1, 2]

The detection of low levels of albumin excretion (microalbuminuria) has been linked to the identification of incipient diabetic kidney disease. This phase calls for aggressive management to prevent or retard overt diabetic nephropathy.

The reference ranges for microalbumin are detailed in the table below. [3, 4]

Table 1. American Diabetic Association Classification of Microalbuminuria (Open Table in a new window)

Spot Collection	Timed Collection	24-hr Collection	Category
Less than 30 mcg/mg creatinine	Less than 20 mcg/min	Less than 30 mg	Normal
30-300 mcg/mg creatinine	20-200 mcg/min	30-300 mg	Microalbuminuria
More than 300 mcg/mg creatinine	More than 200 mcg/min	More than 300 mg	Clinical albuminuria

A normal finding for albumin in urine is less than 2 mg/dL, with normal albumin/creatinine ratios being as follows [5]:

- Males: < 17 mg albumin/g creatinine
- Females: < 25 mg albumin/g creatinine

N-Terminal Telopeptide

The biomarker N-terminal telopeptide (NTX), as detected in urine, is reported in nmol of bone collagen equivalents (BCE)/mmol creatinine. Therefore, detectable levels of creatinine in urine are needed to report normalized levels of NTX. [1]

The reference ranges for NTX in urine, as measured in nm BCE/mm creatinine, are as follows [2]:

- Male: 21-83
- Female (premenopausal): 17-94
- Female (postmenopausal): 26-124

The reference ranges for NTX in serum, as measured in nm BCE, are as follows [2]:

- Male: 5.4-24.2
- Female: 6.2-19

Neisseria Gonorrhoeae Culture

Neisseria gonorrhoeae culture is indicated in the diagnosis of *N gonorrhoeae* infection. *N gonorrhoeae* causes the sexually transmitted disease gonorrhea, among other diseases.

N gonorrhoeae culture results in uninfected persons are negative, meaning no growth.

Osmotic Fragility of Erythrocytes

The osmotic fragility test (OFT) is used to measure erythrocyte resistance to hemolysis while being exposed to varying levels of dilution of a saline solution.

There is no true consensus among laboratories in terms of a reference range of values for the osmotic fragility of erythrocytes.

Incubation of erythrocytes at 37°C for 24 hours increases the test's sensitivity.

Normal findings [1]:

- Hemolysis begins at 0.5% NaCl
- Hemolysis complete at 0.3% NaCl

Parathyroid Hormone

Parathyroid hormone (PTH) is produced by the 4 parathyroid glands, which reside behind the thyroid gland in the anterior neck. The release of PTH is normally stimulated by low calcium levels in the body. PTH release results in a signal to the bones to release calcium into the bloodstream and also to the kidneys to resorb calcium in the collecting system and excrete phosphorus.

In addition, PTH plays an active role in the intestines, resulting in the conversion of vitamin D into its active form (PTH increases the activation of 25-hydroxy vitamin D to 1,25-dihydroxy vitamin D in the kidneys), which then stimulates the intestines to absorb both calcium and phosphorus. [1]

The reference ranges for PTH are as follows [2]:

- Intact (whole): 10-65 pg/mL or 10-65 ng/L (SI units)
- N terminal: 8-24 pg/mL
- C terminal: 50-330 pg/mL

Parathyroid Hormone-Related Peptide

No detectable (or minimal) parathyroid hormone–related protein (PTHrP) is normal.

Partial Thromboplastin Time - Lupus Anticoagulant Screen

Activated partial thromboplastin time (aPTT): 30-40 seconds [1]

PTT: 60-70 seconds [1]

Patients receiving anticoagulant therapy: 1.5-2.5 times the control value in seconds [1]

Possible critical values [1]:

- APTT: > 70 seconds
- PTT: > 100 seconds

In general, healthy subjects do not have a prolonged aPTT and do not have lupus anticoagulant (LA) activity.

Partial Thromboplastin Time, Activated

Partial thromboplastin time (PTT) and activated partial thromboplastin time (aPTT) are used to test for the same functions; however, in aPTT, an activator is added that speeds up the clotting time and results in a narrower reference range. The aPTT is considered a more sensitive version of the PTT and is used to monitor the patient's response to heparin therapy.

The reference range of the aPTT is 30-40 seconds. [1, 2, 3]

The reference range of the PTT is 60-70 seconds.

In patients receiving anticoagulant therapy, the reference range is 1.5-2.5 times the control value in seconds.

Critical values that should prompt a clinical alert are as follows:

- aPTT: More than 70 seconds (signifies spontaneous bleeding)
- PTT: More than 100 seconds (signifies spontaneous bleeding)

Pericardial Fluid Analysis

Pericardial fluid is collected via pericardiocentesis or open surgical drainage.

The specimen stability is as follows:

- Room temperature - 7 days
- Refrigerated - 7 days
- Frozen - 28 days

Cells may degenerate during storage. Therefore, the pericardial fluid sample for cytopathology study should be sent to the laboratory as soon as possible in a fresh state or refrigerated at 2-8º C.

The volume must be a minimum of 2 mL for each laboratory test.

Referring to each laboratory for more specific instructions about sample collection and transport is important.

Routine panels are as follows:

- Cell count with differential
- Glucose level
- Pericardial fluid total protein
- Pericardial fluid lactate dehydrogenase (LDH)
- Serum Complement (anti-dsDNA, rheumatoid factor [RF], antinuclear antibody [ANA])

- Gram stain and culture (at least 3 culture bottles from pericardial fluid)

Special panels are as follows:

- Cytology (if malignancy is suspected)
- Tumor markers (if malignancy is suspected)
- Adenosine deaminase (if tuberculosis [TB] is suspected)
- Polymerase chain reaction (PCR) for *Mycobacterium tuberculi* (if TB is suspected)
- Pericardial interferon-gamma (interferon-gamma) if TB is suspected
- Viral cultures
- Molecular analysis (PCR) for bacteriological, viral, or fungal agents
- B-type natriuretic peptide (BNP)

Normal findings

Less than 50 mL of clear, straw-colored fluid with no bacteria, blood, or malignant cells evident

Pertussis Test

Pertussis is a respiratory tract infection caused by the gram-negative coccobacillus *Bordetella pertussis*. Pertussis is transmitted by droplet transfer (usually from sneezing or coughing) from an infected person. Pertussis is also known as whooping cough.

In most cases, a negative pertussis result indicates the absence of whooping cough.

Phenobarbital Level

Phenobarbital is a barbiturate that reduces excitatory synaptic responses by acting on $GABA_A$ receptors. It is most commonly used in the treatment of seizures, including tonic-clonic seizures and in status epilepticus. Studies have also shown its efficacy in treating benzodiazepine toxification and perinatal asphyxia. [1, 2]

The therapeutic reference range of phenobarbital is 10-30 mcg/mL. [3]

The toxic reference range of phenobarbital is >40 mcg/mL.

Phenytoin Level

Phenytoin is used as both an abortive and preventive medication in seizure management. [1, 2, 3]

The total phenytoin reference range varies by age, as follows:

- Children and adults: 10-20 µg/mL [4]
- Neonates: 8-15 µg/mL

Toxic phenytoin levels are defined as greater than 30 µg/mL. [4]

Lethal levels are defined as greater than 100 µg/mL.

The reference range of free phenytoin is 1-2.5 µg/mL.

In patients with renal failure associated with hypoalbuminemia, free phenytoin levels may be more accurate than total phenytoin levels. [5, 6] However, the Sheiner-Tozer formula (below) can be used to correct the phenytoin level. [5, 7]

Adjusted concentration = measured total concentration / [(0.2 x albumin) + 0.1]

Phosphate (Phosphorus)

Phosphate concentration is characterized by a high physiologic variation, depending on age, gender, physiologic state (eg, pregnancy), and even season (due to the seasonal variation of vitamin D, which is directly involved in the regulation of phosphate concentration).

Reference intervals based on patient age are as follows [1] :

- Adult: 3.0-4.5 mg/dL or 0.97-1.45 mmol/L (SI units)
- Elderly: values slightly lower than adult
- Child: 4.5-6.5 mg/dL or 1.45-2.1 mmol/L (SI units)
- Newborn: 4.3-9.3 mg/dL or 1.4-3 mmol/L (SI units)

The possible critical value is < 1 mg/dL.

Plasminogen

Plasminogen (PLG) is a glycoprotein (molecular weight 92 kDa) synthesized in the liver, and it circulates in the blood, with a half-life of 2.2 days. Plasminogen is the precursor of plasmin,

which lyses fibrin clots to fibrin degradation products (FDP) and D-dimer; the conversion to active protease is mediated by tissue-type (tPA) and urokinase-type (uPA) plasminogen activators. Generated plasmin is quickly inactivated by its main inhibitor alpha2-antiplasmin. [1, 2, 3]

Normal findings: 2.4-4.4 Committee on Thrombolytic Agents (CTA) units/mL

Plasminogen Activator Inhibitor 1

Plasminogen activator inhibitor-1 (PAI-1) testing is indicated for unexplained mild-to-moderate delayed bleeding disorders, typically associated with trauma or surgery. [1]

Normal findings [2]:

- Antigen assay: 2-46 ng/mL
- Activity: < 31.1 IU/mL

Platelet Aggregation

With regard to normal findings, results depend on the platelet agonist employed, [1] with the reference range being a normal biphasic pattern of aggregation in response to specific platelet activators

Porphobilinogen

Porphobilinogen (PBG) is measured in patients with symptoms that suggest acute intermittent porphyria, variegate porphyria, or hereditary coproporphyria.

Normal findings

Porphobilinogens: 0-2 mg/24 hr or 0-8.8 µmol/day (SI units)

Potassium

Potassium is an electrolyte, which is a mineral in the blood that can be measured by a blood test. Potassium is ingested through food and electrolyte-enhanced beverages and excreted primarily through urine, with a minority portion removed through the gastrointestinal tract.

The reference ranges for blood potassium levels are as follows [1]:

- Adult/elderly: 3.5-5.0 mEq/L or 3.5-5.0 mmol/L (SI units)
- Child: 3.4-4.7 mEq/L
- Infant: 4.1-5.3 mEq/L
- Newborn: 3.9-5.9 mEq/L

Results can be affected by diet, infusion of potassium-containing fluids, or an infusion of glucose or insulin.

Possible critical values are as follows [1]:

- Adult: < 2.5 or >6.5 mEq/L
- Newborn: < 2.5 or >8 mEq/L

Procainamide Level

Procainamide is a class 1a antiarrhythmic that is used to treat various ventricular and atrial arrhythmias. Procainamide and its breakdown product, N-acetylprocainamide (NAPA), are both powerful antiarrhythmics that necessitate careful monitoring. [1]

The therapeutic concentration of procainamide is 4-8 µg/mL. The half-life is 3-5 hours. The toxic concentration is 16 µg/mL or greater, although symptoms may develop at 8-10 µg/mL.

The therapeutic concentration of NAPA is also 4-8 µg/mL, and its half-life is approximately 7 hours. As with procainamide, the toxic concentration of NAPA is 16 µg/mL or greater, although symptoms may develop at 8-10 µg/mL.

The therapeutic concentration of both procainamide and N-acetylprocainamide (combined) is 30 µg/mL or less. The toxic concentration is any level in excess of the therapeutic concentration (≥30 µg/mL).

Procalcitonin (PCT)

Procalcitonin (PCT), a protein that consists of 116 amino acids, is the peptide precursor of calcitonin, a hormone that is synthesized by the parafollicular C cells of the thyroid and

involved in calcium homeostasis. Procalcitonin arises from endopeptidase-cleaved preprocalcitonin.
The reference value for procalcitonin in adults is less than 0.1 ng/mL. Levels greater than 0.25 ng/mL can indicate the presence of an infection.
Progesterone
Progesterone is produced in the luteal phase of the cycle. For the change from the luteal back to the follicular phase, progesterone decreases gonadotrophin-releasing hormone (GnRH) pulse frequency to suppress gonadotropin release and reset the hypothalamic-pituitary-gonadal axis. The mechanism of action of progesterone-containing contraceptives is to suppress GnRH.
Progesterone decreases endometrial proliferation and develops secretory endometrium. The abrupt decline in progesterone toward the end of the cycle causes the onset of menstruation. The effect of estrogen causing endometrial hyperplasia is necessary prior to the effect of progesterone on the endometrium for the normal menstrual pattern. Progesterone causes the endocervical glands to secrete a scant viscid material that decreases penetration of the cervix by sperm. By suppressing menstruation and uterine contractility, progesterone helps to maintain pregnancy.
Reference ranges for progesterone assay
< 9 years: < 20 ng/dL [1]
10-15 years: < 20 ng/dL [1]
Adult male: 10-50 ng/dL [1]
Adult female [1]:

- Follicular phase: < 50 ng/dL
- Luteal: 300-2500 ng/dL
- Postmenopausal: < 40 ng/dL

Pregnancy [1]:

- First trimester: 725-4400 ng/dL
- Second trimester: 1950-8250 ng/dL
- Third trimester: 6500-22,900 ng/dL

Prolactin
The reference ranges for prolactin in females is as follows: [1]

- Adult female: 3-27 ng/mL
- Pregnant female: 20-400 ng/mL

The reference range for prolactin in adult males is 3-13 ng/mL.
Prostate-Specific Antigen Testing
Prostate-specific antigen (PSA) is a protein produced by normal prostate cells. This enzyme participates in the dissolution of the seminal fluid coagulum and plays an important role in fertility. The highest amounts of PSA are found in the seminal fluid, although some PSA escapes the prostate and can be found in the serum. [1, 2, 3, 4, 5, 6] PSA was originally identified by scientists in Japan. The government had requested that a means be found to identify semen in rape victims. The protein the researchers identified was called semenogelin.
In the United States, Richard Ablin and his associates independently identified this protein, which they called prostate-specific antigen. They were also looking for an identification method for semen in rape victims but were unaware of the Japanese research, since the journal in which that work had been published was not readily available to them.
Because the protein has since been found in other parts of the body and is also present in small amounts in women, the term prostate-specific antigen is a bit of a misnomer.
PSA is not a true diagnostic test for prostate cancer, but rapidly rising values of PSA in the serum may be associated with prostate cancer. [7] The PSA level also tends to rise in men with benign prostatic hyperplasia (BPH) and usually increases as the prostate grows. PSA levels are also typically elevated in men with acute bacterial prostatitis. Even though "normal" PSA

values are listed, each male has his own PSA value, and changes may reflect a number of events.

Since 1986, when tests for measuring PSA levels in serum were introduced into clinical practice, early diagnosis and management of prostate cancer has been revolutionized, and much has been learned about the strengths and weaknesses of these assays. PSA testing not only helps identify men in whom a prostate biopsy would be appropriate but also assists in assessing the response to therapy, determining tumor progression, and, in its most controversial role, screening for prostate cancer. [8, 9, 10]

Studies have indicated that a PSA of less than 1 confers a 1.5% probability of developing an active cancer. A PSA of greater than 4 increases the probability to 29.5%.

The prostate begins growing around age 40 years and never stops. It may be walnut sized in young men, but in men over age 40 years the gland can attain a much greater size. As stated above, the PSA tends to increase as the prostate becomes larger.

Screening for prostate cancer

PSA levels have been used in screening large populations of men for prostate cancer and have been shown to be useful. Studies have found that PSA screening makes a real difference in the detection of this disease and subsequent patient survival.

Before the PSA era, an abnormality in the prostate had to be palpably evident before a biopsy would be performed, and nearly 70% of men diagnosed with prostate cancer already had extraprostatic or metastatic disease. Since the advent of PSA evaluation, fewer than 3% of men have metastases at the time of diagnosis, and 75% of men have nonpalpable cancer, with the cancer being detected from a biopsy performed because of a rapidly rising or markedly elevated PSA level.

Despite the apparent survival advantage conferred by PSA screening, in 2008 the US Preventive Services Task Force (USPSTF) recommended against screening for prostate cancer in men aged 75 years or older, and in 2012 the task force recommended against screening regardless of age. [11, 12] The USPSTF has since modified this position and currently supports a dialogue between doctors and patients aged 55-69 years, while also recommending that men aged 70 years or older not undergo PSA testing. The task force's recommendations are based on concerns that screening does not have a large impact on mortality from prostate cancer and that it is associated with potential harms, "including false-positive results that require additional testing and possible prostate biopsy; overdiagnosis and overtreatment; and treatment complications, such as incontinence and erectile dysfunction." [13]

Consistent with the USPSTF's recommendations against prostate cancer screening, the detected incidence of prostate cancer dropped between 2007 and 2014, falling by approximately 40%. However, between 2014 and 2019, the incidence rose by 3% annually, this increase having resulted from an annual rise of about 4.5% in diagnoses of regional- and distant-stage prostate cancer. The increased incidence of advanced-stage disease actually started as early as 2011. [12, 14]

Despite USPSTF recommendations, urologists themselves are capable of deciding what screening tests and exams are necessary for each patient. Age should not be the determining factor in assessing whether a digital rectal examination (DRE) and a PSA test are needed. The patient and the physician should review the options and proceed accordingly. Even with the 2007-2014 detection reduction, many urologists have apparently not paid attention to the USPSTF's recommendations, as evidenced by a study by Kalavacherla et al, which indicated that a large percentage of older males are being screened for prostate cancer. The study, which used the 2020 Behavioral Risk Factor Surveillance System (BRFSS), from the US Centers for Disease Control and Prevention, found PSA screening rates to be 55.3% for males aged 70-74 years, 52.1% for men aged 75-79 years, and 39.4% for males aged 80 years or older. [15]

There is no specific age restriction for obtaining and tracking PSA. Men with a family history of prostate cancer can begin screening at age 40 years. The initial PSA sets the baseline.

The 2010 update of the American Cancer Society (ACS) guideline for early detection of prostate cancer stresses the importance of involving patients in deciding whether or not to test for prostate cancer. The ACS notes that PSA testing may reduce the likelihood of dying from prostate cancer but that there may be risks associated with the treatment of prostate cancer that would not have developed if the disease had been left undetected. [16] Of course, there may also be risks if a cancer is not detected.

Most clinicians determine which men should undergo PSA testing on the basis of age, symptoms, family history, expected longevity, general medical condition, physical examination findings, and, often, the patient's request for the test. Urologists obtain PSA measurements for most of their male patients in the appropriate age group because they believe that they have an obligation to detect any prostate cancer at the earliest possible stage of its development.

The leading cause of malpractice claims against urologists is the failure to diagnose prostate cancer in a timely manner. Primary care physicians and internists also are increasingly being held liable for failure to obtain PSA testing for their patients and for failure to refer those with elevated PSA levels to a urologist.

Physicians have an obligation to discuss the risks and benefits of PSA testing with their patients. Ample information about PSA testing is also available from the American Cancer Society and the American Urological Association. Unfortunately, the Internet contains a lot of misinformation on the subject.

The current strategy before performing a prostate biopsy is to obtain a prostate magnetic resonance imaging (MRI) scan. This imaging study can indicate the location of sites within the prostate that are suspicious for cancer. On a scale of 1-5, a 1/5 or a 2/5 indicates a low probability for a cancer being present. A 4/5 or a 5/5 indicates a high probability, 70-90%, for the presence of cancer cells. A 3/5 indicates a 30-50% probability of cancer. By denoting abnormal sites within the prostate, MRI allows "targeted" biopsies to be done.

Protein C

Protein C: 70-150% of normal activity [1]

Protein C levels are lower in females, with males and females experiencing a decrease with age.

Protein S

Protein S, a vitamin K–dependent plasma glycoprotein, is synthesized in the endothelium. The 2 forms of protein S are a free form and a complex form. The free form of protein S is active. The bound form comprises 65% of the total protein S, and it is complexed to C4b-binding protein (C4bBP) and is inactive. The availability of C4bBP regulates the proportion of the free and bound forms of protein S. Synthesis of protein S occurs in the liver, endothelial cells, and megakaryocytes. The half-life of protein S is 42 hours. [1]

Normal findings

Protein S: 60-130% of normal activity [2]

Protein S levels are low at birth and do not reach adult values until approximately age 6 months. Patient age, sex, health history, the method used for the test, and many other factors can affect laboratory test results, possibly causing results to vary.

Prothrombin Time

A basic understanding of the coagulation pathway is required to interpret prothrombin time (PT) result (see the image below). The prothrombin time is a measure of the integrity of the extrinsic and final common pathways of the coagulation cascade. This consists of tissue factor and factors VII, II (prothrombin), V, X, and fibrinogen. The test is performed by adding

calcium and thromboplastin, an activator of the extrinsic pathway, to the blood sample then measuring the time (in seconds) required for fibrin clot formation.
Normal values include the following [1]:

- The reference range for prothrombin time is 11.0-12.5 seconds; 85%-100% (although the normal range depends on reagents used for PT)
- Full anticoagulant therapy: >1.5-2 times control value; 20%-30%
- The reference range for the international normalized ratio (INR) is 0.8-1.1

Possible critical values are as follows [1]:

- 20 seconds
- INR: >5.5

Red Cell Distribution Width (RDW) Test
he red cell distribution width (RDW) test measures variation in red blood cell size or red blood cell volume as a part of a complete blood count (CBC). It is used along with other red blood cell (RBC) indices, especially mean corpuscular volume (MCV), to help determine the causes of anemia.
RDW is elevated in accordance with variation in red cell size (anisocytosis); that is, when elevated RDW is reported on complete blood count, marked anisocytosis (increased variation in red cell size) is expected on peripheral blood smear review.
The reference range for RDW is as follows:

- RDW-SD 39-46 fL [1]
- RDW-CV 11.6-14.6% in adult [2]

Reference ranges may vary depending on the individual laboratory and patient's age.
Indications/Applications
Red cell distribution width (RDW) laboratory test is a part of a standard complete blood count (CBC), and it is used along with other RBC indices, especially mean corpuscular volume (MCV) to help determine the causes of anemia.
Considerations
Elevated RDW provides a clue for heterogenous red cell size (anisocytosis) and/or the presence of 2 red cell populations, since other RBC indices (MCV, MCH and MCHC) reflect average values and may not adequately reflect RBC changes where mixed RBC populations are present, such as dimorphic RBC populations in sideroblastic anemia or combined iron deficiency anemia (decreased MCV and MCH) and megaloblastic anemia (increased MCV). Peripheral blood smear review can help confirm the above findings in these circumstances.
Reptilase Time
The reference range for reptilase time depends on the test kit or instrumentation used in the laboratory but is usually below 20 seconds (ie, 15-19 seconds). Healthy infants aged 6 months or younger may have a slightly prolonged reptilase time by 2-3 seconds.
Reticulocyte Count and Reticulocyte Hemoglobin Content
The reticulocyte count is used to estimate the degree of effective erythropoiesis, [1] which can be reported as absolute reticulocyte count or as a reticulocyte percentage.
The reference ranges for the reticulocyte count are as follows [2]:

- Adult/elderly/child: 0.5-2%
- Infant: 0.5-3.1%
- Newborn: 2.5-6.5%

Note that the reference ranges for automated reticulocyte count (absolute reticulocyte count), immature reticulocyte fraction (IRF), and reticulocyte specific hemoglobin content (mean reticulocyte hemoglobin content [CHr] and reticulocyte hemoglobin equivalent [Ret-He]) vary owing to the different methods and different instruments used. Each laboratory should determine reference values according to their own methods and instruments. A comparison of

different reference ranges as reported by different authors can be found in a review published article by Piva et al.

Reverse Transcriptase-Polymerase Chain Reaction

The diagnosis of many infectious diseases, both viral and bacterial, may include the use of reverse transcriptase–polymerase chain reaction (RT-PCR).

Rheumatoid Factor

Antibodies directed against the Fc fragment of immunoglobulin G (IgG) are called rheumatoid factors (RFs). They are heterogenous and usually composed of immunoglobulin M (IgM). Because of this, most assays detect only IgM. RFs are used as a marker in individuals with suspected rheumatoid arthritis (RA) or other autoimmune conditions. [1, 2, 3, 4, 5]

Normal findings are negative (ie, < 60 U/mL by nephelometric testing). Values may be slightly higher in elderly patients.

Ristocetin Cofactor (Functional von Willebrand Factor)

Reference ranges for age groups are as follows [1, 2]:

- Newborn (< 6 mo) - 50-200% (IU/dL)
- Children (1-10 y) - 40-130% (blood type O); 50-180% (non-O blood type)
- Adults - 50-150% (blood type O); 60-180% (non-O blood type)

Serum Calcium

Calcium concentration, both total and free, is characterized by a high physiological variation, depending on age, sex, physiological state (eg, pregnancy), and even season (owing to the seasonal variation of vitamin D, which is directly involved in the regulation of calcium concentration). Therefore, separate reference intervals have been established according to the age and sex of the individual being tested.

Total calcium reference ranges are as follows [1]:

- < 10 days: 7.6-10.4 mg/dL; 1.9-2.6 mmol/L
- Umbilical: 9-11.5 mg/dL; 2.25-2.88 mmol/L
- 10 days-2 years: 9-10.6 mg/dL; 2.3-2.65 mmol/L
- Child: 8.8-10.8 mg/dL; 2.2-2.7 mmol/L
- Adult: 9-10.5 mg/dL; 2.25-2.62 mmol/L (Values tend to be reduced in elderly persons.)

Possible critical values for total calcium are < 6 mg/dL or >13 mg/dL.

Serum Cortisol

Cortisol is the main adrenal glucocorticoid and plays a central role in glucose metabolism and in the body's response to stress. Adrenal cortisol production is regulated by adrenocorticotropic hormone (ACTH), which is synthesized by the pituitary gland in response to hypothalamic corticotropin-releasing hormone (CRH). Serum cortisol in turn inhibits the production of both CRH and ACTH (negative feed-back loop), and this system self-regulates to control the proper level of cortisol production. The coordinated stimulatory and inhibitory connections between CRH, ACTH, and cortisol are referred to as the hypothalamic-pituitary-adrenal (HPA) axis.

Free serum cortisol reference range

8 AM: 0.121-1.065 mcg/dL [1]

Total serum cortisol reference ranges

Adult/elderly [1]:

- 8 AM: 5-23 mcg/dL or 138-635 nmol/L (SI units)
- 4 PM: 3-13 mcg/dL or 83-359 nmol/L (SI units)

Child 1-16 years [1]:

- 8 AM: 3-21 mcg/dL
- 4 PM 3-10 mcg/dL

Newborn: 1-24 mcg/dL [1]

Urine (24-hour)
Adult/elderly: < 100 mcg/24 hr or < 276 nmol/day (SI units) [1]
Adolescent: 5-55 mcg/24 hr [1]
Child: 2-27 mcg/24 hr [1]
Saliva
7 AM-9 AM: 100-750 ng/dL [1]
3 PM-5 PM: < 401 ng/dL [1]
11 PM-midnight: < 100 ng/dL [

Serum Osmolality

The serum or plasma osmolality is a measure of the different solutes in plasma. Among other applications, serum osmolality is indicated to evaluate the etiology of hyponatremia and may be used to screen for alcohol intoxication by means of the osmolal gap.

The reference ranges for serum osmolality are as follows [1]:

- Adult/elderly: 285-295 mOsm/kg H_2O or 285-295 mmol/kg (SI units)
- Child: 275-290 mOsm/kg H_2O

Possible critical values are as follows [1]:

- < 265 mOsm/kg H_2O
- >320 mOsm/kg H_2O

Serum Osteocalcin

Osteocalcin is a noncollagenous, 49 amino acid glutamate-rich polypeptide bone matrix protein with a molecular weight of about 5800 kDa. Osteoblasts produce osteocalcin and incorporate it into the bone matrix. Osteocalcin is released into the circulation from the matrix during bone resorption and, therefore, is considered a marker of bone turnover rather than a specific marker of bone formation. [1]

The reference ranges for osteocalcin are as follows: [2, 3]

- Younger than 18 years - Not established
- Adult males (>22 y) - 5.8-14 ng/mL
- Adult females (>22 y) - 3.1-14.4 ng/mL

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Serum Protein Electrophoresis

Serum protein electrophoresis (SPEP) is an easy, inexpensive method of separating proteins based on their net charge, size, and shape. The 2 major types of protein present in the serum are albumin and the globulin proteins. Albumin is the major protein component of serum and represents the largest peak that lies closest to the positive electrode. [1] Globulins make up a much smaller fraction of the total serum protein but represent the primary focus of interpretation of serum protein electrophoresis. Five globulin categories are represented: alpha-1, alpha-2, beta-1, beta-2, and gamma, with the gamma fraction being closest to the negative electrode.

Adults/elderly

Reference ranges are as follows [2]:

- Total protein - 6.4-8.3 g/dL or 64-83 g/L (SI units)
- Albumin - 3.5-5 g/dL or 35-50 g/L (SI units)

- Globulin - 2.3-3.4 g/dL
- Alpha-1 globulin - 0.1-0.3 g/dL or 1-3 g/L (SI units)
- Alpha-2 globulin - 0.6-1 g/dL or 6-10 g/L (SI units)
- Beta globulin - 0.7-1.1 g/dL or 7-11 g/L (SI units)

Children

Total protein

Reference ranges are as follows [2]:

- Premature infant - 4.2-7.6 g/dL
- Newborn - 4.6-7.4 g/dL
- Infant - 6-6.7 g/dL
- Child - 6.2-8 g/dL

Albumin

Reference ranges are as follows [2]:

- Premature infant - 3-4.2 g/dL
- Newborn - 3.5-5.4 g/dL
- Infant - 4.4-5.4 g/dL
- Child - 4-5.9 g/dL

Serum Sodium

Measurement of serum sodium is routine in assessing electrolyte, acid-base, and water balance, as well as renal function. Sodium accounts for approximately 95% of the osmotically active substances in the extracellular compartment, provided that the patient is not in renal failure or does not have severe hyperglycemia.

The reference range for serum sodium is 135-147 mmol/L, [1] although different assays establish their own reference ranges, which may differ slightly. For the Architect c System that runs integrated chip technology (ICT) sodium, potassium,and chloride assays, the reference range for serum sodium is 136-145 mmol/L.

Serum Tryptase

The reference range is < 11.4 ng/mL.

According to a study, the 95th percentile value for serum tryptase measured in 126 healthy individuals aged 12-61 years was 11.4 ng/mL. The geometric mean is 3.8 ng/mL, and the lower limit of detection is 1 ng/mL. [1]

The reference values for children aged 6 months to 18 years appear to be similar to adult values with a median range of 3.5 ng/mL as determined by a study on 197 children. [2] Infants younger than 6 months, however, have a higher median value of 6.1 ng/mL.

Somatostatin

Somatostatin is a polypeptide that is released in the gastrointestinal tract by delta cells and the hypothalamus. It functions as a key regulatory peptide that has many physiologic effects as an inhibitor for many other hormones, including gastrin, cholecystokinin, glucagon, growth hormone, insulin, secretin, pancreatic polypeptide, vasoactive intestinal peptide, 5-hydroxytryptamine (5-HT), and some anterior pituitary hormones.

The reference range for plasma somatostatin in adults is 10-22 pg/mL, the conversion factor is 0.426, and the SI units are 4.26-9.37 pmol/L. Draw in prechilled tube, separate plasma, and freeze immediately. [1]

Specific Gravity

Urinary specific gravity (SG) is a measure of the concentration of solutes in the urine. It measures the ratio of urine density compared with water density and provides information on the kidney's ability to concentrate urine. A urinary specific gravity measurement is a routine part of urinalysis. [1, 2, 3] The reference range is 1.005-1.030.

Stool Culture

The normal flora of the GI tract is composed of various bacteria and fungi that play a vital role in the digestion of food. They also help restrict the growth of pathogenic organisms. The use of broad spectrum antibiotics may change the balance of the normal flora, inhibiting the growth of normal flora and allowing bacteria resistant to the antibiotic to persist and overgrow. Similarly, the use of anti-neoplastic drugs can lead to bacterial overgrowth that results in abdominal pain and diarrhea.

Normal findings

Normal findings consist of normal intestinal flora.

Stool Ova and Parasite Test

The reference range for stool ova and parasite test is negative (no parasites seen).

Sucrose Hemolysis

The reference range of hemolysis on sucrose hemolysis testing (screening and confirmatory tests) is listed below. [1]

Sucrose hemolysis test (screening)

See the list below:

- No hemolysis visible - Negative result
- Hemolysis present - Positive result

Sucrose hemolysis test (confirmatory)

Hemolysis findings in supernate are as follows:

- < 5% - Inconsequential or negative
- 6-10% - Questionable or borderline
- >10% - Positive

Syphilis Detection Test

Syphilis detection tests are serologic tests used to screen for and confirm infection with *Treponema pallidum*. The reference range for syphilis detection tests reflects an absence of treponemal exposure, as follows:

- Venereal Disease Research Laboratory (VDRL) test: Nonreactive
- Rapid plasma reagin (RPR): Nonreactive
- Fluorescent treponemal antibody absorption test (FTA-ABS): Nonreactive
- *T pallidum* particle agglutination (TP-PA): Nonreactive
- Enzyme immunoassay (EIA): Nonreactive

Theophylline Level

Theophylline is a methylxanthine, a class of molecule similar to the xanthines caffeine and theobromine found in a normal diet. [1, 2] It has a half-life of 8 hours in a healthy person but decreases to 4-5 hours in people who smoke. [3] In the blood, 40-50% of theophylline is bound to proteins.

The reference therapeutic ranges of theophylline are listed below.

Reference ranges of theophylline in the treatment asthma vary by age, as follows:

- Adults: 5-15 µg/mL
- Children: 5-10 µg/mL

The reference range of theophylline in the treatment of acute bronchospasm in adults is 10-15 µg/mL.

The reference range of theophylline in the treatment of neonatal apnea is 6-11 µg/mL.

Throat Culture

Throat culture refers to the growth and isolation of a micro-organism from a specimen taken from the throat. The results guide appropriate therapy in infectious and inflammatory diseases of the throat.

Normal findings [1] : Negative

Thrombin Time

Thrombin time is a screening coagulation test designed to assess fibrin formation from fibrinogen in plasma.
The reference range for the thrombin time is usually less than 20 seconds (ie, 15-19 seconds), but this depends on the test kit/instrumentation used in the laboratory. Healthy infants up to age 6 months may have a slightly prolonged thrombin time by 2-3 seconds.

Thyroglobulin
Thyroglobulin testing is primarily used as a tumor marker to evaluate the effectiveness of treatment for differentiated thyroid cancer and to monitor for recurrence.
Normal findings are as follows. [1]
0-11 months:

- Male - 0.6-5.5 ng/mL
- Female - 0.5-5.5 ng/mL

1-11 years:

- Male - 0.6-50.1 ng/mL
- Female - 0.5-52.1 ng/mL

12 years and older:

- Male - 0.5-53.0 ng/mL
- Female - 0.5-43.0 ng/mL

Thyroid-Binding Globulin
reversibly binds to thyroid hormones 3,5,3'-triiodothyronine (T3) and thyroxine (T4) and carries them in the bloodstream. [1]
The reference ranges for TBG are shown in Table 1. [2]

Age	Male (mg/dL)	Female (mg/dL)
1-5 days	2.2-5.9	2.2-5.9
1-11 months	3.1-5.6	3-5.6
1-9 years	2.5-5	2.5-5
10 to 19 years	2.1-4.6	2.1-4.6
Over age 20 years	1.2-2.5	1.4-3

With oral contraceptive use, the reference range is 1.5-5.5 mg/dL, while in the third trimester of pregnancy, it is 4.7-5.9 mg/dL.
Thyroid-Stimulating Hormone
Normal thyroid-stimulating hormone (TSH) findings are as follows (although values differ between laboratories) [1]:

- Adult: 2-10 µU/mL
- Newborn: 3-18 µU/mL
- Cord: 3-12 µU/mL

Thyroxine
Reference ranges for total thyroxine (TT4) are as follows [1, 2]:

- In newborns up to age 14 days: 11.8-22.6 mcg/dL (152-292 nmol/L)

- In babies and older children: 6.4-13.3 mcg/dL (83-172 nmol/L)
- In adults: 5.4-11.5 mcg/dL (57-148 nmol/L)

Reference ranges for free thyroxine (FT4) are as follows:

- In children/adolescents: 0.8-2 ng/dL (10-26 pmol/L)
- In adults: 0.7-1.8 ng/dL (9-23 pmol/L)
- In pregnant patients: 0.5-1 ng/dL (6.5-13 pmol/L)

Normal value ranges may vary among different laboratories.

SI conversion: pmol/L = 12.9 x ng/dL

Tobramycin Level

Tobramycin is an aminoglycoside antibiotic that is used for treatment of infections of susceptible strains of aerobic gram-negative bacteria that are resistant to less-toxic antibiotics. In particular, it has been more commonly used for definitive or empirical treatment of *Acinetobacter*, *Pseudomonas aeruginosa*, *Escherichia coli, Klebsiella pneumoniae, Providencia stuartii,* and sometimes *Serratia.* [1, 2]

Normal findings [3]:

- Therapeutic level: 5-10 mcg/mL
- Toxic level: > 12 mcg/mL

No standard reference range exists for a tobramycin level when administered as a single-daily dose. Instead, serum concentrations are taken hours after infusion (please see below) and are either plotted graphically onto a nomogram or encoded onto a computer to generate a 24-hour area under the curve (AUC). A final, but less validated, method involves checking a level at the end of the anticipated dosing interval to ensure that it is less than 1 mcg/mL. [4, 5]

For the nomogram method: One serum concentration 6-14 hours after the start of the infusion. Use the nomogram below and adjust as directed

For the 24-hour area under the curve (AUC) method, 2 serum concentrations are taken: The first is 1 hour after infusion and the second is 6 hours after infusion. A computer program then generates a 24-hour AUC and recommends the appropriate dose or interval change (please see below for links to free programs online). [1, 6, 7]

Another commonly used method is to check for a trough level before the second dose would have been given, with the goal of keeping the trough level < 1 mcg/mL

Transferrin Receptor

Transferrin receptors, which are blood proteins, may be elevated in persons with iron deficiency. Transferrin receptor testing is used to measure the level of soluble transferrin receptors, thereby aiding in the evaluation of iron deficiency and in the diagnosis of iron-deficiency anemia.

The reference range of transferrin receptor varies by sex in adults.

Normal findings [1]:

- Men: 2-5 mg/L
- Women: 1.9-4.4 mg/L

Result variations are engendered by the testing method.

Transferrin Saturation

Transferrin saturations of less than 20% indicate iron deficiency, while transferrin saturations of more than 50% suggest iron overload.

The terms transferrin saturation and iron-binding capacity, saturation, are interchangeable; however, this value is now most commonly referred to simply as transferrin saturation. This minimizes confusion with another value, iron-binding capacity, which is used when determining a patient's iron status.

The reference range for transferrin saturation is as follows [1]:

- Male: 20-50%
- Female: 15-50%

Triiodothyronine

Triiodothyronine (T3) levels are obtained in suspected cases of hyperthyroidism, either because the patient has typical symptoms or when the thyroid-stimulation hormone (TSH) levels are lower than normal.

Normal findings [1]:

- 1-3 days: 100-740 ng/dL
- 1-11 months: 105-245 ng/dL
- 1-5 years: 105-270 ng/dL
- 6-10 years: 95-240 ng/dL
- 11-15 years: 80-215 ng/dL
- 16-20 years: 80-210 ng/dL
- 20-50 years: 70-205 ng/dL or 1.2-3.4 nmol/L (SI units)
- >50 years: 40-180 ng/dL or 0.6-2.8 nmol/L (SI units)
- Reversed T3: 10-24 ng/dL

Troponins

Troponins are protein molecules that are part of cardiac and skeletal muscle. Smooth muscle cells do not contain troponins.

Three types of troponins exist—troponin I, troponin T, and troponin C. Each subunit has a unique function: Troponin T binds the troponin components to tropomyosin, troponin I inhibits the interaction of myosin with actin, and troponin C contains the binding sites for Ca^{2+} that helps initiate contraction. [1]

This review discusses troponin as a marker of cardiac injury, as well as its testing, utility, and appropriateness use criteria, and the interpretation of abnormal values.

Normal findings:

Cardiac troponin T: < 0.1 ng/mL [2]

Cardiac troponin I: < 0.03 ng/mL [2]

High-sensitivity troponin T [2]:

- < 14 ng/L for women
- < 22 ng/L for men

Uric Acid

The final breakdown product of purine catabolism in humans is uric acid. The liver and intestinal mucosa produce most of the uric acid. The kidneys eliminate two thirds of the uric acid, with the GI tract excreting the other one third. Uric has a pK_a of 5.75 and 10.3 and thus is a weak acid. The ionized forms of uric acid, urates, are present in synovial fluid and in plasma; approximately 98% exists as monosodium urate, with a pH of 7.4. [1]

During male puberty, serum urate levels begin to rise from those of childhood. Female levels remain low until until after menopause, when values increase and approximate those of men. Serum urate levels can vary with height, blood pressure, body weight, renal function, and alcohol intake. [2]

The reference ranges for uric acid in the blood are as follows [3]:

- Adult male: 4.0-8.5 mg/dL or 0.24-0.51 mmol/L
- Adult female: 2.7-7.3 mg/dL or 0.16-0.43 mmol/L
- Elderly: A slight increase in values may occur
- Child: 2.5-5.5 mg/dL or 0.12-0.32 mmol/L
- Newborn: 2.0-6.2 mg/dL

Other values [3]:

- Physiologic saturation threshold: >6 mg/dL or >0.357 mmol/L
- Therapeutic target for gout: < 6 mg/dL or < 0.357 mmol/L
- Possible critical value in the blood: >12 mg/dL

The reference range for urinary uric acid is as follows [3]:

- 250-750 mg/24 hr or 1.48-4.43 mmol/day (SI units)

Urinalysis

- – Negative
- Leukocyte esterase – Negative
- Bilirubin – Negative
- Urobilirubin – Small amount (0.5-1 mg/dL)
- Blood - ≤3 RBCs
- Protein - ≤150 mg/d
- RBCs - ≤2 RBCs/hpf
- WBCs - ≤2-5 WBCs/hpf
- Squamous epithelial cells - ≤15-20 squamous epithelial cells/hpf
- Casts – 0-5 hyaline casts/lpf
- Crystals – Occasionally
- Bacteria – None
- Yeast - None

Urinary Free Cortisol

Urinary free cortisol measurements are used primarily in the diagnosis of hypercortisolism caused by Cushing syndrome. [1, 2, 3]

Reference ranges for urinary free cortisol vary by age, as follows:

- Age 0-2 years - Not established
- Age 3-8 years - 1.4-20 µg/24 h
- Age 9-12 years - 2.6-37 µg/24 h
- Age 13-17 years - 4-56 µg/24 h
- Age 18 years or older - 3.5-45 µg/24 h

Urinary N-Methylhistamine

The primary application of urinary N-methylhistamine (NMH) testing is in the diagnosis and monitoring of mast-cell disorders, including mastocytosis, anaphylaxis, and other severe systemic allergic reactions. [1, 2, 3, 4, 5, 6, 7]

The reference range for urinary NMH varies according to subject age, as follows:

- Age 0-5 years - 120-510 µg/g creatinine
- Age 6-16 years - 70-330 µg/g creatinine
- Older than16 years - 30-200 µg/g creatinine

Urine Calcium

Calcium is one of the most abundant minerals in the human body. It has roles as the primary component of the transmembrane electrical gradient, in bone mineralization, and as an enzyme cofactor in the coagulation cascade. The body normally keeps serum and intracellular calcium levels under tight control through bone resorption and urinary excretion. The reference ranges of urinary calcium are dependent on the diet and the ability of its intestinal absorption.

- Males: 25-300 mg/24-hour specimen*
- Females: 20-275 mg/24-hour specimen*
- Hypercalciuria: >350 mg/24-hour specimen

(*These levels are reflective of individuals with average, unrestricted calcium intake, which is 600-800 mg/day.)

Furthermore, accurate interpretation of urine calcium concentration should be done in relation to glomerular filtrate (GF), considering the following equation:

UCa(mg/100 ml GF) = [UCa (mg/dl) X Serum Creatinine (mg/dl)] / Urine Creatinine (mg/dl)

A value exceeding 0.16 mg/100 ml GF suggests an intense osteoclastic activity and bone resorption, and it is useful is evaluating renal stone disease and high turnover osteoporosis. [1]

Urine Culture

Urine specimen - No growth in 24-48 hours

Urine Osmolality

Urine osmolality is used to measure the number of dissolved particles per unit of water in the urine. As a measure of urine concentration, it is more accurate than specific gravity. Urine osmolality is useful in diagnosing disorders of urinary concentration such diabetes insipidous and in assessing hydration status. Often, the assessment of any disorder involving antidiuretic hormone (ADH) will require both serum and urine osmolality to assess concentrating ability of the kidney.

Normal urine osmolality is as follows [1] :

- 12- to 14-hour fluid restriction: >850 mOsm/kg H_2O (SI units)
- Random specimen: 50-1200 mOsm/kg H_2O, depending on fluid intake, or 50-1200 mmol/kg (SI units)

Urine Sodium

rine sodium (Na) analysis is usually ordered when it is necessary to distinguish between various forms of renal failure and to classify hyponatremia. [1]

Normal urine sodium values include the following [2] :

- Reference range: 40-220 mEq/day or 40-220 mmol/day (SI units)
- Spot urine: >20 mEq/L
- Fractional excretion of sodium (FE_{Na}): 1-2%

Valproic Acid Level

Valproic acid is an 8-carbon 2-chain fatty acid that is metabolized by the liver and processed at a variable rate based on the patient's liver function and age, in addition to patient's other routine medications with which valproic acid may interact. At therapeutic concentrations, valproic acid mediates prolonged recovery of voltage-activated Na+ channels, thereby inhibiting repetitive firing induced by depolarization of cortical and spinal cord neurons. Its action is similar to that of other common anticonvulsants, such as phenytoin and carbamazepine.

The therapeutic range for valproic acid is 50-100 mcg/mL. The toxic level is >100 mcg/mL. [1]

Vancomycin Level

Vancomycin is an antibiotic drug used to treat serious, life-threatening infections by gram-positive bacteria that are resistant to less-toxic agents.

The reference range for vancomycin trough levels is 5-15 mcg/mL. The reference range for vancomycin peak levels is 20-40 mcg/mL. [

Vanillylmandelic Acid (VMA)

Vanillylmandelic acid (VMA), a metabolic by-product of norepinephrine and epinephrine, can be used to detect neuroblastoma and other tumors of neural crest origin.

Normal findings [1]

- Adult/elderly: < 6.8 mg/24 hr or < 35 µmol/24 hr (SI units)
- Adolescent: 1-5 mg/24 hr
- Child: 1-3 mg/24 hr
- Infant: < 2 mg/24 hr
- Newborn: < 1 mg/24 hr

Vitamin B1 (Thiamine)

Thiamine, or vitamin B1, is involved in a number of functions in the body, including nervous system (axonal conduction) and muscular functioning (electrolyte flow in these cells), carbohydrate metabolism, enzymatic processes, and production of hydrochloric acid needed for digestion. [1, 2]

In whole blood, the reference range of vitamin B1 (thiamine) is 2.5-7.5 µg/dL, or 74-222 nmol/L.

A stimulation of over 20%-25% during a red blood cell transketolase measurement using thiamine pyrophosphate (TTP) indicates deficiency.
The exact range depends on the laboratory used.
Vitamin B2
Plasma vitamin B2: 1-19 mcg/L
Vitamin B2 (Riboflavin)
Vitamin B2, or riboflavin, is a water-soluble vitamin most commonly found in the body in the form of the flavocoenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD), the latter being most abundant.
Reference ranges are as follows:

- Serum or plasma: 4-24 µg/dL or 106-638 nmol/L
- Urine: >80 µg/dL or >213 nmol/dL
- Erythrocyte: 10-50 µg/dL or 266-1330 nmol/dL

Vitamin B6
Vitamin B6 is a complex of 6 vitamers: pyridoxal, pyridoxol, pyridoxamine, and their 5'-phosphate esters. Vitamin B6 deficiency causes blood, skin, and nerve changes.
The reference range for pyridoxal phosphate (PLP), the biologically active form of vitamin B6, is 5-50 µg/L.
Vitamin C (Ascorbic Acid)
Vitamin C, also known as ascorbic acid, is a water-soluble vitamin.
The reference range of vitamin C is 0.6-2 mg/dL.
Vitamin D3 1,25-Dihydroxyvitamin D
The biologically active form of vitamin D is 1,25-dihydroxyvitamin D ($1,25(OH)_2$ D). Measurement of serum levels of $1,25(OH)_2$ D should be considered upon suspicion of deficiency or excess of this form of the vitamin.
Reference ranges for $1,25(OH)_2$ D may be reported as either pg/mL or pmol/L. The molecular weight of $1,25(OH)_2$ D is approximately 416.7, yielding the following conversion factors: 1 pmol/L = 0.42 pg/mL; conversely, 1 pg/mL = 2.4 pmol/L.
Reference ranges for $1,25(OH)_2$ D are as follows [1]:

- Males: 18-64 pg/mL
- Females: 18-78 pg/mL

Vitamin D3 25-Hydroxyvitamin D
The major circulating form of vitamin D is 25-hydroxyvitamin D (25(OH)D); thus, the total serum 25(OH)D level is currently considered the best indicator of vitamin D supply to the body from cutaneous synthesis and nutritional intake.
The reference range of the total 25(OH)D level is 25-80 ng/mL.
Vitamin E
Vitamin E is a fat-soluble vitamin that acts as an antioxidant and free-radical scavenger in lipophilic environments. Vitamin E requires bile for absorption, and 25% of it is absorbed orally. The vitamin is stored in adipose tissue, liver, and muscle.
The reference range of vitamin E in adults is 5.5-17 µg/mL. In children, it is 3-18.4 µg/mL.
Vitamin K
Vitamin K is an essential, lipid-soluble vitamin that plays a vital role in the production of coagulation proteins.
The reference range of vitamin K is 0.2-3.2 ng/mL, but impaired blood clotting has been associated with levels below 0.5 ng/mL by one source. [1] Another source cites a reference range of 0.10-2.2 ng/mL.
von Willebrand Factor Antigen (Factor VIII:R Antigen)

- Newborn < 6 mo: 60-190% (blood type O); 75-230% (non-O blood type)
- Children 1-10 years: 50-150% (blood type O); 60-160% (non-O blood type)

- Adults: 60-160% (blood type O); 70-200% (non-O blood type)

von Willebrand Factor Multimers

The von Willebrand factor (vWF) multimer analysis is primarily a qualitative test to identify variants of type II von Willebrand disease (vWD); therefore, there are no predefined reference ranges for its analysis.