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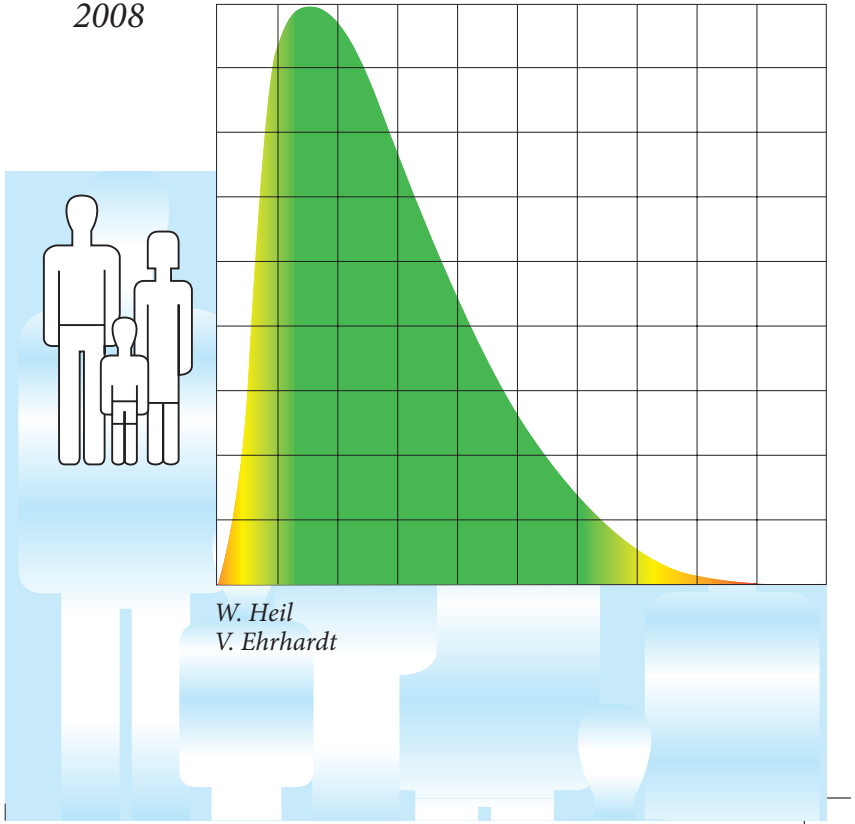
Switzerland

Heil/Ehrhardt · Reference Ranges for Adults and Children 2008

Reference Ranges for Adults and Children

Pre-Analytical Considerations

2008



W. Heil
V. Ehrhardt

Preface, 9th Edition

In order to fulfill increased regulatory standards the contents of this brochure are now to orientate closer by the information included in the package inserts of Roche Diagnostics' test kits. As a consequence a number of changes and modifications concerning the indicated reference ranges as well as the citated literature turned out to be necessary. The resulting number changes compared to the 8th edition of this brochure necessitated the publication of a revised 9th edition.

As a result of differing printing dates, it is possible that differences may occur between the information given here and that appears in the package inserts. In such cases the data given in the insert, enclosed with the kit, applies.

The reference ranges listed in this brochure are guide values which may depend on the specific method used. Therefore, each laboratory should investigate the transferability of the expected values to its own patient population and if necessary determine its own reference ranges.

PD Dr. W. Heil, Wuppertal
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Mannheim, March 2008

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Status: July 2008

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List of abbreviations

BSA	Body surface area		
C_4bBP	C_4-binding Protein		
CA	Tumour-related carbohydrate antigen		
CO_2	Carbon dioxide		
CSF	Cerebrospinal fluid		
CTAD	Citrate, theophylline, adenosine, dipyridamole		
d	Day		
DGKC	German Society of Clinical Chemistry		
EDTA	Ethylene diamine tetraacetic acid		
EGTA	1,2-bis (2-amino ethoxyethane)tetraacetic acid		
ELISA	Enzyme-linked immuno-sorbent assay		
Eq	Equivalent		
	mEq	milliequivalent	
f	Female		
g	Gram		
	mg	Milligram	(10^{-3} g)
	µg	Microgram	(10^{-6} g)
	ng	Nanogram	(10^{-9} g)
	pg	Picogram	(10^{-12} g)
h	Hour		
H_2	Hydrogen		
Hb	Hemoglobin		
Hct (PCV)	Hematocrit (packed cell volume)		
HPLC	High pressure liquid chromatography		
IFCC	International Federation of Clinical Chemistry		
INR	International Normalized Ratio		
kat	Katal		
	mkat	Millikatal	(10^{-3} kat)
	µkat	Microkatal	(10^{-6} kat)
	nkat	Nanokatal	(10^{-9} kat)
	pkat	Picokatal	(10^{-12} kat)

L	Liter		
	dL	Deciliter	(10^{-1} L)
	mL	Milliliter	(10^{-3} L)
	µL	Microliter	(10^{-6} L)
	nL	Nanoliter	(10^{-9} L)
	pL	Picoliter	(10^{-12} L)
	fL	Femtoliter	(10^{-15} L)
m	Male		
m	Meter		
	mm	Millimeter	(10^{-3} m)
	µm	Micrometer	(10^{-6} m)
	m^2	Square meter	
	μm^3	Cubic micrometer	
MCH	Mean corpuscular hemoglobin		
	Hb/RBC (hemoglobin content of one red cell)		
MCHC	Mean corpuscular hemoglobin concentration		
MCV	Mean corpuscular volume		
mil	Million		
min	Minute		
mol	Mole		
	mmol	Millimole	(10^{-3} mol)
	µmol	Micromole	(10^{-6} mol)
	nmol	Nanomole	(10^{-9} mol)
	pmol	Picomole	(10^{-12} mol)
	fmol	Femtomole	(10^{-15} mol)
mosmol	Milliosmole (10^{-3} osmole)		
mth	Month		
NACB	National Academy of Clinical Biochemistry		
NCEP	National Cholesterol Education Program		
NGSP	National Glycohemoglobin Standardization Program		
O_2	Oxygen		
Pa	Pascal		
	kPa	(10^3 pascal)	
pCO_2	Partial pressure of carbon dioxide		

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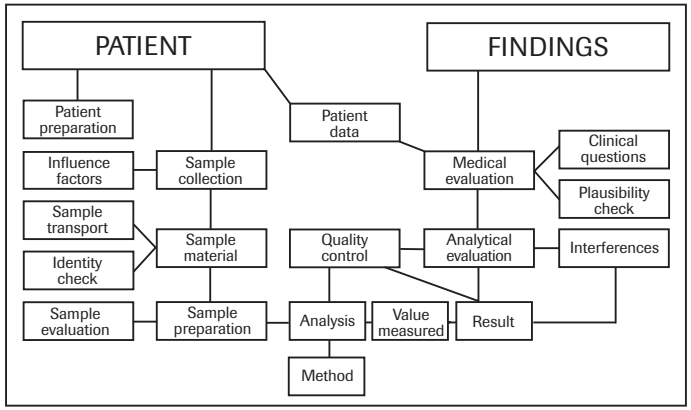
pH	Negative decimal logarithm of the hydrogen ion activity		
pO_2	Partial pressure of oxygen		
ppm	Parts per million		
pt	Particle		
	Mpt	Megaparticle	(10^6 particle)
	Gpt	Gigaparticle	(10^9 particle)
	Tpt	Teraparticle	(10^{12} particle)
s	Second		
U	Unit (international)		
	kU	Kilo unit	(10^3 units)
UV	Ultraviolet		
w	Week		
yr	Year		

1 Pre-analytical considerations

Assay findings in the field of clinical chemistry can be divided into the following categories:

– preanalytical phase
– analytical phase
– analytical evaluation
– postanalytical phase.

The following chart illustrates details of the preanalytical and analytical phases as well as analytical and medical evaluation and how the individual steps are related to one another. The accuracy of a laboratory analysis greatly depends on the preanalytical phase.



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1.1 Influence factors

The following should be taken into account during sample collection:

- After food intake glucose, cholesterol, triglycerides, iron, inorganic phosphate and amino acids are present in elevated concentrations in blood (103).
- If the patient is moved from a recumbent to an upright position, the concentration of corpuscular and macromolecular substances such as leucocytes, erythrocytes, hemoglobin, hematocrit, total protein, enzymes, lipoproteins and protein-bound ions (e. g. calcium, iron) increase by up to 10 %.
- Some drugs may affect the test performed.
- Compress vein for maximum 1 min.
- Large quantities of alcohol over an extended period of time cause an increase in γ-GT activity, CDT and MCV.
- Smokers have elevated CO-Hb- and CEA-concentrations.
- Substantial diurnal variations can be observed in the case of some analytes, e. g. hormones (epinephrine, aldosterone, corticotropin, cortisol, norepinephrine, prolactin, somatotropin, testosterone), electrolyte excretion in urine, serum hemoglobin and iron. Therefore it is recommended to collect samples between 7 and 9 a.m.
- Patients undergoing tolerance tests should be prepared as described in section 2.12 "Function tests"".

If possible, sample collection should always take place under standardized conditions, i. e. when the patient is fasting, always with the patient in the same position (seated or recumbent), around the same time of day and following brief venous stasis.

1.2 Sample collection

Clinical chemistry:
Clinical chemical assays are almost exclusively performed on serum or plasma. Serum is obtained from spontaneously coagulated whole blood, plasma via the addition of anticoagulants (EDTA, citrate, oxalate or heparinate). Differences between serum and plasma are generally observed in the determination of potassium, inorganic phosphate and LDH, and in electrophoresis of fibrinogen (281). In thrombocytosis patients with thrombocyte values above $500 \times 10^3/\mu L$ (500 Gpt/L) a potassium determination cannot be performed in serum; it is necessary to use heparinized plasma instead.

Glucose:
Since the rate of glycolysis is around 7 % per hour, a glycolysis inhibitor, e.g. sodium fluoride, mannose or iodoacetate must be added to the blood sample prior to determination of the glucose concentration.

Hematology:
In the vast majority of hematological analyses, venous blood treated with EDTA is used.
In isolated cases, EDTA-induced pseudothrombocytopenia can develop, which is of no significance clinically. Use of citrated blood returns cell numbers to normal.

Coagulation:
In coagulation tests, citrated plasma (one part 3.2 % [0.11 mol/L]* sodium citrate solution and nine parts blood) is used for assay purposes. It is essential to mix the sodium citrate solution and the blood **exactly** in the relationship 1 + 9. Blood treated with EDTA or oxalate cannot be used for coagulation assays, since these substances may cause more rapid

* sometimes one part 3.9 % [0.129 mol/L] is used

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inactivation of factors V and VIII, for example. Hemolytic samples or samples which have started to coagulate should be discarded.

Urine:
In urinalysis it must be noted that there are considerable diurnal variations in the excretion of some substances, that urine must be pretreated for stabilization of catecholamines, for example, and that it is essential to collect all the urine excreted during the specified period. For the determination of calcium, the *entire* amount of urine excreted over 24 hours must be acidified and heated.

CSF:
CSF collected for the assay of clinical chemistry analytes should be treated with EDTA to preclude fibrin clot formation since an accurate cell count can otherwise not be obtained.

1.3 Transport and storage of sample material

Centrifugation should generally take place no more than 1 hour after sample collection. If samples are to be despatched, only serum or plasma should be used unless whole blood is absolutely necessary for the analysis.
With regard to clinical chemical determinations, the use of a separator gel in the collection tube has proved advantageous in preventing cellular constituents from entering the serum.

Clinical chemistry (102):
Electrolytes, substrates and enzymes in the sample (serum, plasma) are usually stable for 4 days when stored in the refrigerator at + 4 °C (exceptions: acid phosphatase, ammonium, lactate) and are stable for at least one day at room temperature. If long-term storage is necessary, it is advisable to freeze the sample at – 20 °C unless it is to be used for determination of LDH, Lp[a] or α-HBDH. Repeated thawing should be avoided.

Plasma glucose determinations:
Plasma should be separated from cellular constituents (centrifuged) no later than 30 minutes after collection of the blood sample. Avoid hemolysis. Sample material which has been separated from cellular constituents or in which glycolysis has been prevented via the addition of a glycolysis inhibitor, e. g. sodium fluoride (NaF), can be refrigerated for up to 7 days.

Hematology (96):
When kept in the closed tube, the cellular constituents and hemoglobin are stable for one day. It should, however, be noted that the blood smear must be prepared within 3 hours (93).

Coagulation (95, 101):
In coagulation analysis, determination of the analytes should always take place as soon as possible. If this is not feasible, platelet-poor plasma must be frozen *immediately* at – 20 °C or – 40 °C. Plasma for Quick, PTT, thrombin time and fibrinogen can be stored for about 4 h at room temperature or in a refrigerator. Fibrinogen, protein C and AT III are stable for 7 days, protein S and factors V and VIII for 4 hours only.

Urine:
Urine sediment should be evaluated within 2 to 3 hours at the latest. Freezing or refrigeration of the specimen is not recommended because of salt precipitation.

CSF (214):
CSF cells must be counted within the period of one hour.

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1.4 Assessment of sample material

Blood gases (184):
Blood gas determinations should be performed immediately. If this is not possible, the blood specimens collected in glass containers can be placed in iced water for up to 2 hours.

Hemolysis (102):
Determination of potassium, magnesium or LDH is not possible even in slightly hemolytic serum. Considerable hemolysis also affects other tests.

Bilirubinemia:
To avoid interference by icteric samples, the visual recognition of hyperbilirubinemia is often not sufficiently sensitive. This is particularly true when samples are simultaneously colorized by other pigments (e.g., hemoglobin).
Spectral bilirubin interferences can be removed by blanking, such as with the kinetic Jaffé methods. Chemical bilirubin interference of H_2O_2 - forming enzymatic methods based on the Trinder reaction can be avoided by selection and choice of optimal concentrations of test components. (84).

Serum Indices:
On the Roche/Hitachi, COBAS INTEGRA® and **cobas**® modular platforms Serum Indices (icterus, lipemia, hemolysis) are measured.
The package inserts of Roche's clinical chemistry reagents indicate for every test the Serum Index (I, L, H) limit above which the method is significantly interfered.
On the **cobas**® platforms the Serum Index limits are electronically deposed and a Serum Index flag only appears if the respective test is actually significantly affected by the present interferent concentration.

Lipemia:
Lipemic sera may interfere with photometric determinations. In this case, it is necessary to remove the lipoproteins.

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2 Reference ranges

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Acetoacetate	Adults	0.2–0.4 mg/dL	20–40 µmol/L	16	
α_1-Acid glycoprotein		50–120 mg/dL	0.5–1.2 g/L	237	CRM 470 standardization
Acid phosphatase (ACP), total prostatic	f	< 6.5 U/L	<0.108 µkat/L	218	Roche Diagnostics, α-naphthyl phosphate, pentandiole-activated, Roche/Hitachi, **cobas**® instruments
	m	< 6.6 U/L	<0.110 µkat/L		
		< 3.5 U/L	<0.058 µkat/L		
total prostatic	m	< 7.3 U/L	<0.120 µkat/L	218	COBAS INTEGRA® instruments
		< 1.9 U/L	<0.030 µkat/L		
Adenosine monophosphate, 3′-5′, cycl. (cAMP)	Adults f	4.3–7.6 ng/mL	13–23 nmol/L	43	EDTA plasma
	m	4.6–8.6 ng/mL	14–26 nmol/L		
Adrenocorticotrophic hormone, Corticotropin (ACTH)	Adults	7.2–63.6 pg/mL	1.6–13.9 pmol/L	218	Roche Diagnostics, ACTH Elecsys®, samples drawn 7–10 a.m.
Alanine aminotransferase, glutamate pyruvate transaminase (GPT, ALAT, ALT)	Newborns, children, adolescents 1 d	<31 U/L	<0.50 µkat/L	68	IFCC, without pyridoxal phosphate
	2–5 d	<52 U/L	<0.85 µkat/L		
	6 d–6 mth	<60 U/L	<1.00 µkat/L		
	7–12 mth	<57 U/L	< 0.95 µkat/L		
	1–3 yr	<39 U/L	<0.65 µkat/L		
	4–6 yr	<39 U/L	<0.65 µkat/L		
	7–12 yr	<39 U/L	<0.65 µkat/L		
	13–17 yr f	<23 U/L	<0.40 µkat/L		
	m	<26 U/L	<0.45 µkat/L		
	Children, adolescents	w/o pyp / with pyp	w/o pyp / with pyp	94	IFCC, with and without pyridoxal phosphate
	<1 yr	<56 U/L / <71 U/L	<0.93 µkat/L / <1.18 µkat/L		
	1–3 yr	<29 U/L / <31 U/L	<0.48 µkat/L / <0.52 µkat/L		
	4–6 yr	<29 U/L / <36 U/L	<0.48 µkat/L / <0.60 µkat/L		
	7–12 yr	<37 U/L / <44 U/L	<0.62 µkat/L / <0.73 µkat/L		
	13–17 yr	<37 U/L / <45 U/L	<0.62 µkat/L / <0.75 µkat/L		
	Adults, >17 yr f	<33 U/L	<0.52 µkat/L	218, 260	according to IFCC, without pyridoxal phosphate
	m	<41 U/L	<0.68 µkat/L		
	Adults f	<35 U/L	<0.60 µkat/L	137, 218, 270	IFCC, with pyridoxal phosphate, consensus values
	m	<50 U/L	<0.85 µkat/L		
	f	<34 U/L	<0.56 µkat/L	238	IFCC, with pyridoxal phosphate, hospital patients
	m	<45 U/L	<0.74 µkat/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Alanine amino-transferase, glutamate pyruvate transaminase (GPT, ALAT, ALT)	Newborn–12 mth	f	<45 U/L	<0.77 µkat/L	218, 299	IFCC, with pyridoxal phosphate
		m	<45 U/L	<0.77 µkat/L		
	13 mth–60 yr	f	<35 U/L	<0.60 µkat/L		
		m	<40 U/L	<0.68 µkat/L		
	61 a–90 yr	f	<28 U/L	<0.48 µkat/L		
		m	<40 U/L	<0.68 µkat/L		
	>90 yr	f	<24 U/L	<0.41 µkat/L		
		m	<38 U/L	<0.65 µkat/L		
	Adults, ≥18 yr	f	<46 U/L	<0.77 µkat/L	227	Nordic Reference Interval Project (NORIP), methods traceable to IFCC
		m	<45 U/L	<0.75 µkat/L		
	Adults	f	<32 U/L	<0.53 µkat/L	218	Reflotron®, blood, serum, plasma
		m	<41 U/L	<0.68 µkat/L		
Albumin	Adults		3.97–4.94 g/dL	39.7–49.4 g/L	218	Roche Diagnostics, bromocresol-green method, CRM 470 standardization.
			3.56–4.61 g/dL	35.6–46.1 g/L	218	Roche Diagnostics, immunoturbidimetric method, CRM 470 standardization.
			3.49–4.75 g/dL	34.9–47.5 g/L	218	Roche Diagnostics, bromocresol-purple-method, CRM 470 standardization.
	Adults		3.5–5.2 g/dL	35–52 g/L	218, 237	CRM 470 standardization, consensus values
	≤4 d		2.8–4.4 g/dL	28–44 g/L	218, 299	Bromocresol-green/bromocresol-purple/immunoturbidimetric/nephelometric methods, CRM 470 standardization.
	5 d–14 yr		3.8–5.4 g/dL	38–54 g/L		
	15–18 yr		3.2–4.5 g/dL	32–45 g/L		
Aldosterone	Recumbent		29–145 ng/L	80–400 pmol/L	116	RIA, method-dependent
	Standing		65–285 ng/L	180–790 pmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Alkaline phosphatase (AP), total	Children, adolescents	1 d	<600 U/L	<10.00 µkat/L	68	DGKC, optimized, recommendations 1972, calculated with a conversion factor of 1.52 (25 °C → 37 °C)
		2–5 d	<553 U/L	<9.20 µkat/L		
		6 d–6 mth	<1076 U/L	<17.95 µkat/L		
		7–12 mth	<1107 U/L	<18.45 µkat/L		
		1–3 yr	<673 U/L	<11.20 µkat/L		
		4–6 yr	<644 U/L	<10.75 µkat/L		
		7–12 yr	<720 U/L	<12.00 µkat/L		
	13–17 yr	f	<448 U/L	<7.45 µkat/L		
		m	<936 U/L	<15.60 µkat/L		
	Adults	f	<240 U/L	<4.00 µkat/L	224	DGKC (calculated for 37 °C)
		m	<270 U/L	<4.50 µkat/L		
	Children, adolescents	<1 yr	<390 U/L	<6.50 µkat/L	94	IFCC
		1–3 yr	<409 U/L	<6.82 µkat/L		
		4–6 yr	<347 U/L	<5.78 µkat/L		
	7–12 yr	f	<312 U/L	<5.20 µkat/L		
		m	<316 U/L	<5.27 µkat/L		
	13–17 yr	f	<329 U/L	<5.48 µkat/L		
		m	<381 U/L	<6.35 µkat/L		
	20–50 yr	f	<98 U/L	<1.65 µkat/L	272	IFCC
		m	<128 U/L	<2.15 µkat/L		
	> 60 yr	f	<141 U/L	<2.35 µkat/L		
		m	<119 U/L	<2.00 µkat/L		
	Adults	f	<105 U/L	<1.75 µkat/L	270	Consensus values of DGKC and VDGH
		m	<130 U/L	<2.20 µkat/L		
	Children, adolescents	1 d	<250 U/L	<4.17 µkat/L	218, 68	Calculated from data published for the ALP opt. method (DGKC) using a factor of 0.417.
		2–5 d	<231 U/L	<3.84 µkat/L		
		6 d–6 mth	<449 U/L	<7.49 µkat/L		
		7–12 mth	<462 U/L	<7.69 µkat/L		
		1–3 yr	<281 U/L	<4.67 µkat/L		
		4–6 yr	<269 U/L	<4.48 µkat/L		
		7–12 yr	<300 U/L	<5.00 µkat/L		
	13–17 yr	f	<187 U/L	<3.11 µkat/L		
		m	<390 U/L	<6.51 µkat/L		
bone	Adults	f	<120 U/L	<2.00 µkat/L	224	DGKC (calculated for 37 °C)
		m	<150 U/L	<2.50 µkat/L		
Aluminium	Adults		<3 µg/L	<0.11 µmol/L	67	Use only tubes specifically designed for determination of trace elements

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Ammonia	Adults f	<82 µg/dL	<48 µmol/L	218	Roche/Hitachi instruments
	m	<94 µg/dL	<55 µmol/L		
	f	<87 µg/dL	<51 µmol/L	218	COBAS INTEGRA®/**cobas®** instruments
	m	<102 µg/dL	<60 µmol/L		
α-Amylase, total	Adults	<100 U/L	<1.67 µkat/L	218	IFCC, Reflotron®, COBAS INTEGRA®, **cobas®**, Roche/Hitachi instruments
α-Amylase, pancreatic	<1 yr	<8 U/L	<0.13 µkat/L	2	IFCC
	1–9 yr	<31 U/L	<0.52 µkat/L		
	10–18 yr	<39 U/L	<0.65 µkat/L		
	Adults	<53 U/L	<0.90 µkat/L	218	Reflotron®, COBAS INTEGRA®, **cobas®**, Roche/Hitachi instruments
Amyloid A		0.8–9.7 mg/L	0.8–9.7 mg/L	155	
Anion gap		8–16 mmol/L	8–16 mmol/L	194	
Antibody to cyclic citrullinated peptide (Anti-CCP)		17 U/mL	17 U/mL	218	Anti-CCP Elecsys® Optimum cut-off (sensitivity: 67.7 %; specificity: 97.0 %)
Anti-DNAse B	Children 2 yr	<240 U/mL	<240 kU/L	131	
	3 yr	<60 U/mL	< 60 kU/L		
	4 yr	<240 U/mL	<240 kU/L		
	5 yr	<320 U/mL	<320 kU/L		
	6 yr	<480 U/mL	<480 kU/L		
	7–10 yr	<640 U/mL	<640 kU/L		
	11 yr	<800 U/mL	<800 kU/L		
	12 yr	<480 U/mL	<480 kU/L		
	Adults	<480 U/mL	<480 kU/L		
Antistreptolysin O (ASLO)	Children 2 yr	<160 U/mL	<160 kU/L	131	Reference ranges vary with season and geographical area.
	3–4 yr	<120 U/mL	<120 kU/L		
	5 yr	<160 U/mL	<160 kU/L		
	6–9 yr	<240 U/mL	<240 kU/L		
	10–12 yr	<320 U/mL	<320 kU/L		
	Adults	<200 U/mL	<200 kU/L	218, 292	Immunoturbidimetric method, COBAS INTEGRA®, **cobas®**, Roche/Hitachi instruments
	Children <6 yr	<150 U/mL	<150 kU/L		
	6–18 yr	200–240 U/mL	200–240 kU/L		
Anti-thyreoglobulin, thyreoglobulin autoantibodies (Anti-TG)	Children, adolescents				
	Newborn	<134 U/mL	<134 kU/L	219	Anti-TG Elecsys®, reference range study
	6 d–3 mth	<146 U/mL	<146 kU/L		
	4–12 mth	<130 U/mL	<130 kU/L		
	1–6 yr	<38 U/mL	<38 kU/L		
	7–11 yr	<37 U/mL	<37 kU/L		
	12–20 yr	<64 U/mL	<64 kU/L		
	Healthy subjects	<115 U/mL	<115 kU/L	218	Anti-TG Elecsys®

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Anti-thyroidea peroxidase, thyroid peroxidase antibodies (Anti-TPO)	Children, adolescents				
	Newborn	<117 U/mL	<117 kU/L	219	Anti-TPO Elecsys®
	6 d–3 mth	<47 U/mL	<47 kU/L		
	4–12 mth	<32 U/mL	<32 kU/L		
	1–6 yr	<13 U/mL	<13 kU/L		
	7–11 yr	<18 U/mL	<18 kU/L		
	12–20 yr	<26 U/mL	<26 kU/L		
	Healthy subjects	<34 IU/mL	<34 kIU/L	218	
α_1-Antitrypsin	<1 mth	124–348 mg/dL	23.2–65.1 µmol/L	54	Immunonephelometric assay, CRM 470 standardization
	2–6 mth	111–297 mg/dL	20.8–55.5 µmol/L		
	7 mth–2 yr	95–251 mg/dL	17.8–46.9 µmol/L		
	3 yr–19 yr	110–280 mg/dL	20.6–52.4 µmol/L		
	Adults	90–200 mg/dL	16.6–36.8 µmol/L	218, 237	Immunoturbidimetric assay, CRM 470 standardization
Anti-TSHR (antibodies to TSH receptor)	Healthy subjects	Negative: <1.5 U/L Indeterminate: 1.5–1.75 U/L Positive: >1.75 U/L	Negative: <1.5 U/L Indeterminate: 1.5–1.75 U/L Positive: >1.75 U/L	218	Anti-TSHR Elecsys®
Apolipoprotein A-I	Adults f	104–202 mg/dL	1.04–2.02 g/L	218	
	m	108–225 mg/dL	1.08–2.25 g/L		
Apolipoprotein B	Adults f	0.60–1.17 g/L	2.27–4.43 µmol/L	218	
	m	0.66–1.33 g/L	2.50–5.04 µmol/L		
Aspartate aminotransferase, glutamate oxaloacetate aminotransaminase (GOT, ASAT, AST)	Children, adolescents				
	1 d	<122 U/L	<2.05 µkat/L	68	IFCC, without pyridoxal phosphate
	2–5 d	<110 U/L	<1.85 µkat/L		
	6 d–6 mth	<84 U/L	<1.40 µkat/L		
	7–12 mth	<89 U/L	<1.50 µkat/L		
	1–3 yr	<56 U/L	<0.95 µkat/L		
	4–6 yr	<52 U/L	<0.85 µkat/L		
	7–12 yr	<51 U/L	<0.85 µkat/L		
	13–17 yr f	<27 U/L	<0.45 µkat/L		
	m	<33 U/L	<0.60 µkat/L		
	Children, adolescents	w/o pyp / with pyp	w/o pyp / with pyp	94	IFCC, with and without pyridoxal phosphate
	<1 yr	<58 U/L / <96 U/L	<0.97 µkat/L / <1,60 µkat/L		
	1–3 yr	<59 U/L / <71 U/L	<0.98 µkat/L / <1.18 µkat/L		
	4–6 yr	<48 U/L / <53 U/L	<0.80 µkat/L / <0.88 µkat/L		
	7–12 yr	<44 U/L / <50 U/L	<0.73 µkat/L / <0.83 µkat/L		
	13–17 yr	<39 U/L / <46 U/L	<0.65 µkat/L / <0.77 µkat/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Aspartate amino-transferase, glutamate oxaloacetate aminotransaminase (GOT, ASAT, AST)	Adults f	<35 U/L	<0.60 µkat/L	137, 218, 270	IFCC, with pyridoxal phosphate
	m	<50 U/L	<0.85 µkat/L		
	f	<31 U/L	<0.52 µkat/L	238	IFCC, with pyridoxal phosphate, hospitalized patients
	m	<35 U/L	<0.58 µkat/L		
	f	<35 U/L	<0.58 µkat/L	227	Nordic Reference Interval Project (NORIP), methods traceable to IFCC
	m	<45 U/L	<0.75 µkat/L		
	f	≤32 U/L	≤0.53 µkat/L	218, 260	Acc. to the optimized standard method (comparable to the IFCC method without pyridoxal phosphate activation), calculated values (25 °C → 37 °C).
	m	≤40 U/L	≤0.67 µkat/L		
	f	<33 U/L	<0.55 µkat/L	218	Reflotron®, blood, serum, plasma
	m	<40 U/L	<0.67 µkat/L		
Bilirubin, total	Neonates (premature) 1 d	< 8.2 mg/dL	< 140 µmol/L	134	
	2 d	< 12 mg/dL	< 205 µmol/L		
	3–5 d	< 24 mg/dL	< 410 µmol/L		
	≥ 4 w	< 1.5 mg/dL	< 26 µmol/L		
	Newborns (full term), children 1 d	<8.7 mg/dL	<150 µmol/L	264	
	2 d	<11.3 mg/dL	<193 µmol/L		
	3 d	<12.7 mg/dL	<217 µmol/L		
	4–6 d	<12.6 mg/dL	<216 µmol/L		
	>1 mth	<1.0 mg/dL	<17 µmol/L		
	Adults	<1.1 mg/dL	<18.7 µmol/L	285	
Bilirubin, direct (conjugated)		<0.2 mg/dL	<3.4 µmol/L	299	
		<0.1 mg/dL	<1.7 µmol/L	264	
	Neonates	<0.6 mg/dL	<10 µmol/L	247	
CA 15–3		<25 U/mL	<25 kU/L	218	CA 15–3 Elecsys®
CA 19–9		<27 U/mL	<27 kU/L	218	CA 19–9 Elecsys®
CA 72–4		<6.9 U/mL	<6.9 kU/L	218	CA 72–4 Elecsys®
CA 125		<35 U/mL	<35 kU/L	218	CA 125 II Elecsys®
C_{3C}-complement		90–180 mg/dL	0.9–1.8 g/L	237	CRM 470 standardization
C_4-complement		10–40 mg/dL	0.1–0.4 g/L	237	CRM 470 standardization
Cadmium		<2.7 µg/L	<24 nmol/L	82	Whole blood, AAS
Calcitonin	Adults f	≤14 ng/L	≤3.9 pmol/L	299	
	m	≤19 ng/L	≤5.3 pmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Calcium, total	Adults	8.6–10.3 mg/dL	2.15–2.58 mmol/L	266	Photometric assay
		8.8–10.2 mg/dL	2.20–2.54 mmol/L	266	AAS
	Cord blood	8.2–11.2 mg/dL	2.05–2.80 mmol/L	299	
	Newborns, premature	6.2–11.0 mg/dL	1.55–2.75 mmol/L		
	Children <10 d	7.6–10.4 mg/dL	1.90–2.60 mmol/L		
	11 d–2 yr	9.0–11.0 mg/dL	2.25–2.75 mmol/L		
	3–12 yr	8.8–10.8 mg/dL	2.20–2.70 mmol/L		
	13–18 yr	8.4–10.2 mg/dL	2.10–2.55 mmol/L		
	Adults 18–60 yr	8.6–10.0 mg/dL	2.15–2.50 mmol/L		
	61–90 yr	8.8–10.2 mg/dL	2.20–2.55 mmol/L		
	>90 yr	8.2–9.6 mg/dL	2.05–2.40 mmol/L		
		8.6–10.2 mg/dL	2.15–2.55 mmol/L	218	Roche/Hitachi, COBAS INTEGRA®, **cobas**® systems.
Calcium, free, ionized	Adults	4.7–5.2 mg/dL	1.17–1.29 mmol/L	244	
		4.6–5.3 mg/dL	1.16–1.32 mmol/L	266	
Carcinoembryonic antigen (CEA)	Non-smokers 20–69 yr	3.8 ng/mL	3.8 µg/L	218	CEA Elecsys®
	≥ 40 yr	5.0 ng/mL	5.0 µg/L		
	Smokers 20–69 yr	5.5 ng/mL	5.5 µg/L		
	≥ 70 yr	6.5 ng/mL	6.5 µg/L		
Carnitin, free	1–12 mth	0.71–1.83 mg/dL	15–39 µmol/L	31	
	1–7 yr	0.85–1.74 mg/dL	18–37 µmol/L		
	8–15 yr	1.46–2.02 mg/dL	31–43 µmol/L		
	Adults f	0.85–2.16 mg/dL	17.9–45.5 µmol/L	242	
	m	1.18–2.40 mg/dL	24.6–51.0 µmol/L		
Catecholamines					
– Norepinephrine		185–275 ng/L	1100–1600 pmol/L	206	Plasma with addition of glutathione and EGTA
– Epinephrine		30–85 ng/L	170–470 pmol/L		
– Dopamine		30–85 ng/L	200–550 pmol/L		
Ceruloplasmin		20–60 mg/dL	1.49–4.40 µmol/L	218, 237	Immunoturbidimetric method, CRM 470 standardization
Chloride	Children 1–7 d	97–108 mEq/L	97–108 mmol/L	247	ISE
	8 d–1 mth	97–108 mEq/L	97–108 mmol/L		
	2–6 mth	97–108 mEq/L	97–108 mmol/L		
	7 mth–1 yr	97–106 mEq/L	97–106 mmol/L		
	>1 yr	97–107 mEq/L	97–107 mmol/L		
	Adults	98–107 mEq/L	98–107 mmol/L	218, 299	Indirect ISE, coulometry
		101–110 mEq/L	101–110 mmol/L	218	Direct ISE

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Cholesterol, total	1–30 d	f	62–155 mg/dL	1.60–4.01 mmol/L	247	EDTA plasma yields 3–6 % lower values than serum.
		m	54–151 mg/dL	1.40–3.90 mmol/L		
	31–182 d	f	62–141 mg/dL	1.60–3.65 mmol/L		
		m	81–147 mg/dL	2.09–3.80 mmol/L		
	183–365 d	f	76–216 mg/dL	1.97–5.59 mmol/L		
		m	76–179 mg/dL	1.97–4.63 mmol/L		
	1–3 yr	f	108–193 mg/dL	2.79–4.99 mmol/L		
		m	85–182 mg/dL	2.20–4.71 mmol/L		
	4–6 yr	f	106–193 mg/dL	2.74–4.99 mmol/L		
		m	110–217 mg/dL	2.84–5.61 mmol/L		
	7–9 yr	f	104–210 mg/dL	2.69–5.43 mmol/L		
		m	110–211 mg/dL	2.84–5.46 mmol/L		
	10–12 yr	f	105–218 mg/dL	2.72–5.64 mmol/L		
		m	105–223 mg/dL	2.72–5.77 mmol/L		
	13–15 yr	f	108–205 mg/dL	2.79–5.30 mmol/L		
		m	91–204 mg/dL	2.35–5.28 mmol/L		
	16–18 yr	f	92–234 mg/dL	2.38–6.05 mmol/L		
		m	82–192 mg/dL	2.12–4.97 mmol/L		
	No risk		<200 mg/dL	<5.2 mmol/L	46	Classification acc. to NCEP ATP III
	Moderate risk		200–239 mg/dL	5.2–6.2 mmol/L		
	High risk		≥240 mg/dL	≥6.2 mmol/L		
Cholesterol, HDL	Major risk		≥40 mg/dL	<1.0 mmol/L	46	Classification acc. to NCEP ATP III
	"Negative" risk		≤60 mg/dL	<1.6 mmol/L		
	No risk	f	>65 mg/dL	>1.68 mmol/L	261	European guidelines
		m	>55 mg/dL	>1.45 mmol/L		
	Moderate risk	f	45–65 mg/dL	1.15–1.68 mmol/L		
		m	35–55 mg/dL	0.9–1.45 mmol/L		
	High risk	f	<45 mg/dL	<1.15 mmol/L		
		m	<35 mg/dL	<0.90 mmol/L		
Cholesterol, LDL	Adults		<155 mg/dL	<4.0 mmol/L	65	
	Adult levels	Optimum	<100 mg/dL	<2.59 mmol/L	46, 218	Classification acc. to NCEP ATP III
		Near/above optimum	100–129 mg/dL	2.59–3.34 mmol/L		
		Borderline high	130–159 mg/dL	3.35–4.12 mmol/L		
		High	160–189 mg/dL	4.13–4.92 mmol/L		
		Very high	≥190 mg/dL	≥4.92 mmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Cholinesterase (CHE)	m, w >41 yr	5.32–12.92 kU/L	89–215 µkat/L	29, 218	Pseudocholinesterase, butyrylthiocholine iodide, Roche Diagnostics. Calculated with a temperature conversion factor of 1.52 (25 → 37 °C)
	w, 16–40 yr, not pregnant, not taking oral contraceptives	4.26–11.25 kU/L	71–188 µkat/L		
	w, 18–40 yr, pregnant or taking oral contraceptives	3.65–9.120 kU/L	61–152 µkat/L		
Dibucaine inhibition test	Normal individuals	Inhibition: >75 %	Inhibition: >0.75	200	
Chromium	Fasting volunteers	1.0–1.5 µg/L	20–30 nmol/L	241	Special tubes required
Copper	<4 mth	8.9–46 µg/dL	1.4–7.2 µmol/L	159	
	5–6 mth	25–108 µg/dL	4–17 µmol/L		
	7–12 mth	51–133 µg/dL	8–21 µmol/L		
	1–5 yr	83–152 µg/dL	13–24 µmol/L		
	6–9 yr	83–133 µg/dL	13–21 µmol/L		
	10–13 yr	83–121 µg/dL	13–19 µmol/L		
	14–19 yr f	70–159 µg/dL	11–25 µmol/L		
	m	64–114 µg/dL	10–18 µmol/L		
	Adults f	76–152 µg/dL	12–24 µmol/L	171	
	m	70–140 µg/dL	11–22 µmol/L		
Cortisol	7–10 h	6.2–19.4 µg/dL	171–536 nmol/L	218	Cortisol Elecsys®
	16–20 h	2.3–11.9 µg/dL	64–327 nmol/L		
C-peptide of insulin		1.1–4.4 ng/mL	0.37–1.47 nmol/L	218	C-peptide Elecsys®
C-reactive Protein (CRP)	Adults	<0.50 mg/dL	<47.6 nmol/L	89, 218	Immunoturbidimetric method, CRM 470 standardization, consensus value for adults
high sensitive	Neonates <3 w	<0.41 mg/dL	<39.0 nmol/L	218, 233	Immunoturbidimetric method, CRM 470 standardization
	Children 2 mth–15 yr	<0.28 mg/dL	<26.7 nmol/L		
	Adults	<0.50 mg/dL	<47.6 nmol/L		
	f 50–64 yr	<0.85 mg/dL	<80.9 nmol/L	105	Immunonephelometric method, CRM 470 standardization
	>65 yr	<0.66 mg/dL	<62.8 nmol/L		
	m 50–64 yr	<0.79 mg/dL	<75.2 nmol/L		
	>65 yr	<0.68 mg/dL	<64.7 nmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	Reference Ranges SI	References	Notes
Creatine kinase (CK), total		1 d	<712 U/L	<11.9 µkat/L	68	NAC activated, DGKC, optimized, recommendations 1972
		2–5 d	<652 U/L	<10.9 µkat/L		
		6 d–6 mth	<295 U/L	<4.90 µkat/L		
		7–12 mth	<203 U/L	<3.40 µkat/L		
		1–3 yr	<228 U/L	<3.80 µkat/L		
		4–6 yr	<149 U/L	<2.50 µkat/L		
	7–12 yr	f	<154 U/L	<2.55 µkat/L		
		m	<247 U/L	<4.10 µkat/L		
	13–17 yr	f	<123 U/L	<2.05 µkat/L		
		m	<270 U/L	<4.50 µkat/L		
	Adults	f	<180 U/L	<2.01 µkat/L	218, 299	
		m	<200 U/L	<3.34 µkat/L		
	Adults	f	<170 U/L	<2.85 µkat/L	137, 218	Consensus values
		m	<190 U/L	<3.20 µkat/L		
		f	<192 U/L	<3.21 µkat/L	138, 218	
		m	<308 U/L	<5.14 µkat/L		
		f	<145 U/L	<2.41 µkat/L	217, 238	IFCC, hospital patients
		m	<171 U/L	<2.85 µkat/L		
		f	<170 U/L	<2.84 µkat/L	218	Roche Diagnostics, Reflotron®
		m	<195 U/L	<3.26 µkat/L		
Creatine kinase MB (CK-MB)		Adults	<25 U/L	<0.42 µkat/L	269, 218	Consensus values
mass	Adults	f	<2.88 ng/mL	<2.88 µg/L	218	CK-MB Elecsys®
		m	<4.94 ng/mL	<4.94 µg/L		
Creatinine		Neonates, premature	<1.04 mg/dL	<91 µmol/L	218, 233	Jaffé method, Roche Diagnostics
		Neonates, full term	<0.85 mg/dL	<75 µmol/L		
	Children	2–12 mth	<0.42 mg/dL	<37 µmol/L		
		1–2 yr	<0.41 mg/dL	<36 µmol/L		
		3–4 yr	<0.47 mg/dL	<42 µmol/L		
		5–6 yr	<0.59 mg/dL	<52 µmol/L		
		7–8 yr	<0.60 mg/dL	<53 µmol/L		
		9–10 yr	<0.73 mg/dL	<65 µmol/L		
		11–12 yr	<0.79 mg/dL	<70 µmol/L		
		13–14 yr	<0.87 mg/dL	<77 µmol/L		
	Adults	f	<0.90 mg/dL	<80 µmol/L	172, 218	Jaffé method, Roche Diagnostics
		m	<1.20 mg/dL	<106 µmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Creatinine	Neonates, premature	<0.98 mg/dL	<87 µmol/L	218, 233	Enzymatic method, Roche Diagnostics
	Neonates, full term	<0.88 mg/dL	<77 µmol/L		
	Children 2–12 mth	<0.39 mg/dL	<34 µmol/L		
	1–2 yr	<0.35 mg/dL	<31 µmol/L		
	3–4 yr	<0.42 mg/dL	<37 µmol/L		
	5–6 yr	<0.47 mg/dL	<42 µmol/L		
	7–8 yr	<0.53 mg/dL	<47 µmol/L		
	9–10 yr	<0.64 mg/dL	<56 µmol/L		
	11–12 yr	<0.68 mg/dL	<60 µmol/L		
	13–14 yr	<0.77 mg/dL	<68 µmol/L		
	Adults f	<0.95 mg/dL	<84 µmol/L	172, 218	Enzymatic method, Roche Diagnostics
	m	<1.17 mg/dL	<104 µmol/L		
β-CrossLaps	w premenopausal	<573 pg/mL	<573 ng/L	218	β-Cross Laps Elecsys®
	postmenopausal	<1008 pg/mL	<1008 ng/L		For postmenopausal women on hormon
	m 30–50 yr	<584 pg/mL	<584 ng/L		replacement therapy the ref. values
	51–70 yr	<704 pg/mL	<704 ng/L		of premenopausal women are valid.
	>70 yr	<854 pg/mL	<854 ng/L		
CYFRA 21–1		< 3.3 ng/mL	<3.3 µg/L	218	CYFRA 21–1 Elecsys®
Cystatin C	Children <1 mth	1.1–2.2 mg/L	1.1–2.2 mg/L	205	
	1–12 mth	0.5–1.4 mg/L	0.5–1.4 mg/L		
	>12 mth	0.5–1.0 mg/L	0.5–1.0 mg/L		
	Adults 20–50 yr	0.7–1.2 mg/L	0.7–1.2 mg/L	190	
	>50 yr	0.8–1.6 mg/L	0.8–1.6 mg/L		
	Adults 20–70 yr	0.47–1.09 mg/L	0.47–1.09 mg/L	218	Roche Diagnostics, Roche/Hitachi, COBAS INTEGRA®, **cobas**® systems.
Dehydroepiandro-sterone sulfate (DHEA-S)	10–14 yr f	33.9–280 µg/dL	0.92–7.60 µmol/L	218	DHEA-S Elecsys®
	m	24.4–247 µg/dL	0.66–6.70 µmol/L		
	15–19 yr f	65.1–368 µg/dL	1.77–9.99 µmol/L		
	m	70.2–492 µg/dL	1.91–13.4 µmol/L		
	20–24 yr f	148–407 µg/dL	4.02–11.0 µmol/L		
	m	211–492 µg/dL	5.73–13.4 µmol/L		
	25–34 yr f	98.8–340 µg/dL	2.68–9.23 µmol/L		
	m	160–449 µg/dL	4.34–12.2 µmol/L		
	35–44 yr f	60.9–337 µg/dL	1.65–9.15 µmol/L		
	m	88.9–427 µg/dL	2.41–11.6 µmol/L		
	45–54 yr f	35.4–256 µg/dL	0.96–6.95 µmol/L		
	m	44.3–331 µg/dL	1.20–8.98 µmol/L		
	55–64 yr f	18.9–205 µg/dL	0.51–5.56 µmol/L		
	m	51.7–295 µg/dL	1.40–8.01 µmol/L		
	65–74 yr f	9.40–246 µg/dL	0.26–6.68 µmol/L		
	m	33.6–249 µg/dL	0.91–6.76 µmol/L		
	75 yr f	12.0–154 µg/dL	0.33–4.18 µmol/L		
	m	16.2–123 µg/dL	0.44–3.34 µmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Dehydroepiandrosterone sulfate (DHEA-S)	Children <1 w	2.93–16.5 µmol/L	108–607 µg/dL	218	DHEA-S Elecsys®
	1–4 w	0.86–11.7 µmol/L	31.6–431 µg/dL		
	1–12 m	0.09–3.35 µmol/L	3.4–124 µg/dL		
	1–4 yr	0.01.–0.53 µmol/L	0.47–19.4 µg/dL		
	5–9 yr	0.08–2.31 µmol/L	2.8–85.2 µg/dL		
Elastase	Healthy lab. workers	<160 µg/L	<160 µg/L	186	ELISA, reference range depends on test used.
Erythropoietin	1–3 yr f	<15.9 U/L	<15.9 U/L	143	Serum
	m	<17.9 U/L	<17.9 U/L		
	4–6 yr f	<8.5 U/L	<8.5 U/L		
	m	<21.9 U/L	<21.9 U/L		
	7–9 yr f	<8.2 U/L	<8.2 U/L		
	m	<13.5 U/L	<13.5 U/L		
	10–12 yr f	<9.1 U/L	<9.1 U/L		
	m	<14.0 U/L	<14.0 U/L		
	13–15 yr f	<20.5 U/L	<20.5 U/L		
	m	<14.4 U/L	<14.4 U/L		
	16–18 yr f	<14.2 U/L	<14.2 U/L		
	m	<15.2 U/L	<15.2 U/L		
	Adults	5–25 U/L	5–25 U/L		
Estradiol (E2)	1–10 yr f	6.0–27 pg/mL	22.0–99 pmol/L	218	Estradiol II Elecsys®
	m	5.0–20 pg/mL	18.4–73 pmol/L		
	f Follicular phase	12.5–166 pg/mL	46–607 pmol/L		
	Ovulatory phase	85.5–498 pg/mL	315–1828 pmol/L		
	Luteal phase	43.8–211 pg/mL	161–774 pmol/L		
	Postmenopause	5.0–54.7 pg/mL	18.4–201 pmol/L		
	Pregnancy, 1st trimester	215–4300 pg/mL	789–15780 pmol/L		
	m	7.6–43 pg/mL	28–156 pmol/L		
Estriol (E3)	Pregnants 28–30 w	38–140 ng/mL	132–486 nmol/L	299	
	31–32 w	35–330 ng/mL	121–1145 nmol/L		
	33–36 w	48–350 ng/mL	167–1215 nmol/L		
	37–40 w	95–460 ng/mL	330–1596 nmol/L		
Fatty acids, free	Adults	<20 mg/dL	<0.7 mmol/L	16	
Ferritin	Children, adolescents				
	<1 yr	12–327 ng/mL	12–327 µg/L	94	
	1–3 yr	6–67 ng/mL	6–67 µg/L		
	4–6 yr	4–67 ng/mL	4–67 µg/L		
	7–12 yr f	7–84 ng/mL	7–84 µg/L		
	m	14–124 ng/mL	14–124 µg/L		
	13–17 yr f	13–68 ng/mL	13–68 µg/L		
	m	14–152 ng/mL	14–152 µg/L		
	17–60 yr f	15–150 ng/mL	15–150 µg/L	164, 218	Elecsys® Ferritin
	20–60 yr m	30–400 ng/mL	30–400 µg/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
α_1-Fetoprotein (AFP)	Children, adolescents				
	<30 d	50,0–100,000 ng/mL	41.5–83,000 U/mL	247	
	1–3 mth	40.0–1000 ng/mL	33.2–830 U/mL		
	4 mth–18 yr	<12.0 ng/mL	<9.96 U/mL		
	Pregnancy w 14	<27.9 ng/mL	<23.2 U/mL	218	AFP Elecsys®
	(median) w 15	<30.9 ng/mL	<25.6 U/mL		
	w 16	<36.1 ng/mL	<30.0 U/mL		
	w 17	<40.4 ng/mL	<33.5 U/mL		
	w 18	<48.3 ng/mL	<40.1 U/mL		
	w 19	<54.8 ng/mL	<45.5 U/mL		
	Adults	≤7.0 ng/mL	≤5.8 U/mL		
Fluoride	Adults	0.019–112 µg/L	1.0–5.9 µmol/L	196	Heparin plasma
Folic acid, serum	≤1 yr f	6.2–23 ng/mL	14–52 nmol/L	109	
	m	7.1–23 ng/mL	16–51 nmol/L		
	2–3 yr f	1.7–16 ng/mL	3.9–36 nmol/L		
	m	2.5–15 ng/mL	5.7–34 nmol/L		
	4–6 yr f	2.7–14 ng/mL	6.1–32 nmol/L		
	m	0.5–13 ng/mL	1.1–29 nmol/L		
	7–9 yr f	2.4–13 ng/mL	5.4–30 nmol/L		
	m	2.3–12 ng/mL	5.2–27 nmol/L		
	10–12 yr f	1.0–10 ng/mL	2.3–23 nmol/L		
	m	1.5–11 ng/mL	3.4–25 nmol/L		
	13–18 yr f	1.2–7.1 ng/mL	2.7–16 nmol/L		
	m	1.2–8.8 ng/mL	2.7–20 nmol/L		
	Normal	3.1–17.5 ng/mL	7.0–39.7 nmol/L	145	
	Borderline deficient	2.2–3.0 ng/mL	5.0–6.8 nmol/L		
	Deficient	<2.2 ng/mL	<5.0 nmol/L		
	Excessive	>17.5 ng/mL	>39.7 nmol/L		
		4.6–18.7 ng/mL	10.4–42.4 nmol/L	218	Folate III Elecsys®; European study (USA: see package insert)
Folic acid, red blood cells (RBC Folate)		263–1028 ng/mL	597–2334 nmol/L	218	RBC Folate II Elecsys®; European study, MODULAR *ANALYTICS* E 170, **cobas® e** 601 (USA, Australia: see package insert)
		416–1367 ng/mL	944–3103 nmol/L		Elecsys® 2010, **cobas® e** 411
Follicle stimulating hormone (FSH)	f Follicular phase	3.5–12.5 mU/mL	3.5–12.5 U/L	218	FSH Elecsys®
	Ovulatory phase	4.7–21.5 mU/mL	4.7–21.5 U/L		
	Luteal phase	1.7–7.7 mU/mL	1.7–7.7 U/L		
	Postmenopause	25.8–134.8 mU/mL	25.8–134.8 U/L		
	m	1.5–12.4 mU/mL	1.5–12.4 U/L		

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Tiefe Cyan Magenta Yellow

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
free PSA/total PSA ratio (fPSA/tPSA)		≤0.10 / 0.11–0.18	0.19–0.25 / >0.25	218	Free PSA Elecsys®, probability of finding prostate cancer by age in years.
	m 50–59 yr	49.2 % / 26.9 %	18.3 % / 9.1 %		
	60–69 yr	57.5 % / 33.9 %	23.9 % / 12.2 %		
	≥70 yr	64.5 % / 40.8 %	29.7 % / 15.8 %		
Free thyroxine (FT_4)	Adults m	1.0–1.7 ng/dL	13.1–21.3 pmol/L	219	FT_4 Elecsys®
	f	1.0–1.6 ng/dL	12.3–20.2 pmol/L		
	Pregnants 1st trimester	0.9–1.5 ng/dL	12.1–19.6 pmol/L		
	2nd trimester	0.8–1.3 ng/dL	9.6–17.0 pmol/L		
	3rd trimester	0.7–1.2 ng/dL	8.4–15.6 pmol/L		
	Children, adolescents				
	Newborn	0.86–2.49 ng/dL	11.0–32.0 pmol/L		
	6 d–3 mth	0.89–2.20 ng/dL	11.5–28.3 pmol/L		
	4–12 mth	0.92–1.99 ng/dL	11.9–25.6 pmol/L		
	1–6 yr	0.96–1.77 ng/dL	12.3–22.8 pmol/L		
	7–11 yr	0.97–1.67 ng/dL	12.5–21.5 pmol/L		
	12–20 yr	0.98–1.63 ng/dL	12.6–21.0 pmol/L		
		0.93–1.7 ng/dL	12.0–22.0 pmol/L	218	FT_4 Elecsys®
	Adults	1.0–1.6 ng/dL	12.8–20.4 pmol/L	146	FT_4 Elecsys®, healthy blood donors, selected acc. to NACB recommendations
Free triiodothyronine (FT_3)	Adults m	2.7–4.3 pg/mL	4.1–6.7 pmol/L	219	FT_3 Elecsys®
	f On contraceptiva	2.6–4.5 pg/mL	3.9–6.9 pmol/L		
	Not on contraceptiva	2.3–4.2 pg/mL	3.6–6.4 pmol/L		
	Pregnants 1st trimester	2.5–3.9 pg/mL	3.8–6.0 pmol/L		
	2nd trimester	2.1–3.6 pg/mL	3.2–5.5 pmol/L		
	3rd trimester	2.0–3.3 pg/mL	3.1–5.0 pmol/L		
	Children, adolescents				
	Newborn	1.73–6.30 pg/mL	2.65–9.68 pmol/L		
	6 d–3 mth	1.95–6.04 pg/mL	3.00–9.28 pmol/L		
	4–12 mth	2.15–5.83 pg/mL	3.30–8.95 pmol/L		
	1–6 yr	2.41–5.50 pg/mL	3.69–8.46 pmol/L		
	7–11 yr	2.53–5.22 pg/mL	3.88–8.02 pmol/L		
	12–20 yr	2.56–5.01 pg/mL	3.93–7.70 pmol/L		
	Adults, euthyroid	2.0–4.4 pg/mL	3.1–6.8 pmol/L	218	FT_3 Elecsys®, routine samples from commercial laboratory
		2.5–4.3 pg/mL	3.9–6.7 pmol/L		FT_3 Elecsys®, apparently healthy blood donors
	Adults	2.6–4.4 pg/mL	4.0–6.8 pmol/L		FT_3 Elecsys®, healthy blood donors, selected acc. to NACB recommendations
Fructosamine	Adults	205–285 µmol/L	205–285 µmol/L	295	
Fructose	Adults	<0.6 mg/dL	<0.03 mmol/L	123	
FTI		4.6–11.7	4.6–11.7	218	CEDIA® T-uptake

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
FT_4I	Euthyroid subjects				
	Germany, Japan	4.8–12.7 µg/dL	62–164 nmol/L	218, 219	T_4 Elecsys® and T-uptake Elecsys®
	USA	4.4–11.4 µg/dL	57–147 nmol/L		
	Adults m	5.6–10.7 µg/dL	72.2–138 nmol/L	219	T_4 Elecsys® and T-uptake Elecsys®
	f On contraceptiva	6.2–12.1 µg/dL	79.7–156 nmol/L		
	Not on contraceptiva	5.1–11.5 µg/dL	66.1–148 nmol/L		
	Children, adolescents				
	Newborn	5.08–20.8 µg/dL	65.3–268 nmol/L		
	6 d–3 mth	5.48–18.0 µg/dL	70.5–232 nmol/L		
	4–12 mth	5.68–16.8 µg/dL	73.1–216 nmol/L		
	1–6 yr	5.93–15.0 µg/dL	76.3–193 nmol/L		
	7–11 yr	5.97–13.9 µg/dL	76.1–170 nmol/L		
	12–20 yr	5.91–13.2 µg/dL	74.4–162 nmol/L		
Galactose	Adults	<0.5 mg/dL	<0.03 mmol/L	123	
Gastrin		40–59 pg/mL	20–28 pmol/L	252	Fasting, deep-freeze immediately, RIA
Glucose	Newborns Cord blood	63–158 mg/dL	3.5–8.8 mmol/L	265	Criteria for diagnosing diabetes mellitus (67):
	1 h	36–99 mg/dL	2.0–5.5 mmol/L		1. Incidental glucose concentration >200 mg/dL
	2 h	39–89 mg/dL	2.2–4.9 mmol/L		(11.1 mmol/L) or
	5–14 h	34–77 mg/dL	1.9–4.3 mmol/L		2. Fasting glucose >126 mg/dL (7 mmol/L) or
	20–28 h	46–81 mg/dL	2.6–4.5 mmol/L		3. Glucose concentration 2 hours after
	40–52 h	48–79 mg/dL	2.7–4.4 mmol/L		oGTT >200 mg/dL (11.1 mmol/L)
	Children (fasting)	60–100 mg/dL	3.3–5.6 mmol/L		
	Adults	74–106 mg/dL	4.1–5.9 mmol/L	299	Plasma is recommended.
	60–90 yr	82–115 mg/dL	4.6–6.4 mmol/L		
	>90 yr	75–121 mg/dL	4.2–6.7 mmol/L		
	Children	60–100 mg/dL	3.3–5.6 mmol/L		
	Newborns 1 d	40–60 mg/dL	2.22–3.33 mmol/L	298	
	>1 d	50–80 mg/dL	2.78–4.44 mmol/L		

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Tiefe Cyan Magenta Yellow

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Glucose	Fetal	54–103 mg/dL	3.0–5.7 mmol/L	78	Plasma
	Infants	50–180 mg/dL	2.8–10.0 mmol/L		
	Adults	65–110 mg/dL	3.6–6.1 mmol/L		
	Adults				
	Venous plasma	74–109 mg/dL	4.5–6.0 mmol/L	218, 265	Following the recommendations of the ADA reagarding Impaired Fasting Glucose, non-pregnants
	Venous whole blood	65–100 mg/dL	3.5–5.5 mmol/L		
	Capillary whole blood	65–100 mg/dL	3.5–5.5 mmol/L		
	Capillary plasma	74–109 mg/dL	4.5–6.0 mmol/L		
	Pregnants				
	Venous plasma	74–95 mg/dL	4.5–5.3 mmol/L	265	Following the recommendations of the Deutsche Diabetesgesellschaft and the Deutsche Gesellschaft für Gynäkologie und Geburtshilfe
	Venous whole blood	65–85 mg/dL	3.5–4.7 mmol/L		
	Capillary whole blood	65–85 mg/dL	3.5–4.7 mmol/L		
	Capillary plasma	74–105 mg/dL	4.5–6.0 mmol/L		
	Preprandial	70–100 mg/dL	3.9–5.6 mmol/L	265	Plasma (venous, capillary)
	1 h postprandial	<140 mg/dL	<7.8 mmol/L		
	2 h postprandial	<120 mg/dL	<6.7 mmol/L		
		<126 mg/dL	<7.0 mmol/L	259	Fasting plasma glucose, Expert Committee on the Diagnosis and Classification of Diabetes mellitus/ADA
	Adults	60–109 mg/dL	3.3–6.1 mmol/L	218	Reflotron® system, blood, serum, plasma
Glutamate dehydrogenase (GLDH)	Newborns	<11.7 U/L	<195 nkat/L	218, 278, 300	DGKC, optimized, recommendations 1972, calculated values (25 → 37 °C)
	Children 1–30 d	<10.6 U/L	<177 nkat/L		
	1–6 mth	<6.8 U/L	<113 nkat/L		
	7–12 mth	<5.6 U/L	<93 nkat/L		
	13–24 mth	<4.5 U/L	<75 nkat/L		
	2–3 yr	<4.2 U/L	<70 nkat/L		
	13–15 yr	<5.1 U/L	<85 nkat/L		
	Adults f	<4.8 U/L	<80 nkat/L	218	DGKC, optimized, calculated values (25 → 37 °C)
	m	<6.4 U/L	<110 nkat/L		
	f	<5 U/L	<80 nkat/L	218, 270	Consensus values
	m	<7 U/L	<120 nkat/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
γ-Glutamyl transferase (γ-GT)	Newborns, children, adolescents 1 d	<151 U/L	<2.50 µkat/L	68	Method according to Szasz
	2–5 d	<185 U/L	<3.10 µkat/L		
	6 d–6 mth	<204 U/L	<3.40 µkat/L		
	7–12 mth	<34 U/L	<0.55 µkat/L		
	1–3 yr	<18 U/L	<0.30 µkat/L		
	4–6 yr	<23 U/L	<0.40 µkat/L		
	7–12 yr	<17 U/L	<0.30 µkat/L		
	13–17 yr f	<33 U/L	<0.55 µkat/L		
	m	<45 U/L	<0.75 µkat/L		
	Children, adolescents				
	<1 yr	<203 U/L	<3.38 µkat/L	94	IFCC
	1–3 yr	<87 U/L	<1.45 µkat/L		
	4–6 yr	<26 U/L	<0.43 µkat/L		
	7–12 yr	<31 U/L	<0.52 µkat/L		
	13–17 yr	<29 U/L	<0.48 µkat/L		
	Adults f	<36 U/L	<0.60 µkat/L	1, 218	Standardized according to Szasz
	m	<61 U/L	<1.02 µkat/L		
	f	<42 U/L	<0.70 µkat/L	218	Standardized according to IFCC
	m	<71 U/L	<1.19 µkat/L		
	f	<40 U/L	<0.67 µkat/L	270	IFCC, consensus values
	m	<60 U/L	<1.00 µkat/L		
	f	<38 U/L	<0.63 µkat/L	238	IFCC, hospital patients
	m	<55 U/L	<0.92 µkat/L		
Glycerol, free	Adults	0.5–1.6 mg/dL	60–180 µmol/L	16	
Growth hormone (STH, somatotropin)	Adults	<5 µg/L	<5 µg/L	161	Fasting, RIA
Haptoglobin	Adults	30–200 mg/dL	3.0–20.0 µmol/L	218, 237	Immunoturbidimetry, CRM 470 standardization
Hp 1–1	f	91–160 mg/dL	9.1–16.0 µmol/L	153	Immunonephelometric assay
	m	87–142 mg/dL	8.7–14.2 µmol/L		
Hp 2–1	f	82–123 mg/dL	8.2–12.3 µmol/L		
	m	74–124 mg/dL	7.4–12.4 µmol/L		
Hp 2–2	f	58–99 mg/dL	5.8–9.9 µmol/L		
	m	52–101 mg/dL	5.2–10.1 µmol/L		
HbA_{1c}	Healthy metabolism	2.9–4.2 % 4.8–5.9 %	0.029–0.042 0.048–0.059	129, 218	Immunoturbidimetric assay, IFCC values DCCT/NGSP values
Hemoglobin (free Hb in plasma)	Outpatients	<6 mg/dL	<60 mg/L	24	EDTA tubes, method according to Harboe
Hemopexin	Adults f	58–131 mg/dL	0.58–1.31 g/L	173	
	m	56–111 mg/dL	0.56–1.11 g/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Homocysteic acid	f <30 yr	0.8–1.9 mg/L	6–14 µmol/L	236	
	30–59 yr	0.7–1.8 mg/L	5–13 µmol/L		
	>60 yr	0.9–1.9 mg/L	7–14 µmol/L		
	m <30 yr	0.8–1.9 mg/L	6–14 µmol/L		
	30–59 yr	0.8–2.2 mg/L	6–16 µmol/L		
	60–84 yr	0.8–2.3 mg/L	6–17 µmol/L		
	>85 yr	2.0–4.0 mg/L	15–30 µmol/L	106	
Human chorionic gonadotropin (hCG)	f Premenopause, non-pregnant	<1 mU/mL	<1 U/L	218	hCG + β Elecsys®, pregnant women: see package insert.
	Postmenopause	<7 mU/mL	<7 U/L		
	m	<2 mU/mL	<2 U/L		
	f Premenopause, non-pregnant	<1 mU/mL	<1 U/L	218	hCG STAT Elecsys®
	Postmenopause	<7 mU/mL	<7 U/L		
	m	<3 mU/mL	<3 U/L		
α-Hydroxybutyrate dehydrogenase (α-HBDH)	Adults	<182 U/L	<3.03 µkat/L	64, 218	DGKC, opt., recommendations 1972, calculated with a conversion factor (25 → 37 °C)
β-Hydroxybutyrate	Adults	0.3–1.2 mg/dL	30–120 µmol/L	16	
17-Hydroxy-progesterone	Adults f	0.2–3.4 ng/mL	0.6–10.3 nmol/L	286	
	m	1.0–2.4 ng/mL	3.0–7.3 nmol/L		
Immunoglobulin A, IgA	<1 yr	<81 mg/dL	<5.06 µmol/L	160, 218	Values recalculated (WHO, → CRM 470 standardization)
	1–3 yr	16–98 mg/dL	1.00–6.13 µmol/L		
	4–6 yr	27–190 mg/dL	1.69–11.9 µmol/L		
	7–9 yr	33–298 mg/dL	2.06–18.6 µmol/L		
	10–11 yr	52–199 mg/dL	3.25–12.4 µmol/L		
	12–13 yr	57–350 mg/dL	3.56–21.9 µmol/L		
	14–15 yr	46–243 mg/dL	2.88–15.2 µmol/L		
	16–19 yr	60–339 mg/dL	3.75–21.9 µmol/L		
	Adults	70–400 mg/dL	4.38–25 µmol/L	89, 218	Immunoturbidimetric method, CRM 470 standardization
Immunoglobulin D, IgD	Adults	0.3–14 mg/dL	0.003–0.14 g/L	299	
Immunoglobulin E, IgE	Neonates	<0.36 µg/dL	<1.5 U/mL	53, 218	
	Children, adolescents 1 yr	<3.6 µg/dL	<15 U/mL		
	2–5 yr	<14.4 µg/dL	<60 U/mL		
	6–9 yr	<21.6 µg/dL	<90 U/mL		
	10–15 yr	<48 µg/dL	<200 U/mL		
	Adults	<24 µg/dL	<100 U/mL		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Immunoglobulin G, IgG	Neonates	227–1378 mg/dL	15.1–91.9 µmol/L	160	Immunonephelometric method, values recalculated (WHO, → CRM 470 standardization)
	1–3 yr	442–895 mg/dL	29.5–59.7 µmol/L		
	4–6 yr	492–1430 mg/dL	32.8–95.4 µmol/L		
	7–9 yr	559–1439 mg/dL	37.3–96.0 µmol/L		
	10–11 yr	681–1523 mg/dL	45.4–101.6 µmol/L		
	12–13 yr	741–1513 mg/dL	49.4–100.9 µmol/L		
	14–15 yr	699–1671 mg/dL	46.6–111.5 µmol/L		
	16–19 yr	536–1547 mg/dL	35.8–103.2 µmol/L		
	Adults	700–1600 mg/dL	7.0–16 g/L	89, 218	Immunoturbidimetric method, CRM 470 standardization
IgG subclasses		IgG_1 IgG_2	IgG_1 IgG_2		
	5 yr	560–1270 40–440 mg/dL	5.6–12.7 0.4–4.4 g/L	180	
	6 yr	620–1130 50–400 mg/dL	6.2–11.3 0.5–4.0 g/L		
	7 yr	540–1050 90–350 mg/dL	5.4–10.5 0.9–3.5 g/L		
	8 yr	560–1050 70–450 mg/dL	5.6–10.5 0.7–4.5 g/L		
	9 yr	390–1140 70–470 mg/dL	3.9–11.4 0.7–4.7 g/L		
	10 yr	440–1080 60–400 mg/dL	4.4–10.8 0.6–4.0 g/L		
	11 yr	640–1090 90–430 mg/dL	6.4–10.9 0.9–4.3 g/L		
	12 yr	600–1150 90–480 mg/dL	6.0–11.5 0.9–4.8 g/L		
	13 yr	610–1150 90–790 mg/dL	6.1–11.5 0.9–7.9 g/L		
	Adults	480– 950 170–690 mg/dL	4.8– 9.5 1.7–6.9 g/L		
		IgG_3 IgG_4	IgG_3 IgG_4		
	5 yr	30–100 10– 80 mg/dL	0.3–1.0 0.1–0.8 g/L		
	6 yr	30– 80 20– 90 mg/dL	0.3–0.8 0.2–0.9 g/L		
	7 yr	30–110 20–110 mg/dL	0.3–1.1 0.2–1.1 g/L		
	8 yr	20–110 10– 80 mg/dL	0.2–1.1 0.1–0.8 g/L		
	9 yr	40–120 20–100 mg/dL	0.4–1.2 0.2–1.0 g/L		
	10 yr	30–120 10– 90 mg/dL	0.3–1.2 0.1–0.9 g/L		
	11 yr	30– 90 20–100 mg/dL	0.3–0.9 0.2–1.0 g/L		
	12 yr	40–100 20– 90 mg/dL	0.4–1.0 0.2–0.9 g/L		
	13 yr	20–110 10– 80 mg/dL	0.2–1.1 0.1–0.8 g/L		
	Adults	30– 80 20–110 mg/dL	0.3–0.8 0.2–1.1 g/L		
Immunoglobulin M, IgM	Children, adolescents				
	<1 yr	<1.21 g/L	<1.24 µmol/L	160	Immunonephelometric method, values recalculated (WHO, → CRM 470 standardization)
	1–3 yr	0.16–1.22 g/L	0.16–1.26 µmol/L		
	4–6 yr	0.20–1.76 g/L	0.21–1.81 µmol/L		
	7–9 yr	0.26–1.74 g/L	0.27–1.79 µmol/L		
	10–11 yr	0.26–1.50 g/L	0.27–1.55 µmol/L		
	12–13 yr	0.29–2.00 g/L	0.30–2.06 µmol/L		
	14–15 yr	0.19–1.57 g/L	0.20–1.62 µmol/L		
	16–19 yr	0.20–2.17 g/L	0.21–2.24 µmol/L		
	Adults	0.4–2.3 g/L	0.4–2.4 µmo/L	89, 218	Immunoturbidimetry, CRM 470 standardization

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Immunoglobulin light chains					
kappa		138–375 mg/dL	1.38–3.75 g/L	218	Immunoturbidimetric assay,
lambda		93–242 mg/dL	0.93–2.42 g/L		CRM 470 standardization
kappa/lambda ratio		1.17–2.93	1.17–2.93		
Insulin	Healthy individuals	2.6–24.9 µU/mL	17.8–173 pmol/L	218	Insulin Elecsys®, fasting
Iron	1–30 d f	29–127 µg/dL	5.2–22.7 µmol/L	246	
	m	32–112 µg/dL	5.7–20.0 µmol/L		
	1–12 mth f	25–126 µg/dL	4.5–22.6 µmol/L		
	m	27–109 µg/dL	4.8–19.5 µmol/L		
	1–3 yr f	25–101 µg/dL	4.5–18.1 µmol/L		
	m	29–91 µg/dL	5.2–16.3 µmol/L		
	4–6 yr f	28–93 µg/dL	5.0–16.7 µmol/L		
	m	25–115 µg/dL	4.5–20.6 µmol/L		
	7–9 yr f	30–104 µg/dL	5.4–18.6 µmol/L		
	m	27–96 µg/dL	4.8–17.2 µmol/L		
	10–12 yr f	32–104 µg/dL	5.7–18.6 µmol/L		
	m	28–112 µg/dL	5.0–20.0 µmol/L		
	13–15 yr f	30–109 µg/dL	5.4–19.5 µmol/L		
	m	26–110 µg/dL	4.7–19.7 µmol/L		
	16–18 yr f	33–102 µg/dL	5.9–18.3 µmol/L		
	m	27–138 µg/dL	4.8–24.7 µmol/L		
	Adults f	37–145 µg/dL	6.6–26 µmol/L	288	
	m	59–158 µg/dL	11–28 µmol/L		
Iron-binding capacity, total (TIBC)	Adults	228–428 µg/dL	41–77 µmol/L	218	Roche/Hitachi systems
Unsaturated (UIBC)		110–370 µg/dL	20–66 µmol/L	218	Roche/Hitachi systems
		112–346 µg/dL	20–62 µmol/L	218	COBAS INTEGRA®, **cobas**® systems
Lactate	Adults	4.5–19.8 mg/dL	0.5–2.2 mmol/L	299	Venous plasma, fluoride/oxalate tubes
		4.5–14.4 mg/dL	0.5–1.6 mmol/L		Arterial plasma, fluoride/oxalate tubes
		<15.3 mg/dL	<1.7 mmol/L		Venous blood, deproteinized
		<11.3 mg/dL	<1.3 mmol/L		Arterial blood, deproteinized

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Lactate dehydrogenase (LDH)	1 d	<1327 U/L	<22.1 µkat/L	68	DGKC, optimized
	2–5 d	<1732 U/L	<28.9 µkat/L		
	6 d–6 mth	<975 U/L	<16.3 µkat/L		
	7–12 mth	<1100 U/L	<18.3 µkat/L		
	1–3 yr	<850 U/L	<14.2 µkat/L		
	4–6 yr	< 615 U/L	<10.3 µkat/L		
	7–12 yr f	<580 U/L	<9.65 µkat/L		
	m	<764 U/L	<12.7 µkat/L		
	13–17 yr f	<436 U/L	<7.25 µkat/L		
	m	<683 U/L	<11.4 µkat/L		
	Children, adolescents				
	<1 yr	<451 U/L	<7.52 µkat/L	94	IFCC
	1–3 yr	<344 U/L	<5.73 µkat/L		
	4–6 yr	<314 U/L	<5.23 µkat/L		
	7–12 yr	<332 U/L	<5.53 µkat/L		
	13–17 yr	<279 U/L	<4.65 µkat/L		
	Adults	<480 U/L	<8.00 µkat/L	218, 289	DGKC, optimized, calculated with conversion factor (25 °C → 37 °C)
	Adults >60 yr	<509 U/L	<8.48 µkat/L	33	SFBC method
	f	<223 U/L	<3.72 µkat/L	138	IFCC, liquid
	m	<232 U/L	<3.72 µkat/L		
	f	<247 U/L	<4.12 µkat/L	238	IFCC, hospitalized patients
	m	<248 U/L	<4.13 µkat/L		
	Neonates 4–20 d	<600 U/L	<10.0 µkat/L	163	Standard method, 1994
	Children 2–15 yr	<300 U/L	<5.00 µkat/L		
	Adults f	<214 U/L	<3.55 µkat/L		
	m	<225 U/L	<3.75 µkat/L		
		<250 U/L	<4.2 µkat/L	270	Consensus values
Lead	Adults ≤60 yr	<250 µg/L	<1.21 µmol/L	271	Whole blood, AAS
	>60 yr	<320 µg/L	<1.54 µmol/L		
Lipase	Neonates	<34 U/L	<0.57 µkat/L	2	Colorimetric assay
	Children ≤ 12 yr	<31 U/L	<0.52 µkat/L		
	Juveniles 16–18 yr	<55 U/ L	<0.92 µkat/L		
	Adults	<60 U/L	<1.00 µkat/L	125, 218	Colorimetric assay
Lp [a]	Adults	<30 mg/dL	<0.30 g/L	218	Immunoturbidimetric assay. Lp [a] serum concentrations in healthy persons exhibit an asymmetric distribution and may exceed 100 mg/dL (1.00 g/L). Values >30 mg/dL (0.3 g/L) are associated with higher risk of atherosclerosis.

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Luteinizing hormone (LH)	f Follicular phase	2.4–12.6 mU/mL	2.4–12.6 U/L	218	LH Elecsys®
	Ovulatory phase	14–96 mU/mL	14–96 U/L		
	Luteal phase	1.0–11.4 mU/mL	1.0–11.4 U/L		
	Postmenopause	7.7–59 mU/mL	7.7–59 U/L		
	m	1.7–8.6 mU/mL	1.7–8.6 IU/L		
Lysozyme	Adults	3.0–9.0 mg/L	3.0–9.0 mg/L	183	
α_2-Macroglobulin	Adults	130–300 mg/dL	1.3–3.0 g/L	237	Consensus values, CRM 470 standardization
Magnesium, total	Children, adolescents, newborns	1.5–2.2 mg/dL	0.62–0.91 mmol/L	218, 299	AAS
	5 mth–6 yr	1.7–2.3 mg/dL	0.70–0.95 mmol/L		
	7–12 yr	1.7–2.1 mg/dL	0.70–0.86 mmol/L		
	13–20 yr	1.7–2.2 mg/dL	0.70–0.91 mmol/L		
	Adults	1.6–2.6 mg/dL	0.66–1.07 mmol/L		
	60–90 yr	1.6–2.4 mg/dL	0.66–0.99 mmol/L		
	>90 yr	1.7–2.3 mg/dL	0.70–0.95 mmol/L		
ionized		1.12–1.46 mg/dL	0.46–0.60 mmol/L	118	Ion-selective electrode
erythrocytes		4.01–6.44 mg/dL	1.65–2.65 mmol/L	299	AAS
Mannose binding protein (MBP)	Adults	0.3–4.1 mg/L	0.3–4.1 mg/L	155	
Mercury	Adults, children	<7.2 µg/L	<36 nmol/L	230	Whole blood, AAS
β_2-Microglobulin	Adults	0.8–2.2 mg/L	68–186 nmol/L	218	Immunoturbidimetric assay
Myoglobin	Adults f	19–51 ng/mL	19–51 µg/L	130, 218	Roche/Hitachi systems, immunoturbidimetric assay
	m	23–72 ng/mL	23–72 µg/L		
	f	7–64 ng/mL	7–64 µg/L	218	COBAS INTEGRA® instruments, immunoturbidimetric assay
	m	16–76 ng/mL	16–76 µg/L		
	f	25–58 ng/mL	25–58 µg/L	218	Myoglobin Elecsys®
	m	28–72 ng/mL	28–72 µg/L		
	f	7–64 ng/mL	7–64 µg/L	218	Roche CARDIAC M, heparinized venous blood
	m	16–76 ng/mL	16–76 µg/L		
Neuron specific enolase (NSE)	Healthy subjects	<16.3 ng/mL	<16.3 µg/L	218	NSE Elecsys®

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
N-terminal pro brain natriuretic peptide (NT-proBNP)	Children 1–16 yr f	<83 pg/mL	<9.8 pmol/L	208	Reference range shialy, proBNP Elecsys®
	m	<62 pg/mL	<7.3 pmol/L		
	Adults <75 yr	125 pg/mL	14.8 pmol/L	85, 218	Recommended cut-off values to discriminate normal and abnormal cardiac function.
	≥75 yr	450 pg/mL	53.1 pmol/L		
	Adults				
	<45yr f	<177.6 pg/mL	<21.0 pmol/L	218	Reference ranges, proBNP Elecsys®
	m	<92.6 pg/mL	<10.9 pmol/L		
	45–54 yr f	<192.0 pg/mL	<22.7 pmol/L		
	m	<137.5 pg/mL	<16.2 pmol/L		
	55–64 yr f	<225.7 pg/mL	<26.6 pmol/L		
	m	<176.8 pg/mL	<20.9 pmol/L		
	65–74 yr f	<352.7 pg/mL	<41.6 pmol/L		
	m	<229.1 pg/mL	<27.0 pmol/L		
	≥75 yr f	<624.0 pg/mL	<73.6 pmol/L		
	m	<851.9 pg/mL	<100.5 pmol/L		
Osmolality	Neonates	265–275 mosmol/kg	265–275 mmol/kg	134	
	Adults ≤60 yr	275–295 mosmol/kg	275–295 mmol/kg		
	>60 yr	280–300 mosmol/kg	280–300 mmol/kg		
Osteocalcin	f Premenopausal	<43 ng/mL	<43 µg/L	218	N-MID Osteocalcin Elecsys®, for postmenopausal women under hormone replacement therapy the ref. values for premenopausal women are valid.
	Postmenopausal	<46 ng/mL	<46 µg/L		
	m <30 yr	<70 ng/mL	<70 µg/L		
	30–50 yr	<42 ng/mL	<42 µg/L		
	>50 yr	<46 ng/mL	<46 µg/L		
P1NP	f Postmenopausal				
	on HRT	14.3–58.9 ng/mL	14.3–58.9 µg/L	218	P1NP Elecsys®
	no HRT	20.3–76.3 ng/mL	20.3–76.3 µg/L		
	Premenopausal	15.1–58.6 ng/mL	15.1–58.6 µg/L		
Pancreatic elastase	Adults	<3.8 ng/mL	<3.8 ng/mL	36	

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Parathyrin, Parathyroid hormone (PTH)	2–4 yr f	3.6–32 ng/L	0.38–3.4 pmol/L	45	
	m	5.7–34 ng/L	0.60–3.6 pmol/L		
	5–6 yr f	1.0–13 ng/L	0.10–1.4 pmol/L		
	m	4.4–16 ng/L	0.46–1.7 pmol/L		
	7–8 yr f	2.7–25 ng/L	0.28–2.6 pmol/L		
	m	2.5–27 ng/L	0.26–2.8 pmol/L		
	9–10 yr f	2.0–30 ng/L	0.21–3.2 pmol/L		
	m	4.6–34 ng/L	0.48–3.6 pmol/L		
	11–12 yr f	4.3–34 ng/L	0.45–3.6 pmol/L		
	m	2.5–25 ng/L	0.26–2.6 pmol/L		
	13–14 yr f	1.6–37 ng/L	0.17–3.9 pmol/L		
	m	1.4–26 ng/L	0.15–2.7 pmol/L		
	15–16 yr f	1.2–39 ng/L	0.13–4.1 pmol/L		
	m	4.5–36 ng/L	0.47–3.8 pmol/L		
		3–51 ng/L	0.32–5.4 pmol/L	250	Chemiluminescence immunoassay
	Adults	12–50 ng/L	1.26–5.3 pmol/L	149	
		15–65 ng/L	1.6–6.9 pmol/L	218	PTH Elecsys®
Phosphate, inorganic	Children, adolescents				
	1–30 d	3.9–7.7 mg/dL	1.25–2.50 mmol/L	263	
	1–12 mth	3.5–6.6 mg/dL	1.15–2.15 mmol/L		
	1–3 yr	3.1–6.0 mg/dL	1.00–1.95 mmol/L		
	4–6 yr	3.3–5.6 mg/dL	1.05–1.80 mmol/L		
	7–9 yr	3.0–5.4 mg/dL	0.95–1.75 mmol/L		
	10–12 yr	3.2–5.7 mg/dL	1.05–1.85 mmol/L		
	13–15 yr	2.9–5.1 mg/dL	0.95–1.75 mmol/L		
	16–18 yr	2.7–4.9 mg/dL	0.95–1.60 mmol/L		
	Adults	2.6–4.5 mg/dL	0.84–1.45 mmol/L		
		2.7–4.5 mg/dL	0.87–1.45 mmol/L	218	
Phosphohexose isomerase (PHI)		20–90 U/L	0.35–1.50 µkat/L	239	
Potassium	Adults	3.5–5.1 mEq/L	3.5–5.1 mmol/L	218, 299	Roche Diagnostics, indirect ISE, serum
	f	3.4–4.4 mEq/L	3.4–4.4 mmol/L		flame photometry, plasma
	m	3.5–4.5 mEq/L	3.5–4.5 mmol/L		
	Children 1–7 d	3.2–5.5 mEq/L	3.2–5.5 mmol/L	247	Plasma, dry slide technology
	8–31 d	3.4–6.0 mEq/L	3.4–6.0 mmol/L		
	1–6 mth	3.5–5.6 mEq/L	3.5–5.6 mmol/L		
	7 mth–1 yr	3.5–6.1 mEq/L	3.5–6.1 mmol/L		
	>1 yr	3.3–4.6 mEq/L	3.3–4.6 mmol/L		
	Adults	3.7–5.5 mEq/L	3.7–5.5 mmol/L	218	COBAS INTEGRA®, direct ISE, serum
		3.6–4.5 mEq/L	3.6–4.5 mmol/L		COBAS INTEGRA®, direct ISE, plasma
		3.6–5.0 mEq/L	3.6–5.0 mmol/L	218	Reflotron®, serum
		3.5–4.6 mEq/L	3.5–4.6 mmol/L		Reflotron®, plasma

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Prealbumin (Transthyretin)	Children <1 mth	7–39 mg/dL	0.07–0.39 g/L	54	Immunonephelometry, CRM 470 standardization
	1–6 mth	8–34 mg/dL	0.08–0.34 g/L		
	7 mth–6 yr	12–36 mg/dL	0.12–0.36 g/L		
	Adults	20–40 mg/dL	0.20–0.40 g/L	237	
Pregnancy-associated plasma protein A (PAPP-A)	Healthy non-pregnant donors	<7.15 mIU/L	<7.15 mIU/L	218	PAPP-A Elecsys®, Roche study no. R04P026
Procalcitonin		<0.5 ng/mL	<0.5 µg/L	176	
Progesterone	w Follicular phase	0.2–1.5 ng/mL	0.6–4.7 nmol/L	218	Progesterone II Elecsys®
	Ovulatory phase	0.8–3.0 ng/mL	2.4–9.4 nmol/L		
	Luteal phase	1.7–27 ng/mL	5.3–86 nmol/L		
	Postmenopause	0.1–0.8 ng/mL	0.3–2.5 nmol/L		
	m	0.2–1.4 ng/mL	0.7–4.3 nmol/L		
Prolactin	Children, adolescents				
	f	0.3–95.0 ng/mL	0.3–95.0 µg/L	49	Chemiluminescence immunoassay
	m	3.7–81.2 ng/mL	3.7–81.2 µg/L		
	1–12 mth f	0.2–29.9 ng/mL	0.2–29.9 µg/L		
	m	0.3–28.9 ng/mL	0.3–28.9 µg/L		
	1–3 yr f	1.0–17.1 ng/mL	1.0–17.1 µg/L		
	m	2.3–13.2 ng/mL	2.3–13.2 µg/L		
	4–6 yr f	1.6–13.1 ng/mL	1.6–13.1 µg/L		
	m	0.8–16.9 ng/mL	0.8–16.9 µg/L		Conversion of ng/mL to mU/L depends on the type of standard used
	7–9 yr f	0.3–12.9 ng/mL	0.3–12.9 µg/L		
	m	1.9–11.6 ng/mL	1.9–11.6 µg/L		
	10–12 yr f	1.9–9.6 ng/mL	1.9–9.6 µg/L		
	m	0.9–12.9 ng/mL	0.9–12.9 µg/L		
	13–15 yr f	3.0–14.4 ng/mL	3.0–14.4 µg/L		
	m	1.6–16.6 ng/mL	1.6–16.6 µg/L		
	16–18 yr f	2.1–18.4 ng/mL	2.1–18.4 µg/L		
	m	2.7–15.2 ng/mL	2.7–15.2 µg/L		
	Adults f	6.0–29.9 ng/mL	127–637 mU/L	218	Prolactin Elecsys®
	m	4.6–21.4 ng/mL	98–456 mU/L		
Prostate specific antigen, total (tPSA)	m <40 yr	<1.4 ng/mL	<1.4 µg/L	218	PSA Elecsys®
	40–50 yr	<2.0 ng/mL	<2.0 µg/L		
	51–60 yr	<3.1 ng/mL	<3.1 µg/L		
	61–70 yr	<4.1 ng/mL	<4.1 µg/L		
	>70 yr	<4.4 ng/mL	<4.4 µg/L		

free PSA/total PSA ratio (fPSA/tPSA)	m	≤0.10	0.11–0.18	0.19–0.25	>0.25	218	Free PSA Elecsys®, probability of finding prostate cancer by age in years.
	50–59 yr	49.2 %	26.9 %	18.3 %	9.1 %		
	60–69 yr	57.5 %	33.9 %	23.9 %	12.2 %		
	≥70 yr	64.5 %	40.8 %	29.7 %	15.8 %		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Protein, total	Children, adolescents				
	1 w	4.4–7.6 g/dL	44–76 g/L	218, 299	
	7 mth–12 mth	5.1–7.3 g/dL	51–73 g/L		
	1–2 yr	5.6–7.5 g/dL	56–75 g/L		
	>3 yr	6.0–8.0 g/dL	60–80 g/L		
	Newborns	4.6–7.0 g/dL	46–70 g/L		
	Premature	3.6–6.0 g/dL	36–60 g/L		
	Umbilical cord	4.8–8.0 g/dL	48–80 g/L		
	Adults	6.4–8.3 g/dL	64–83 g/L		
Electrophoresis					
Albumin		55–69 %	0.55–0.69	79	Ponceau Red S
α_1-Globulin		1.6–5.8 %	0.02–0.06		
α_2-Globulin		5.9–11 %	0.06–0.11		
β-Globulin		7.9–14 %	0.08–0.14		
γ-Globulin		11–18 %	0.11–0.18		
Pyruvate	Adults	0.36–0.59 mg/dL	41–67 µmol/L	152	Whole blood, deproteinize immediately using ice-cold perchloric acid.
Rheumatoid factor (RF)	Adults	<14 IU/mL	<14 kIU/L	218	Immunoturbidimetric method, Roche Diagnostics
S100	Apparently healthy adults	≤0.105 µg/L	≤0.105 µg/L	218	S100 Elecsys®
Selenium		67–105 µg/L	0.85–1.33 µmol/L	150	Whole blood
		45–83 µg/L	0.57–1.05 µmol/L		Plasma
Sexual hormone binding globulin (SHBG)	f 17–50 yr	26.1–110 nmol/L	26.1–110 nmol/L	218	SHBG Elecsys®, free testosterone/androgen index: see package insert.
	Postmenopausal, untreated	14.1–68.9 nmol/L	14.1–68.9 nmol/L		
	m 17–65 yr	14.5–48.4 nmol/L	14.5–48.4 nmol/L		
Sodium	Children <7 d	131–144 mEq/L	131–144 mmol/L	247	Indirect ISE
	8 d–1 mth	132–142 mEq/L	132–142 mmol/L		
	2–6 mth	132–140 mEq/L	132–140 mmol/L		
	7 m–1 yr	131–140 mEq/L	131–140 mmol/L		
	>1 yr	132–141 mEq/L	132–141 mmol/L		
	Adults ≤90 yr	136–145 mEq/L	136–145 mmol/L	299	Flame emission photometry, indirect ISE
	>90 yr	132–146 mEq/L	132–146 mmol/L		
	Adults	146–157 mEq/L	146–157 mmol/L	218	COBAS INTEGRA®, direct ISE
Sorbitol		0.5–0.9 mg/dL	27–49 µmol/L	28	Plasma, deproteinize immediately.
Squamous cell carcinoma antigen (SCC)		<2.0 ng/mL	<20 µg/L	299	Freeze sample immediately.

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Testosterone	Children, adolescents, m				
	<1 yr	0.12–0.21 ng/mL	0.42–0.72 nmol/L	218	Testosterone Elecsys®
	1–6 yr	0.03–0.32 ng/mL	0.10–1.12 nmol/L		
	7–12 yr	0.03–0.68 ng/mL	0.10–2.37 nmol/L		
	13–17 yr	0.28–11.1 ng/mL	0.98–38.5 nmol/L		
	Adults f	0.06–0.82 ng/mL	0.22–2.9 nmol/L		
	m	2.8–8.0 ng/mL	9.9–27.8 nmol/L		
Thallium		<5 µg/L	<24 nmol/L	299	Whole blood, AAS
Thyroglobulin	Children, adolescents				
	Newborns	25–307 ng/mL	25–307 µg/L	219	Thyroglobulin ElecsysÂ*, reference range study
	6 d–3 mth	20–228 ng/mL	20–228 µg/L		
	4–12 mth	18–125 ng/mL	18–125 µg/L		
	1–6 yr	9.0–67 ng/mL	9.0–67 µg/L		
	7–11 yr	5.1–43 ng/mL	5.1–43 µg/L		
	12–20 yr	2.6–36 ng/mL	2.6–36 µg/L		
	Healthy subjects	1.4–78 ng/mL	1.4–78 µg/L	218	Thyroglobulin Elecsys®
Thyroid stimulating hormone (TSH)	Children, adolescents				
	Newborns	0.70–15.2 µU/mL	0.70–15.2 mU/L	219	TSH Elecsys®, reference range study
	6 d–3 mth	0.72–11.0 µU/mL	0.72–11.0 mU/L		
	4–12 mth	0.73–8.35 µU/mL	0.73–8.35 mU/L		
	1–6 yr	0.70–5.97 µU/mL	0.70–5.97 mU/L		
	7–11 yr	0.60–4.84 µU/mL	0.60–4.84 mU/L		
	12–20 yr	0.51–4.30 µU/mL	0.51–4.30 mU/L		
	Healthy blood donors	0.40–3.77 µU/mL	0.40–3.77 mU/L	146	TSH Elecsys®, group selected acc. to National Academy of Clinical Biochemistry (NACB) recommendations
	Healthy subjects	0.27–4.2 µU/mL	0.27–4.2 mU/L	218	TSH Elecsys®
Thyroxine (T_4)	Children, adolescents				
	Newborns	5.04–18.5 µg/dL	64.9–239 nmol/L	219	T_4 Elecsys®, reference range study
	6 d–3 mth	5.41–17.0 µg/dL	69.6–219 nmol/L		
	4–12 mth	5.67–16.0 µg/dL	73.0–206 nmol/L		
	1–6 yr	5.95–14.7 µg/dL	76.6–189 nmol/L		
	7–11 yr	5.99–13.8 µg/dL	77.1–178 nmol/L		
	12–20 yr	5.91–13.2 µg/dL	76.1–170 nmol/L		
	Adults	5.1–14.1 µg/dL	66–181 nmol/L	218	T_4 Elecsys®
	Healthy blood donors	5.5–12.2 µg/dL	70.5–157 nmol/L	146	T_4 Elecsys®, group selected acc. to NACB recommendations
	Adults	4–12 µg/dL	51.6–154.8 nmol/L	218	Roche Diagnostics, fluorescence polarization immunoassay
	Adults	4.5–12 µg/dL	58.1–154.8 nmol/L	218	Roche Diagnostics, homogeneous enzyme immunoassay

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Thyroxine-binding capacity (as TBI)		0.8–1.3	0.8–1.30	218, 219	T-uptake Elecsys®
Transferrin	Adults	2.0–3.6 g/L	25.2–45.4 µmol/L	89, 218, 237	Immunoturbidimetric assay, CRM 470 standardization
Transferrin, carbohydrate deficient (as % CDT)	Adults	≤3.0 %	≤3.0 %	218	Roche Diagnostics, immunoturbidimetric assay, elevated values indicate alcohol misuse.
Transferrin receptor, soluble (sTfR)	6–24 mth	1.37–2.85 mg/L	1.37–2.85 mg/L	144	Enzyme immunoassay
	2–6 yr	1.05–3.05 mg/L	1.05–3.05 mg/L		
	7–12 yr	1.16–2.72 mg/L	1.16–2.72 mg/L		
	≤18 yr	0.84–2.32 mg/L	0.84–2.32 mg/L		
	Adults				
	f 18–45 yr	1.9–4.4 mg/L	22–52 nmol/L	141	Roche Diagnostics, immunoturbidimetric assay
	m 18–60 yr	2.2–5.0 mg/L	26–59 nmol/L		
Transferrin saturation (TS)		16–45 %	16–45 %	262	TS [%] = Fe [µg/dL] × 70.9/Transferrin [mg/dL]
Triglycerides	Premature	<62 mg/dL	<0.7 mmol/L	78	
	Adults ≤65 yr	<200 mg/dL	<2.3 mmol/L	65, 218	
	>65 yr	<325 mg/dL	<3.7 mmol/L	33	
		<150 mg/dL	<1.7 mmol/L	46	Cutpoint acc. to NECP ATP III
Triiodothyronine (T_3)	Children, adolescents				
	Newborns	0.73–2.88 ng/mL	1.12–4.43 nmol/L	219	T_3 Elecsys®, reference range study
	6 d–3 mth	0.80–2.75 ng/mL	1.23–4.22 nmol/L		
	4–12 mth	0.86–2.65 ng/mL	1.32–4.07 nmol/L		
	1–6 yr	0.92–2.48 ng/mL	1.42–3.80 nmol/L		
	7–11 yr	0.93–2.31 ng/mL	1.43–3.55 nmol/L		
	12–20 yr	0.91–2.18 ng/mL	1.40–3.34 nmol/L		
	Adults, euthyroid	0.80–2.0 ng/mL	1.2–3.1 nmol/L	218	T_3 Elecsys®
Troponin I	Adults	≤0.16 ng/mL	≤0.16 µg/L	15, 22	Chemiluminescence immunoassay, Troponin I Elecsys®
	Neonates	≤0.183 ng/mL	≤0.183 µg/L	22	Enzyme immunoassay
Troponin T	Children < 7 d	≤0.35 ng/mL	≤0.35 µg/L	165	Troponin T Elecsys®
	8–30 d	≤0.20 ng/mL	≤0.20 µg/L		
	31–120 d	≤0.1 ng/mL	≤0.1 µg/L		
	121 d–1 yr	≤0.03 ng/mL	≤0.03 µg/L		
	Neonates	≤0.097 ng/mL	≤0.097 µg/L	22	Troponin T Elecsys®
	Healthy volunteers	<0.01 ng/mL	<0.01 µg/L	218	Troponin T Elecsys®
		0.1 ng/mL	0.1 µg/L	218	Cut-off acc. to WHO criteria
	Adults	<0.03 ng/mL	< 0.03 µg/L	132	Roche CARDIAC T

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
T-uptake (free thyroxine binding capacity)	Blood donors	24.3–39.0 %	0.243–0.390	218	Roche Diagnostics, homogeneous enzyme immunoassay
Urea	Children 1–3 yr	11–36 mg/dL	1.8–6.0 mmol/L	268	
	4–13 yr	15–36 mg/dL	2.5–6.0 mmol/L		
	14–19 yr	18–45 mg/dL	2.9–7.5 mmol/L		
	Adults	17–43 mg/dL	2.8–7.2 mmol/L		
	f, <50 yr	15–40 mg/dL	2.6–6.7 mmol/L		
	f, >50 yr	21–43 mg/dL	3.5–7.2 mmol/L		
	m, <50 yr	19–44 mg/dL	3.2–7.3 mmol/L		
	m, >50 yr	18–55 mg/dL	3.0–9.2 mmol/L		
	Adults				
	f 18–49 yr	16–38 mg/dL	2.6–6.4 mmol/L	227	NORIP
	≥50 yr	19–47 mg/dL	3.1–7.9 mmol/L		
	m 18–49 yr	19–49 mg/dL	3.2–8.1 mmol/L		
	≥50 yr	21–49 mg/dL	3.5–8.1 mmol/L		
Uric acid	Children				
	f 1–30 d	1.0–4.6 mg/dL	59–271 µmol/L	267	
	31–365 d	1.1–5.4 mg/dL	65–319 µmol/L		
	1–3 yr	1.8–5.0 mg/dL	106–295 µmol/L		
	4–6 yr	2.0–5.1 mg/dL	118–301 µmol/L		
	7–9 yr	1.8–5.5 mg/dL	106–325 µmol/L		
	10–12 yr	2.5–5.9 mg/dL	148–348 µmol/L		
	13–15 yr	2.2–6.4 mg/dL	130–378 µmol/L		
	16–18 yr	2.4–6.6 mg/dL	142–389 µmol/L		
	m 1–30 d	1.2–3.9 mg/dL	71–230 µmol/L		
	31–365 d	1.2–5.6 mg/dL	71–330 µmol/L		
	1–3 yr	2.1–5.6 mg/dL	124–330 µmol/L		
	4–6 yr	1.8–5.5 mg/dL	106–325 µmol/L		
	7–9 yr	1.8–5.4 mg/dL	106–319 µmol/L		
	10–12 yr	2.2–5.8 mg/dL	130–342 µmol/L		
	13–15 yr	3.1–7.0 mg/dL	183–413 µmol/L		
	16–18 yr	2.1–7.6 mg/dL	124–448 µmol/L		
	Adults f	2.3–6.1 mg/dL	137–363 µmol/L		Recommended upper limit of males: 7 mg/dL (416 µmol/L)
	m	3.6–8.2 mg/dL	214–488 µmol/L		
	f	2.4–5.7 mg/dL	142.8–339.2 µmol/L	218	Roche/Hitachi, COBAS INTEGRA®, **cobas**®, Reflotron® systems
	m	3.4–7.0 mg/dL	202.3–416.5 µmol/L		
	Adults				
	f 18–49 yr	2.6–5.8 mg/dL	155–350 µmol/L	227	NORIP
	≥50 yr	2.6–6.7 mg/dL	155–400 µmol/L		
	m ≥18 yr	3.9–8.1 mg/dL	230–480 µmol/L		

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Vitamin A (Retinol)	≤15 yr	f	185–841 µg/dL	6.5–29.4 µmol/L	110	HPLC
		m	113–805 µg/dL	3.9–28.1 µmol/L		
	16–35 yr	f	331–1079 µg/dL	11.6–37.7 µmol/L		
		m	460–1240 µg/dL	16.1–43.3 µmol/L		
	36–60 yr	f	619–1119 µg/dL	21.6–39.1 µmol/L		
		m	626–1322 µg/dL	21.8–46.1 µmol/L		
	>60 yr	f	380–1116 µg/dL	13.3–38.9 µmol/L		
		m	600–1275 µg/dL	20.9–44.5 µmol/L		
Vitamin B_1 (Thiamine)			0.13–0.75 µg/dL	5–28 nmol/L	293	HPLC, serum
			1.9–4.9 µg/dL	71–185 nmol/L		HPLC, whole blood
Vitamin B_2 (Riboflavin)			10–50 µg/dL	0.27–1.33 µmol/L	299	HPLC, fluorimetry
Vitamin B_6 (Pyridoxal phosphate)			1.0–2.4 µg/dL	39–98 nmol/L	21	HPLC
Vitamin B_{12}	<1 yr	f	228–1515 pg/mL	168–1115 pmol/L	109	RIA
		m	293–1210 pg/mL	216–891 pmol/L		
	2–3 yr	f	416–1210 pg/mL	307–892 pmol/L		
		m	264–1215 pg/mL	195–897 pmol/L		
	4–6 yr	f	313–1410 pg/mL	231–1040 pmol/L		
		m	245–1075 pg/mL	181–795 pmol/L		
	7–9 yr	f	247–1175 pg/mL	182–866 pmol/L		
		m	271–1170 pg/mL	200–863 pmol/L		
	10–12 yr	f	196–1020 pg/mL	145–752 pmol/L		
		m	183–1090 pg/mL	135–803 pmol/L		
	13–18 yr	f	182–820 pg/mL	134–605 pmol/L		
		m	214–864 pg/mL	158–638 pmol/L		
	Adults	Europe	191–663 pg/mL	141–489 pmol/L	218	Vitamin B_{12} Elecsys®
		USA	211–946 pg/mL	156–698 pmol/L		
Vitamin C		Adults	0.4–1.8 mg/dL	20–100 µmol/L	57	
Vitamin D_3, 25-OH		Children, adults	10–44 ng/mL	25–110 nmol/L	21	Approximate reference range based on three studies.
		Healthy individuals	5.2–60.4 ng/mL	13–151 nmol/L	250	Chemiluminescence assay
		Adults	11.1–42.9 ng/mL	27.7–107 nmol/L	218	Vitamin D_3 Elecsys®, Roche Diagnostics, population-based reference range, Germany, summer time
		Children. adults	>30 ng/mL	>75 nmol/L	280	Health-based reference range

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2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Vitamin E (α-Tocopherol)	<15 yr	f	0.4–1.2 mg/dL	9.3–28 µmol/L	110	EDTA plasma, HPLC
		m	0.5–1.1 mg/dL	12–26 µmol/L		
	16–35 yr	f	0.5–1.2 mg/dL	12–27 µmol/L		
		m	0.4–1.3 mg/dL	9.3–31 µmol/L		
	36–60 yr	f	0.7–1.5 mg/dL	16–34 µmol/L		
		m	0.7–1.6 mg/dL	16–36 µmol/L		
	>60 yr	f	0.7–1.6 mg/dL	16–36 µmol/L		
		m	0.8–1.6 mg/dL	19–38 µmol/L		
Vitamin K	Adults		0.17–0.68 µg/L	0.38–1.51 nmol/L	21	HPLC, fasting
Zinc		<4 mth	65–137 µg/dL	10–21 µmol/L	159	
		4–12 mth	65–130 µg/dL	10–20 µmol/L		
		1–5 yr	65–118 µg/dL	10–18 µmol/L		
		6–9 yr	78–105 µg/dL	12–16 µmol/L		
	10–13 yr	f	78–118 µg/dL	12–18 µmol/L		
		m	78–98 µg/dL	12–15 µmol/L		
	14–19 yr	f	59–98 µg/dL	9–15 µmol/L		
		m	65–118 µg/dL	10–18 µmol/L		
	Adults		46–150 µg/dL	7–23 µmol/L	150	Plasma
			425–560 µg/dL	65–86 µmol/L		Whole blood
Zinc protoporphyrin			17–77 µg/L	0.27–1.23 µmol/L	299	Whole blood (heparine EDTA), hematofluorimetric test.

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2.2 Hematology

Analyte	Goup	Reference Ranges Conventional	SI	References	Notes
CO-Hb	Non-smokers	<2.2 %	<0.022	55	
	Smokers	<10.5 %	<0.105		
Differential leucocyte count					
Band neutrophils	Infants	<8 %	<0.08	214	Blood must be smeared within 3 hours (93)
	Children	3–6 %	0.03–0.06		
	Adults	3–5 %	0.03–0.05		
Segmented neutrophils	Infants	17–60 %	0.17–0.60		
	Children	25–60 %	0.25–0.60		
	Adults	50–70 %	0.50–0.70		
Eosinophils	Infants	1–5 %	0.01–0.05		
	Children	1–5 %	0.01–0.05		
	Adults	2–4 %	0.02–0.04		
Basophils	Infants	<1 %	<0.01		
	Children	<1 %	<0.01		
	Adults	<1 %	<0.01		
Monocytes	Infants	1–11 %	0.01–0.11		
	Children	1–6 %	0.01–0.06		
	Adults	2–8 %	0.02–0.08		
Lymphocytes	Infants	20–70 %	0.20–0.70		
	Children	25–50 %	0.25–0.50		
	Adults	25–40 %	0.25–0.40		
Eosinophiles		80–360 mil/µL	80–360 mpt/L	25	
Erythrocytes	1 d	4.3–6.3 mil/µL	4.3–6.3 tpt/L	122	
	2–6 d	4.0–6.8 mil/µL	4.0–6.8 tpt/L		
	14–23 d	3.7–6.1 mil/µL	3.7–6.1 tpt/L		
	24–37 d	3.2–5.6 mil/µL	3.2–5.6 tpt/L		
	40–50 d	3.1–5.1 mil/µL	3.1–5.1 tpt/L		
	2–2.5 mth	2.8–4.8 mil/µL	2.8–4.8 tpt/L		
	3–3.5 mth	3.1–4.7 mil/µL	3.1–4.7 tpt/L		
	5–7 mth	3.2–5.2 mil/µL	3.2–5.2 tpt/L		
	8 mth-3 yr	3.6–5.2 mil/µL	3.6–5.2 tpt/L		
	5 yr	3.7–5.7 mil/µL	3.7–5.7 tpt/L		
	10 yr	3.8–5.8 mil/µL	3.8–5.8 tpt/L		
	Adults f	4.1–5.1 mil/µL	4.1–5.1 tpt/L	294	
	m	4.5–5.9 mil/µL	4.5–5.9 tpt/L		
Erythrocyte sedimentation rate (ESR)	Adults ≤50 yr f	<25 mm/1 h	<25 mm/1 h	56	Citrated blood
	m	<15 mm/1 h	<15 mm/1 h		
	Adults >50 yr f	<30 mm/1 h	<30 mm/1 h		
	m	<20 mm/1 h	<20 mm/1 h		

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2.2 Hematology

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Glucose-6-phosphate dehydrogenase (G-6-P-DH)		7.9–16.3 U/g Hb	0.52–1.04 mU/mol Hb	299	Blood treated with heparinate or EDTA, 37 °C
Hematocrit (Hct, PCV)	1 d	44–72 %	0.44–0.72	122	
	2–6 d	50–82 %	0.50–0.82		
	14–23 d	42–62 %	0.42–0.62		
	24–37 d	31–59 %	0.31–0.59		
	40–50 d	30–54 %	0.30–0.54		
	2–2.5 mth	30–46 %	0.30–0.46		
	3 -3.5 mth	31–43 %	0.31–0.43		
	5–7 mth	32–44 %	0.32–0.44		
	8 mth–3 yr	35–43 %	0.35–0.43		
	5 yr	31–43 %	0.31–0.43		
	10 yr	33–45 %	0.33–0.45		
	Adults f	35–47 %	0.35–0.47		
	m	40–52 %	0.40–0.52		
Hemoglobin (Hb) in blood	1 d	15.2–23.6 g/dL	9.4–14.7 mmol/L	122	
	2–6 d	15.0–24.6 g/dL	9.3–15.3 mmol/L		
	14–23 d	12.7–18.7 g/dL	7.9–11.6 mmol/L		
	24–37 d	10.3–17.9 g/dL	6.4–11.1 mmol/L		
	40–50 d	9.0–16.6 g/dL	5.6–10.3 mmol/L		
	2–2.5 mth	9.2–13.6 g/dL	5.7–8.4 mmol/L		
	3–3.5 mth	9.6–12.8 g/dL	6.0–7.9 mmol/L		
	5–7 mth	10.1–12.9 g/dL	6.3–8.0 mmol/L		
	8–10 mth	10.5–12.9 g/dL	6.5–8.0 mmol/L		
	11–13.5 mth	10.7–13.1 g/dL	6.6–8.1 mmol/L		
	1.5–3 yr	10.8–12.8 g/dL	6.7–7.9 mmol/L		
	5 yr	10.7–14.7 g/dL	6.6–9.1 mmol/L		
	10 yr	10.8–15.6 g/dL	6.7–9.7 mmol/L		
	Adults f	12.3–15.3 g/dL	7.6–9.5 mmol/L	294	
	m	14.0–17.5 g/dL	8.7–10.9 mmol/L		
	>70 yr f	11.7–16.2 g/dL	7.3–10.1 mmol/L	189	
	m	12.1–17.6 g/dL	7.5–10.9 mmol/L		
	>75 yr f	11.6–16.1 g/dL	7.2–10.0 mmol/L		
	m	11.8–17.5 g/dL	7.3–10.9 mmol/L		
	>81 yr f	10.9–15.5 g/dL	6.8–9.6 mmol/L		
	m	11.6–16.3 g/dL	7.2–10.1 mmol/L		
Hb composition					
HbA_0		90–94 %	0.90–0.94	294	
HbA_1		4–8 %	0.04–0.08		
HbA_2		1.4–3.0 %	0.014–0.03		
HbF		0.3–1.0 %	0.003–0.01		

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2.2 Hematology

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Leucocytes	12 h	13,000–38,000/µL	13.0–38.0 gpt/L	56	
	1 d	9,400–34,000/µL	9.4–34.0 gpt/L		
	1 w	5,000–21,000/µL	5.0–21.0 gpt/L		
	2 w	5,000–20,000/µL	5.0–20.0 gpt/L		
	4 w	5,000–19,500/µL	5.0–19.5 gpt/L		
	2 mth	5,500–18,000/µL	5.5–18.0 gpt/L		
	4–12 mth	6,000–17,500/µL	6.0–17.5 gpt/L		
	2 yr	6,000–17,000/µL	6.0–17.0 gpt/L		
	4 yr	5,500–15,500/µL	5.5–15.5 gpt/L		
	6 yr	5,000–14,500/µL	5.0–14.5 gpt/L		
	8–12 yr	4,500–13,500/µL	4.5–13.5 gpt/L		
	14–16 yr	4,500–13,000/µL	4.5–13.0 gpt/L		
	18 yr	4,500–12,500/µL	4.5–12.5 gpt/L		
	20 yr	4,500–11,500/µL	4.5–11.5 gpt/L		
	Adults	4,400–11,300/µL	4.4–11.3 gpt/L	294	
MCH (Hb/RBC)	1 d	33–41 pg/cell	2.0–2.5 fmol/cell	122	
	2–6 d	29–45 pg/cell	1.8–2.8 fmol/cell		
	14–37 d	26–38 pg/cell	1.6–2.4 fmol/cell		
	40–50 d	25–37 pg/cell	1.6–2.3 fmol/cell		
	2–2.5 mth	24–36 pg/cell	1.5–2.2 fmol/cell		
	3–3.5 mth	23–36 pg/cell	1.4–2.2 fmol/cell		
	5–10 mth	21–33 pg/cell	1.3–2.0 fmol/cell		
	11 mth–5 yr	23–31 pg/cell	1.4–1.9 fmol/cell		
	10 yr	22–34 pg/cell	1.4–2.1 fmol/cell		
	Adults	28–33 pg/cell	1.7–2.0 fmol/cell	294	
MCHC	1 d	31–35 g/dL	19–22 mmol/L	122	
	2–6 d	24–36 g/dL	15–22 mmol/L		
	14–23 d	26–34 g/dL	16–21 mmol/L		
	24–37 d	25–37 g/dL	16–23 mmol/L		
	40 d–7 mth	26–34 g/dL	16–21 mmol/L		
	8–13.5 mth	28–32 g/dL	17–20 mmol/L		
	1.5–3 yr	26–34 g/dL	16–21 mmol/L		
	5–10 yr	32–36 g/dL	20–22 mmol/L		
	Adults	33–36 g/dL	20–22 mmol/L	294	

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2.2 Hematology

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
MCV	1 d	98–122 μm³	98–122 fL	122	
	2–6 d	94–150 μm³	94–150 fL		
	14–23 d	84–128 μm³	84–128 fL		
	24–37 d	82–126 μm³	82–126 fL		
	2–2.5 mth	81–121 μm³	81–121 fL		
	3–3.5 mth	77–113 μm³	77–113 fL		
	5–7 mth	73–109 μm³	73–109 fL		
	8–10 mth	74–106 μm³	74–106 fL		
	11–13.5 mth	74–102 μm³	74–102 fL		
	1.5–3 yr	73–101 μm³	73–101 fL		
	5 yr	72–88 μm³	72–88 fL		
	10 yr	69–93 μm³	69–93 fL		
	Adults	80–96 μm³	80–96 fL	294	
Methemoglobin	Non-smokers/smokers	<1.2 %	<0.012	55	
Osmotic resistance of erythrocytes	No hemolysis	>0.5 % NaCl	>0.005 NaCl	56	Heparinized blood
	Complete hemolysis	<0.3 % NaCl	<0.003 NaCl		
Pyruvate kinase in erythrocytes		11–16 U/g Hb	0.7–1.1 mU/mol Hb	71	Heparinized or EDTA blood
Reticulocytes	1 d	30–70 ‰	$30–70 \times 10^{-3}$	294	
	3 d	10–30 ‰	$10–30 \times 10^{-3}$		
	7 d	<10 ‰	$<10 \times 10^{-3}$		
	1 mth	2–20 ‰	$2–20 \times 10^{-3}$		
	1.5 mth	3–35 ‰	$3–35 \times 10^{-3}$		
	2 mth	4–48 ‰	$4–48 \times 10^{-3}$		
	2.5 mth	3–42 ‰	$3–42 \times 10^{-3}$		
	3 mth	3–36 ‰	$3–36 \times 10^{-3}$		
	>4 mth	2–28 ‰	$2–28 \times 10^{-3}$		
	Adults	5–15 ‰	$5–15 \times 10^{-3}$	56	
Reticulocyte hemoglobin equivalent ($RET\text{-}H_e$)	Adults	28.2–35.7 pg	28.2–35.7 pg	269	Derived from Ret-Y as determined on a Sysmex XE 2100 hematology analyzer

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2.2 Hematology

Analyte	Group		Reference Ranges Conventional	Reference Ranges SI	References	Notes
Thrombocytes	1–5 yr	f	229–553 × 10^3/µL	229–553 Gpt/L	80	
		m	217–497 × 10^3/µL	217–497 Gpt/L		
	6–10 yr	f	184–488 × 10^3/µL	184–488 Gpt/L		
		m	181–521 × 10^3/µL	181–521 Gpt/L		
	11–15 yr	f	154–442 × 10^3/µL	154–442 Gpt/L		
		m	156–408 × 10^3/µL	156–408 Gpt/L		
	16–20 yr	f	154–386 × 10^3/µL	154–386 Gpt/L		
		m	140–392 × 10^3/µL	140–392 Gpt/L		
	21–30 yr	f	154–386 × 10^3/µL	154–386 Gpt/L		
		m	140–336 × 10^3/µL	140–336 Gpt/L		
	31–40 yr	f	170–394 × 10^3/µL	170–394 Gpt/L		
		m	132–356 × 10^3/µL	132–356 Gpt/L		
	41–50 yr	f	149–409 × 10^3/µL	149–409 Gpt/L		
		m	139–403 × 10^3/µL	139–403 Gpt/L		
	51–60 yr	f	177–393 × 10^3/µL	177–393 Gpt/L		
		m	136–380 × 10^3/µL	136–380 Gpt/L		
	61–70 yr	f	152–396 × 10^3/µL	152–396 Gpt/L		
		m	150–362 × 10^3/µL	150–362 Gpt/L		
	>70 yr	f	149–409 × 10^3/µL	149–409 Gpt/L		
		m	139–335 × 10^3/µL	139–335 Gpt/L		
Volume						
– Blood		f	49–69 mL/kg	0.049–0.069 L/kg	56	
		m	44–79 mL/kg	0.044–0.079 L/kg		
– Erythrocytes		f	19–29 mL/kg	0.019–0.029 L/kg		
		m	20–37 mL/kg	0.020–0.037 L/kg		
– Plasma		f	28–41 mL/kg	0.028–0.041 L/kg		
		m	23–44 mL/kg	0.023–0.044 L/kg		

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Reference Range
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Tiefe Cyan Magenta Yellow

2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Antiphospholipid antibodies (APA)		No antibodies	No antibodies	273	ELISA, Asserachrom®* APA
α_2-Antiplasmin	2–10 yr	108–155 %	1.08–1.55	191	
	11–18 yr	79–161 %	0.79–1.61		
	Adults	80–120 %	0.80–1.2	218	Photometric assay
	Full-term infants 1 d	0.55–1.15 U/mL	0.55–1.15 U/mL	4	
	5 d	0.70–1.30 U/mL	0.70–1.30 U/mL		
	30 d	0.76–1.24 U/mL	0.76–1.24 U/mL		
	90 d	0.76–1.40 U/mL	0.76–1.40 U/mL		
	180 d	0.83–1.39 U/mL	0.83–1.39 U/mL		
	Adults	0.68–1.36 U/mL	0.68–1.36 U/mL		
Antithrombin III	Infants, premature 1 d	20–51 %	0.20–0.51	199	
	4 d	21–51 %	0.21–0.51		
	7 d	40–54 %	0.40–0.54		
	Infants, full-term 1 d	44–84 %	0.44–0.84		
	7 d	34–70 %	0.34–0.70		
	Children 2–10 yr	>67 %	>0.67	191	
	11–18 yr	>81 %	>0.81		
	Adults	>80 %	>0.80	108	Activity test, chromogenic substrate
Bleeding time	1–5 yr	<10 min	<10 min	13	Modification of the method according to Mielke
	6–10 yr	<13 min	<13 min		
	11–16 yr	<8 min	<8 min		
	Adults	<7 min	<7 min		
C4bBP	1 d	<66 %	<0.66	253	
	1 w–2 mth	25–74 %	0.25–0.74		
	3–4 mth	43–75 %	0.43–0.75		
	5–6 mth	45–95 %	0.45–0.95		
	7–12 mth	50–110 %	0.50–1.10		
	Adults	74–140 %	0.74–1.40		
D-Dimer	1–6 yr	< 0.6 µg/mL	< 0.6 mg/L	215	ELISA
	7–12 yr	< 0.5 µg/mL	< 0.5 mg/L		
	13–18 yr	< 0.7 µg/mL	< 0.7 mg/L		
	Pregnancy <20 w	<2.2 µg/mL	<2.2 mg/L	179	
	21–40 w	<4.3 µg/mL	<4.3mg/L		
	Adults	<0.5 µg/mL	<0.5 mg/L	218	Enzyme immunoassay
		<0.5 µg/mL	< 0.5 mg/L	218	Immunoturbidimetric assays, Roche CARDIAC D-Dimer

* Asserachrom is a trademark of Diagnostica STAGO

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Factor II	Neonates	31–59%	0.31–0.59	202	
	Adults	>70%	>0.70	20	
Factor V	Neonates	42–182%	0.42–1.82	202	
	Adults	>70%	> 0.70	20	
Factor VII	Neonates	34–95 %	0.34–0.95	228	
	10 yr f	60–122 %	0.60–1.22		
	m	56–140 %	0.56–1.40		
	13 yr f	69–131 %	0.69–1.31		
	m	68–125 %	0.68–1.25		
	Adults	>70 %	>0.70	20	
		55–170 %	0.55–1.70	218	
Factor VIII	2–10 yr	52–300 %	0.52–3.00	192	
	11–18 yr	54–170 %	0.54–1.70		
	Adults	>70 %	>0.70	20	
	Adults	60–150 %	0.60–1.50	218	
Factor IX	Neonates	11–55%	0.11–0.55	192	
	2–10 yr	60–98%	0.60–0.98	283	
	Adults	>60%	>0.60		
Factor X	Neonates	24–45%	0.24–0.45	191	
	Adults	>70%	>0.70	20, 218	
Factor XI	1–16 yr	56–156%	0.56–1.56	72	
	Adults	>70 %	>0.70	20	
	Adults	60–150 %	0.60–1.50	218	
Factor XII	1–16 yr	52–192 %	0.52–1.92	72	Newborns have approx. 50 % of the adult value
	Adults	>60 %	>0.60	20, 218	
Factor XIII	Adults	>60 %	>0.60	20	
Fibrin monomers	Adults	<20 µg/mL	<20 mg/L	154	Agglutination test

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Fibrinogen	Infants, premature 1 d	150–370 mg/dL	1.5–3.7 g/L	12	
	5 d	160–420 mg/dL	1.6–4.2 g/L		
	1 mth	150–410 mg/dL	1.5–4.1 g/L		
	3 mth	150–350 mg/dL	1.5–3.5 g/L		
	6 mth	150–360 mg/dL	1.5–3.6 g/L		
	Infants, full-term 1 d	160–400 mg/dL	1.6–4.0 g/L	11	
	5 d	160–460 mg/dL	1.6–4.6 g/L		
	1 mth	160–380 mg/dL	1.6–3.8 g/L		
	3 mth	150–380 mg/dL	1.5–3.8 g/L		
	6 mth	160–390 mg/dL	1.6–3.9 g/L		
	2–10 yr	140–360 mg/dL	1.4–3.6 g/L	191	
	11–18 yr	160–390 mg/dL	1.6–3.9 g/L		
	Adults	200–400 mg/dL	2.0–4.0 g/L	218	Fibrinogen levels increase during pregnancy
Fibrin(ogen) degradation products (FDP)	Adults	<10 µg/mL	<10 mg/L	251	
Fibrinopeptide A		<3 µg/mL	<3 mg/L	7	Enzyme immunoassay
Fibronectin	Adults	<300 mg/L	<0.3 g/L	20	
Heparin cofactor II	Adults	>60 %	>0.60	20	
Hepato Quick	Children	>50 %	>0.50	69	Citrated plasma, citrated blood, whole blood
	Adults	>70 %	>0.70		
High molecular weight kininogen (HMWKG)	1–16 yr	47–123 %	0.47–1.23	72	
	Adults	>70 %	>0.70	20	
International normalized ratio (INR)	Atrial fibrillation/flutter		INR 2.0–3.0	182	When determining the INR the bleeding and thrombosis risk has to be considered individually for each patient.
	Valvular defects		INR 2.0–3.0		
	Valve replacements				
	a) Mechanical valves		INR 2.0–3.0		
	Bileaflet valves/tilting disc valves				
	– in aortic position				
	– in mitral position		INR 2.5–3.5		
	"Caged Ball" valves		INR 2.5–3.5		
	Mechanical valve + embolism		INR 2.5–3.5		
	b) Bioprosthetic valves		INR 2.0–3.0		For 3 months
	Deep vein thrombosis/pulmonary embolism		INR 2.0–3.0		

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
α_2-Macroglobulin	Full-term infants 1 d	0.95–1.83 U/mL	0.95–1.83 U/mL	4	
	5 d	0.98–1.98 U/mL	0.98–1.98 U/mL		
	1 mth	1.06–1.94 U/mL	1.06–1.94 U/mL		
	3 mth	1.26–2.26 U/mL	1.26–2.26 U/mL		
	6 mth	1.49–2.33 U/mL	1.49–2.33 U/mL		
	Adults	0.52–1.20 U/mL	0.52–1.20 U/mL		
(Activated) Partial thromboplastin time (PTT, APTT)	Premature infants 1 d	<79 s	<79 s	12	Values are reagent- and age-dependent.
	5 d	<74 s	<74 s		
	1 mth	<63 s	<63 s		
	3 mth	<51 s	<51 s		
	6 mth	<53 s	<53 s		
	Full-term infants 1 d	<55 s	<55 s	11	
	5 d	<60 s	<60 s		
	1 mth	<55 s	<55 s		
	3 mth	<50 s	<50 s		
	6 mth	<43 s	<43 s		
	2–10 yr	<43 s	<43 s	283	Neothromtin
	Adults	<38 s	<38 s		
	2–10 yr	<42 s	<42 s		Actin FS
	Adults	<40 s	<40 s		
	Adults	24–33 s	24–33 s	218	Kaolin-activated APTT
Plasmin-α_2-anti-plasmin complex	1–6 yr	95–420 µg/L	95–420 µg/L	215	
	7–12 yr	80–370 µg/L	80–370 µg/L		
	13–18 yr	90–450 µg/L	90–450 µg/L		
	Adults	90–365 µg/L	90–365 µg/L		
Plasminogen	Neonates	42–66 %	0.42–0.66	166	
	2– 10 yr	55–127 %	0.55–1.27	192	
	11–18 yr	64–133 %	0.64–1.33		
	Adults	>70 %	>0.70	191	Colorimetric test
	Full-term infants 1 d	1.25–2.65 U/mL	1.25–2.65 U/mL	4	
	5 d	1.41–2.93 U/mL	1.41–2.93 U/mL		
	1 mth	1.26–2.70 U/mL	1.26–2.70 U/mL		
	3 mth	1.74–3.22 U/mL	1.74–3.22 U/mL		
	6 mth	2.21–3.81 U/mL	2.21–3.81 U/mL		
	Adults	2.48–4.24 U/mL	2.48–4.24 U/mL		

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Plasminogen activator inhibitor (PAI)		<10 AU/mL	<10 kAU/L	48	Colorimetric test, AU = arbitrary unit
	Full-term infants 1 d	2.0–15.1 U/mL	2.0–15.1 U/mL	4	
	5 d	<8.1 U/mL	<8.1 U/mL		
	1 mth	<8.8 U/mL	<8.8 U/mL		
	3 mth	1.0–15.3 U/mL	1.0–15.3 U/mL		
	6 mth	6.0–13.0 U/mL	6.0–13.0 U/mL		
	Adults	< 11.0 U/mL	< 11.0 U/mL		
Platelet factor 4 (PF4)		<5 U/mL	<5 kU/L	9	Enzyme immunoassay, CTAD collection tubes
Prekallikrein	1–16 yr	47–171 %	0.47–1.71	72	
	Adults	>50 %	>0.50	20	
Protein C	Neonates	0.20–0.44 U/mL	0.20–0.44 kU/L	202	Antigen concentration
	2–10 yr	64–150 %	0.64–1.50	192	
	11–18 yr	63–130 %	0.63–1.30		
	Adults	70–140 %	0.70–1.40	218	Protein C concentration, enzyme immunoassay
	Adults	70–130 %	0.70–1.30	218	Protein C activity, chromogenic method and clotting test
Activity/antigen concentration ratio	1 d	0.63–1.35	0.63–1.35	255	
	2 d	0.29–1.37	0.29–1.37		
	3 d	0.66–1.30	0.66–1.30		
	4 d	0.57–1.45	0.57–1.45		
	1 mth	0.76–1.20	0.76–1.20		
Protein S, total	1 d	17–53 %	0.17–0.53	253	Concentration: Enzyme immunoassay. In pregnancy often low values. After the first centrifugation step, the plasma must be centrifuged a second time and separated from cells, immediately freeze the supernatant.
	1 w–2 mth	35–64 %	0.35–0.64		
	3–4 mth	50–86 %	0.50–0.86		
	5–6 mth	64–105 %	0.64–1.05		
	7–12 mth	66–120 %	0.66–1.20		
	Adults	70–140 %	0.70–1.40	34	
Protein S, free	1 d	32– 84 %	0.32–0.84	253	
	1 w–2 mth	50–100 %	0.50–1.00		
	3–4 mth	64–98 %	0.64–0.98		
	5–6 mth	60–125 %	0.60–1.25		
	7–12 mth	70–140 %	0.70–1.40		
	Adults f	50–120 %	0.50–1.20	218	Clotting test
	m	65–145 %	0.65–1.45		

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Prothrombin fragments 1+2	1–6 yr	0.35–1.20 nmol/L	0.35–1.20 nmol/L	215	Enzyme immunoassay
	7–12 yr	0.36–1.28 nmol/L	0.36–1.28 nmol/L		
	13–18 yr	0.28–1.40 nmol/L	0.28–1.40 nmol/L		
	Adults	0.38–1.14 nmol/L	0.38–1.14 nmol/L		
Prothrombin time (PT)	6 mth–5 yr	53–100 %	0.53–1.00	191	Therapeutic range in percent is method dependent and corresponds to INR: 2.0–4.5. Values >100 % are of no clinical significance.
	6 yr–7 yr	65–100 %	0.65–1.00		
	8–16 yr	77–100 %	0.77–1.00		
	Adults	>70 %	>0.70	218	
Reptilase time	Adults	<20 s	<20 s	290	
Thrombin AT III complex (TAT)	1–6 yr	0.8–3.5 µg/L	0.8–3.5 µg/L	215	Enzyme immunoassay
	7–12 yr	0.6–4.1 µg/L	0.6–4.1 µg/L		
	13–18 yr	0.7–3.8 µg/L	0.7–3.8 µg/L		
	Adults	0.6–3.6 µg/L	0.6–3.6 µg/L		
Thrombin coagulase	Adults	<23 s	<23 s	290	
Thrombin time	Premature infants 1 d	<30 s	<30 s	12	
	5 d	<29 s	<29 s		
	1 mth	<30 s	<30 s		
	3 mth	<31 s	<31 s		
	6 mth	<32 s	<32 s		
	Neonates 1 d	<28 s	<28 s	11	
	5 d	<29 s	<29 s		
	1 mth	<29 s	<29 s		
	3 mth	<30 s	<30 s		
	6 mth	<31 s	<31 s		
	Adults	<22 s	<22 s	20	
		Normal range: ≤21 s Ctrl. of heparin therapy: ≤13 s	Normal range: ≤21 s Ctrl. of heparin therapy: ≤13 s	218	
β-Thromboglobulin	Adults	<40 U/mL	<40 kU/L	9	Enzyme immunoassay, plasma. Urine: approx. 0.5 % of plasma value.
Tissue factor pathway inhibitor	Adults	>70 %	> 0,70	20	

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2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Tissue plasminogen activator (t-PA)		<12 ng/mL	<12 µg/L	20	t-PA levels increase with age, smoking, physical exercise, stress. Venous stasis induces an increase of t-PA levels.
	Adults	1–12 ng/mL	1–12 µg/L	218	Enzyme immunoassay
	Full-term infants 1 d	5.0–18.9 ng/mL	5.0–18.9 µg/mL	4	
	5 d	4.0–10.0 ng/mL	4.0–10.0 µg/L		
	30 d	1.0–6.0 ng/mL	1.0–6.0 µg/L		
	3 mth	1.0–5.0 ng/mL	1.0–5.0 µg/L		
	6 mth	1.0–6.0 ng/mL	1.0–6.0 µg/L		
	Adults	1.4–8.4 ng/mL	1.4–8.4 µg/L		
von Willebrand factor (vWF)	2–10 yr	54–200 %	0.54–2.00	192	
	Adults	50–160 %	0.50–1.60	218	Enzyme immunoassay, lower results with blood group 0.

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2.4 Blood gases

Analyte	Group		Reference Ranges Conventional	Reference Ranges SI	References	Notes
Base excess		Adults	– 2 to + 3 mmol/L	– 2 to + 3 mmol/L	184	Blood, arterial, venous
O_2-saturation		Adults	94–98 % 70–80 %	0.94–0.98 0.70–0.80	184	Blood, arterial Blood, venous
pCO_2	Children	A. umb. V. umb.	35–80 mm Hg 30–57 mm Hg	4.7–10.7 kPa 4.0–7.6 kPa	184	Blood
	Children	1 d 10 d–3 mth 4–12 mth	29–61 mm Hg 27–43 mm Hg 27–40 mm Hg	4.0–8.0 kPa 3.5–5.7 kPa 3.6–5.3 kPa		
	Adults	w m	32–43 mm Hg 35–46 mm Hg	4.3–5.7 kPa 4.7–6.1 kPa		
pH	Children	A. umb. V. umb.	7.09–7.40 7.15–7.45	7.09–7.40 7.15–7.45	184	Blood
	Children	1 d 10 d–3 mth 4–12 mth	7.20–7.41 7.34–7.45 7.38–7.45	7.20–7.41 7.34–7.45 7.38–7.45		
	Adults		7.37–7.45 7.35–7.43	7.37–7.45 7.35–7.43		Blood, arterial Blood, mixed venous
pO_2	Children	A. umb. V. umb. 10 d–3 mth Adults	< 22 mm Hg 16–35 mm Hg 70–85 mm Hg 71–104 mm Hg 36–44 mm Hg	< 2.9 kPa 2.2–4.7 kPa 9.3–11.4 kPa 9.5–13.9 kPa 4.8–5.9 kPa	184	Blood Blood, arterial Blood, mixed venous
Standard bicarbonate	Children	V. umb.	12–21 mmol/L	12–21 mmol/L	184	Blood
	Children	1 d 10 d–3 mth 4–12 mth Adults	19–23 mmol/L 19–25 mmol/L 20–24 mmol/L 21–26 mmol/L	19–23 mmol/L 19–25 mmol/L 20–24 mmol/L 21–26 mmol/L		
			22–29 mmol/L	22–29 mmol/L		Serum, plasma

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2.5 Therapeutic drug monitoring

Analyte	Group	Therapeutic Range* Conventional	SI	Reference	Notes
Acetaminophene		10–30 µg/mL	66–199 µmol/L	218	Immunoturbidimetric assay, Roche Diagnostics
Acetylsalicylic acid		50–300 µg/mL	0.83–1.66 mmol/L	193	Blood collection: 1–3 h after oral dose.
Amikacin		Peak: 20–25 µg/mL Trough: 5–10 µg/mL	34–43 µmol/L 9–17 µmol/L	218	Fluorescence polarization immunoassay, immunoturbidimetric immunoassay, Roche Diagnostics
Benzodiazepine		<200 µg/mL	<200 mg/L	218	Immunoturbidimetric assay, Roche Diagnostics, laboratory-dependent cutoff in *urine*.
Caffeine		5–20 µg/mL	26–103 µmol/L	193	
Carbamazepine		8–12 µg/mL	33.8–50.8 µmol/L	218	Homogeneous enzyme immunoassay, immunoturbidimetric assay, Roche Diagnostics
		6–12 µg/mL	25.4–50.8 µmol/L		Fluorescence polarization immunoassay, Roche Diagnostics
Chloramphenicol		10–25 µg/mL	31–77 µmol/L	193	
Cyclosporine		No firm therapeutic range exists.	Range must be established for the specific assay used.	218	Whole blood
Digitoxin		10–30 ng/mL	13–39 nmol/L	218	Fluorescence polarization immunoassay, turbidimetric immunoassay, electrochemiluminescence immunoasay, Roche Diagnostics
Digoxin		0.9–2.0 ng/mL	1.2–2.6 nmol/L	218	Electrochemiluminescence immunoassay, homogeneous enzyme immunoassay, Roche Diagnostics
		0.8–2.0 ng/mL	1.0–2.6 nmol/L		Fluorescence polarization immunoassay, immunoturbidimetric immunoassay, Roche Diagnostics
Disopyramide		2–5 µg/mL	6–15 µmol/L	193	
Ethosuximide		40–100 µg/mL	283–708 µmol/L	193	
Gentamicin		Peak: 6–10 µg/mL Trough: 0.5–2.0 µg/mL	12.5–20.9 µmol/L 1.0–4.2 µmol/L	218	Fluorescence polarization immunoassay, immunoturbidimetric immunoassay, Roche Diagnostics
		Peak: 6–10 µg/mL Trough: 0.5–2.0 µg/mL	10.5–20.9 µmol/L 1.0–4.2 µmol/L		Homogeneous enzyme immunoassay, Roche Diagnostics
Lidocaine		1.5–6 µg/mL	6–26 µmol/L	218	Fluorescence polarization immunoassay, Roche Diagnostics, blood collection: during infusion
Lithium		0.6–1.2 mEq/L	0.6–1.2 mmol/L	218	Colorimetric assay, direct ISE, Roche Diagnostics, blood collection: 12 h after final dose

* The therapeutic range given is a general recommendation which can only be clinically interpreted in conjunction with the toxicity and the therapeutic efficacy of the drug monitored.

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2.5 Therapeutic drug monitoring

Analyte	Therapeutic Range* Group	Conventional	SI	References	Notes
Methotrexate		A generally applicable therapeutic range is not available.	Therapeutic concentrations depend on the treatment protocol.	299	Collect specimen at 0.5 or 2 h after i.v. or p.o. low dose, respectively. Collect specimen at 24, 48, and 72 h after high-dose infusion.
Mycophenolic acid, total (MPA)		Therapeutic range not yet fully established and dependent	on transplant type and co-administered drugs.	218	
N-Acetytylprocainamide (NAPA)		5–30 µg/mL	18.1–108.3 µmol/L	218	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics; commonly accepted therapeutic range for the sum of NAPA and procainamide. For effective treatment, some patients may require serum/plasma levels outside thise range.
Phenobarbital		15–40 µg/mL	65–172 µmol/L	218	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics; some patients may require serum/plasma levels outside thise range to obtain effective seizure control.
Phenytoin	Premature infants Adults	6–14 µg/mL approx. 10–20 µg/mL	24–56 µmol/L approx. 40–80 µmol/L	218	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics.
Primidone		5–12 µg/mL	22.9–50 µmol/L	218	Fluorescence polarization immunoassay, Roche Diagnostics.
Procainamide		4–10 µg/mL	16.9–42.3 µmol/L	218	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics.
Quinidine		1.5–5 µg/mL	4.6–15 µmol/L	218	Thrapeutic ranges established with unspecific methods that measure quinidine as well as quinidine metabolites.
Salicylic acid		30–100 µg/mL 150–300 µg/mL	0.22–0.72 mmol/L 1.09–2.17 mmol/L	218	Antipyretic/analgetic conditions. Anti-inflammatory/rheumatic fever conditions. Colorimetric assay, enzymatic UV test; Roche Diagnostics.
Tacrolimus		5–20 ng/mL (trough)	4–16 µmol/L (trough)	299	

* The therapeutic range given is a general recommendation which can only be clinically interpreted in conjunction with the toxicity and the therapeutic efficacy of the drug monitored.

2.5 Therapeutic drug monitoring

Analyte	Group	Therapeutic Range* Conventional	SI	References	Notes
Theophylline		approx. 10–20 µg/mL	approx. 56–111 µmol/L	218	Homogeneous immunoassay, fluorescence immunoassay, immunoturbidimetric assay, Roche Diagnostics.
Tobramycin		Peak: 6–10 µg/mL Trough: 0.5–2.0 µg/mL	Peak: 12.8–21.4 µmol/L Trough: 1.1–4.3 µmol/L	218	Homogeneous immunoassay, fluorescence immunoassay, Roche Diagnostics
Valproic acid free fraction		50–100 µg/mL 5–15 % of the plasma value	347–693 µmol/L 0.05–0.15 of the plasma value	218	Homogeneous immunoassay, fluorescence immunoassay, Roche Diagnostics Fluorescence immunoassay, Roche Diagnostics
Vancomycin		Peak: 20–40 µg/mL Trough: 5–10 µg/mL	Peak: 14–28 µmol/L Trough: 3.5–7.0 µmol/L	218	Homogeneous immunoassay, fluorescence immunoassay, Roche Diagnostics

* The therapeutic range given is a general recommendation which can only be clinically interpreted in conjunction with the toxicity and the therapeutic efficacy of the drug monitored.

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2.6.1 Urinalysis, urinary sediment and status

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Bacteria	Children	$<10^3$/µL	$<10^9$/L	218	Chamber count
	Adults	$<10^5$/µL	$<10^{11}$/L		
Specific gravity	Neonates	1.012 g/mL	1.012 g/mL	218	Daily urine, normal diet
	Children	1.002–1.006 g/mL	1.002–1.006 g/mL		
	Adults	1.002–1.030 g/mL	1.002–1.030 g/mL		
Urinary sediment					
Erythrocytes		0–1 per field (<5/µL)	0–1 per field (<5 Mpt/L)	214	Group classification per field
Leucocytes		1–4 per field (<10/µL)	1–4 per field (<10 Mpt/L)		(magnification × 400):
Squamous					Not detectable
epithelial cells		5–15 per field	5–15 per field		0–1
Renal epithelial cells		Not detectable	Not detectable		1–4
Casts					5–15
hyaline		Only occasional	Only occasional		15–50
epithelial		Not detectable	Not detectable		> 50
erythrocyte		Not detectable	Not detectable		Crowding
granulated		Not detectable	Not detectable		
leucocyte		Not detectable	Not detectable		
Bacteria		Not detectable	Not detectable		Group classification per field
Yeast cells		Not detectable	Not detectable		(magnification × 400):
Trichomonads		Not detectable	Not detectable		Not detectable
Salts		Not detectable	Not detectable		(+)
					+
					++
					+++
					Crowding

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2.6.1 Urinalysis, urinary sediment and status

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Urinary status					
Bilirubin		<0.2 mg/dL	<3.4 µmol/L	218	Combur[10]Test®
Erythrocytes		<5/µL	<5 Mpt/L		
Glucose		<15 mg/dL	<0.84 mmol/L		Fasting
Ketone bodies (acetacetate)		<5 mg/dL	<0.5 mmol/L		
Leucocytes		<10/µL	<10 Mpt/L		
Nitrite		Not detectable	Not detectable		
pH		4.8–7.4	4.8–7.4		
Protein		<10 mg/dL	<0.1 g/L		
Specific gravity		1.015–1.025 g/mL	1.015–1.025		
Urobilinogen		<1 mg/dL	<16.9 µmol/L		
Urine volume	Neonates	15–60 mL/24 h	0.02–0.06 L/d	47	Normal liquid intake
	2 mth–1 yr	250–500 mL/24 h	0.25–0.50 L/d		
	2–3 yr	600–750 mL/24 h	0.60–0.75 L/d		
	>10 yr	700–1 500 mL/24 h	0.70–1.50 L/d		
	Adults	1 000–1 500 mL/24 h	1.00–1.50 L/d		

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2.6.2 Clinical chemical urinalysis

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
α_1-Acid glycoprotein (Orosomucoid)	1 mth–15 yr	<4.4 mg/g crea	<0.5g/mol crea	112	Radial immunodiffusion, spontaneously voided urine.
Adenosine monophosphate, 3′–5′, cycl.	Adults	<1.6 mg/g crea	<560 µmol/mol crea	275	Deep-freeze immediately
Albumin	Children <1 mth	<252 mg/L	<21 mg/mmol crea	112	Spontaneously voided urine, radial immunodiffusion
	1–12 mth	<12.3 mg/L	<3.8 mg/mmol crea		
	1–5 yr	<19.0 mg/L	<3.3 mg/mmol crea		
	6–10 yr	<30.4 mg/L	<2.7 mg/mmol crea		
	11–15 yr	<25.5 mg/L	<2.1 mg/mmol crea		
	Adults	<20 mg/g crea or	<2.26 g (34.35 µmol)/mol crea	218	2nd morning urine
	Children 3–5 yr	<20 mg/L or <37 mg/g or <2 mg/dL or <30 mg/24 h	<0.304 µmol/L or <0.304 µmol/L or <0.456 µmol/d		24 h-urine Immunoturbidimetric assay, Roche Diagnostics
δ-Aminolevulic acid	Adults	<6.4 mg/24 h	<49 µmol/d	60	24 h-urine to be acidified with HCl, pH 2–3
α-Amylase, total	Adults f	≤447 U/L	≤7.46 µkat/L	218	Spontaneously voided urine
	m	≤491 U/L	≤8.20 µkat/L		
pancreatic	Adults f	≤390 U/g crea	≤6.51 µkat/g crea		Amylase/creatinine quotient
	m	≤283 U/g crea	≤4.73 µkat/g crea		
Calcium	Children	<6 mg/kg/24 h	<0.15 mmol/kg/d	134	24 h-urine, acidified (pH <2) with HCl
	Adults f	<260 mg/24 h	<6.5 mmol/d		
	m	<320 mg/24 h	<8.0 mmol/d		
		100–321 mg/24 h or	2.5–8.0 mmol/d or	218	24 h-urine (assumed volume: 1.5 L)
		6.8–21.3 mg/dL	1.7–5.3 mmol/L		
Carnitin, free	Neonates	1.4–16 µmol/24 h	1.4–16 µmol/d	242	
	Infants	50–250 µmol/24 h	50–250 µmol/d		
	Adults	60–600 µmol/24 h	60–600 µmol/d		
Catecholamines					
Norepinephrine	Adults	23–105 µg/24 h	136–620 nmol/d	58	24 h-urine with 1 g boric acid, HPLC
Epinephrine		4–20 µg/24 h	22–109 nmol/d		
Dopamine		190–450 µg/24 h	1.26–2.98 µmol/d		
Chloride	Adults	75–199 mEq/L	75–199 mmol/L	148	24 h-urine
		46–168 mEq/L	46–168 mmol/L		1st morning urine
		110–250 mEq/24 h	110–250 mmol/d	299	24 h-urine
Citrate (as citric acid)	Adults	<805 mg/24 h	<4.2 mmol/d	107	
Copper	Adults	10–60 µg/24 h	0.16–0.94 µmol/d	171	
Cortisol, free	Adults	36–137 µg/24 h	100–379 nmol/d	218	24 h-urine, Cortisol Elecsys®

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2.6.2 Clinical chemical urinalysis

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
C-Peptide	Adults	17.2–181 µg/24 h	5.74–60.3 nmol/d	218	24 h-urine, C-Peptide Elecsys®
Creatinine	Adults f	28–217 mg/dL	2.47–19.2 mmol/L	172	Roche Diagnostics, kinetic Jaffé method, rate-blanked, compensated, 1st morning urine.
	m	39–259 mg/dL	3.46–22.9 mmol/L		
	f	0.74- 1.57 g/24 h	6.6–13.9 mmol/d	126	Roche Diagnostics, kinetic Jaffé method, rate-blanked, compensated, 24 h-urine.
	m	1.04–2.35 g/24 h	9.2–20.7 mmol/d		
	f	29–226 mg/dL	2.55–20.0 mmol/L	172	Roche Diagnostics, enzymatic method, 1st morning urine.
	m	40–278 mg/dL	3.54–24.6 mmol/L		
	f	0.72–1.51 g/24 h	6.3–13.4 mmol/d	126	Roche Diagnostics, enzymatic method, 24 h-urine.
	m	0.98–2.20 g/24 h	8.6- 19.4 mmol/d		
Creatinine clearance	Adults	71.2–151 mL/min	71.2–151 mL/min	126	Roche Diagnostics, Jaffé kin., rate-blanked, compensated, measured.
		82.5–120 mL/min	82.5–120 mL/min		Calculated acc. to Cockroft-Gault.
		77–132.2 mL/min	77–132.2 mL/min		Calculated using MDRD study formula.
		52.1–110 mL/min	52.1–110 mL/min		Roche Diagnostics, Jaffé kin., rate-blanked, non-compensated, measured.
		67.5–141 mL/min	67.5–141 mL/min		Calculated acc. to Cockroft-Gault.
		64.3–97.7 mL/min	64.3–97.7 mL/min		Calculated using MDRD study formula.
		66.3–143 mL/min	66.3–143 mL/min		Roche Diagnostics, enzym. method, measured.
		79.9–167 mL/min	79.9–167 mL/min		Calculated acc. to Cockroft-Gault.
		76.6–127.3 mL/min	76.6–127.3 mL/min		Calculated using MDRD study formula.
Cystine	Clinical patients	5.5–37 mg/24 h	46–306 pmol/d	157	24 h-urine, pH 2–3
Deoxypyridinolin					
total		19–64 µg/g crea	5–17 µmol/mol crea	23	
free		6–35 µg/g crea	1.6–9.3 µmol/mol crea		
Fructose	Adults	<60 mg/24 h	<0.3 mmol/d	105	
Galactose	Neonates	<60 mg/dL	<3.3 mmol/L	105	
	Adults	<14 mg/24 h	<0.1 mmol/d		
Glomerular filtration rate (GFR)	30 yr	79–131 mL/min	79–131 mL/min	81	^{51}Cr-EDTA clearance
	50 yr	75–121 mL/min	75–121 mL/min		
	70 yr	54–102 mL/min	54–102 mL/min		
Glucose	Adults	<20 mg/dL	<1.1 mmol/L	218	1st morning urine.
		<15 mg/dL	<0.8 mmol/L		Spontaneously voided urine.
		<17 mg/dL	<0.96 mmol/L	148	24 h-urine
5-Hydroxyindole acetic acid	Adults	<8 mg/24 h	<41 µmol/d	284	24 h-urine, HPLC
Hydroxyproline	Adults, 26–75 yr	4.8–25 mg/24 h × m^2 body surf.	37–190 µmol/d × m^2 body surf.	38	24 h-urine

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2.6.2 Clinical chemical urinalysis

Analyte	Group		Reference Ranges Conventional	Reference Ranges SI	References	Notes
Immunoglobulin light chains κ/λ ratio		Adults	0.70–4.50	0.70–4.50	218	Roche Diagnostics, immunoturbidimetric method
Immunoglobulin G (IgG)	Children	<1mth	18.8–50 mg/L	18.8–50 mg/L	112	Spontaneously voided urine, radial immunodiffusion
		1–12 mth	Not detectable	Not detectable		
		1–5 yr	3.7–5.3 mg/L	3.7–5.3 mg/L		
		6–10 yr	5.4–8.3 mg/L	5.4–8.3 mg/L		
		11–15yr	7.1–11.1 mg/L	7.1–11.1 mg/L		
		Adults	<9 mg/24 h (<9 mg/g crea)	<9 mg/d (<1.0 g/mol crea)	88	Roche Diagnostics, immunoturbidimetric method
Iron			<98 µg/24 h	<1.8 µmol/d	235	24 h-urine
Lysozyme			<3.6 mg/24 h	<3.6 mg/d	299	
Magnesium			9.7–12.2 mg/24 h	4–5 mmol/d	226	24 h-urine
			7.3–12.2mg/dL	3.0–5.0 mmol/L	299	24 h-urine
Mercury		Adults	< 26 µg/L	< 130 nmol/L	230	
α_1-Microglobulin	Children	<1 mth	28–55 mg/L	28–55 mg/L	112	Radial immunodiffusion, spontaneously voided urine.
		1–12 mth	1.1–4.2 mg/L	1.1–4.2 mg/L		
		1–5 yr	3.7–4.8 mg/L	3.7–4.8 mg/L		
		6–10 yr	4.1–7.4 mg/L	4.1–7.4 mg/L		
		11–15 yr	5.7–8.0 mg/L	5.7–8.0 mg/L		
		Adults	<20 mg/24 h (<1.2 mg/dL) <14 mg/g (<1.58 g/mol) crea	<20 mg/d (<12 mg/L) <52.6 mmol/mol crea	218	24 h-urine 2nd morning urine
Osmolality			400–800 mosmol/kg	400–800 mmol/kg	133	
Oxalate	Children					
	1–12 mth	f	<23 mg/24 h	<0.27 mmol/d	114	24 h-urine collected with 10 mL conc. HCl
		m	<57 mg/24 h	<0.65 mmol/d		
	1–3 yr	f	<38 mg/24 h	<0.43 mmol/d		
		m	<44 mg/24 h	<0.50 mmol/d		
	4–6 yr	f	<35 mg/24 h	<0.40 mmol/d		
		m	<41 mg/24 h	<0.47 mmol/d		
	7–9 yr	f	<38 mg/24 h	<0.44 mmol/d		
		m	<31 mg/24 h	<0.35 mmol/d		
	10–12 yr	f	<35 mg/24 h	<0.40 mmol/d		
		m	<32 mg/24 h	<0.37 mmol/d		
	13–15 yr	f	<39 mg/24 h	<0.44 mmol/d		
		m	<35 mg/24 h	<0.40 mmol/d		
		Adults	<45 mg/24 h	< 0.50 mmol/d	107	
Phosphate, inorganic		12–60 yr	0.4–1.3 g/24 h	13–42 mmol/d	104	24 h-urine, on nonrestricted diet
			40–140 mg/dL	13–44 mmol/L	148	1st morning urine

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2.6.2 Clinical chemical urinalysis

Analyte	Reference Ranges Group	Conventional	SI	References	Notes
Porphyrins					
Total porphyrin	Adults	<100 µg/24 h	<120 nmol/d	60	Protect sample from light
Uroporphyrin		<24 µg/24 h	<29 nmol/d		
Heptacarboxy-porphyrin		<3 µg/24 h	<4 nmol/d		
Hexacarboxy-porphyrin		<2 µg/24 h	<3 nmol/d		
Pentacarboxy-porphyrin		<4 µg/24 h	<6 nmol/d		
Coproporphyrin		14–78 µg/24 h	21–119 nmol/d		
Tricarboxy-porphyrin		<2 µg/24 h	<2 nmol/d		
Dicarboxy-porphyrin		<1 µg/24 h	<1 nmol/d		
Potassium	Adults	32–83 mEq/L	32–83 mmol/L	148	24 h-urine
		20–80 mEq/L	20–80 mmol/L		1st morning urine
		25–125 mEq/24 h	25–125 mmol/24 h	299	24 h-urine
Protein, Total	Adults	<15 mg/dL	<150 mg/L	128	Benzethonium chloride method, random urine
		<14 mg/dL	<140 mg/L	299	Turbidimetry, nephelometry, 24 h-urine
		<150 mg/24 h	<150 mg/d	218	Benzethonium chloride method, 24 h-urine
Pyridinolin, total	Adults	103–260 µg/g crea	27–68 µmol/mol crea	23	24 h-urine or spontaneously voided urine. Sampling between 11 a.m. and 1 p.m.
free		40–159 µg/g crea	10–42 µmol/mol crea		
Sodium	Adults	71–171 mEq/L	71–171 mmol/L	148	24 h-urine
		54–190 mEq/L	54–190 mmol/L		1st morning urine
		40–220 mEq/24 h	40–220 mmol/24 h	299	24 h-urine
Transferrin	Adults	<1 mg/g crea	<113 mg/mol crea	88	Spontaneously voided urine
		<1 mg/24 h	<1 mg/d		24 h-urine
Urea	Adults	<35 g/24 h	<580 mmol/d	234	24 h-urine
		0.9–3.0 g/dL	150–500 mmol/L		1st morning urine
		25.8–42.6 g/24 h	430–710 mmol/d	299	24 h-urine
Uric acid	Adults	0.20–1.00 g/24 h	1.2–6.0 mmol/d	234	24 h-urine, concn. considerably diet-related
		37–92 mg/dL	2.2–5.5 mmol/L	148	1st morning urine, concn. considerably diet-related
Vanillylmandelic acid (VMA)	Adults	3.3–6.5 mg/24 h	18–33 µmol/d	297	

2.7 Urinary calculi, gallstones

Concrement	Major components	References
Gallstones	Bilirubin	99
	Calcium carbonate	
	Cholesterol	
Urinary calculi	Calcium hydrogen phosphate dihydrate	99
	Calcium oxalate dihydrate	
	Calcium oxalate monohydrate	
	Carbonate apatite	
	Cystine	
	2,8-Dihydroxyadenine	
	Magnesium ammonium phosphate hexahydrate	
	Magnesium ammonium phosphate monohydrate	
	Mono-ammonium urate	
	Mono-sodium urate monohydrate	
	Protein	
	Uric acid	
	Uric acid dihydrate	
	Xanthine	

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2.8 CSF

Analyte	Group	Reference Range Conventional	Reference Range SI	References	Notes
Albumin	Adults	110–350 mg/L	110–350 mg/L	211	
Albumin, CSF/serum ratio	Children ≤15 yr	5.0×10^{-3}	5.0×10^{-3}	210, 218	
	Adults ≤40 yr	6.5×10^{-3}	6.5×10^{-3}		
	≤60 yr	8.0×10^{-3}	8.0×10^{-3}		
Cells	Neonates	<32 leucocytes/μL	<32 mpt leucocytes/L	214	
	Adults	<3 leucocytes/μL	<3 mpt leucocytes/L		
Glucose	Children	60–80 mg/dL	3.33–4.44 mmol/L	218	
	Adults	40–70 mg/dL	2.22–3.89 mmol/L		
IgA	Adults	0.5–6.0 mg/L	3.1–37.5 nmol/L	211	
IgG	Adults	10–40 mg/L	66.7–266.8 nmol/L	211	
IgM	Adults	0.05–0.8 mg/L	0.05–0.8 nmol/L	211	
Lactate	Neonates	10–60 mg/dL	1.1–6.7 mmol/L	299	
	Children 3–10 d	10–40 mg/dL	1.1–4.4 mmol/L		
	>10 d	10–25 mg/dL	1.1–2.8 mmol/L		
	Adults	10–22 mg/dL	1.1–2.4 mmol/L	98	
Protein, total	Premature infants				
	27–32 w of pregnancy	68–240 mg/dL	0.68–2.40 g/L	134	
	33–36 w of pregnancy	67–230 mg/dL	0.67–2.30 g/L		
	37–40 w of pregnancy	58–150 mg/dL	0.58–1.50 g/L		
	1 d–1 mth	25–72 mg/dL	0.25–0.72 g/L		
	2–3 mth	20–72 mg/dL	0.20–0.72 g/L		
	4–6 mth	15–50 mg/dL	0.15–0.50 g/L		
	7–12 mth	10–45 mg/dL	0.10–0.45 g/L		
	2 yr	10–40 mg/dL	0.10–0.40 g/L		
	3–4 yr	10–38 mg/dL	0.10–0.38 g/L		
	5–8 yr	10–43 mg/dL	0.10–0.43 g/L		
	Adults	<45 mg/dL	<0.45 g/L		
Electrophoresis					
Prealbumin		5.4–9.0 %	0.054–0.090	141	
Albumin		55.3–65.9 %	0.553–0.659		
α_1-Globulin		2.8–5.6 %	0.028–0.056		
α_2-Globulin		2.8–4.8 %	0.028–0.048		
β-Globulin		9.9–15.5 %	0.099–0.155		
γ-Globulin		8.2–14.6 %	0.082–0.146		

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2.9 Stool

Analyte	Reference Ranges Conventional	SI	References	Notes
Albumin	<100 µg/fecal smear	<100 µg/fecal smear	185	
Blood	Not detectable	Not detectable	214	No intake of fish, meat, radish, horseradish, iron- or copper-containing preparations 3 days prior to test
Chymotrypsin	Adults >13.2 U/g	>220 nkat/g	218	
Composition	Dry substance 10–60 g/24 h Volume of water 100–180 mL/24 h Neutral fats <7 g/24 h Bile acid 300–400 mg/24 h Stercobilinogen + Stercobilin 60–200 mg/24 h	10–60 g/d 100–180 mL/d <7 g/d 300–400 mg/d 60–200 mg/d	214	
Copper	<46 µg/g stool	<0.72 µmol/g stool	52	
Lactoferrin	<2.4 µg/g stool	<2.4 µg/g stool	276	
Pancreatic elastase	Neonates 5–195 µg/g stool Infants, children 168–4420 µg/g stool Adults >200 µg/g stool 100–200 µg/g stool < 100 µg/g stool	5–195 µg/g stool 168–4420 µg/g stool >200 µg/g stool 100–200 µg/g stool <100 µg/g stool	258 231	 Normal Light to medium insufficiency Strong insufficiency
Weight	Adults 100–250 g/24 h	100–250 g/d	214	
Zinc	Adults <408 µg/g stool	<408 µg/g stool	52	

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2.10 Spermiogram

Analyte	Reference Ranges	References
α-Glucosidase	> 20 mU/ejaculate	291
Acid phosphatase	> 200 µmol/ejaculate	
Citrate	> 52 µmol/ejaculate	
Fructose	> 13 µmol/ejaculate	
Leucocytes	< 1 mil/mL	
MAR test	< 10 % of spermatozoa with adhesive particles or erythrocytes	
Morphology	> 30 % normally formed spermatozoa	
Motility	> 50 % spermatozoa with progressive motility (categories a and b) or > 25 % spermatozoa with rapid progressive motility (category a)	
pH	7.2 – 7.8	
Sperm concentration	> 20 mil spermatozoa/mL	
Total sperm count	> 40 mil spermatozoa/ejaculate	
Vitality	> 75 % vital spermatozoa, i.e. cells not absorbing eosin dye	
Volume	> 2 mL	
Zinc	> 2.4 µmol/ejaculate	

Analyte	Reference Ranges	References
Normozoosperms	Normal ejaculate findings	291
Oligozoosperms	< 20 mil spermatozoa/mL	
Cryptozoosperms	< 1 mil spermatozoa/mL	
Polyzoosperms	> 250 mil spermatozoa/mL	
Asthenozoosperms	< 50 % of spermatozoa with progressive motility (categories a and b) and < 25 % of spermatozoa with motility of category a	
Teratozoosperms	< 30 % of spermatozoa with normal morphology	
Oligoasthenoteratozoosperms	Combination of oligo-, astheno- and teratozoosperms	
Azoosperms	No spermatozoa in the ejaculate	
Parvisemia	Ejaculate volume < 2 mL	
Hypersemia	Ejaculate volume > 6 mL	
Aspermia	No ejaculate	
Hemosperms	Erythrocytes in ejaculate	

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2.11 Extravascular body fluids

Amniotic fluid		
Analyte	**Reference Ranges**	**Ref.**
Albumin	< 3.0 g/L	
Bicarbonate	11 – 45 mmol/L	39
Bilirubin	< 0.1 mg/dL	
Calcium	0.86 – 2.57 mmol/L	
CEA	< 107 µg/L	61
Chloride	83 – 111 mmol/L	39
Creatinine	0.2 – 0.7 mg/dL	39
Erythropoietin	1.2 – 6.5 U/L	37
Glucose	45 – 76 mg/dL	39
hCG	< 4300 IU/L	61
Lysozyme	6 – 12 mg/L	91
Osmolality	268 – 280 mosmol/kg	39
Phosphate, inorg.	0.5 – 2.8 mmol/L	39
Potassium	3.7 – 4.4 mmol/L	39
Prolactin	< 70 nmol/L	61
Protein	< 4.0 g/L	
Sodium	139 – 144 mmol/L	39
Urea	12 – 32 mg/dL	

Ascites			
Analyte	**Reference Ranges**		**Ref.**
	Nonmalignant	**Malignant**	
CEA	< 2.5 µg/L	> 2.5 µg/L	
Cholesterol	< 45 mg/dL	> 45 mg/dL	76
LDH	< 60 % of the serum LDH	> 60 % of the serum LDH	
Phospholipids	0.15 – 0.84 mmol/L	0.14 – 1.34 mmol/L	75
Protein	< 30 g/L	> 30 g/L	76
Triglycerides	14 – 164 mg/dL	17 – 849 mg/dL	75

Bile, clear colorless fluid		
Analyte	**Reference Ranges**	**Ref.**
Bilirubin	< 1.3 mg/dL	
Calcium	0.6 – 4.6 mmol/L	
Chloride	94 – 152 mmol/L	274
Cholesterol	6 – 20 mg/dL	
Glucose	< 5 mg/dL	
Lysozyme	< 0.8 mg/L	91
Magnesium	< 0.2 mmol/L	
Osmolality	1006 – 1019 mosmol/kg	
pH	6.64 – 8.46	
Phosphate, inorg.	< 1.0 mmol/L	274
Phospholipids	< 50 mg/dL	
Potassium	3.0 – 6.6 mmol/L	
Protein	< 9 g/L	
Sodium	138 – 162 mmol/L	

Bile, yellow bile		
Analyte	**Reference Ranges**	**Ref.**
Bicarbonate	7 – 42 mmol/L	
Bilirubin	9 – 77 mg/dL	
Calcium	2.3 – 4.9 mmol/L	274
Chloride	80 – 144 mmol/L	
Cholesterol	123 – 209 mg/dL	
Color	yellow	
Glucose	< 8 mg/dL	274
Iron excretion	0.14 – 0.50 µmol/h	204
Magnesium	0.7 – 1.3 mmol/L	
Osmolality	1016 – 1018 mosmol/kg	
pH	5.78 – 8.22	
Phosphate, inorg.	< 0.6 mmol/L	274
Phospholipids	113 – 381 mg/dL	
Protein	2 – 6 g/L	
Potassium	3.8 – 5.4 mmol/L	
Sodium	144 – 170 mmol/L	
Volume	0.5 – 1 L/24 h	

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Coelomic fluid		
Analyte	**Reference Ranges**	**Ref.**
Albumin	2.0 – 11 g/L	39
Bicarbonate	16 – 29 mmol/L	
Bilirubin	< 0.5 mg/dL	
Calcium	1.8 – 3.0 mmol/L	
Chloride	100 – 115 mmol/L	
Creatinine	0.4 – 3.0 mg/dL	
Glucose	50 – 88 mg/dL	
Osmolality	264 – 275 mosmol/kg	
Phosphate, inorg.	1.2 – 12 mmol/L	
Potassium	3.5 – 4.2 mmol/L	
Sodium	135 – 141 mmol/L	
Urea	16 – 41 mg/dL	

Duodenal fluid			
Analyte	**Reference Ranges**		**Ref.**
Calcium	0.7 – 4.2 mmol/L		77
Potassium	4.2 – 11.0 mmol/L		
Sodium	97 – 153 mmol/L		
Amylase	after secretin stimulation	130 – 3400 U/min	225
Bicarbonate		8 – 73 mmol/h	
Chymotrypsin		16 – 150 U/min	
Lipase		950 – 7200 U/min	
Trypsin		1 – 42 mg/min	
Volume		120 – 800 mL/h	

Gastric juice			
Analyte		**Reference Ranges**	**Ref.**
Ammonium		0.6 – 1.9 mmol/L	136
Ascorbic acid		17 – 31 mg/L	207
Calcium		0.6 – 7.0 mmol/L	178
CEA		< 0.5 mg/L	32
Chloride	6 – 48 mth	84 – 119 mmol/L	3
	Adults	57 – 137 mmol/L	178
Citrate		3.3 – 6.5 mg/dL	201
Free acid		< 78 mmol/L	178
β-Glucosidase		< 5.0 mg/L	221
Lactate		1.9 – 3.7 mg/dL	201
LDH		< 35 U/L	221
Lysozyme		43 – 106 mg/L	91
Magnesium		0.5 – 3.2 mmol/L	178
Mucin		< 0.4 g/L	17
pH	6 – 48 mth	2.0 – 4.0	3
	Adults	1.6 – 2.4	207
Potassium	6 – 48 mth	10.7 – 14.2 mmol/L	3
	Adults	5.0 – 11.8 mmol/L	178
Pyruvate		0.5 – 0.8 mg/dL	190
Sodium	6 – 48 mth	60 – 69 mmol/L	3
	Adults	32 – 84 mmol/L	178
Urea		0.7 – 1.6 mg/dL	201
Uric acid		0.7 – 1.4 mg/dL	201

Lymph		
Analyte	**Reference Ranges**	**Ref.**
Albumin	12 – 42 g/L	277
Amylase	50 – 83 U/L	
Calcium	1.7 – 3.0 mmol/L	
Chloride	85 – 130 mmol/L	
Cholesterol	65 – 220 mg/dL	
Erythrocytes	50 – 600/µL	
Glucose	48 – 200 mg/dL	
GOT	22 – 40 U/L	
GPT	5 – 21 U/L	
Leucocytes	400 – 6800/µL	
pH	7.4 – 7.8	
Potassium	3.8 – 5.0 mmol/L	
Protein	22 – 60 g/L	
Sodium	104 – 108 mmol/L	
Triglycerides	higher than in serum	
Urea	17 – 36 mg/dL	

Differentiation between chyle and pseudochyle is possible with the detection of chylomicrons (only in chyle) and triglycerides 2 to 8 times higher in chyle than in pseudochyle (45).

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Milk, human		
Analyte	**Reference Ranges**	**Ref.**
Calcium	7.2 – 8.4 mmol/L	70
Chloride	10.9 – 14.6 mmol/L	282
Cholesterol	7.0 – 9.5 mg/dL	29
Copper	197 – 751 µg/L	119
Folate	8 – 13 µg/dL	222
γ-GT	1300 – 8300 U/L	197
Iron	0.20 – 1.71 mg/L	119
Lactose	62 – 78 g/L	282
Lysozyme	55 – 75 mg/L	91
Magnesium	1.4 – 1.7 mmol/L	70
Phosphate, inorg.	4.0 – 4.9 mmol/L	70
Phospholipids	5.5 – 12.3 mg/dL	29
Potassium	10.6 – 13.0 mmol/L	70
Protein	19 – 20 g/L	135
Sodium	4.0– 6.0 mmol/L	29
Triglycerides	1.9 – 3.9 g/dL	19
Vitamin A	30 – 60 µg/dL	222
Vitamin B_1	17 – 24 µg/dL	
Vitamin B_2	40 – 60 µg/dL	
Vitamin B_6	9 – 31 µg/dL	
Vitamin B_{12}	16 – 97 µg/dL	
Vitamin C	3.8 – 17 mg/dL	
Vitamin E	0.2 – 0.3 mg/dL	
Vitamin K	0.12 – 0.92 µg/dL	
Zinc	0.75 – 4.0 mg/L	119

Nasal secretion		
Analyte	**Reference Ranges**	**Ref.**
Calcium	1.0 – 1.8 mmol/L	63
Glucose	< 10 mg/dL	142
β_2-Microglobulin	not detectable	63
Potassium	6 – 28 mmol/L	
Protein	1 – 35 g/L	
Sodium	90 – 148 mmol/L	

Pancreatic juice			
Analyte		**Reference Ranges**	**Ref.**
Amylase	after stimulation	400 – 1780 U/min	213
Bicarbonate		> 70 mmol/L	
Chymotrypsin		28 – 154 U/min	
Lipase		780 – 3500 U/min	
Potassium		3 – 10 mmol/L	167
Protein		0.2 – 1.0 g/L	296
Trypsin		56 – 335 U/min	213
Volume		> 1.6 mL/min	213

Peritoneal fluid		
Analyte	**Reference Ranges**	**Ref.**
Amylase	88 – 109 U/L	92
Creatinine	0.5 – 2.0 mg/dL	170
D-dimer	< 0.77 mg/L	287
Urea	3 – 27 mg/dL	170
Volume	1 – 9 mL	287

Pleural fluid			
Analyte	**Reference Ranges**		**Ref.**
	Transsudate	**Exsudate**	
LDH	< 200 U/L	> 200 U/L	169
LDH punctate/ serum ratio	< 0.6	> 0.6	
Protein	< 3 g/dL	> 3 g/dL	
Protein punctate/ serum ratio	< 0.5	> 0.5	
Cells	1000 – 5000/µL		30
Mesothelial cells	3 – 70 %		
Monocytes	30 – 75 %		
Lymphocytes	2 – 30 %		
Granulocytes	< 10 %		
Glucose	equal to plasma		
pCO_2	105 – 565 mmHg		279
pH	7.07 – 7.71		279
Protein	1.0 – 2.0 g/dL		30
Albumin	50 – 70 % of protein		
Volume	0.1 – 0.2 mL/kg body weight		

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Saliva			
Analyte	**Reference Ranges**		**Ref.**
	Parotid saliva	**Submandibular saliva**	
Calcium	1.5 – 2.5 mmol/L		177
Flowrate	0.8 – 17 mL/15 min	0.4 – 9.8 mL/15 min	14
IgA	0.2 – 8.8 IU/mL	< 4.5 IU/mL	14
pH	5.1 – 6.3	5.9 – 7.3	73
Potassium	14 – 26 mmol/L		177
Protein	0.7 – 21 g/L	0.3 – 5.5 g/L	14
Sodium	10 – 54 mmol/L		177
	Mixed saliva		
Albumin	246 – 344 mg/L		87
ALP	< 11 U/L		209
Ammonium	1.1 – 12.0 mmol/L		117
Amylase	11 900 – 304 700 U/L		209
Calcium	0.88 – 2.05 mmol/L		209
Cells	0.67 – 9.73 x 10^6/g		
Macrophages	33 – 86 %		
Neutrophiles	11 – 64 %		
Bronchial epithelial cells	< 4 %		26
Lymphocytes	< 3 %		
Eosinophiles	< 1 %		
Chloride	5 – 40 mmol/L		86
CO_2	< 11 mmol/L		209
Cortisol morning	3 – 43 nmol/L		218
evening	< 10 nmol/L		218
Creatinine	0.07 – 0.20 mg/dL		134
Glucose	< 2 mg/dL		
GOT	< 43 U/L		209
GPT	< 11 U/L		
IgA	42 – 174 mg/L		87
LDH	113 – 609 U/L		209
Lysozyme	6 – 12 mg/L		91
Magnesium	0.08 – 0.56 mmol/L		
Osmolality	52 – 111 mosmol/kg		
pH	6.42 – 7.41		209
Phospate, inorg.	1.4 – 13.2 mmol/L		
Potassium	6.4 – 37 mmol/L		
Protein	1.1 – 1.8 g/L		87
Sodium	2 – 21 mmol/L		86
Testosteron	0.18 – 0.26 µg/L		243
Urea	17 – 41 mg/dL		209
Uric acid	0.7 – 6.0 mg/dL		209

Sweat			
Analyte		**Reference Ranges**	**Ref.**
Ammonium		1.4 – 4.7 mmol/L	35
Chloride	6 – 15 yr f	41 – 102 mmol/L	
	m	41 – 100 mmol/L	
	16 – 25 yr f	71 – 96 mmol/L	
	m	60 – 101 mmol/L	
	26 – 35 yr f	75 – 100 mmol/L	
	m	71 – 102 mmol/L	6
	36 – 45 yr f	71 – 102 mmol/L	
	m	90 – 103 mmol/L	
	46 – 55 yr f	75 – 108 mmol/L	
	m	96 – 107 mmol/L	
Glucose		< 7 mg/dL	168
Lactate		21 – 57 mmol/L	241
Lysozyme		0.06 – 0.14 mg/L	
α_1-Microglobulin		6 – 34 µg/L	100
β_2-Microglobulin		3.6 – 6.4 µg/L	
pH		4.0 – 6.8	86
Potassium	6 – 15 yr f	10.7 – 13.6 mmol/L	
	m	11.4 – 23.2 mmol/L	
	16 – 25 yr f	18.8 – 28.2 mmol/L	
	m	13.5 – 40.0 mmol/L	
	26 – 35 yr f	20.0 – 28.8 mmol/L	
	m	22.0 – 43.6 mmol/L	
	36 – 45 yr f	16.3 – 33.0 mmol/L	
	m	28.2 – 44.8 mmol/L	
	46 – 55 yr f	23.0 – 25.2 mmol/L	
	m	32.8 – 40.0 mmol/L	
Sodium	6 – 15 yr f	39 – 102 mmol/L	6
	m	44 – 105 mmol/L	
	16 – 25 yr f	77 – 94 mmol/L	
	m	62 – 113 mmol/L	
	26 – 35 yr f	83 – 98 mmol/L	
	m	75 – 119 mmol/L	
	36 – 45 yr f	79 – 97 mmol/L	
	m	75 – 136 mmol/L	
	46 – 55 yr f	92 – 109 mmol/L	
	m	65 – 146 mmol/L	
Urea		56 – 234 mg/dL	257
Uric acid		0.2 – 0.7 mg/dL	257
Volume		500 mL/24 h	86

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Synovial fluid		
Analyte	**Reference Ranges**	**Ref.**
C_{3C}	0.23 – 0.77 mg/dL	27
Cell count	< 800/µL	229
Colour	light yellow and clear	
Glucose	equal to plasma	
Hyaluronic acid	1.5 – 2.5 g/L	41
IgA	0.6 – 8.2 mg/dL	27
IgG	1.1 – 19.2 mg/dL	
IgM	0.4 – 1.9 mg/dL	
Immunoglobulins	about 50 % serum conc.	232
Interleukin-1β	< 1.5 pg/mL	5
Lactate	equal to plasma	232
LDH	< 240 U/L	232
pH	7.3 – 7.6	51
Protein	< 25 g/L	232
Salts	no	
Segmented granulocytes	< 10 %	
Serotonin	< 0.5 nmol/L	5
Uric acid	equal to serum	232
Volume	nearly 3.5 mL	232

Tears		
Analyte	**Reference Ranges**	**Ref.**
Albumin	14 – 26 mg/L	175
Chloride	128 mmol/L	86
Cholesterol	10 – 25 mg/dL	111
Glucose	76 – 288 mg/dL	120
HbA_{1c}	6.4 – 11.1 %	120
IgA	206 – 450 mg/L	175
IgG	3 – 7 mg/L	
IgM	5 – 13 mg/L	
Lactoferrin	3 – 7 mg/L	
Lysozyme	2.1 – 3.7 g/L	
$β_2$-Microglobulin	1.3 – 2.1 g/L	
pH	7.1 – 8.7	86
Potassium	16 mmol/L	86
Protein	7.5 – 8.9 g/L	174
Sodium	146 mmol/L	86
Volume	1 – 2 mL/24 h	86

2.12 Function tests

1. Oral glucose tolerance test (96)

– The patient eats a mixed diet consisting of more than 150 g carbohydrates per day over a period of 3 days.

– Any drugs known to affect glucose metabolism should be discontinued 3 days before the test.

– The patient must fast for a period of 12 hours.

– A urine sample taken from the fasting patient should be tested for glucose and ketone bodies (a positive test-strip result is a contraindication for an OGTT).

– The patient drinks a solution of 75 g oligosaccharides; children: 1.75 g glucose per kg body weight up to a maximum of 75 g. Exception: Pregnant women receive 50 g glucose to screen for gestational diabetes.

– The patient should remain seated during the test.

– A blood sample is collected from the fasting patient, then after 120 minutes.

		Glucose concentration			
		Plasma		Capillary blood	
		fasting	120 min.	fasting	120 min.
Normal range	mg/dL	< 110	< 140	< 95	< 140
	mmol/L	< 6.1	< 7.8	< 5.3	< 7.8
Borderline range	mg/dL	110 – 126	140 – 199	95 – 110	140 – 199
	mmol/L	6.1 – 7.0	7.8 – 11.1	5.3 – 6.1	7.8 – 11.1
Pathological range (Diabetes mellitus)	mg/dL	> 126	> 200	> 110	> 200
	mmol/L	> 7.0	> 11.1	> 6.1	> 11.1

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2. Hydrogen (H_2) breath test (157)

– The patient must fast for a period of 12 hours and not eat any heavy foods 24 hours prior to the test.

– The patient should not smoke or drink any mineral water 12 hours prior to the test.

– The patient drinks a solution of 50 g lactose and 300 mL water in 5 minutes.

– Children are administered 2 g lactose per kg body weight up to a maximum of 50 g lactose.

– The H_2 concentration is measured in the breath expired prior to the start of the test, then at 30, 60 and 90 minute intervals following administration of the lactose.

– Reference range: A rise of < 20 ppm in the H_2 concentration of the alveolar air between the lowest and the highest value finally expired (refer also to curve constructed).

3. Creatinine clearance (126)

– Void the bladder of prior to the test and discard the urine.

– Collect urine over a period exactly 24 hours. Do not add stabilizing agents; store urine in the refrigerator or at room temperature.

– A blood sample should be collected at the beginning and end of the collection period.

– The volume of the urine collected should be measured exactly, mixed thoroughly and approximately 10 mL sent to the laboratory.

I. Calculation formula for a body surface area of 1.73 m^2

$$C_{cr} = \frac{U \times V}{S} \text{ (mL/min)}$$

II. Calculation formula for other body surface areas

$$C_{cr} = \frac{U \times V \times 1.73}{S \times BSA} \text{ (mL/min/1.73 } m^2\text{)}$$

Note: For accurate evaluation of the endogenous creatinine clearance rate, it is necessary to perform two serum creatinine determinations at 24-hour intervals. The values obtained should not differ from each other by more than 10 %.

Since the determination of the C_{Cr} based on a timed urine collection is inconvenient and often unreliable, various mathematical approaches for the estimation of C_{Cr} from the serum creatinine concentration were suggested. Two of these approaches have found wide recognition:

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I. Calculation according to Cockroft-Gault

Males:

$$C_{cr} = \frac{140 - age \times weight}{75 \times S} \text{ (mL/min)}$$

Females:

$$C_{cr} = \frac{140 - age \times weight \times 0.85}{75 \times S} \text{ (mL/min)}$$

II. Calculation according to the modified MDRD (Modification of Diet in Renal Disease) study formula

Males:

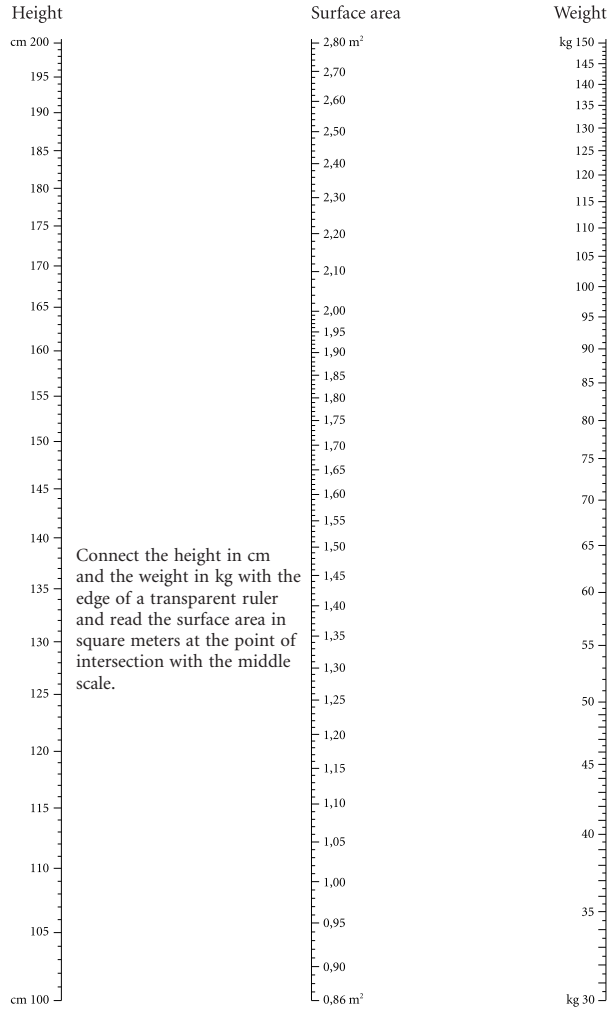
$$C_{cr} = 175 \times S^{-1.154} \times age^{-0.203} \text{ (mL/min)}$$

Females:

$$C_{cr} = 175 \times S^{-1.154} \times age^{-0.203}\ 0.742 \text{ (mL/min)}$$

C_{cr} = Clearance in mL/min
U = Urine creatinine concentration in mg/dL
V = Volume of collected urine in mL, related to 1 min
S = Serum creatinine concentration in mg/dL
BSA = Body surface area in m^2

Nomogram for the determination of body surface area (BSA) in square meters (63)



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4. Lactose tolerance test (189)

– The patient must fast for a period of 12 hours.

– The patient drinks a solution of 50 g lactose in 400 mL water.

– Infants are given 4 g lactose per kg body weight.

– Children older than 2 years are given 2 g lactose per kg body weight up to a maximum of 50 g lactose.

– Capillary blood is collected for glucose determination prior to the start of the test, then at 30, 60, 90 and 120 minute intervals following administration of the lactose.

Reference range: A rise in the blood glucose concentration of > 20 mg/dL (> 1.1 mmol/L) indicates the absence of gastrointestinal disorders.

Notes on test for exclusion of glucose-galactose malabsorption:

Infants:	2 g glucose + 2 g galactose/kg body weight
Children older than 2 years:	1 g glucose + 1 g galactose/kg body weight
Adults:	25 g glucose + 25 g galactose

5. D-xylose absorption test

– The patient must fast for a period of 12 hours.

– The bladder should be voided immediately prior to the test.

– The patient drinks a solution of 25 g D-xylose in 500 mL tea.

– The patient drinks a further 250 mL tea after a period of one to two hours.

– The patient must remain seated during the test.

– Urine is collected over a period of 5 hours.

– Children are administered 5 g D-xylose in 100 mL water or tea.

Reference ranges: Urine (199):
A D-xylose excretion in 5-hour urine of > 4.5 g (30 mmol), i. e. of > 18 % (0.18) of the amount of D-xylose administered.

For children with 4 – 30 kg body weight (225):
A serum D-xylose concentration of > 20 mg/dL (> 1.33 mmol/L) after a period of 1 hour.

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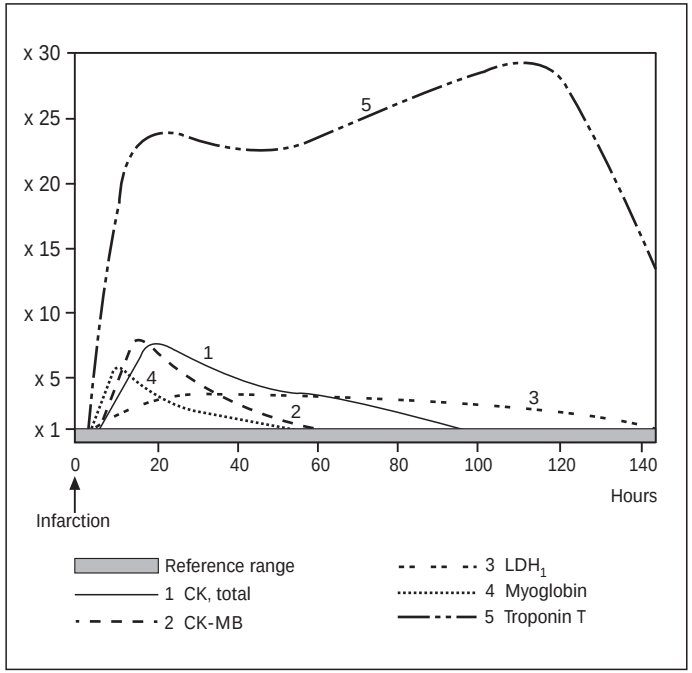
2.13 Characteristic analytes for identification of body fluids

Amniotic fluid	α_1-fetoprotein (AFP) > 10 µg/L
Ascites	No characteristic analytes
Bile	Bile acids (chenodesoxycholic acid)
Cerebrospinal fluid	β_2-Transferrin (not absolutely specific), chloride 113–131 mmol/L, calcium 1.05–1.35 mmol/L, glucose approx. 60–70 % of the plasma concentration, protein < 50 mg/dL (serum 140–160 times higher)
Cyst fluid	Breast cysts: FSH and LH lower than in serum Renal cysts: same composition as urine Ovarian cysts (follicular cysts): estradiol elevated Pancreatic cysts: amylase, lipase
Duodenal contents	High activities of amylase, lipase, trypsin, chymotrypsin
Gastric secretion	pH 1.6–2.4, ammonia > 0.6 mmol/L
Nasal secretion	Glucose < 10 mg/dL, protein 1–35 g/L, potassium 6–28 mmol/L, no β_2-transferrin
Pancreatic secretion	High activities of amylase, lipase, trypsin, chymotrypsin
Pericardial fluid	No characteristic analytes
Peritoneal fluid	Ammonia > 300 µg/dL
Pleural fluid	No characteristic analytes
Saliva	Sodium 2–21 mmol/L, potassium 6–37 mmol/L, chloride 5–40 mmol/L, albumin 246–344 mg/L, salivary amylase
Semen	Sperm
Sweat	Glucose < 7 mg/dL, potassium > 11 mmol/L
Tear fluid	Total protein 7.5–8.9 g/L (10 % of the serum concentration) with large prealbumin fraction
Urine	Creatinine 90–300 mg/dL, urea 0.9–3.0 g/dL, inorganic phosphate 40–140 mg/dL

3 Decision supports

3.1 Enzyme patterns



Typical enhancement of enzyme activities and protein concentrations after acute myocardial infarction (188). The y-axis represents multiples of the upper reference ranges' limits.

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3.2 Lipids

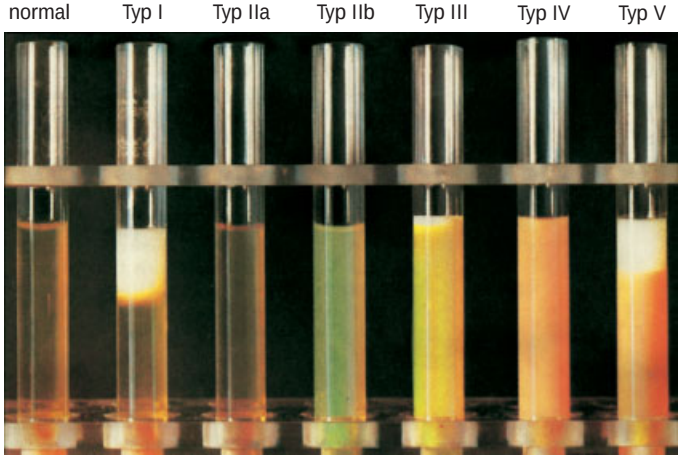
1. The composition of lipoproteins

	Chylo-microns	VLDL	LDL	HDL
Total cholesterol	6 %	8–13 %	45 %	20 %
Phospholipids	4 %	6–15 %	25 %	30 %
Triglycerides	87 %	64–80 %	10 %	2–5 %
Carbohydrates	< 1 %	1–2 %	> 2 %	< 1 %
Proteins	1 %	8–10 %	20 %	48 %
Apoproteins	A, B_{48}, C, E	A, B_{100}, C, D, E	B_{100}	A, C, E
Protein-lipid-ratio	1:100	1:9	1:4	1:1

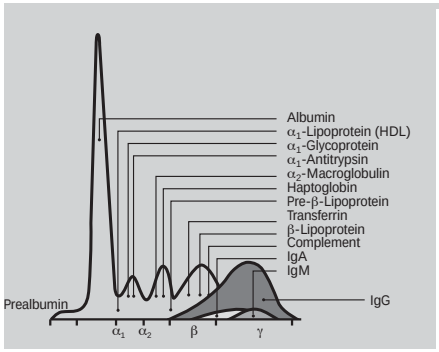
2. Classification of hyperlipoproteinemias according to FREDRICKSON

Classes	Cholesterol	Triglycerides	Appearance of fasting serum
Typ I	< 260 mg/dL	> 1000 mg/dL	forms an upper creamy layer, clear lower phase
Typ IIa	> 300 mg/dL	< 150 mg/dL	clear
Typ IIb	> 300 mg/dL	150–300 mg/dL	clear or turbid
Typ III	350 – 500 mg/dL	350–500 mg/dL	turbid
Typ IV	< 260 mg/dL	200–1000 mg/dL	turbid to milky
Typ V	> 300 mg/dL	> 1000 mg/dL	turbid lower phase

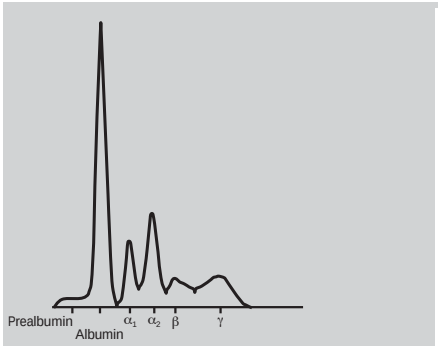
3. Appearance of fasting sera at different classes of hyperlipoproteinemia according to FREDRICKSON



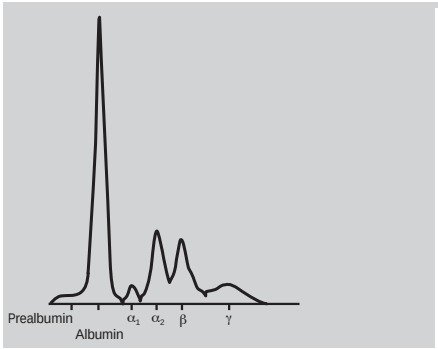
3.3 Electrophoretic patterns of plasma proteins



Protein electrophoresis of healthy persons



Acute inflammation



Nephrotic syndrome

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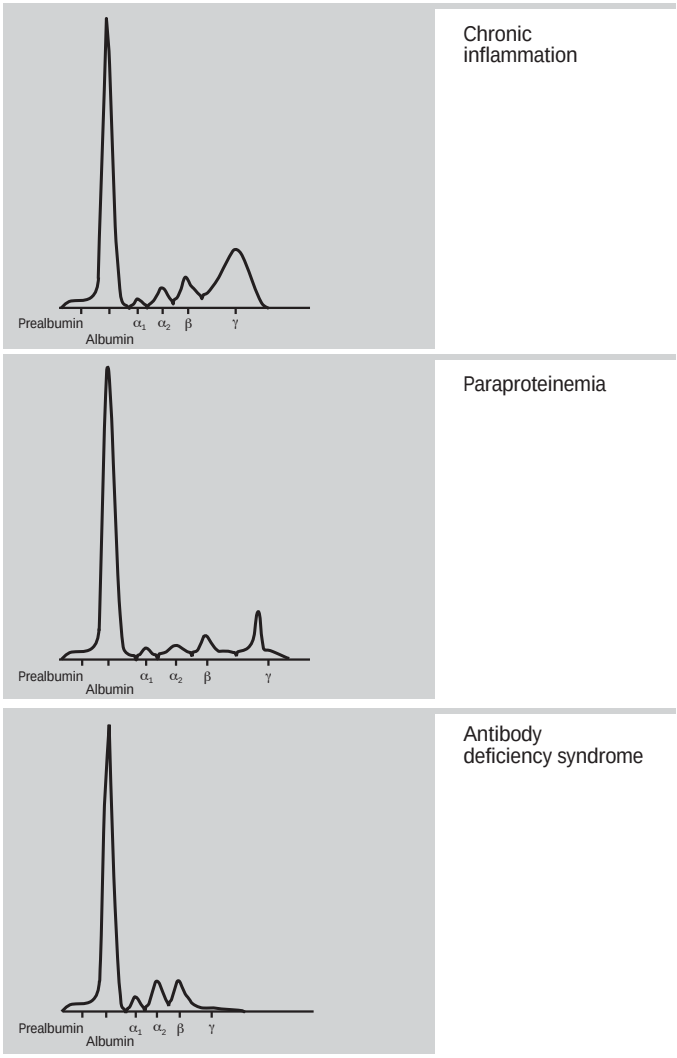
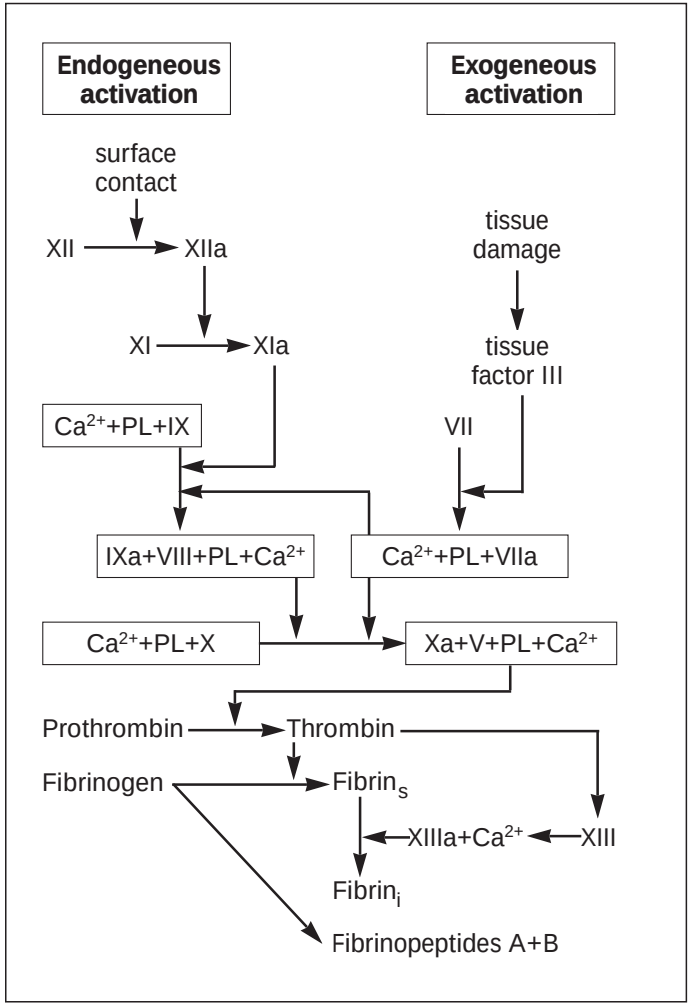


3.4 Schematic representation of blood coagulation



Schematic representation of plasmatic blood coagulation.
PL = phospholipids, s = soluble, i = insoluble

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3.5 Thrombophilia, risk factors

- Elevated triglyceride concentrations
- Elevated LDL concentrations
- Advanced age
- Sex
- Pregnancy or puerperium
- Immobilization
- Heavy cigarette smoking
- Medicines
  - oral contraceptives
  - antifibrinolytica
  - steroids (estrogenes)
- Illnesses with elevated thrombosis risk
  - arteriosclerosis
  - diabetes mellitus
  - malignant disease
- Family medical history
- Relapse thrombosis (recurring thrombosis)
- Unexplained prolongation of aPTT
- Women who have had repeated miscarriages
- Patients suffering from autoimmune diseases
- Operations
- Traumas
- Hyperviscosity syndrome
  - Polycythemia vera
  - Macroglobulinemia
- Infections and sepsis
- Nephrotic syndrome

Sample collection

Prior to all therapy regimes involving heparine or cumarine, withdraw a sample of blood for thrombophilia diagnostic analyses approximately 3 months after the thromboembolitic event and not during an acute phase reaction.

Diagnostics

Coagulation inhibitor deficiency or dysfunction:

- Antithrombin III (AT III)
- Protein C
- Protein S
- APC resistance
- Heparin cofactor II (rare)

Factor XII deficiency (primary finding: prolonged aPTT)

Lupus anticoagulants (primary finding: prolonged aPTT)

Reduced fibrinolytic potential (rare):

- Plasminogen deficiency
- Decreased plasminogen activator (t-PA) concentrations
- Elevated plasminogen activator Inhibitor I (PAI-I) concentrations

Congenital dysfibrinogenemia (rare)

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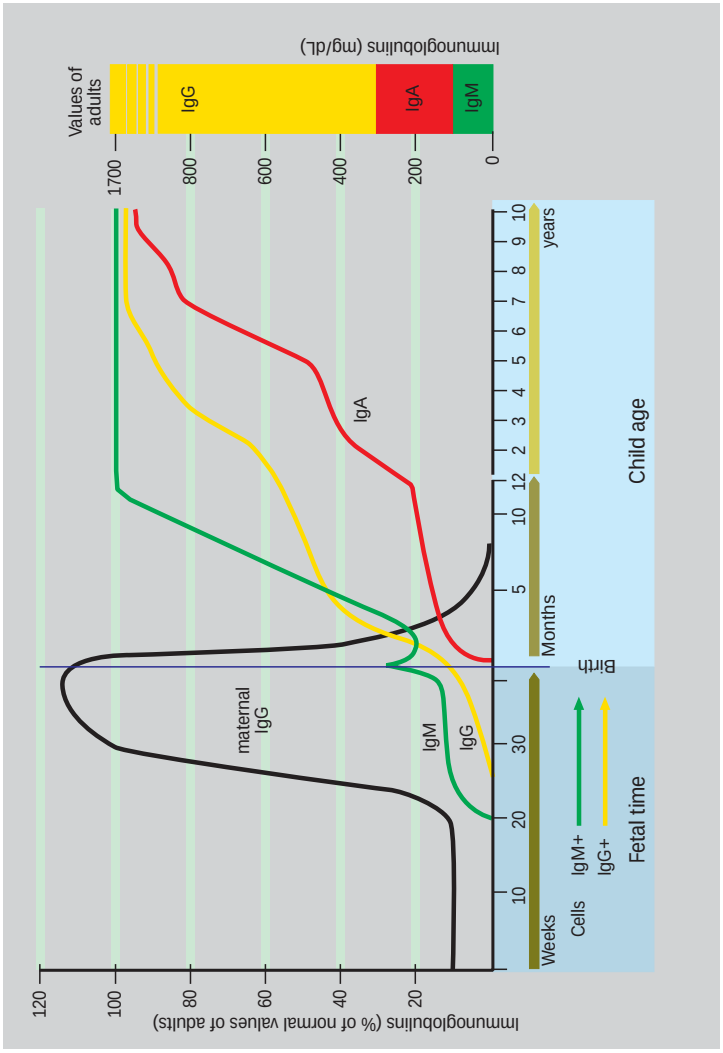
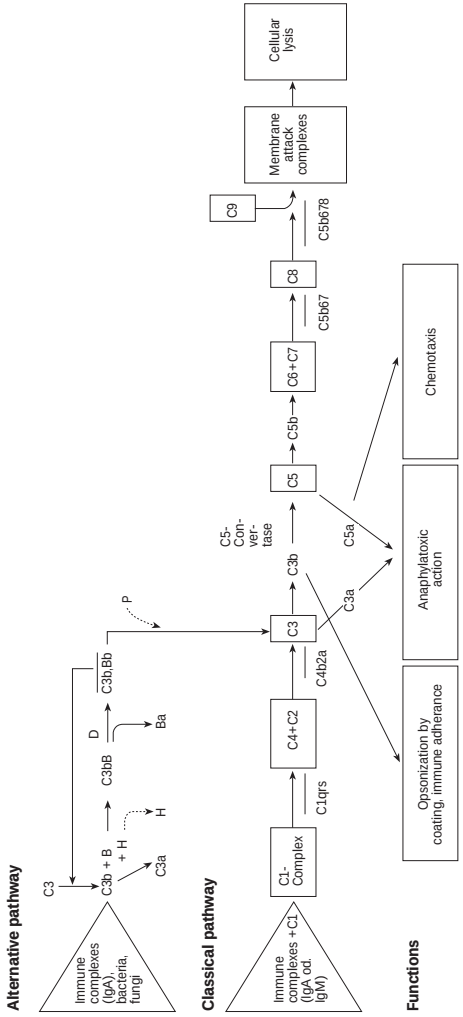
3.6 Age dependence of immunoglobulin synthesis



3.7 Complement system, classical and alternative mechanism



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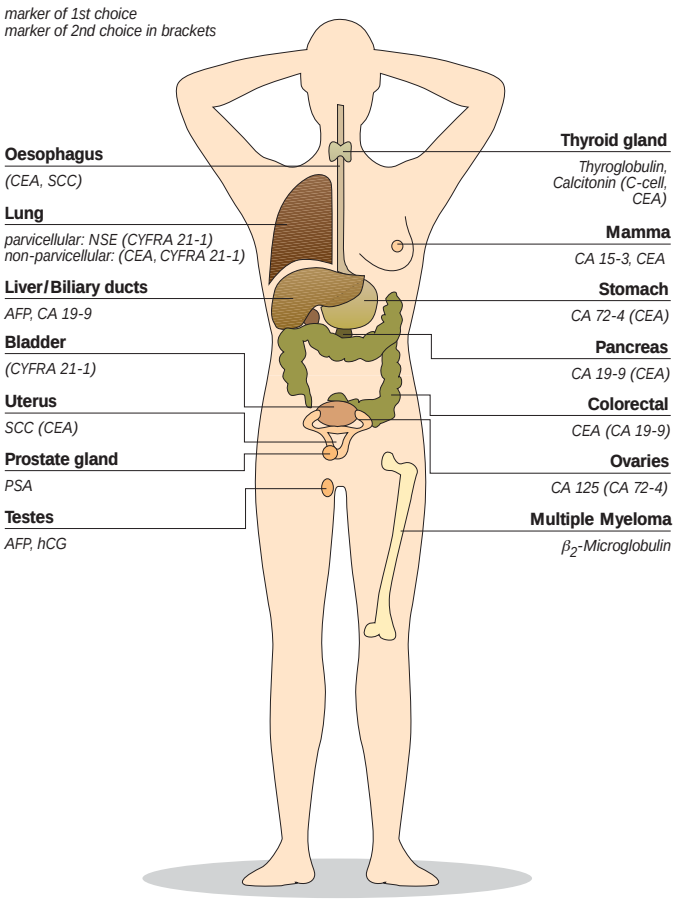
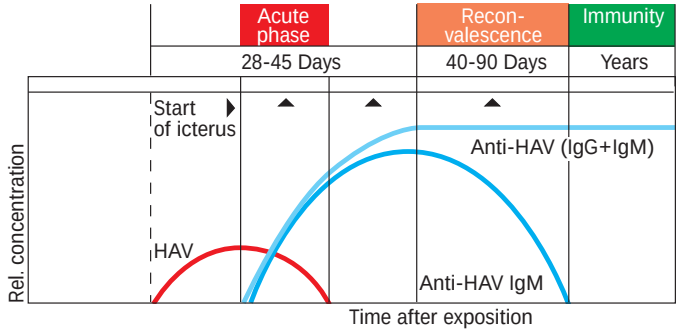
3.8 Tumor markers

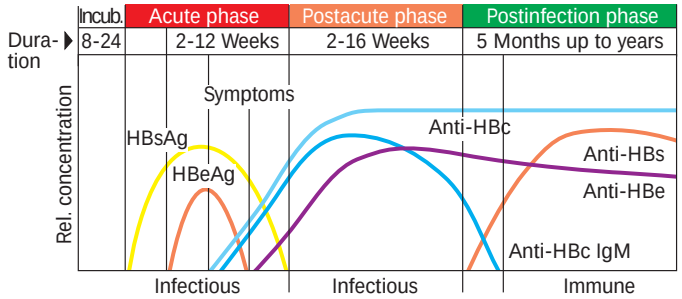
Tumormarkers



3.9 Serological diagnosis of hepatitis A and B



Progress of a hepatitis A infection



Progress of a hepatitis B infection

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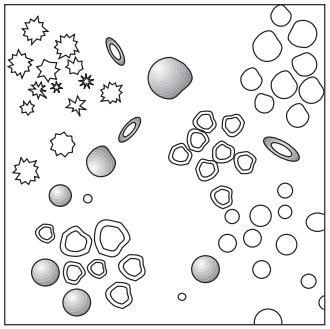
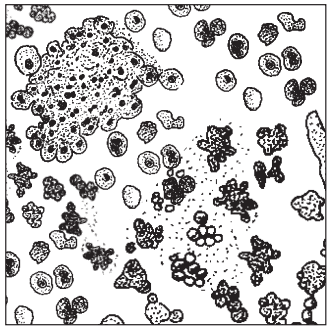
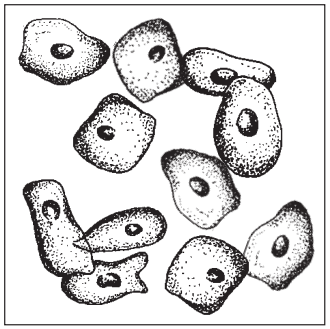
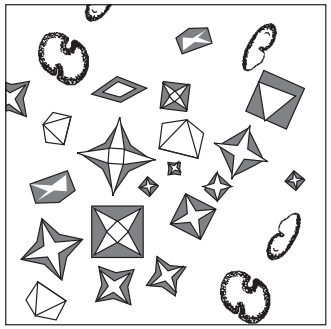
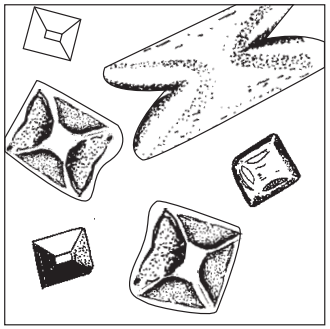
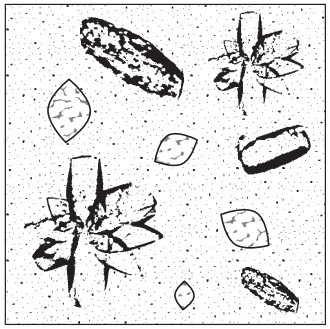
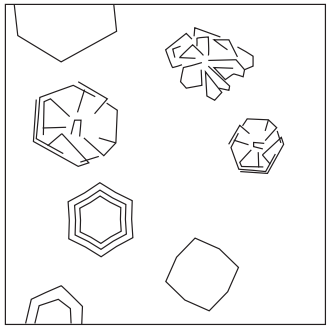
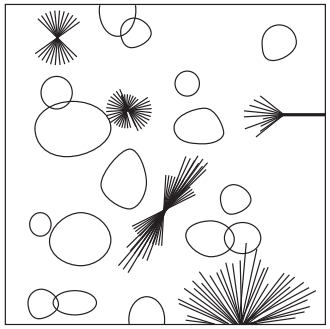
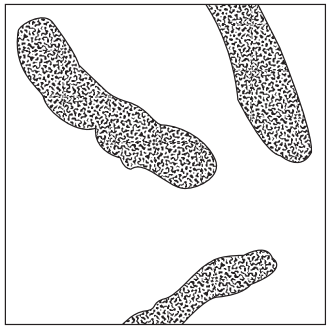
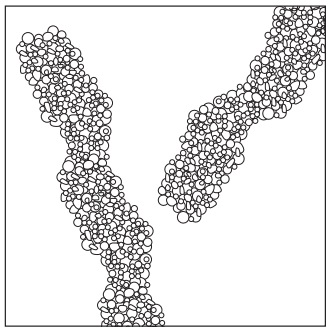
3.10 Urinary sediment

Diagnostically relevant findings in urinary sediment:

upper left:	erythrocytes
upper right:	leucocytes
middle left:	epithelial cells
middle right:	calcium oxalate
lower left:	ammonium-magnesium phosphate (tripelphosphate)

Diagnostically relevant findings in urine sediment:

upper left:	uric acid
upper right:	cystine
middle left:	tyrosine
middle right:	granulated casts
lower left:	erythrocyte casts

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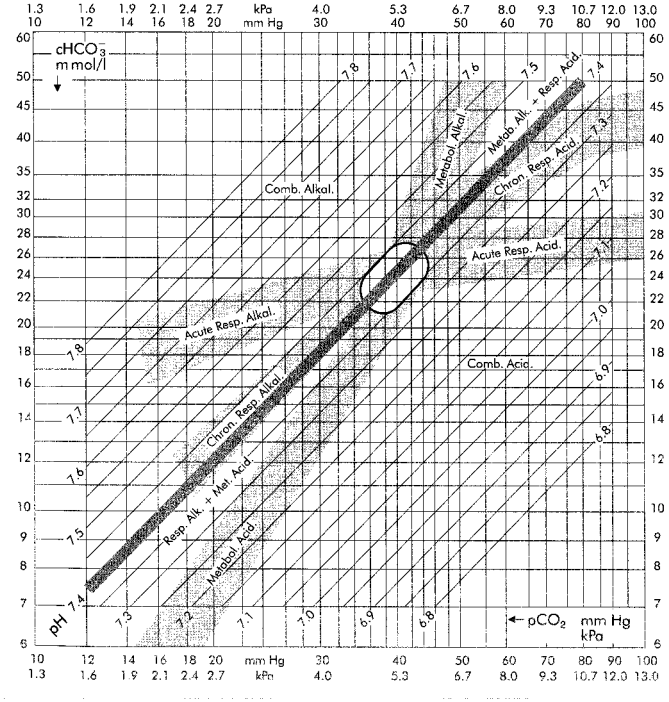
3.11 Nomogram for diagnosing acid-base disorders (185)



Nomogram for diagnosing acid-base disorders considering the degree of compensation. pCO_2 is represented logarithmically on the abscissa. Bicarbonate concentration is reported on the ordinate. The patient's values result in an ordered pair, the status point, which allows the classification of a singular acid-base disorder as acute or chronic or which suggests a combined disorder. If the disorder appears with a normal degree of compensation, the status point is found within one of the corresponding, shaded fields. If the status point doesn't fall within one of these fields, it must be decided which of the following situations is present:

– the disorder just appeared, compensation has not yet taken place.
– the organ which is responsible for compensation, such as the lung for respiratory and the kidney for metabolic disorders, is not functioning properly.
– a second acid-base disorder is present, e.g. respiratory acidosis in ventilatory failure and lactic acidosis might be present simultaneously.

4 Conversion tables

4.1 Conversion table from conventional units to SI units and vice versa (/U refers to urinalysis)

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Acetaminophen	µg/mL	6.62 / 0.151	µmol/L
N-Acetylprocainamide (NAPA)	µg/mL	3.61 / 0.277	µmol/L
α_1-Acid glycoprotein	mg/dL	0.25 / 4.0	µmol/L
ACTH	ng/L	0.2202 / 4.541	pmol/L
Albumin	g/dL	10 / 0.1	g/L
Albumin/U	mg/g crea	0.113 / 8.85	g/mol crea
Aldosterone	ng/dL	27.74 / 0.036	pmol/L
Amikacin	µg/mL	1.71 / 0.585	µmol/L
δ-Aminolevulic acid/U	mg/24 h	7.626 / 0.131	µmol/d
Ammonium (NH_3)	µg/dL	0.587 / 1.703	µmol/L
AMP, 3′-5′-cyclic	ng/mL	3.04 / 0.329	nmol/L
α_1-Antitrypsin	ng/mL	0.184 / 5.435	µmol/L

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Apolipoprotein A-1	mg/dL	0.357 / 2.80	µmol/L
Apolipoprotein B	g/L	1.95 / 0.5128	µmol/L
Ascorbic acid	mg/dL	56.78 / 0.0176	µmol/L
Bilirubin	mg/dL	17.1 / 0.0585	µmol/L
Caffeine	µg/mL	5.15 / 0.194	µmol/L
Calcitonin	ng/L	0.28 / 3.57	pmol/L
Calcium	mg/dL	0.250 / 4.01	mmol/L
Calcium/U	mg/24 h	0.025 / 40.1	mmol/d
Calcium/U	mg/g crea	0.00282 / 355	mol/mol crea
Carbamazepine	mg/L	4.23 / 0.236	µmol/L
Carcinoembryonic antigen (CEA)	ng/mL	16.9 / 0.0592	mIU/mL
Carnitin	mg/dL	21.28 / 0.047	µmol/L
Carotene	µg/dL	0.0186 / 53.69	µmol/L

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Ceruloplasmin	mg/dL	0.0746 / 13.40	µmol/L
Chloramphenicol	µg/mL	3.09 / 0.323	µmol/L
Chloride/U	g/g crea	3.18 / 0.314	mol/mol crea
Cholesterol	mg/dL	0.0259 / 38.61	mmol/L
Citrate	mg/dL	52.1 / 0.019	µmol/L
Citrate/U	mg/24 h	0.0052 / 192	mmol/d
Copper	µg/dL	0.157 / 6.354	µmol/L
Copper/U	µg/24 h	0.0157 / 63.54	µmol/d
Coproporphyrins	µg/L	1.527 / 0.655	nmol/L
Cortisol	µg/dL	27.586 / 0.03625	nmol/L
Cortisol/U	µg/24 h	2.7586 / 0.3625	nmol/d
C-Peptid	ng/mL	0.333 / 3.0	nmol/L
Creatinine	mg/dL	88.4 / 0.0113	µmol/L

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Creatinine/U	g/24 h	8.84 / 0.113	mmol/d
C-reactive protein (CRP)	mg/dL	95.2 / 0.0105	nmol/L
Cystine/U	mg/24 h	8.34 / 0.12	µmol/d
Dehydroepiandrosterone sulfate (DHEA-S)	µg/dL	0.02714 / 36.846	µmol/L
Digitoxin	ng/mL	1.31 / 0.76	nmol/L
Digoxin	ng/mL	1.28 / 0.781	nmol/L
Disopyramide	mg/L	2.95 / 0.339	µmol/L
Dopamine Dopamine/U	ng/L	6.54 / 0.153	pmol/L
Epinephrine	ng/L	5.46 / 0.183	pmol/L
Epinephrine/U	µg/24 h	5.46 / 0.183	nmol/d
Estradiol (E2)	pg/mL	3.67 / 0.273	pmol/L
Estriol (E3)	ng/mL	3.47 / 0.288	nmol/L
Ethanol	mg/dL	0.217 / 4.608	mmol/L

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Ethosuximide	mg/L	7.08 / 0.141	µmol/L
α_1-Fetoprotein (AFP)	ng/mL	0.83 / 1.21	IU/mL
Fluoride	µg/L	0.053 / 19.0	µmol/L
Folic acid	ng/mL	2.266 / 0.441	nmol/L
Fructose	mg/dL	0.0555 / 18.02	mmol/L
Fructose/U	mg/24 h	0.0055 / 180.2	mmol/d
FT_3	pg/mL	1.536 / 0.651	pmol/L
FT_4	ng/dL	12.87 / 0.0777	pmol/L
Galactose	mg/dL	0.0555 / 18.02	mmol/L
Galactose/U	mg/24 h	0.0055 / 180.2	mmol/d
Gentamicin	µg/mL	2.09 / 0.478	µmol/L
Glucose	mg/dL	0.0555 / 18.02	mmol/L
Glycerol	mg/dL	0.109 / 9.209	mmol/L

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Haptoglobin	mg/dL	0.1 / 100	µmol/L
Hemoglobin	g/dL	0.621 / 1.61	mmol/L
Homocysteic acid	mg/L	7.41 / 0.135	µmol/L
β-Hydroxybutyrate	mg/dL	96.2 / 0.0103	µmol/L
17-Hydroxy-corticosteroids	mg/dL	27.59 / 0.036	µmol/d
5-Hydroxyindole acetic acid/U	mg/24 h	5.23 / 0.191	µmol/d
17-Hydroxy-progesterone	ng/mL	3.03 / 0.330	nmol/L
25-Hydroxy-vitamin D_3	ng/mL	2.50 / 0.40	mmol/L
Hydroxyproline	mg/L	7.626 / 0.131	µmol/L
IBC	µg/dL	0.179 / 5.59	µmol/L
IgA	g/L	6.25 / 0.16	µmol/L
IgE	mg/mL	0.42 / 2.4	IU/mL
IgG	g/L	6.67 / 0.150	µmol/L

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
IgM	g/L	1.03 / 0.971	µmol/L
Insulin	µU/mL	6.945 / 0.144	pmol/L
Iron	µg/dL	0.179 / 5.59	µmol/L
Iron/U	µg/24 h	0.0179 / 55.9	µmol/d
Lactate	mg/dL	0.111 / 9.008	mmol/L
Lead	µg/L	0.00483 / 207.2	µmol/L
Lecithin	mg/dL	12.5 / 0.080	µmol/L
Leucine	mg/dL	76.3 / 0.0131	µmol/L
Lidocaine	mg/L	4.27 / 0.234	µmol/L
Lithium	mg/dL	1.441 / 0.6941	mmol/L
Magnesium	mg/dL	0.411 / 2.431	mmol/L
Magnesium/U	mg/24 h	0.0411 / 24.31	mmol/d
Magnesium/U	mg/g crea	0.00465 / 215	mol/mol crea

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Mercury	µg/L	0.0050 / 200.60	µmol/L
Methemoglobin (Hb/4; Mr = 161145.5)	g/dL	621.1 / 0.0016	µmol/L
α_1-Mikroglobulin (Orosomucoid)	mg/L	33.3 / 0.03	nmol/L
α_1-Microglobulin/U	mg/g crea	0.1129 / 8.861	g/mol crea
β_2-Microglobulin	mg/L	84.7 / 0.1181	nmol/L
Myoglobin	ng/mL	0.0571 / 17.513	nmol/L
Norepinephrine	ng/L	5.91 / 0.169	pmol/L
Norepinephrine/U	µg/24 h	5.91 / 0.169	nmol/d
N-terminal-pro brain natriuretic peptide (NT-proBNP)	pg/mL	0.118 / 8.457	pmol/L
Oxalate/U	mg/24 h	11.4 / 0.088	µmol/d
Oxyhemoglobin	%	0.01 / 100	l
Parathyrin (parathyroid hormone, PTH)	ng/L	0.106 / 9.43	pmol/L
pCO_2	mm Hg	0.133 / 7.502	kPa

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Phenobarbital	mg/L	4.31 / 0.232	µmol/L
Phenylalanine	mg/dL	0.061 / 16.5	mmol/L
Phenytoin	mg/L	3.96 / 0.252	µmol/L
Phosphate, inorganic	mg/dL	0.323 / 3.097	mmol/L
Phosphate/U	g/24 h	32.3 / 0.031	mmol/d
Phosphate/U	mg/g crea	0.00361 / 277	mol/mol crea
Phospholipids	mg/dL	0.0129 / 77.52	mmol/L
pO_2	mm Hg	0.133 / 7.502	kPa
Porphobilinogen	mg/L	4.42 / 0.226	µmol/L
Porphyrine/U	µg/24 h	1.2 / 0.833	nmol/d
Potassium	mg/dL	0.256 / 3.91	mmol/L
Prealbumin	mg/dL	0.182 / 5.495	µmol/L
Primidone	mg/L	4.58 / 0.218	µmol/L

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Procainamide	mg/L	4.23 / 0.236	µmol/L
Progesterone	ng/mL	3.18 / 0.314	nmol/L
Prolactin	ng/mL	21.2 / 0.0472	mU/L
Protein	g/dL	10.0 / 0.1	g/L
Protein/U	mg/g crea	0.113 / 8.85	g/mol crea
Pyruvate	mg/dL	113.6 / 0.0088	µmol/L
Quinidine	mg/L	3.08 / 0.325	µmol/L
Salicylate	mg/L	0.00724 / 138	mmol/L
Selenium	µg/L	0.0127 / 78.96	µmol/L
Sexual hormone binding globulin (SHBG)	µg/mL	10.53 / 0.095	nmol/L
Sodium	mg/dL	0.435 / 2.30	mmol/L
Sodium/U	g/g crea	4.90 / 0.204	mol/mol crea
Soluble transferrin receptor (sTfR)	mg/L	11.8 / 0.085	nmol/L

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Sorbitol	mg/dL	54.9 / 0.018	µmol/L
T_3	ng/mL	1.536 / 0.651	nmol/L
T_4	µg/dL	12.87 / 0.078	nmol/L
Testosterone	ng/mL	3.47 / 0.288	nmol/L
Thallium	µg/L	5.92 / 0.169	nmol/L
Theophylline	mg/L	5.55 / 0.180	µmol/L
Tobramycin	mg/L	2.14 / 0.467	µmol/L
Transferrin	mg/dL	0.126 / 7.957	µmol/L
Triglycerides	mg/dL	0.0114 / 87.5	mmol/L
Urea	mg/dL	0.167 / 6.006	mmol/L
Urea/U	g/24 h	16.7 / 0.06	mmol/d
Urea/U	g/g crea	1.883 / 0.531	mol/mol crea
Uric acid	mg/dL	59.5 / 0.0168	µmol/L

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Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Uric acid/U	g/24 h	5.95 / 0.168	mmol/d
Uric acid/U	mg/g crea	0.00067 / 1487	mol/mol crea
Urobilinogen	mg/dL	16.9 / 0.059	µmol/L
Valproic acid	mg/L	6.93 / 0.144	µmol/L
Vancomycin	µg/mL	0.690 / 1.449	µmol/L
Vanillylmandelic acid/U	mg/24 h	5.03 / 0.199	µmol/d
Vitamin A (retinol)	µg/dL	0.0349 / 28.65	µmol/L
Vitamin B_1 (thiamin)	µg/dL	37.7 / 0.0265	nmol/L
Vitamin B_6 (pyridoxal phosphate)	ng/mL	4.05 / 0.247	nmol/L
Vitamin B_{12}	pg/mL	0.738 / 1.355	pmol/L
Vitamin C	mg/dL	56.78 / 0.0176	µmol/L
Vitamin E (α-tocopherol)	mg/dL	23.2 / 0.043	µmol/L
Zinc	µg/dL	0.153 / 6.537	µmol/L

4.2 Conversion factors for enzyme activities: U/L ↔ µkat/L and nkat/L

Unit	Factor	Unit
µkat/L	60	U/L
nkat/L	0.06	U/L
U/L	0.0167	µkat/L
U/L	16.67	nkat/L

1 µkat/L ≙ µmol/s · L
1 nkat/L ≙ 1 nmol/s · L
1 µmol/min ≙ 16.67 nkat
1 µmol/min ≙ 1 U

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5 Sample Stability (84)

Maximum storage time of samples before clinical chemical analyses and possible additives for sample-stabilization						
Analyte	**Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter**	**Stability in serum/plasma/blood/CSF/urine**			**Stabilizer**	**Comments**
		– 20 °C	**4–8 °C**	**20–25 °C**		
Clinical chemistry, serum/plasma, immunological tests						
Acid phosphatase (ACP)	1 h ↘ unstabilized	1 d 4 mth	8 h 8 d	2 h 8 d	5 mg $NaHSO_4$/mL serum (pH 4–5)	Unstabilized Serum > Plasma Stabilize after separation of serum
Albumin	6 d	5 mth	5 mth	2.5 mth		
Alkaline phosphatase	4 d ↘	2 mth	7 d	7 d		
Ammonium	15 min in EDTA heparinate ↗	3 w	2 h	15 min	5 mmol/L serine and 2 mmol/L borate	Avoid contamination by sweat-ammonia
Amylase	4 d ↘	1 yr	7 d	7 d		Avoid contamination by saliva
Antistreptolysin O		6 mth	2 d	2 d		
α_1-Antitrypsin		3 mth	5 mth	3 mth		
Anti-TSHR		1 mth	3 d			Ref. 220
Apolipoprotein A-I		2 mth	3 d	1 d		Only freeze once
Apolipoprotein B		2 mth	3 d	1 d		Only freeze once
Bilirubin	unstable ↘	6 mth	7 d	1 d		Keep in the dark
C_{3C}-Complement	1 h	8 d	8 d	4 d		Recommend plasma, pretreat serum
C_4-Complement	1 d		2 d	2 d		
CA 15–3		3 mth	5 d			
CA 19–9	7 d ↘	3 mth	1 mth	7 d		
CA 72–4	7 d	3 mth	1 mth	7 d		
CA 125	3 d ↘	3 mth	5 d	3 d		
Calcium total- ionized	2 d ↘ 15 min ↗ 1 d*	8 mth	3 w 2 h	7 d 3 d*	Ca-titrated heparin	*24 h stable in gel tubes as primary tubes; 72 h stable after centrifugation in closed tubes
Carcinoembryonic Antigen (CEA)	3 d	6 mth	7 d	7 d		
Catecholamines Norepinephrine Epinephrine Dopamine	1 h (unstabilized)	1 mth 6 mth stabilized	2 d	1 d	Glutathione 1.2 mg/mL + EGTA	
Ceruloplasmin		3 mth	2 w	8 d		

Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Chloride	1 d ↘	> 1 yr	7 d	7 d		
Cholesterol total- HDL- LDL-	 7 d ↗ 2 d ↗ 1 d ↘	 3 mth 3 mth 3 mth	 7 d 7 d 7 d	 7 d 2 d 1 d		
Cholinesterase	7 d ↘	1 yr	1 yr	1 yr		
Copper	7 d	> 1 yr	2 w	2 w		
Cortisol	7 d	3 mth	7 d	7 d		
C-reactive protein (CRP)	7 d after centrif.	3 yr	2 mth	15 d		
Creatinine	2–3 d ↗	3 mth	7 d	7 d		
Creatine kinase (CK)	7 d ↘	4 w	7 d	2 d	SH-donators	Store in the dark CK-BB unstable
β-CrossLaps Serum Heparin plasma EDTA plasma	 3 mth 3 mth 3 mth	 8 h 1 d 8 d	 8 h 1 d 1 d			Ref. 220
CYFRA 21–1		6 mth	1 mth			Ref. 220

Cystatin C		1 mth	1 w	2 d		
Erythropoietin	6–24 h	5 mth		2 w		
Estradiol (E2)	1 d	1 yr	3 d	1 d		
Estriol (E3)		1 yr	2 d	1 d		
Ferritin		1 yr	7 d	7 d		
α_1-Fetoprotein (AFP)	7 d	3 mth	7 d	3 d		
Folic acid	30 min ↘	8 w	6 h	30 min	Ascorbic acid 2 mg/mL	
Follicle stimulating hormone (FSH)	7 d ↘	1 yr	2 w	2 w		
Free thyroxine (FT_4)		3 mth	8 d	2 d		
Free triiodothyronine (FT_3)		3 mth	2 w	1 d		
Fructosamine	12 h ↗	2 mth	2 w	3 d		
γ-GT	1 d ↘	> 1 yr	7 d	7 d		
GLDH		4 w	7 d	7 d		
Glucose hemolysate plasma	10 min ↘	1 d ↘	7 d 7 d	2 d ↘ 2 d	Fluoride monoiodo acetate	Nonenzymatic glycolysis, stability depends on the number of cells
GOT (ASAT)	7 d ↘	3 mth	7 d	4 d		
GPT (ALAT)	4 d ↘	7 d	7 d	3 d		

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Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Growth hormone (STH, somatotropin)	1 d	3 mth	8 d	1 d	EDTA	
Haptoglobin	8 d	3 mth	8 mth	3 mth		Method-dependent
HbA_{1c}	3 d (EDTA-blood)	6 mth	7 d	3 d		
Human chorionic gonadotropin (hCG)		1 yr	3 d	1 d		
Immunoglobulin A	17 d	8 mth	8 mth	8 mth		
Immunoglobulin D		6 mth	7 d	7 d		
Immunoglobulin E		6 mth	7 d	7 d		
Immunoglobulin G	11 d	8 mth	8 mth	4 mth		
Immunoglobulin M	17 d	6 mth	4 mth	2 mth		
Insulin	15 min	6 mth	1 d	4 h		
Iron	2 h ↗	> 1 yr	3 w	7 d		Interference by EDTA, citrate, oxalate
Lactate	< 5 min, unstable ↗↗	3 d	3 d	3 d	Mannose/fluoride, oxalate/monoiodo acetate	Deproteinization recommended
			6 d	6 d	with deproteinization	

LDH	1 h ↗	6 w	7 d	7 d		Serum > plasma (hemolysis)
Lipase		1 yr	7 d	7 d		
Lipoprotein [a], (Lp [a])			2 w	2 d		Do not freeze
Luteinizing hormone (LH)	7 d	1 yr	3 d	1 d		
α_2-Macroglobulin			7 d	7 d		
Magnesium	1 d ↗	1 yr	7 d	7 d		
Myoglobin	1 h ↘	3 mth	1 w	2 d		
Neuron specific enolase (NSE)	2 h ↗	3 mth	7 d	7 d	Heparin	Freeze only once serum > plasma (platelets, hemolysis)
Osmolality		3 mth	1 d	3 h		
P1NP		6 mth	5 d	24 h		Ref. 220
pro BNP		12 mth	6 d	3 d		Ref. 220
Parathyrin	6 h (24 h in EDTA)	6 mth	2 d	8 h	EDTA	Method-dependent
Phosphate (inorg.)	1 h ↗↗	1 yr	4 d	1 d		Platelet-dependent (serum)
Potassium	1 h ↗↗	1 yr	1 w	1 w		Serum > plasma (hemolysis, thrombocytolysis)

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Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Progesterone	7 d	1 yr	3 d	1 d		
Prolactin	2 d	1 yr	3 d	1 d		
Prostate specific antigen (PSA) total free	7 d 7 d	3 mth 1 mth ↗	1 mth 7 d	7 d 7 d		
Protein total electrophoresis	1 d	1 yr 3 w	4 w 7 d	6 d 1 d		
Rheumatoid factor (RF)		1 mth	3 d	1 d		
Sodium	4 d ↘	1 yr	2 wk	2 wk		
Testosterone	7 d 1 d ↗ in women	1 yr	3 d	1 d		
Thyroglobulin	2 d	1 mth	3 d	1 d		
Thyroid stimulating hormone (TSH)		1 mth	7 d			Ref. 220
Thyroxine (T_4)	7 d	1 mth	3 d	5 d		
Transferrin	11 d	6 mth	8 mth	4 mth		

Triglycerides	7 d ↗	>1 yr	7 d	2 d		
Triiodothyronine (T_3)		3 mth	8 d	2 d		
Troponin T	8 h	3 mth	1 d	1 d		
Urea	1 d ↗	1 yr	7 d	7 d		
Uric acid	7 d ↗	6 mth	7 d	3 d		
Vitamin A		2 yr	1 mth			Protect from light
Vitamin B_1		1 yr				Protect from light
Vitamin B_2		1 mth				Protect from light
Vitamin B_6	Unstable without EDTA	Days	Hours	30 min	EDTA-Plasma	Protect from light Ref. 220
Vitamin B_{12}		2 mth	2 d; serum in separation gel tubes: 1d	2 d	EDTA-Plasma	Protect from light
Vitamin C	3 h (4 °C)	3 w	3 h			Protect from light
Vitamin D	3 d			3 d	Metaphosphate (60 mg/mL)	Protect from light
Vitamin E	8 h ↘	1 yr	1 mth			Protect from light
Vitamin K	unstable	3 mth	unstable			Protect from light
Zinc	30 min ↗	1 yr	2 w	1 w		

Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Hematology						
Differential leucocyte count Band neutrophils Segmented neutrophils Monocytes Lymphocytes Eosinophils Basophils	 2–12 h 3–12 h 2–12 h 3 h–4 d 12 h–6 d 2 h–2 d				Dried blood smears are more stable	Lower filling of sample tube decreases stability (EDTA↗). Do not keep in the refrigerator. Instrument-dependent.
Erythrocytes	4 d		7 d	4 d		EDTA blood
Erythrocyte sedimentation rate (ESR)	2 h					Temperature-dependent; 1 part of citrate, 4 parts of blood
Hematocrit (centrif.)	1 d↗		4 h		In K_2-EDTA more stable than in K_3-EDTA	
Hemoglobin in blood	4 d		7 d	4 d		EDTA blood
Leucocytes	7 d					EDTA blood
Reticulocytes	1 d					EDTA blood
Thrombocytes	7 d		4 d			EDTA blood
Coagulation, plasma/blood						
Antithrombin III	8 h	1 mth	2 w	7 d		
D-Dimer	8 h	6 mth	4 d	8 h		
Factor II		4 w		6 h		
Factor V		4 w	2 d	1 d		Centrifugation at 4 °C
Factor VII			unstable	6 h		
Factor VIII		2 w	4 h	3 h		
Factor IX		4 w		6 h		
Factor X		4 w		6 h		
Factor XI			unstable	6 h		
Factor XII			unstable	6 h		
Factor XIII		1 mth		4 h		
Fibrin monomers	1 d	3 mth	1 d	2 h		
Fibrinogen	8 h	1 mth	7 d	7 d		
Fibrin(ogen) degradation products (FDP)	unstable↗↗	1 mth	1 d	3 h	Add 10 U thrombin and 150 IU kallikrein per mL blood	Heparin inhibits thrombin effect

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Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Fibrinopeptide A			2 h			
Hepato Quick		4 w	2 d	6 h		
Partial thrombo-plastin time (PTT)	8–12 h	1 mth	2–8 h	2–8 h		Reagent dependent; reduced stability in heparin plasma
Protein C		1 mth	7 d	7 d		Avoid repeated thawing
Protein S		4 h	4 h	4 h		Separate cell-free plasma after centri-fugation
Prothrombin time (PT)	8 h	1 mth	1 d	1 d		Reagent dependent
Reptilase time		1 mth	4 h	4 h		
Thrombin time	4 h ↗	1 mth	2 d	4 h		Reagent dependent
von Willebrand-factor		6 mth	7 d	2 d		

Blood gases						
Base excess	< 15 min ↗		2 h			Stability depends on pH
Bicarbonate	Unstable Recommended: 4 °C, 30 min	2 w	7 d	1 d (closed) 1 h (open)		Close the tube
pCO_2	15 min		2 h			Close the tube
pH	15 min ↘		2 h			Close the tube, decrease due to formation of lactate, increase due to loss of CO_2
pO_2	15 min ↘		2 h			Close the tube
Therapeutic drug monitoring						
Benzodiazepine	< 1 d		5 mth ↘	5 mth ↘		
Carbamazepine	2 d	1 mth	7 d	2 d		
Cyclosporine A+G	13 d		13 d	21 d	EDTA	Store the hemolysate
Digitoxin		6 mth	3 mth	2 w		
Digoxin		6 mth	3 mth	2 w		
Disopyramide		5 mth	2 w			
Ethosuximide		5 mth	4 w			
Gentamicin	4 h	4 w	4 w	4 h		

Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Lidocaine			6 h			
Lithium	1 h ↘	6 mth	7 h	1 d		Do not use Li-heparinate
Methotrexate		6 mth	3 d			Protect from light
Phenobarbital	2 d	6 mth	6 mth	6 mth		
Phenytoin	2 d	5 mth	4 w	2 d		Unstable in SST tubes
Primidone		5 mth	4 w			
Procainamide		6 mth	2 w			
Quinidine			1 d			
Theophylline		3 mth	3 mth	3 mth		
Tobramycin		1 mth	3 d	< 2 h		Lower values in heparin plasma
Valproic acid	2 d	3 mth	7 d	2 d		

Urinanalysis						
Albumin		6 mth	1 mth	7 d		Do not freeze (nephelometry)
δ-Aminolevulic acid		1 mth	4 d	1 d	pH 6–7 with 0.3 % $NaHCO_3$	Protect from light
Amylase		3 w	10 d	2 d		Avoid contamination by saliva
Calcium		3 w	4 d	2 d	pH < 2	Crystallization upon cooling unless acidified
Catecholamines Norepinephrine Epinephrine Dopamine		20 d	4 d	4 d		pH < 2 and sodium metabisulfite (250 mg/L) enhance stability: – 20 and + 4 °C: 1 yr + 25 °C: 3 w
Citrate		4 w		1 d	1 vol % thymol, 5 mL/L; pH < 1.7	Unstable in native urine
Cocaine		4 mth	3 w		pH 5, ascorbic acid	
Copper		1 yr	7 d	3 d		
Creatinine		6 mth	6 d	2 d		
Cystine		1 yr	3 mth	7 d	Acidify with HCl	

Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
Glucose		2 d	2 h	2 h ↘		Decrease depends on the number of cells and bacteria
5-Hydroxyindole acetic acid		2 d	2 d	2 h	Acidify	
Hydroxyproline		5 d	5 d	5 d	Acidify	
Immunoglobulin G (IgG)			1 mth	7 d		Do not freeze (nephelometry)
Iron		> 1 yr	7 d	3 d		
Magnesium		1 yr	3 d	3 d	pH < 2	
α_1-Microglobulin		6 mth	1 mth	7 d		
Osmolality		3 mth	7 d	3 h		
Oxalate		4 mth (pH 1.5)	unstable ↘	unstable ↘	pH 2 (HCl), 1 vol % thymol, 5 mL/L urine	Vitamin C ↗
pH	unstable ↗		unstable ↗	unstable ↗		Increases by formation of NH_3

Phosphate, inorg.				unstable 2 d (pH < 5)	1 vol % thymol, 5 mL/L	Precipitates at alkaline pH
Porphobilinogen		1 mth (pH 6)	7 d	4 d (pH 6)	pH 6–7	pH < 5 ↘ protect from light
Porphyrine		1 mth	7 d	4 d	pH 6–7	Protect from light
Potassium		1 yr	2 mth	45 d		
Protein		1 mth	7 d	1 d		
Sediment Casts Epithelial cells Erythrocytes Leucocytes Test strips Bacteria (nitrite) Erythrocytes Protein				 1 d 1 d 1 h 1 h 1 h 1 h 1 h		Do not freeze or store the urine refrigerated. Osmolarity > 300 mosmol/kg
Sodium		1 yr	45 d	45 d		
Urea		4 w	7 d	2 d		
Uric acid	unstable at pH < 7	unstable	unstable	4 d	Alkalize at pH > 8	Precipitates at pH < 7
Vanillinmandelic acid		> 1 yr	7 d	7 d	pH 3–5	

Analyte	Stability in primary sample (e.g. blood) at room temperature and tendency of change thereafter	Stability in serum/plasma/blood/CSF/urine			Stabilizer	Comments
		– 20 °C	4–8 °C	20–25 °C		
CSF						
Albumin		1 yr	2 mth	1 d		
Glucose		months	3 d	5 h ↘		
IgG		unstable	7 d	1 d		
Lactate		months	1 h	30 min ↗	Monoiodoacetate	
Leucocytes			3–5 h	1–2 h		
Protein		1 yr	6 d	1 d		
Tumor cells			3–5 h	1–2 h		

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