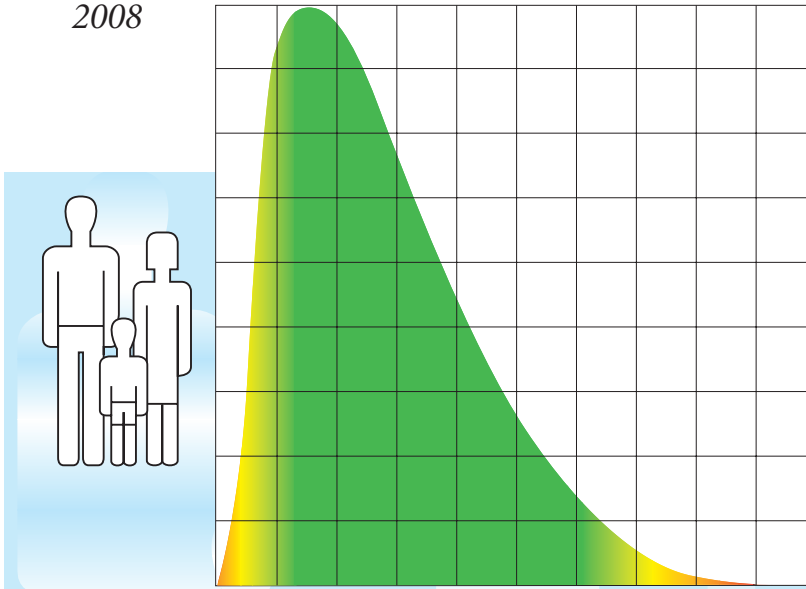
Roche

Reference Ranges for Adults and Children

Pre-Analytical Considerations

2008



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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.

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Contents

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
IU	International Unit
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

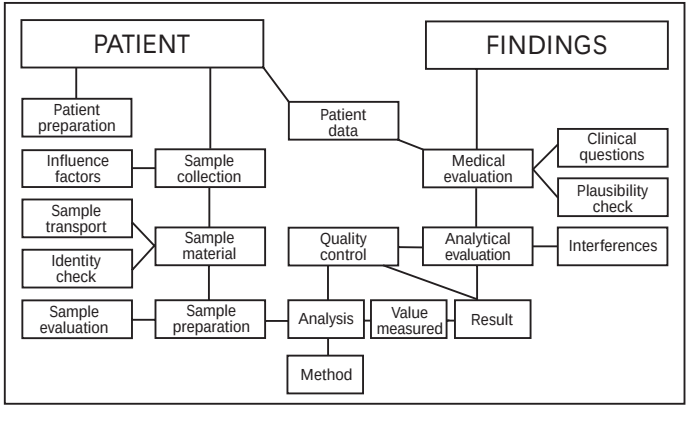
pH	Negative decimal logarithm of the hydrogen ion activity		
pO_2	Partial pressure of oxygen		
ppm	Parts per million		
pt	Particle		
	Mpt	Megaparticle	(10^6 particle)
	Gpt	Gigaparticle	(10^9 particle)
	Tpt	Teraparticle	(10^{12} particle)
s	Second		
U	Unit (international)		
	kU	Kilo unit	(10^3 units)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

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.



1.1 Factors affecting blood collection

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 (102).
- 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) increases 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 only observed in the determination of potassium, inorganic phosphate and LDH, and in electrophoresis of fibrinogen (286). In thrombocytosis patients with thrombocyte values above 500 000/µL (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

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 separation gel in the collection tube has proved advantageous in preventing cellular constituents from entering the serum.

Clinical chemistry (101):
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 (95):
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 (94, 100):
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 possible because of salt precipitation.

CSF (215):
CSF cells must be counted within the period of one hour.

Blood gases (185):
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.

1.4 Assessment of sample material

Hemolysis (101):
Determination of potassium, magnesium or LDH is not possible even in slightly hemolytic serum. Considerable hemolysis also affects other tests. If hemolysis is observed, then a fresh sample must be requested immediately.

Bilirubinemia:
Bilirubin concentrations above 5 mg/dL (86 µmol/L) may affect the determination of uric acid (PAP method). Uric acid plus (liquid) from Roche Diagnostics GmbH does not show bilirubin interferences up to 40 mg/dL (685 µmol/L). Similarly, bilirubin concentrations above 10 mg/dL (170 µmol/L) may affect the determination of triglycerides (GPO-PAP method) and, depending upon the sample, the assay of creatinine (Jaffé and enzymatic methods). Roche Diagnostics Creatinine Plus (liquid) test is not affected by bilirubin up to 25 mg/dL (430 µmol/L). Bilirubin interference can be precluded in the determination of creatinine by centrifuging serum using a disposable filter to give a bilirubin-free ultrafiltrate (52).

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

In the following list of analytes, any additional points not covered in the above sections 1.1 to 1.4 are specified in the “Notes” column.

2 Reference ranges

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	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	239	CRM 470 standardization
Acid phosphatase (ACP), total prostatic	f	< 6.5 U/L	<0.108 µkat/L	220	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	220	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 (ACTH)		7.2–63.6 pg/mL	1.6–13.9 pmol/L	220	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	69	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	139	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	220	IFCC, without pyridoxal phosphate
	m	<41 U/L	<0.68 µkat/L		
	Adults f	<35 U/L	<0.60 µkat/L	137, 220, 273	IFCC, with pyridoxal phosphate, consensus values
	m	<50 U/L	<0.85 µkat/L		
	f	<34 U/L	<0.56 µkat/L	240	IFCC, with pyridoxal phosphate, hospital patients
	m	<45 U/L	<0.74 µkat/L		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Reference Ranges				References	Notes
	Group		Conventional	SI		
Alanine amino-transferase, glutamate pyruvate transaminase (GPT, ALAT, ALT)	Newborn–12 mth	f	<45 U/L	<0.77 μkat/L	220, 304	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	229	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	220	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	220	Roche Diagnostics, bromocresol-green method
			3.56–4.61 g/dL	35.6–46.1 g/L	220	Roche Diagnostics, immunoturbidimetric method
			3.49–4.75 g/dL	34.9–47.5 g/L	220	Roche Diagnostics, bromocresol-purple-method
	Adults		3.5–5.2 g/dL	35–52 g/L	220, 239	CRM 470 standardization, consensus values
	≤4 d		2.8–4.4 g/dL	28–44 g/L	220, 304	Bromocresol-green/bromocresol-purple/immunoturbidimetric/nephelometric methods
	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		

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	69	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	226	DGKC (calculated for 37 °C)
		m	<270 U/L	<4.50 µkat/L		
	Children, adolescents	<1 yr	<390 U/L	<6.50 µkat/L	139	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	275	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	273	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	220, 69	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		
	Adults	f	<104 U/L	<1.75 µkat/L	1	IFCC, modified liquid
		m	<129 U/L	<2.15 µkat/L		
	Adults	f	<104 U/L	<1.75 µkat/L	1, 220	Roche Diagnostics, Reflotron®
		m	<129 U/L	<2.15 µkat/L		
bone	Adults	f	<120 U/L	<2.00 µkat/L	226	DGKC (calculated for 37 °C)
		m	<150 U/L	<2.50 µkat/L		
Aluminium		Adults	<3 µg/L	<0.11 µmol/L	68	Only use tubes specifically designed for determination of trace elements

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	220	Roche/Hitachi instruments
	m	<94 µg/dL	<55 µmol/L		
	f	<87 µg/dL	<51 µmol/L	220	COBAS INTEGRA®/**cobas®** instruments
	m	<102 µg/dL	<60 µmol/L		
α-Amylase, total	Adults	<100 U/L	<1.67 µkat/L	220	Reflotron®, COBAS INTEGRA®, **cobas®**, Roche/Hitachi instruments
α-Amylase, pancreatic	<1 yr	<8 U/L	<0.13 µkat/L	2	
	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	220	Reflotron®, COBAS INTEGRA®, **cobas®**, Roche/Hitachi instruments
Amyloid A		0.8–9.7 mg/L	0.8–9.7 mg/L	156	
Anion gap		8–16 mmol/L	8–16 mmol/L	195	
Antibody to cyclic citrullinated peptide (Anti-CCP)		17 U/mL	17 U/mL	220	Anti-CCP Elecsys® Optimum cut-off (sensitivity: 67.7 %; specificity: 97.0 %)
Anti-DNAse B	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		
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	220, 297	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 IU/mL	<134 kIU/L	221	Anti-TG Elecsys®, reference range study
	6 d–3 mth	<146 IU/mL	<146 kIU/L		
	4–12 mth	<130 IU/mL	<130 kIU/L		
	1–6 yr	<38 IU/mL	<38 kIU/L		
	7–11 yr	<37 IU/mL	<37 kIU/L		
	12–20 yr	<64 IU/mL	<64 kIU/L		
	Healthy subjects	<115 IU/mL	<115 kIU/L	220	Anti-TG Elecsys®

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Reference Ranges				References	Notes
	Group	Conventional		SI		
Anti-thyroidea peroxidase, thyroid peroxidase antibodies (Anti-TPO)	Children, adolescents					
	Newborn	<117 IU/mL		<117 kIU/L	221	Anti-TPO Elecsys®
	6 d–3 mth	<47 IU/mL		<47 kIU/L		
	4–12 mth	<32 IU/mL		<32 kIU/L		
	1–6 yr	<13 IU/mL		<13 kIU/L		
	7–11 yr	<18 IU/mL		<18 kIU/L		
	12–20 yr	<26 IU/mL		<26 kIU/L		
	Healthy subjects	<34 IU/mL		<34 kIU/L	220	
α_1-Antitrypsin	<1 mth	124–348 mg/dL		23.2–65.1 µmol/L	55	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	220, 239	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	220	Anti-TSHR Elecsys®
Apolipoprotein A-I	Adults f	104–163 mg/dL		1.04–1.63 g/L	220	
	m	109–172 mg/dL		1.09–1.72 g/L		
Apolipoprotein B	Adults f	0.60–1.17 g/L		1.17–2.28 µmol/L	220	
	m	0.66–1.33 g/L		1.28–2.59 µmol/L		
Aspartate aminotransferase, glutamate oxaloacetate aminotransaminase (GOT, ASAT, AST)	Children, adolescents					
	1 d	<122 U/L		<2.05 µkat/L	69	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	139	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		
	Adults, >17 yr f	<31 U/L		<0.52 µkat/L	69, 220	IFCC, without pyridoxal phosphate
	m	<37 U/L		<0.62 µkat/L		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
Aspartate aminotransferase, glutamate oxaloacetate aminotransaminase (GOT, ASAT, AST)	Adults f	<35 U/L	<0.60 µkat/L	137, 220, 273	IFCC, with pyridoxal phosphate
	m	<50 U/L	<0.85 µkat/L		
	f	<31 U/L	<0.52 µkat/L	240	IFCC, with pyridoxal phosphate, hospitalized patients
	m	<35 U/L	<0.58 µkat/L		
	f	<35 U/L	<0.58 µkat/L	229	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	220	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	220	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	266	
	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	290	
Bilirubin, direct (conjugated)		<0.2 mg/dL	<3.4 µmol/L	305	
		<0.1 mg/dL	<1.7 µmol/L	266	
	Neonates	<0.6 mg/dL	<10 µmol/L	249	
CA 15–3		<25 U/mL	<25 kU/L	220	CA 15–3 Elecsys®
CA 19–9		<27 U/mL	<27 kU/L	220	CA 19–9 Elecsys®
CA 72–4		<6.9 U/mL	<6.9 kU/L	220	CA 72–4 Elecsys®
CA 125		<35 U/mL	<35 kU/L	220	CA 125 II Elecsys®
C_{3C}-complement		90–180 mg/dL	0.9–1.8 g/L	239	CRM 470 standardization
C_4-complement		10–40 mg/dL	0.1–0.4 g/L	239	CRM 470 standardization
Cadmium		<2.7 µg/L	<24 nmol/L	83	Whole blood, AAS
Calcitonin		<100 ng/L	<28 pmol/L	259	Radioimmuno assay

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	268	Photometric assay
		8.8–10.2 mg/dL	2.20–2.54 mmol/L	268	AAS
	Cord blood	8.2–11.2 mg/dL	2.05–2.80 mmol/L	304	
	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	220	Roche/Hitachi, COBAS INTEGRA®, **cobas**® systems.
Calcium, free, ionized	Adults	4.7–5.2 mg/dL	1.17–1.29 mmol/L	245	Perform assay immediately after anaerobic sample collection, determine pH value.
		4.6–5.3 mg/dL	1.16–1.32 mmol/L	269	
Carcinoembryonic antigen (CEA)	Non-smokers 20–69 yr	3.8 ng/mL	3.8 µg/L	220	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	244	
	m	1.18–2.40 mg/dL	24.6–51.0 µmol/L		
Catecholamines					
– Norepinephrine		185–275 ng/L	1100–1600 pmol/L	207	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	220, 239	Immunoturbidimetric method, CRM 470 standardization
Chloride	Children 1–7 d	97–108 mEq/L	97–108 mmol/L	249	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	220, 304	Indirect ISE, coulometry
		101–110 mEq/L	101–110 mmol/L	220	Direct ISE

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	Reference Ranges SI	References	Notes
Cholesterol, total	1–30 d	f	62–155 mg/dL	1.60–4.01 mmol/L	249	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	220	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	66	
	Adult levels	Optimum	<100 mg/dL	<2.60 mmol/L	46	Classification acc. to NCEP ATP III
	Near/above optimum		100–129 mg/dL	2.60–3.35 mmol/L		
	Borderline high		130–159 mg/dL	3.36–4.15 mmol/L		
	High		160–189 mg/dL	4.16–4.90 mmol/L		
	Very high		>190 mg/dL	>4.90 mmol/L		
	Low risk		<100 mg/dL	<2.6 mmol/L	217	Target values acc. to ATP III
	Moderate risk		<135 mg/dL	<3.5 mmol/L		
	High risk		>160 mg/dL	>4.1 mmol/L		

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, 220	Pseudocholinesterase, butyrylthiocholine iodide, Roche Diagnostics.
	w, 16–40 yr, not pregnant, not taking oral contraceptives	4.26–11.25 kU/L	71–188 µkat/L		Calculated with a temperature conversion factor of 1.52 (25 → 37 °C)
	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	201	
Chromium	Fasting volunteers	1.0–1.5 µg/L	20–30 µmol/L	243	Special tubes required
Copper	<4 mth	8.9–46 µg/dL	1.4–7.2 µmol/L	160	
	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	172	
	m	70–140 µg/dL	11–22 µmol/L		
Cortisol	7–10 h	6.2–19.4 µg/dL	171–536 nmol/L	220	Cortisol Elecsys®
	16–20 h	2.3–11.9 µg/dL	64–327 nmol/L		
C-peptide		1.1–4.4 ng/mL	0.37–1.47 nmol/L	220	C-peptide Elecsys®
C-reactive Protein (CRP)	Adults	<0.50 mg/dL	<47.6 nmol/L	89, 220	Immunoturbidimetric method, CRM 470 standardization, consensus value for adults
high sensitive	Neonates <3 w	<0.41 mg/dL	<39.0 nmol/L	220, 235	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	104	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		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Creatine kinase (CK), total		1 d	<712 U/L	<11.9 µkat/L	69	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	<170 U/L	<2.85 µkat/L	138	
		m	<190 U/L	<3.20 µkat/L		
		f	<192 U/L	<3.20 µkat/L	137, 220	Consensus values
		m	<308 U/L	<5.15 µkat/L		
		f	<145 U/L	<2.41 µkat/L	219, 240	IFCC, hospital patients
		m	<171 U/L	<2.85 µkat/L		
		f	<170 U/L	<2.84 µkat/L	220	Roche Diagnostics, Reflotron®
		m	<195 U/L	<3.26 µkat/L		
Creatine kinase MB (CK-MB)		Adults	<25 U/L	<0.42 µkat/L	138, 220	
	Adults	20–60 yr	<24 U/L	<40 µkat/L	220, 274	Consensus values
mass	Adults	f	<2.88 ng/mL	<2.88 µg/L	220	CK-MB Elecsys®
		m	<4.94 ng/mL	<4.94 µg/L		
Creatinine		Neonates, premature	<1.04 mg/dL	<91 µmol/L	220, 235	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	173, 220	Jaffé method, Roche Diagnostics
		m	<1.20 mg/dL	<106 µmol/L		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Creatinine	Neonates, premature	<0.98 mg/dL	<87 µmol/L	220, 235	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	173, 220	Enzymatic method, Roche Diagnostics
	m	<1.17 mg/dL	<104 µmol/L		
β-CrossLaps	w premenopausal	<573 pg/mL	<573 ng/L	220	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	220	CYFRA 21–1 Elecsys®
Cystatin C	Children <1 mth	1.1–2.2 mg/L	1.1–2.2 mg/L	206	
	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	191	
	>50 yr	0.8–1.6 mg/L	0.8–1.6 mg/L		
	20–50 yr	0.56–0.90 mg/L	0.56–0.90 mg/L	220	Roche Diagnostics, Roche/Hitachi,
	51–70 yr	0.58–1.09 mg/L	0.58–1.09 mg/L		COBAS INTEGRA®, **cobas**® systems.
Dehydroepiandro-sterone sulfate (DHEA-S)	10–14 yr f	<280 µg/dL	<7.6 µmol/L	220	DHEA-S Elecsys®
	m	<247 µg/dL	<6.7 µmol/L		
	15–19 yr f	<368 µg/dL	<10.0 µmol/L		
	m	<492 µg/dL	<13.4 µmol/L		
	20–24 yr f	<407 µg/dL	<11.0 µmol/L		
	m	<492 µg/dL	<13.4 µmol/L		
	25–34 yr f	<340 µg/dL	<9.23 µmol/L		
	m	<449 µg/dL	<12.2 µmol/L		
	35–44 yr f	<337 µg/dL	<9.15 µmol/L		
	m	<427 µg/dL	<11.6 µmol/L		
	45–54 yr f	<256 µg/dL	<6.95 µmol/L		
	m	<331 µg/dL	<8.98 µmol/L		
	55–64 yr f	<205 µg/dL	<5.56 µmol/L		
	m	<295 µg/dL	<8.01 µmol/L		
	65–74 yr f	<246 µg/dL	<6.68 µmol/L		
	m	<249 µg/dL	<6.76 µmol/L		
	>75 yr f	<154 µg/dL	<4.18 µmol/L		
	m	<123 µg/dL	<3.34 µmol/L		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Elastase	Healthy lab. workers	<160 µg/L	<160 µg/L	187	Citrated plasma
Erythropoietin	1–3 yr f	<15.9 U/L	<15.9 U/L	144	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	220	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	304	
	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	139	
	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	13–150 ng/mL	13–150 µg/L	165, 220	
	20–60 yr m	30–400 ng/mL	30–400 µg/L		

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 IU/mL	249	
	1–3 mth	40.0–1000 ng/mL	33.2–830 IU/mL		
	4 mth–18 yr	<12.0 ng/mL	<9.96 IU/mL		
	Pregnancy w 14	<27.9 ng/mL	<23.2 IU/mL	220	AFP Elecsys®
	(median) w 15	<30.9 ng/mL	<25.6 IU/mL		
	w 16	<36.1 ng/mL	<30.0 IU/mL		
	w 17	<40.4 ng/mL	<33.5 IU/mL		
	w 18	<48.3 ng/mL	<40.1 IU/mL		
	w 19	<54.8 ng/mL	<45.5 IU/mL		
	Adults	≤7.0 ng/mL	≤5.8 IU/mL		
Fluoride	Adults	0.019–112 µg/L	0.23–5.9 µmol/L	197	Plasma
Folic acid, serum	≤1 yr f	6.2–23 ng/mL	14–52 nmol/L	108	Radioimmuno assay
	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	146, 220	
	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		
		3.8–16.0 ng/mL	8.6–36.3 nmol/L	220	Folate II Elecsys®; European study (USA, Australia: see package insert)
Folic acid, red blood cells (RBC Folate)		263–1028 ng/mL	597–2334 nmol/L	220	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 mIU/mL	3.5–12.5 IU/L	220	FSH Elecsys®
	Ovulatory phase	4.7–21.5 mIU/mL	4.7–21.5 IU/L		
	Luteal phase	1.7–7.7 mIU/mL	1.7–7.7 IU/L		
	Postmenopause	25.8–134.8 mIU/mL	25.8–134.8 IU/L		
	m	1.5–12.4 mIU/mL	1.5–12.4 IU/L		

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
free PSA/total PSA ratio (fPSA/tPSA)		≤0.10 / 0.11–0.18	0.19–0.25 / >0.25	220	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	221	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	220	FT_4 Elecsys®
	Adults	1.0–1.6 ng/dL	12.8–20.4 pmol/L	147	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	221	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	220	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	300	
Fructose	Adults	<0.6 mg/dL	<0.03 mmol/L	123	
FTI		4.6–11.7	4.6–11.7	220	CEDIA® T-uptake

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
FT_4I	Euthyroid subjects				
	Germany, Japan	4.8–12.7 µg/dL	62–164 nmol/L	220, 221	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	221	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	Immediate deproteinization
Gastrin		40–59 pg/mL	20–28 pmol/L	254	Fasting, deep-freeze immediately, RIA
Glucose	Newborns Cord blood	63–158 mg/dL	3.5–8.8 mmol/L	267	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	304	Serum, plasma
	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		
	>1 d	50–80 mg/dL	2.78–4.44 mmol/L		

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	79	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	220, 267	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	267	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	267	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	262	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	220	Reflotron® system, blood, serum, plasma
Glutamate dehydrogenase (GLDH)	Newborns	<11.7 U/L	<195 nkat/L	220, 283, 305	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	220	DGKC, optimized, calculated values (25 → 37 °C)
	m	<6.4 U/L	<110 nkat/L		
	f	<5 U/L	<80 nkat/L	220, 273	Consensus values
	m	<7 U/L	<120 nkat/L		

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	69	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	139	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, 220	Standardized according to Szasz
	m	<61 U/L	<1.02 µkat/L		
	f	<42 U/L	<0.70 µkat/L	220	Standardized according to IFCC
	m	<71 U/L	<1.19 µkat/L		
	f	<40 U/L	<0.67 µkat/L	273	IFCC, consensus values
	m	<60 U/L	<1.00 µkat/L		
	f	<38 U/L	<0.63 µkat/L	240	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	162	Fasting, RIA
Haptoglobin	Adults	30–200 mg/dL	3.0–20.0 µmol/L	220, 239	Immunoturbidimetry, CRM 470 standardization
Hp 1–1	f	91–160 mg/dL	9.1–16.0 µmol/L	154	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 %	0.029–0.042	129, 220	Immunoturbidimetric assay, IFCC values
		4.8–5.9 %	0.048–0.059		DCCT/NGSP values
		4.4–5.7 %	0.044–0.057	304	HPLC
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	174	
	m	56–111 mg/dL	0.56–1.11 g/L		

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	105	
Human chorionic gonadotropin (hCG)	f Premenopause, non-pregnant	<1 mU/mL	<1 U/L	220	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	220	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	65, 220	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	291	
	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	161, 220	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, 220	Immunoturbidimetric method, CRM 470 standardization
Immunoglobulin D, IgD	Adults	0.3–14 mg/dL	0.003–0.14 g/L	304	
Immunoglobulin E, IgE	Neonates	<0.36 µg/dL	<1.5 IU/mL	54, 220	
	Children, adolescents 1 yr	<3.6 µg/dL	<15 IU/mL		
	2–5 yr	<14.4 µg/dL	<60 IU/mL		
	6–9 yr	<21.6 µg/dL	<90 IU/mL		
	10–15 yr	<48 µg/dL	<200 IU/mL		
	Adults	<24 µg/dL	<100 IU/mL		

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Immunoglobulin G, IgG	Neonates	227–1378 mg/dL	15.1–91.9 µmol/L	161	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, 220	Immunoturbidimetric method, CRM 470 standardization
IgG subclasses		IgG_1 IgG_2	IgG_1 IgG_2	181	
	5 yr	560–1270 40–440 mg/dL	5.6–12.7 0.4–4.4 g/L		
	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	161	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, 220	Immunoturbidimetry, CRM 470 standardization

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	220	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	220	Insulin Elecsys®, fasting
Iron	1–30 d f	29–127 µg/dL	5.2–22.7 µmol/L	248	
	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	293	
	m	59–158 µg/dL	11–28 µmol/L		
Iron-binding capacity, total (TIBC)	Adults	228–428 µg/dL	41–77 µmol/L	220	Roche/Hitachi systems
Unsaturated (UIBC)		110–370 µg/dL	20–66 µmol/L	220	Roche/Hitachi systems
		112–346 µg/dL	20–62 µmol/L	220	COBAS INTEGRA®, **cobas**® systems
Lactate	Adults	4.5–19.8 mg/dL	0.5–2.2 mmol/L	304	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

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	69	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	139	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	220, 294	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	240	IFCC, hospitalized patients
	m	<248 U/L	<4.13 µkat/L		
	Neonates 4–20 d	<600 U/L	<10.0 µkat/L	164	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	273	Consensus values
Lead	Adults ≤60 yr	<250 µg/L	<1.21 µmol/L	274	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, 220	Colorimetric assay
Lp [a]	Adults	<30 mg/dL	<0.30 g/L	220	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.
	Adults f	11 mg/dL	0.11 g/L		Median values found in apparently healthy Caucasian Europeans.
	m	9 mg/dL	0.09 g/L		

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 mIU/mL	2.4–12.6 IU/L	220	LH Elecsys®
	Ovulatory phase	14–96 mIU/mL	14–96 IU/L		
	Luteal phase	1.0–11.4 mIU/mL	1.0–11.4 IU/L		
	Postmenopause	7.7–59 mIU/mL	7.7–59 IU/L		
	m	1.7–8.6 mIU/mL	1.7–8.6 IU/L		
Lysozyme	Adults	3.0–9.0 mg/L	3.0–9.0 mg/L	184	
α_2-Macroglobulin	Adults	130–300 mg/dL	1.3–3.0 g/L	239	Consensus values, CRM 470 standardization
Magnesium, total	Newborns	1.5–2.2 mg/dL	0.62–0.91 mmol/L	220, 304	AAS
	Children, adolescents				
	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	304	AAS
Mannose binding protein (MBP)	Adults	0.3–4.1 mg/L	0.3–4.1 mg/L	156	
Mercury	Adults, children	<7.2 µg/L	<36 nmol/L	232	Whole blood, AAS
β_2-Microglobulin	Adults	<170 µg/dL	<1.7 mg/L	220	Immunoturbidimetric assay
Myoglobin	Adults f	19–51 ng/mL	19–51 µg/L	130, 220	Roche/Hitachi systems, immunoturbidimetric assay
	m	23–72 ng/mL	23–72 µg/L		
	f	7–64 ng/mL	7–64 µg/L	220	COBAS INTEGRA® instruments, immunoturbidimetric assay
	m	16–76 ng/mL	16–76 µg/L		
	f	25–58 ng/mL	25–58 µg/L	220	Myoglobin Elecsys®
	m	28–72 ng/mL	28–72 µg/L		
	f	7–64 ng/mL	7–64 µg/L	220	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	220	NSE Elecsys®

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	209	proBNP Elecsys®
	m	<62 pg/mL	<7.3 pmol/L		
	Adults <75 yr	125 pg/mL	14.8 pmol/L	85, 220	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	220	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	220	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	220	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	

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	252	Chemiluminescence immunoassay
	Adults	12–50 ng/L	1.26–5.3 pmol/L	150	
		15–65 ng/L	1.6–6.9 pmol/L	220	PTH Elecsys®
Phosphate, inorganic	Children, adolescents				
	1–30 d	3.9–7.7 mg/dL	1.25–2.50 mmol/L	265	
	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	220	
Phosphohexose isomerase (PHI)		20–90 U/L	0.35–1.50 µkat/L	241	
Potassium	Adults	3.5–5.1 mEq/L	3.5–5.1 mmol/L	220, 304	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	249	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	220	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	220	Reflotron®, serum
		3.5–4.6 mEq/L	3.5–4.6 mmol/L		Reflotron®, plasma

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	Reference Ranges SI	References	Notes
Prealbumin (Transthyretin)	Children <1 mth	7–39 mg/dL	0.07–0.39 g/L	55	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	239	
Pregnancy-associated plasma protein A (PAPP-A)	Healthy non-pregnant donors	<7.15 mIU/L	<7.15 mIU/L	220	PAPP-A Elecsys®, Roche study no. R04P026
Procalcitonin		<0.5 ng/mL	<0.5 µg/L	177	
Progesterone	w Follicular phase	0.2–1.5 ng/mL	0.6–4.7 nmol/L	220	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	220	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	220	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)		≤0.10	0.11–0.18	0.19–0.25	>0.25		
	m 50–59 yr	49.2 %	26.9 %	18.3 %	9.1 %	220	Free PSA Elecsys®, probability of finding prostate cancer by age in years.
	60–69 yr	57.5 %	33.9 %	23.9 %	12.2 %		
	≥70 yr	64.5 %	40.8 %	29.7 %	15.8 %		

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	220, 304	
	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	80	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	153	Whole blood, deproteinize immediately using ice-cold perchloric acid.
Rheumatoid factor (RF)	Adults	<14 IU/mL	<14 kIU/L	220	Immunoturbidimetric method, Roche Diagnostics
S100	Apparently healthy adults	≤0.105 µg/L	≤0.105 µg/L	220	S100 Elecsys®
Selenium		67–105 µg/L 45–83 µg/L	0.85–1.33 µmol/L 0.57–1.05 µmol/L	151	Whole blood Plasma
Sexual hormone binding globulin (SHBG)	f 17–50 yr Postmenopausal, untreated	26.1–110 nmol/L 14.1–68.9 nmol/L	26.1–110 nmol/L 14.1–68.9 nmol/L	220	SHBG Elecsys®, free testosterone/androgen index: see package insert.
	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	249	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	304	Flame emission photometry, indirect ISE
	>90 yr	132–146 mEq/L	132–146 mmol/L		
	Adults	146–157 mEq/L	146–157 mmol/L	220	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	304	Freeze sample immediately.

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	220	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	304	Whole blood, AAS
Thyroglobulin	Children, adolescents				
	Newborns	25–307 ng/mL	25–307 µg/L	221	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	220	Thyroglobulin Elecsys®
Thyroid stimulating hormone (TSH)	Children, adolescents				
	Newborns	0.70–15.2 µU/mL	0.70–15.2 mU/L	221	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	147	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	220	TSH Elecsys®
Thyroxine (T_4)	Children, adolescents				
	Newborns	5.04–18.5 µg/dL	64.9–239 nmol/L	221	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	220	T_4 Elecsys®
	Healthy blood donors	5.5–12.2 µg/dL	70.5–157 nmol/L	147	T_4 Elecsys®, group selected acc. to NACB recommendations
	Adults	4–12 µg/dL	51.6–154.8 nmol/L	220	Roche Diagnostics, fluorescence polarization immunoassay
	Adults	4.5–12 µg/dL	58.1–154.8 nmol/L	220	Roche Diagnostics, homogeneous enzyme immunoassay

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Reference Ranges Group	Conventional	SI	References	Notes
Thyroxine-binding capacity (as TBI)		0.8–1.3	0.8–1.30	220, 221	T-uptake Elecsys®
Transferrin	Adults	130–360 mg/dL	16–45 µmol/L	89, 220, 239	Immunoturbidimetric assay, CRM 470 standardization
Transferrin, carbohydrate deficient (as % CDT)	Adults	≤3.0 %	≤3.0 %	220	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	145	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	142	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 %	264	TS [%] = Fe [µg/dL] × 70.9/Transferrin [mg/dL]
Triglycerides	Premature	<62 mg/dL	<0.7 mmol/L	79	
	Adults ≤65 yr	<200 mg/dL	<2.3 mmol/L	66, 220	
	>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	221	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	220	T_3 Elecsys®
Troponin I	Adults 22–65 yr	≤0.16 ng/mL	≤0.16 µg/L	15	Chemiluminescence immunoassay
	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	166	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	220	Troponin T Elecsys®
		0.1 ng/mL	0.1 µg/L	220	Cut-off acc. to WHO criteria
	Adults	<0.03 ng/mL	< 0.03 µg/L	132	Roche CARDIAC T

2.1 Clinical chemistry and immunological tests, serum/plasma

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
T-uptake (free thyroxine binding capacity)	Blood donors	24.3–39.0 %	0.243–0.390	220	Roche Diagnostics, homogeneous enzyme immunoassay
Urea	Children 1–3 yr	11–36 mg/dL	1.8–6.0 mmol/L	271	
	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	229	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	270	
	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	220	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	229	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		

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 1.9–4.9 µg/dL	5–28 nmol/L 71–185 nmol/L	299	HPLC, serum HPLC, whole blood
Vitamin B_2 (Riboflavin)			10–50 µg/dL	0.27–1.33 µmol/L	304	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	220	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	58	
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	252	Chemiluminescence assay
		Adults	11.1–42.9 ng/mL	27.7–107 nmol/L	220	Vitamin D_3 Elecsys®, Roche Diagnostics, population-based reference range, Germany, summer time
		Children. adults	>30 ng/mL	>75 nmol/L	285	Health-based reference range

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	160	
		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	151	Plasma
			425–560 µg/dL	65–86 µmol/L		Whole blood
Zinc protoporphyrin			17–77 µg/L	0.27–1.23 µmol/L	304	Whole blood (heparine EDTA), hematofluorimetric test.

2.2 Hematology

Analyte	Reference Ranges Goup	Conventional	SI	References	Notes
CO-Hb	Non-smokers	<2.2 %	<0.022	56	
	Smokers	<10.5 %	<0.105		
Differential leucocyte count					
Band neutrophils	Infants	<8 %	<0.08	215	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	299	
	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	57	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		

2.2 Hematology

Analyte	Group	Reference Ranges Conventional	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	306	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	299	
	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	190	
	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	299	
HbA,		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		

2.2 Hematology

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
Leucocytes	12 h	13,000–38,000/μL	13.0–38.0 gpt/L	57	
	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	299	
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	299	
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	299	

2.2 Hematology

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
MCV	1 d	98–122 μm^3	98–122 fL	122	
	2–6 d	94–150 μm^3	94–150 fL		
	14–23 d	84–128 μm^3	84–128 fL		
	24–37 d	82–126 μm^3	82–126 fL		
	2–2.5 mth	81–121 μm^3	81–121 fL		
	3–3.5 mth	77–113 μm^3	77–113 fL		
	5–7 mth	73–109 μm^3	73–109 fL		
	8–10 mth	74–106 μm^3	74–106 fL		
	11–13.5 mth	74–102 μm^3	74–102 fL		
	1.5–3 yr	73–101 μm^3	73–101 fL		
	5 yr	72–88 μm^3	72–88 fL		
	10 yr	69–93 μm^3	69–93 fL		
	Adults	80–96 μm^3	80–96 fL	299	
Methemoglobin	Non-smokers/smokers	<1.2 %	<0.012	56	
Osmotic resistance of erythrocytes	No hemolysis	>0.5 % NaCl	>0.005 NaCl	57	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	72	Heparinized or EDTA blood
Reticulocytes	1 d	30–70 ‰	$30–70 \times 10^{-3}$	299	
	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 ‰	$5–15 \times 10^{-3}$	57	
Reticulocyte hemoglobin equivalent ($RET\text{-}H_e$)	Adults	28.2–35.7 pg	28.2–35.7 pg	272	Derived from Ret-Y as determined on a Sysmex XE 2100 hematology analyzer

2.2 Hematology

Analyte	Group		Reference Ranges Conventional	SI	References	Notes
Thrombocytes	1–5 yr	f	229–553 × 10^3/µL	229–553 Gpt/L	81	
		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	57	
		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		

2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Antiphospholipid antibodies (APA)		No antibodies	No antibodies	276	ELISA, Asserachrom®* APA
α_2-Antiplasmin	2–10 yr	108–155 %	1.08–1.55	192	
	11–18 yr	79–161 %	0.79–1.61		
	Adults	80–120 %	0.80–1.2	220	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	200	
	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	192	
	11–18 yr	>81 %	>0.81		
	Adults	>80 %	>0.80	107	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	255	
	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	216	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	180	
	21–40 w	<4.3 µg/mL	<4.3mg/L		
	Adults	<0.5 µg/mL	<0.5 mg/L	220	Enzyme immunoassay
		<0.5 µg/mL	< 0.5 mg/L	220	Immunoturbidimetric assays, Roche CARDIAC D-Dimer

* Asserachrom is a trademark of Diagnostica STAGO

2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	SI	References	Notes
Factor II	Neonates	31–59%	0.31–0.59	203	
	Adults	>70%	>0.70	20	
Factor V	Neonates	42–182%	0.42–1.82	203	
	Adults	>70%	> 0.70	20	
Factor VII	Neonates	34–95 %	0.34–0.95	230	
	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	220	
Factor VIII	2–10 yr	52–300 %	0.52–3.00	193	
	11–18 yr	54–170 %	0.54–1.70		
	Adults	>70 %	>0.70	20	
	Adults	60–150 %	0.60–1.50	220	
Factor IX	Neonates	11–55%	0.11–0.55	193	
	2–10 yr	60–98%	0.60–0.98	288	
	Adults	>60%	>0.60		
Factor X	Neonates	24–45%	0.24–0.45	192	
	Adults	>70%	>0.70	20, 220	
Factor XI	1–16 yr	56–156%	0.56–1.56	73	
	Adults	>70 %	>0.70	20	
	Adults	60–150 %	0.60–1.50	220	
Factor XII	1–16 yr	52–192 %	0.52–1.92	73	Newborns have approx. 50 % of the adult value
	Adults	>60 %	>0.60	20, 220	
Factor XIII	Adults	>60 %	>0.60	20	
Fibrin monomers	Adults	<20 µg/mL	<20 mg/L	155	Agglutination test

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	192	
	11–18 yr	160–390 mg/dL	1.6–3.9 g/L		
	Adults	200–400 mg/dL	2.0–4.0 g/L	220	Fibrinogen levels increase during pregnancy
Fibrin(ogen) degradation products (FDP)	Adults	<10 µg/mL	<10 mg/L	305	
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	70	Citrated plasma, citrated blood, whole blood
	Adults	>70 %	>0.70		
High molecular weight kininogen (HMWKG)	1–16 yr	47–123 %	0.47–1.23	73	
	Adults	>70 %	>0.70	20	
International normalized ratio (INR)	Atrial fibrillation/flutter		INR 2.0–3.0	183	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		

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	288	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	220	Kaolin-activated APTT
Plasmin-α_2-anti-plasmin complex		1–6 yr	95–420 µg/L	95–420 µg/L	216	
		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	167	
		2– 10 yr	55–127 %	0.55–1.27	193	
		11–18 yr	64–133 %	0.64–1.33		
		Adults	>70 %	>0.70	192	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		

2.3 Coagulation

Analyte	Group	Reference Ranges Conventional	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	73	
	Adults	>50 %	>0.50	20	
Protein C	Neonates	0.20–0.44 U/mL	0.20–0.44 kU/L	203	Antigen concentration
	2–10 yr	64–150 %	0.64–1.50	193	
	11–18 yr	63–130 %	0.63–1.30		
	Adults	70–140 %	0.70–1.40	220	Protein C concentration, enzyme immunoassay
	Adults	70–130 %	0.70–1.30	220	Protein C activity, chromogenic method and clotting test
Activity/antigen concentration ratio	1 d	0.63–1.35	0.63–1.35	257	
	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	255	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	255	
	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	220	Clotting test
	m	65–145 %	0.65–1.45		

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	216	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	192	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	220	
Reptilase time	Adults	<20 s	<20 s	295	
Thrombin AT III complex (TAT)	1–6 yr	0.8–3.5 µg/L	0.8–3.5 µg/L	216	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	295	
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	220	
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	

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	220	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	193	
	Adults	50–160 %	0.50–1.60	220	Enzyme immunoassay, lower results with blood group 0.

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	185	Blood, arterial, venous
O_2-saturation		Adults	94–98 % 70–80 %	0.94–0.98 0.70–0.80	185	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	185	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 mm Hg 7.15–7.45 mm Hg	7.09–7.40 kPa 7.15–7.45 kPa	185	Blood
	Children	1 d 10 d–3 mth 4–12 mth	7.20–7.41 mm Hg 7.34–7.45 mm Hg 7.38–7.45 mm Hg	7.20–7.41 kPa 7.34–7.45 kPa 7.38–7.45 kPa		
	Adults		7.37–7.45 mm Hg 7.35–7.43 mm Hg	7.37–7.45 kPa 7.35–7.43 kPa		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	185	Blood Blood, arterial Blood, mixed venous
Standard bicarbonate	Children	V. umb.	12–21 mmol/L	12–21 mmol/L	185	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

2.5 Therapeutic drug monitoring

Analyte	Therapeutic Range*		Reference	Notes
	Group	Conventional / SI		
Amikacin		Peak: 20–25 µg/mL Trough: 5–10 µg/mL 34–43 µmol/L 9–17 µmol/L	220	Fluorescence polarization immunoassay, immunoturbidimetric immunoassay, Roche Diagnostics
Acetaminophene		10–30 µg/mL 66–199 µmol/L	220	Immunoturbidimetric assay, Roche Diagnostics
Acetylsalicylic acid		50–300 µg/mL 0.83–1.66 mmol/L	194	Blood collection: 1–3 h after oral dose.
Benzodiazepine		<200 µg/mL <200 mg/L	220	Immunoturbidimetric assay, Roche Diagnostics, laboratory-dependent cutoff in *urine*.
Caffeine		5–20 µg/mL 26–103 µmol/L	194	
Carbamazepine		8–12 µg/mL 33.8–50.8 µmol/L	220	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	194	
Cyclosporine		No firm therapeutic range exists. Range must be established for the specific assay used.	220	Whole blood
Digitoxin		10–30 ng/mL 13–39 nmol/L	220	Fluorescence polarization immunoassay, turbidimetric immunoassay, electrochemiluminescence immunoasay, Roche Diagnostics
Digoxin		0.9–2.0 ng/mL 1.2–2.6 nmol/L	220	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	194	
Ethosuximide		40–100 µg/mL 283–708 µmol/L	194	
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	220	Fluorescence polarization immunoassay, immunoturbidimetric immunoassay, Roche Diagnostics
		Peak: 5–8 µg/mL Trough: 1–2 µg/mL 10.5–16.7 µmol/L 2.1–4.2 µmol/L		Homogeneous enzyme immunoassay, Roche Diagnostics
Lidocaine		1.5–6 µg/mL 6–26 µmol/L	220	Fluorescence polarization immunoassay, Roche Diagnostics, blood collection: during infusion
Lithium		0.6–1.2 mEq/L 0.6–1.2 mmol/L	220	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.

2.5 Therapeutic drug monitoring

Analyte	Therapeutic Range*		References	Notes
	Group	Conventional / SI		
Methotrexate		A generally applicable therapeutic range is not available. / Therapeutic concentrations depend on the treatment protocol.	304	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.	220	
N-Acetytylprocainamide (NAPA)		5–30 µg/mL / 18.1–108.3 µmol/L	220	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	220	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	220	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics.
Primidone		5–12 µg/mL / 22.9–50 µmol/L	220	Fluorescence polarization immunoassay, Roche Diagnostics.
Procainamide		4–10 µg/mL / 16.9–42.3 µmol/L	220	Immunoturbidimetric assay, homogeneous immunoassay, fluorescence polarization immunoassay, Roche Diagnostics.
Quinidine		1.5–5 µg/mL / 4.6–15 µmol/L	220	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	220	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)	304	

* 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	Therapeutic Range*		References	Notes
	Group	Conventional / SI		
Theophylline		approx. 10–20 µg/mL approx. 56–111 µmol/L	220	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	220	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	220	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	220	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.

2.6.1 Urinalysis, urinary sediment and status

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
Bacteria	Children	$<10^3$/μL	$<10^9$/L	220	Chamber count
	Adults	$<10^5$/μL	$<10^{11}$/L		
Specific gravity	Neonates,				
	first few days	1.012 g/mL	1.012	220	Daily urine, normal diet
	after first few days	1.002–1.006 g/mL	1.002–1.006		
	Adults	1.015–1.025 g/mL	1.015–1.025		
Urinary sediment					
Erythrocytes		0–1 per field (<5/μL)	0–1 per field (<5 Mpt/L)	215	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

2.6.1 Urinalysis, urinary sediment and status

Analyte	Reference Ranges			References	Notes
	Group	Conventional	SI		
Urinary status					
Bilirubin		<0.2 mg/dL	<3.4 µmol/L	220	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		

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	278	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	<2.26 g (34.35 µmol)/mol crea	220	2nd morning urine
	Children 3–5 yr	<37 mg/g or	<0.304 µmol/L or		24 h-urine
		<2 mg/dL or <30 mg/24 h	<0.304 µmol/L or <0.456 µmol/d		Immunoturbidimetric assay, Roche Diagnostics
δ-Aminolevulic acid	Adults	<6.4 mg/24 h	<49 µmol/d	61	24 h-urine to be acidified with HCl, pH 2–3
α-Amylase, total	Adults	≤460 U/L	≤7.65 µkat/L	220	Spontaneously voided urine
		≤310 U/g crea	≤585 µkat/mol crea		α-amylase/creatinine quotient
pancreatic		≤350 U/L	≤5.85 µkat/L		Spontaneously voided urine
		≤205 U/g crea	≤395 µkat/mol crea		α-amylase/creatinine quotient
Calcium	Children	<6 mg/kg/24 h	<0.15 mmol/kg/d	134	24 h-urine, acidified (pH <2) with HCl
	Adults	100–320 mg/24 h	2.5–8.0 mmol/d		
		100–321 mg/24 h or	2.5–8.0 mmol/d or	220	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	244	
	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	59	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	149	24 h-urine
		46–168 mEq/L	46–168 mmol/L		1st morning urine
		110–250 mEq/24 h	110–250 mmol/d	304	24 h-urine
Citrate (as citric acid)	Adults	<805 mg/24 h	<4.2 mmol/d	106	
Copper	Adults	10–60 µg/24 h	0.16–0.94 µmol/d	172	
Cortisol, free	Adults	36–137 µg/24 h	100–379 nmol/d	220	24 h-urine, Cortisol Elecsys®

2.6.2 Clinical chemical urinalysis

Analyte	Reference Ranges Group	Conventional	SI	References	Notes
C-Peptide	Adults	17.2–181 µg/24 h	5.74–60.3 nmol/d	220	24 h-urine, C-Peptide Elecsys®
Creatinine	Adults f	28–217 mg/dL	2.47–19.2 mmol/L	173	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	173	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	158	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	104	
Galactose	Neonates	<60 mg/dL	<3.3 mmol/L	104	
	Adults	<14 mg/24 h	<0.1 mmol/d		
Glomerular filtration rate (GFR)	30 yr	79–131 mL/min	79–131 mL/min	82	^{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	220	1st morning urine.
		<15 mg/dL	<0.8 mmol/L		Spontaneously voided urine.
		<17 mg/dL	<0.96 mmol/L	149	24 h-urine
5-Hydroxyindole acetic acid	Adults	<8 mg/24 h	<41 pmol/d	289	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

2.6.2 Clinical chemical urinalysis

Analyte	Reference Ranges Group		Conventional	SI	References	Notes
Immunoglobulin light chains κ/λ ratio		Adults	0.70–4.50	0.70–4.50	220	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	237	24 h-urine
Lysozyme			<3.6 mg/24 h	<3.6 mg/d	304	
Magnesium			9.7–12.2 mg/24 h	4–5 mmol/d	228	24 h-urine
			7.3–12.2mg/dL	3.0–5.0 mmol/L	304	24 h-urine
Mercury		Adults	< 26 µg/L	< 130 nmol/L	232	
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	220	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	106	
Phosphate, inorganic		12–60 yr	0.4–1.3 g/24 h	13–42 mmol/d	103	24 h-urine, on nonrestricted diet
			40–140 mg/dL	13–44 mmol/L	149	1st morning urine

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	61	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	149	24 h-urine
		20–80 mEq/L	20–80 mmol/L		1st morning urine
		25–125 mEq/24 h	25–125 mmol/24 h	304	24 h-urine
Protein	Adults	<15 mg/dL	<150 mg/L	128	Benzethonium chloride method, random urine
		<14 mg/dL	<140 mg/L	304	Turbidimetry, nephelometry, 24 h-urine
		<150 mg/24 h	<150 mg/d	220	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	149	24 h-urine
		54–190 mEq/L	54–190 mmol/L		1st morning urine
		40–220 mEq/24 h	40–220 mmol/24 h	304	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	236	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	304	24 h-urine
Uric acid	Adults	0.20–1.00 g/24 h	1.2–6.0 mmol/d	236	24 h-urine, concn. considerably diet-related
		37–92 mg/dL	2.2–5.5 mmol/L	149	1st morning urine, concn. considerably diet-related
Vanillylmandelic acid (VMA)	Adults	3.3–6.5 mg/24 h	18–33 µmol/d	302	

2.7 Urinary calculi, gallstones

Concrement	Major components	References
Gallstones	Bilirubin	98
	Calcium carbonate	
	Cholesterol	
Urinary calculi	Calcium hydrogen phosphate dihydrate	98
	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	

2.8 CSF

Analyte	Group	Reference Range Conventional	Reference Range SI	References	Notes
Albumin	Adults	110–350 mg/L	110–350 mg/L	212	
Albumin, CSF/serum ratio	Children ≤15 yr	5.0×10^{-3}	5.0×10^{-3}	211, 220	
	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	215	
	Adults	<3 leucocytes/μL	<3 mpt leucocytes/L		
Glucose	Children	60–80 mg/dL	3.33–4.44 mmol/L	220	
	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	212	
IgG	Adults	10–40 mg/L	66.7–266.8 nmol/L	212	
IgM	Adults	0.05–0.8 mg/L	0.05–0.8 nmol/L	212	
Lactate	Neonates	10–60 mg/dL	1.1–6.7 mmol/L	304	
	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	97	
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		

2.9 Stool

Analyte	Reference Ranges		Refe-rences	Notes
	Conventional	SI		
Albumin	<100 µg/fecal smear	<100 µg/fecal smear	186	
Blood	Not detectable	Not detectable	215	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	220	
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	215	
Copper	<46 µg/g stool	<0.72 µmol/g stool	53	
Lactoferrin	<2.4 µg/g stool	<2.4 µg/g stool	279	
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	261 233	 Normal Light to medium insufficiency Strong insufficiency
Weight	Adults 100–250 g/24 h	100–250 g/d	215	
Zinc	Adults <408 µg/g stool	<408 µg/g stool	53	

2.10 Spermiogram

Analyte	Reference Ranges	References
α-Glucosidase	> 20 mU/ejaculate	296
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	296
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	

2.11 Extravascular body fluids

Amniotic fluid

Analyte	Reference Ranges	Ref.
Albumin	< 3.0 g/L	39
Bicarbonate	11 – 45 mmol/L	
Bilirubin	< 0.1 mg/dL	
Calcium	0.86 – 2.57 mmol/L	
CEA	< 107 µg/L	62
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	62
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	62
Protein	< 4.0 g/L	39
Sodium	139 – 144 mmol/L	
Urea	12 – 32 mg/dL	

Ascites

Analyte	Reference Ranges		Ref.
	Nonmalignant	Malignant	
CEA	< 2.5 µg/L	> 2.5 µg/L	77
Cholesterol	< 45 mg/dL	> 45 mg/dL	
LDH	< 60 % of the serum LDH	> 60 % of the serum LDH	
Phospholipids	0.15 – 0.84 mmol/L	0.14 – 1.34 mmol/L	76
Protein	< 30 g/L	> 30 g/L	77
Triglycerides	14 – 164 mg/dL	17 – 849 mg/dL	76

Bile, clear colorless fluid

Analyte	Reference Ranges	Ref.
Bilirubin	< 1.3 mg/dL	277
Calcium	0.6 – 4.6 mmol/L	
Chloride	94 – 152 mmol/L	
Cholesterol	6 – 20 mg/dL	
Glucose	< 5 mg/dL	
Lysozyme	< 0.8 mg/L	91
Magnesium	< 0.2 mmol/L	277
Osmolality	1006 – 1019 mosmol/kg	
pH	6.64 – 8.46	
Phosphate, inorg.	< 1.0 mmol/L	
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	277
Bilirubin	9 – 77 mg/dL	
Calcium	2.3 – 4.9 mmol/L	
Chloride	80 – 144 mmol/L	
Cholesterol	123 – 209 mg/dL	
Color	yellow	
Glucose	< 8 mg/dL	277
Iron excretion	0.14 – 0.50 µmol/h	205
Magnesium	0.7 – 1.3 mmol/L	277
Osmolality	1016 – 1018 mosmol/kg	
pH	5.78 – 8.22	
Phosphate, inorg.	< 0.6 mmol/L	
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	

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		78
Potassium	4.2 – 11.0 mmol/L		
Sodium	97 – 153 mmol/L		
Amylase	after secretin stimulation	130 – 3400 U/min	227
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	208
Calcium		0.6 – 7.0 mmol/L	179
CEA		< 0.5 mg/L	32
Chloride	6 – 48 mth	84 – 119 mmol/L	3
	Adults	57 – 137 mmol/L	179
Citrate		3.3 – 6.5 mg/dL	202
Free acid		< 78 mmol/L	179
β-Glucosidase		< 5.0 mg/L	223
Lactate		1.9 – 3.7 mg/dL	202
LDH		< 35 U/L	223
Lysozyme		43 – 106 mg/L	91
Magnesium		0.5 – 3.2 mmol/L	179
Mucin		< 0.4 g/L	17
pH	6 – 48 mth	2.0 – 4.0	3
	Adults	1.6 – 2.4	208
Potassium	6 – 48 mth	10.7 – 14.2 mmol/L	3
	Adults	5.0 – 11.8 mmol/L	179
Pyruvate		0.5 – 0.8 mg/dL	191
Sodium	6 – 48 mth	60 – 69 mmol/L	3
	Adults	32 – 84 mmol/L	179
Urea		0.7 – 1.6 mg/dL	202
Uric acid		0.7 – 1.4 mg/dL	202

Lymph		
Analyte	**Reference Ranges**	**Ref.**
Albumin	12 – 42 g/L	280
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).

Milk, human

Analyte	Reference Ranges	Ref.
Calcium	7.2 – 8.4 mmol/L	71
Chloride	10.9 – 14.6 mmol/L	287
Cholesterol	7.0 – 9.5 mg/dL	29
Copper	197 – 751 µg/L	119
Folate	8 – 13 µg/dL	224
γ-GT	1300 – 8300 U/L	198
Iron	0.20 – 1.71 mg/L	119
Lactose	62 – 78 g/L	287
Lysozyme	55 – 75 mg/L	91
Magnesium	1.4 – 1.7 mmol/L	71
Phosphate, inorg.	4.0 – 4.9 mmol/L	71
Phospholipids	5.5 – 12.3 mg/dL	29
Potassium	10.6 – 13.0 mmol/L	71
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	224
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	64
Glucose	< 10 mg/dL	143
β_2-Microglobulin	not detectable	64
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	214
Bicarbonate		> 70 mmol/L	
Chymotrypsin		28 – 154 U/min	
Lipase		780 – 3500 U/min	
Potassium		3 – 10 mmol/L	168
Protein		0.2 – 1.0 g/L	304
Trypsin		56 – 335 U/min	214
Volume		> 1.6 mL/min	214

Peritoneal fluid

Analyte	Reference Ranges	Ref.
Amylase	88 – 109 U/L	92
Creatinine	0.5 – 2.0 mg/dL	171
D-dimer	< 0.77 mg/L	282
Urea	3 – 27 mg/dL	171
Volume	1 – 9 mL	292

Pleural fluid

Analyte	Reference Ranges		Ref.
	Transsudate	Exsudate	
LDH	< 200 U/L	> 200 U/L	170
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		284
pH	7.07 – 7.71		284
Protein	1.0 – 2.0 g/dL		30
Albumin	50 – 70 % of protein		
Volume	0.1 – 0.2 mL/kg body weight		

Saliva			
Analyte	**Reference Ranges**		**Ref.**
	Parotid saliva	**Submandibular saliva**	
Calcium	1.5 – 2.5 mmol/L		178
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	74
Potassium	14 – 26 mmol/L		178
Protein	0.7 – 21 g/L	0.3 – 5.5 g/L	14
Sodium	10 – 54 mmol/L		178
	Mixed saliva		
Albumin	246 – 344 mg/L		87
ALP	< 11 U/L		210
Ammonium	1.1 – 12.0 mmol/L		117
Amylase	11 900 – 304 700 U/L		210
Calcium	0.88 – 2.05 mmol/L		210
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		210
Cortisol morning	3 – 43 nmol/L		220
evening	< 10 nmol/L		220
Creatinine	0.07 – 0.20 mg/dL		134
Glucose	< 2 mg/dL		
GOT	< 43 U/L		210
GPT	< 11 U/L		
IgA	42 – 174 mg/L		87
LDH	113 – 609 U/L		210
Lysozyme	6 – 12 mg/L		91
Magnesium	0.08 – 0.56 mmol/L		
Osmolality	52 – 111 mosmol/kg		
pH	6.42 – 7.41		210
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		245
Urea	17 – 41 mg/dL		210
Uric acid	0.7 – 6.0 mg/dL		210

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	169
Lactate		21 – 57 mmol/L	243
Lysozyme		0.06 – 0.14 mg/L	
α_1-Microglobulin		6 – 34 µg/L	99
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	260
Uric acid		0.2 – 0.7 mg/dL	260
Volume		500 mL/24 h	86

Synovial fluid		
Analyte	**Reference Ranges**	**Ref.**
C_{3C}	0.23 – 0.77 mg/dL	27
Cell count	< 800/µL	231
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.	234
Interleukin-1β	< 1.5 pg/mL	5
Lactate	equal to plasma	234
LDH	< 240 U/L	234
pH	7.3 – 7.6	51
Protein	< 25 g/L	234
Salts	no	
Segmented granulocytes	< 10 %	
Serotonin	< 0.5 nmol/L	5
Uric acid	equal to serum	234
Volume	nearly 3.5 mL	234

Tears		
Analyte	**Reference Ranges**	**Ref.**
Albumin	14 – 26 mg/L	176
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	176
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	175
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

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:

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 MDRD (Modification of Diet in Renal Disease) study

Males:

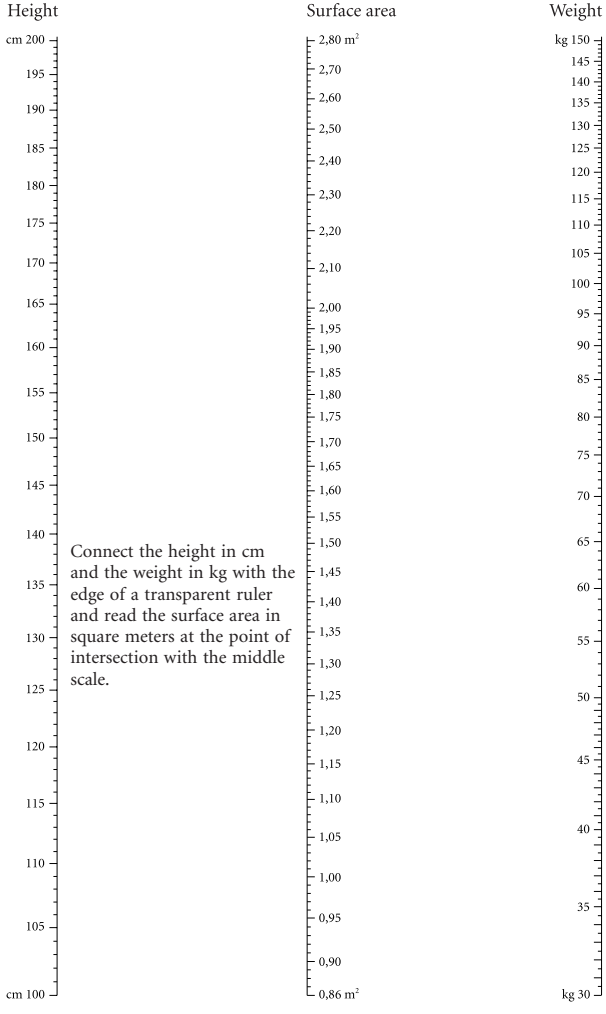
$C_{cr} = 186 \times S^{-1.154} \times age^{-0.203}$ (mL/min)

Females:

$C_{cr} = 186 \times S^{-1.154} \times age^{-0.203}$ (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)



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.

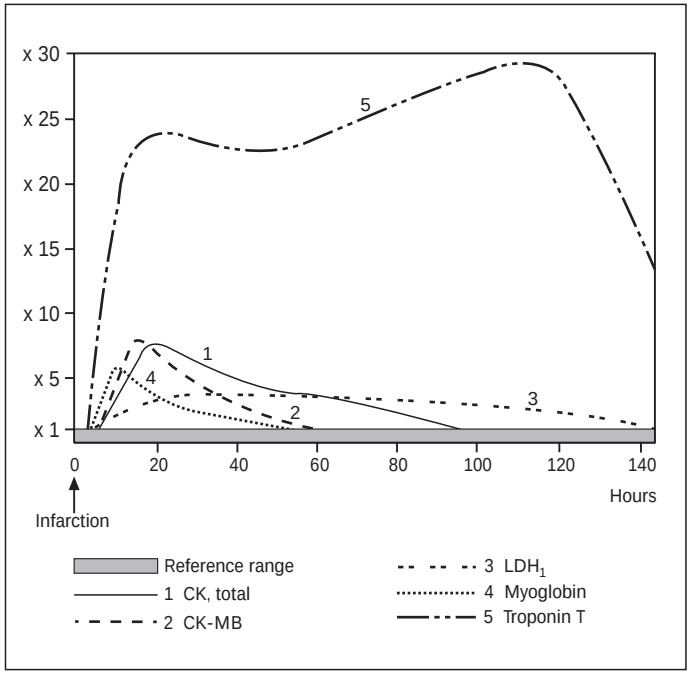
For children with 4 – 30 kg body weight (225):
A serum D-xylose concentration of > 20 mg/dL (> 1.33 mmol/L) after a period of 1 hour.

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.

3.2 Lipids

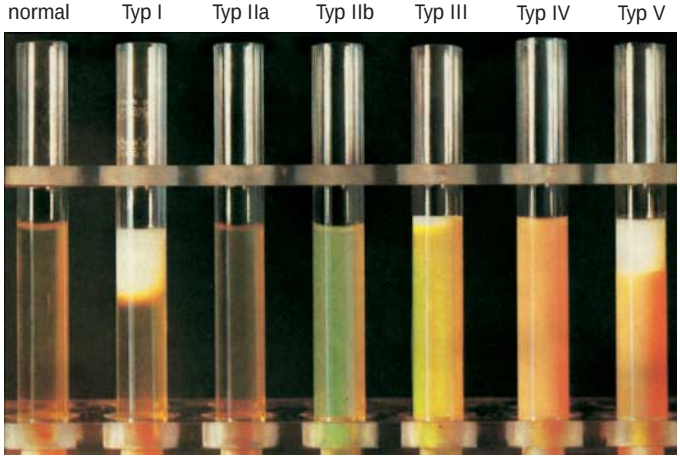
1. The composition of lipoproteins

	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

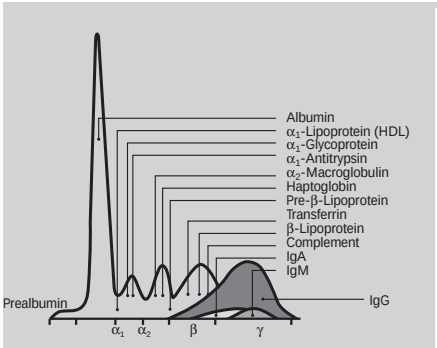
2. Classification of hyperlipoproteinemias according to FREDRICKSON

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

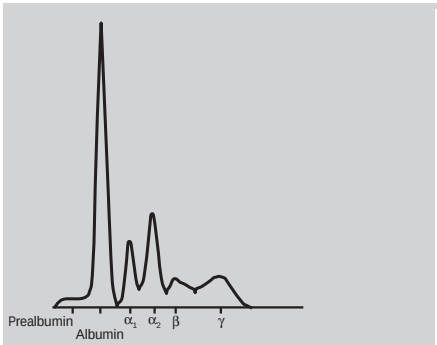
3. Appearance of fasting sera at different classes of hyperlipoproteinemia according to FREDRICKSON



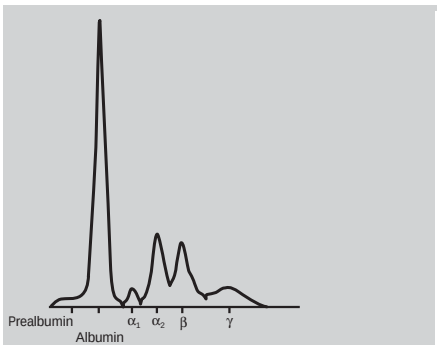
3.3 Electrophoretic patterns of plasma proteins



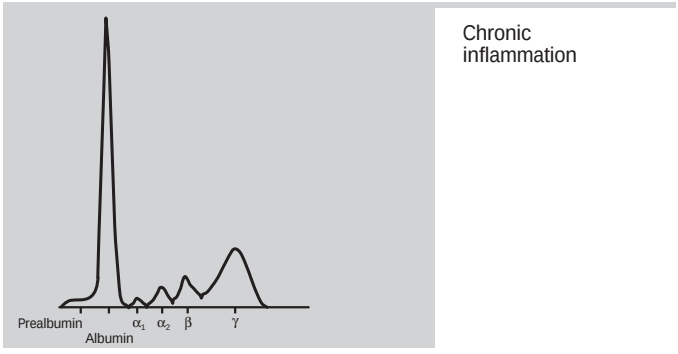
Protein electrophoresis of healthy persons



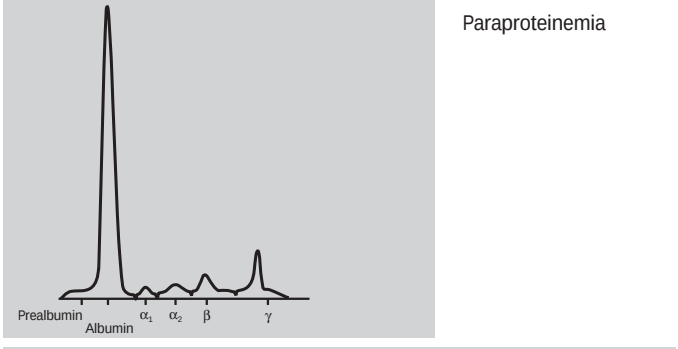
Acute inflammation



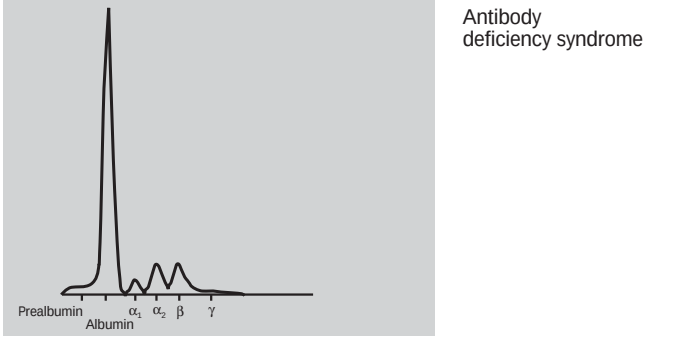
Nephrotic syndrome



Chronic inflammation

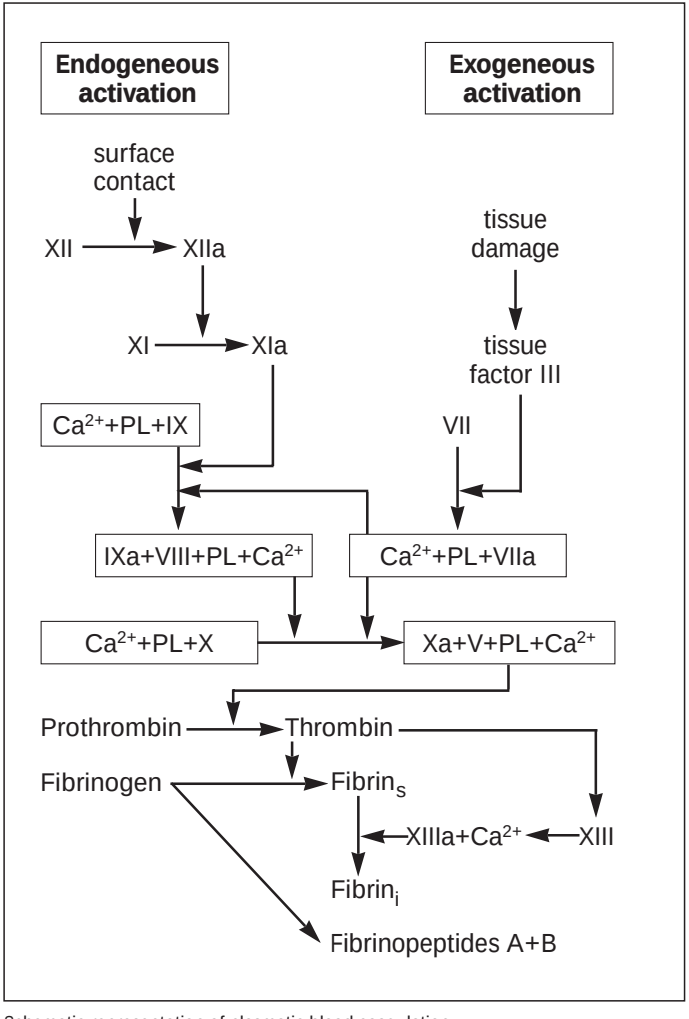


Paraproteinemia



Antibody deficiency syndrome

3.4 Schematic representation of blood coagulation



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

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)

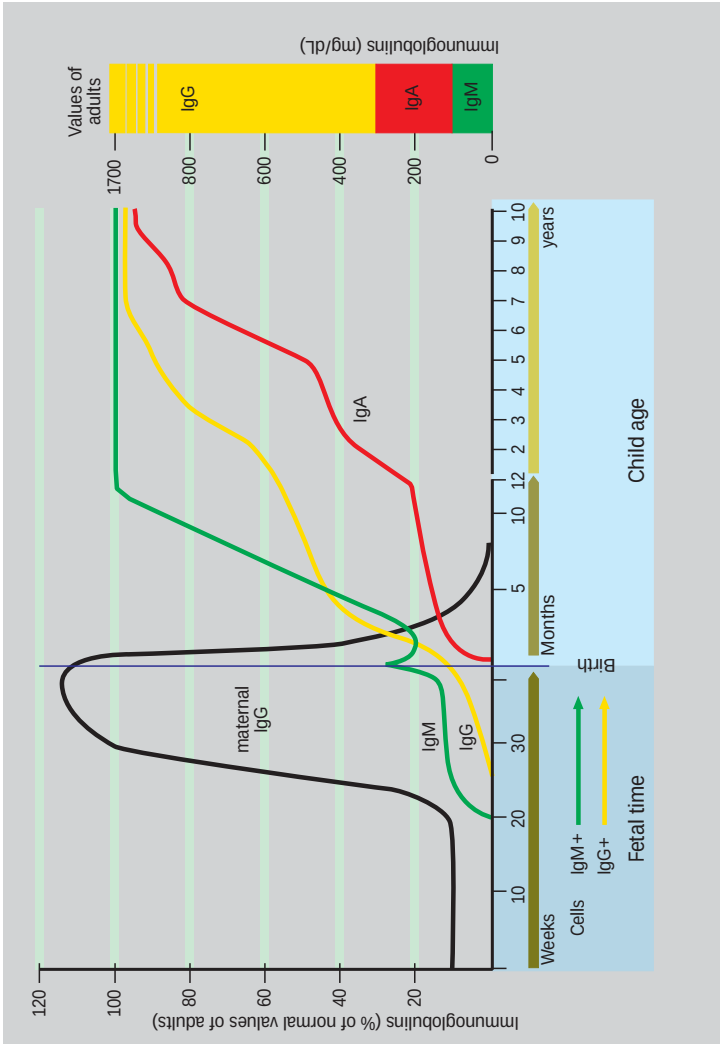
Lupus anticoagulants (primary finding: prolonged aPTT)

Reduced fibrinolytic potential (rare):

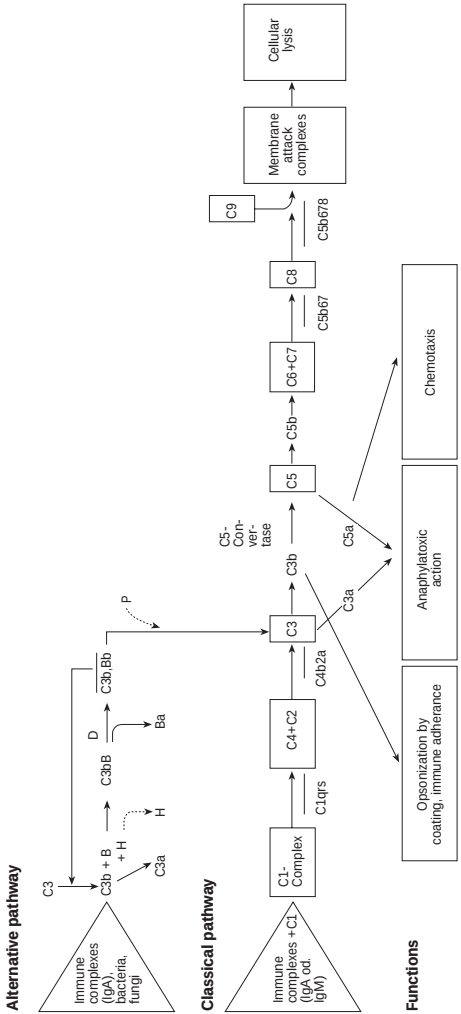
- Plasminogen deficiency
- Decreased plasminogen activator (t-PA) concentrations
- Elevated plasminogen activator Inhibitor I (PAI-I) concentrations

Congenital dysfibrinogenemia (rare)

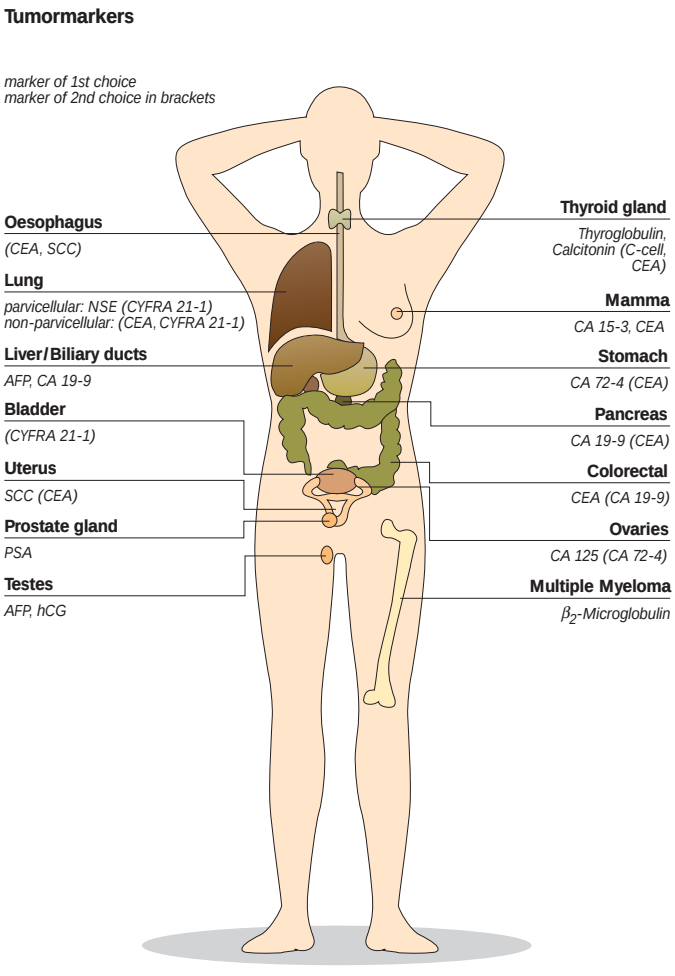
3.6 Age dependence of immunoglobulin synthesis



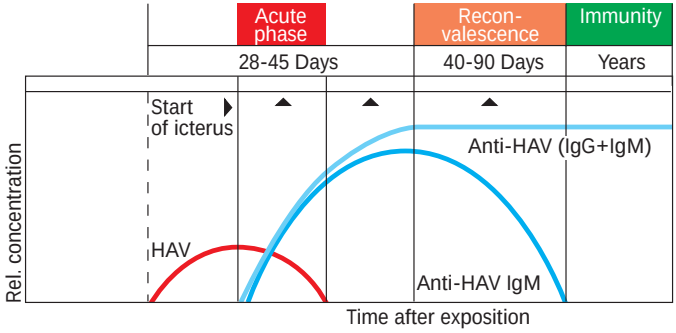
3.7 Complement system, classical and alternative mechanism



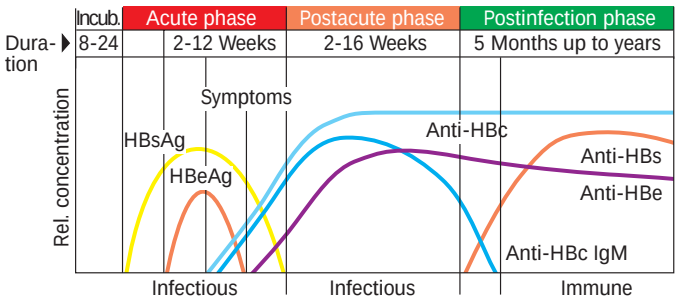
3.8 Tumor markers



3.9 Serological diagnosis of hepatitis A and B

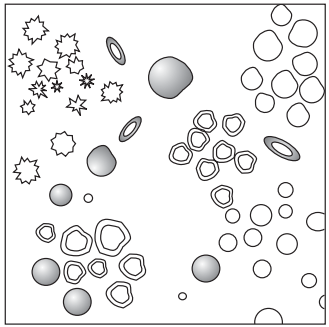


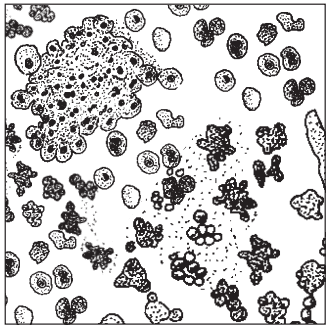
Progress of a hepatitis A infection

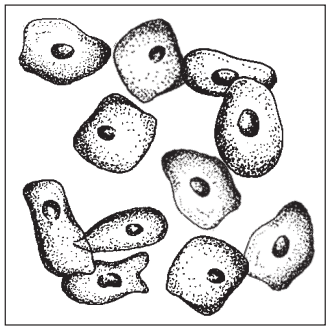


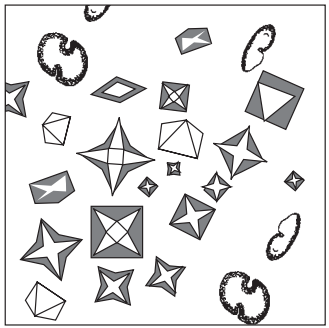
Progress of a hepatitis B infection

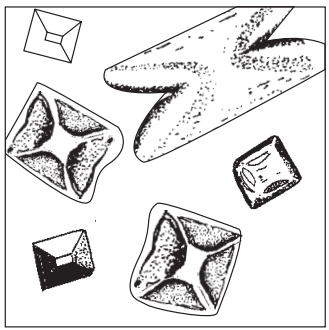
3.10 Urinary sediment





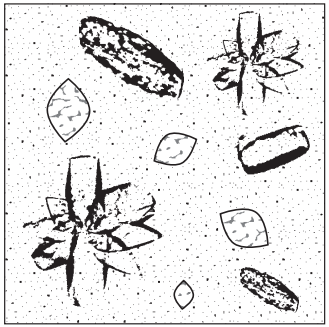


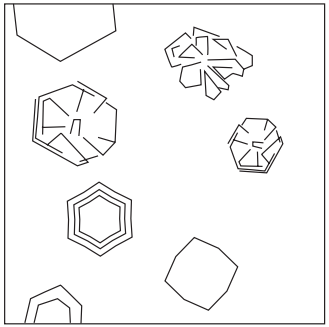


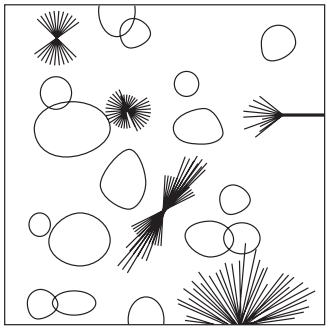


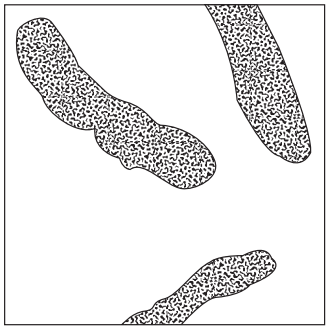
Diagnostically relevant findings in urinary sediment:

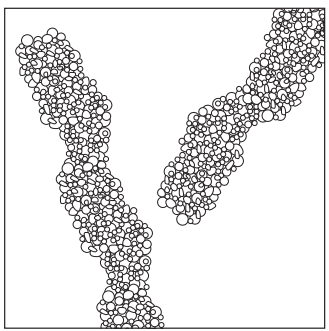
upper left:	erythrocytes
upper right:	leucocytes
middle left:	epithelial cells
middle right:	calcium oxalate
lower left:	ammonium-magnesium phosphate (tripelphosphate)







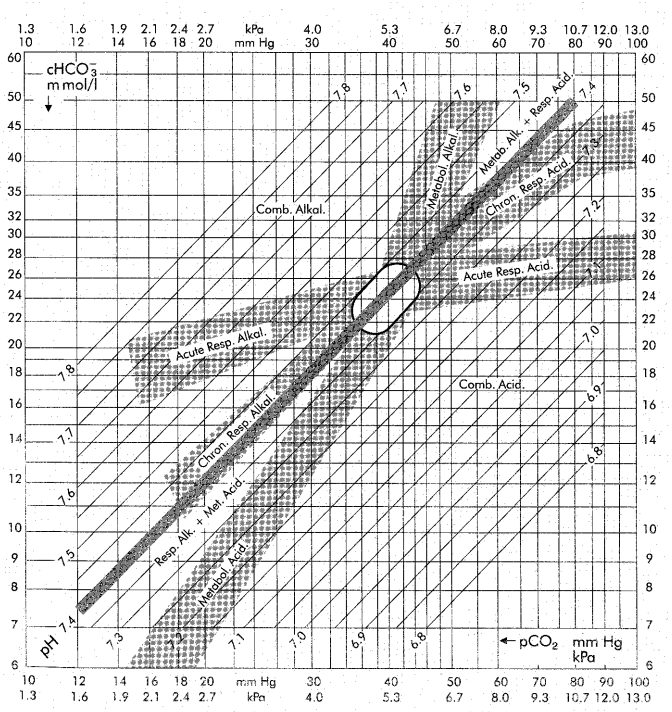




Diagnostically relevant findings in urine sediment:

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

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	µg/dL	0.587 / 1.703	µmol/L
AMP, 3′-5′-cyclic	mg/dL	3.04 / 0.329	nmol/L
α_1-Antitrypsin	ng/mL	0.184 / 5.435	µmol/L

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	mg/dL	0.282 / 3.545	mmol/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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Creatinine	mg/dL	88.4 / 0.0113	μmol/L
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
Dehydroepiandrosteron 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	ng/L	6.54 / 0.153	pmol/L
Dopamine/U	μg/24 h	6.54 / 0.153	nmol/d
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Estriol (E3)	ng/mL	3.47 / 0.288	nmol/L
Ethanol	mg/dL	0.217 / 4.608	mmol/L
Ethosuximide	mg/L	7.08 / 0.141	μmol/L
α_1-Fetoprotein (AFP)	ng/mL	1.21 / 0.83	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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Glucose	mg/dL	0.0555 / 18.02	mmol/L
Glycerol	mg/dL	0.109 / 9.209	mmol/L
Haptoglobin	mg/dL	0.01 / 100	g/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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
IgE	mg/mL	0.42 / 2.4	IU/mL
IgG	g/L	6.67 / 0.150	µmol/L
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Magnesium/U	mg/24 h	0.0411 / 24.31	mmol/d
Magnesium/U	mg/g crea	0.00465 / 215	mol/mol crea
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Parathyrin (para-thyroid hormone, PTH)	ng/L	0.106 / 9.43	pmol/L
pCO_2	mm Hg	0.133 / 7.502	kPa
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Prealbumin	mg/dL	0.182 → / ← 5.495	µmol/L
Primidone	mg/L	4.58 → / ← 0.218	µmol/L
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Sodium/U	g/g crea	4.90 → / ← 0.204	mol/mol crea
Soluble transferrin receptor (sTfR)	mg/L	11.8 → / ← 0.085	nmol/L
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
Urea/U	g/g crea	1.883 → / ← 0.531	mol/mol crea
Uric acid	mg/dL	59.5 → / ← 0.0168	µmol/L
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

Analyte/Parameter	Conventional Units	Conversion Factors	SI Units
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

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		

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 Immunoglobulin D Immunoglobulin E Immunoglobulin G Immunoglobulin M	17 d 11 d 17 d	8 mth 6 mth 6 mth 8 mth 6 mth	8 mth 7 d 7 d 8 mth 4 mth	8 mth 7 d 7 d 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 6 d	3 d 6 d	Mannose/fluoride, oxalate/monoiodo acetate with deproteinization	Deproteinization recommended

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)

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

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 thromboplastin 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 centrifugation
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		

References

1 Abicht K, El-Samalouti V, Junge W, Kroll M, Luthe H, Treskes M, et al. Multicenter evaluation of new liquid GGT and ALP reagents with new reference standardization and determination of reference intervals. Clin Chem Lab Med 2001; 39 (Special Suppl.): S346 (abstract).

2 Abicht K, Heiduk M, Korn S, Klein G. Lipase, p-amylase, CRP-HS and creatinine: Reference intervals from infancy to childhood. Clin Chem Lab Med 2003; 41 (Special Suppl): S205 (abstract).

3 Adamson I, Esangbedo A, Abiodun P. Pepsins in protein-energy malnutrition. Enzyme 1988; 39: 44-9.

4 Albisetti M. The fibrinolytic system in children. Semin Thromb Hemost 2003; 29: 339-47.

5 Alstergren P, Kopp S, Theodorsson E. Synovial fluid sampling from the temporomandibular joint: sample quality criteria and levels of interleukin-1β and serotonin. Acta Odontol Scand 1999; 57: 16-22.

6 Al-Tamer YY, Hadi EA. Age dependent reference intervals of glucose, urea, protein, lactate and electrolytes in thermally induced sweat. Eur J Clin Chem Clin Biochem 1994; 32: 71-7.

7 Amiral J, Adalbert B, Adam M. Application of enzyme immunoassays to coagulation testing. Clin Chem 1984; 30: 1512-6.

8 Amiral J, Plassart V, Minard F. Measurement and clinical relevance of D-dimer by ELISA.

In: Müller-Berghaus G, Scheefers-Borchel U, Sedlmayr E, Henschen A, eds. Proceedings of the fibrinogen workshop, Gießen. Amsterdam: Excerpta Medica, 1986: 285-90.

9 Amiral J, Trebaol IF, Adam M. ELISA evaluation of beta-thromboglobulin and platelet factor 4. Meeting of the Danubian League against Thrombosis and Hemorrhagic Diseases, Istanbul, 1985. (S972, abstract).

10 Amiral J, Walenga IM, Fareed I. Development and performance characteristics of a competitive enzyme immunoassay for fibrinopeptide A. Semin Thromb Hemost 1984; 10: 28-42.

11 Andrew M, Paes B, Milner R, Johnston M, Mitchell L, Tollefsen DM, et al. Development of the human coagulation system in the full-term infant. Blood 1987; 70: 165-72.

12 Andrew M, Paes B, Milner R, Johnston M, Mitchell L, Tollefsen DM, et al. Development of the human coagulation system in the healthy premature infant. Blood 1988; 72: 1651-7.

13 Andrew M, Vegh P, Johnston M, Bowker J, Ofosu F, Mitchell L. Maturation of the hemostatic system during childhood. Blood 1992; 80: 1998-2005.

14 Arglebe C. Altersunterschiede von Flußrate, Gesamtprotein, IgA und drei Enzymen (Amylase, Kallikrein, saure Phosphatase) im stimulierten Parotis- und Submandibularisspeichel von Normalpersonen. In: Haeckel R, ed. Speicheldiagnostik. Darmstadt: GIT 1988: 13-32.

15 Armstrong GP, Barker AN, Patel H, Hart HH. Reference interval for troponin I on the ACS: Centaur assay: a recommendation based on the redefinition of myocardial infarction. Clin Chem 2002; 48: 198-9.

16 Aufenanger J, Kattermann R. Lipid- und Lipoproteinstoffwechsel. In: Greiling H, Gressner AM, eds. Lehrbuch der Klinischen Chemie und Pathobiochemie. Stuttgart, New York: Schattauer; 1995: 300-60.

17 Azuumi Y, Ichikawa T, Ishihara K, Hotta K. The validity of the ethanol precipitation method for the measurement of mucin content in human gastric juices and its possible relationship to gastroduodenal diseases. Clin Chim Acta 1993; 221: 219-25.

18 Bais R, Philcox M. Approved recommendations on IFCC methods for the measurement of catalytic concentration of enzymes. Part 8: IFCC method for lactate dehydrogenase. Eur J Clin Chem Clin Biochem 1994; 32: 639-55.

19 Barbas C, Herrera E. Lipid composition and vitamin E content in human colostrum and mature milk. J Physiol Biochem 1998; 54: 167-74.

20 Barthels M, Poliwoda H. Gerinnungsanalysen, 5th ed. Stuttgart, New York: Thieme, 1997.

21 Bates CJ. Vitamin analysis. Ann Clin Biochem 1997; 34: 599-626.

22 Baum H, Hinze A, Bartels P, Neumeier D. Reference values for cardiac troponin T and I in healthy neonates. Clin Biochem 2004; 37: 1079-82.

23 Becker S, Traber L, Schmidt-Gayk H. Free and peptide-bound pyridinium crosslinks in urine measured in healthy people, patients with bone metastases and women after menopause. In: Schmidt-Gayk H, Blind E, Roth HJ, eds. Calcium regulating hormones and markers of bone metabolism: measurement and interpretation. Heidelberg: Clin Lab Publications, 1997: 141-6.

24 Bednar R, Bayer PM. Freies Hämoglobin im Plasma - Vergleich zweier spektralphotometrischer Methoden. Bilirubin als Störfaktor. Laboratoriumsmedizin 1994; 18: 196-9.

25 Begemann H, Begemann M. Praktische Hämatologie, 9th ed. Stuttgart, New York: Thieme, 1989.

26 Belda J, Leigh R, Parameswaran K, O'Byrne PM, Sears MR, Hargreave FE. Induced sputum cell counts in healthy adults. Am J Respir Crit Care Med 2000; 161: 475-8.

27 Bergmann KC, Kulka B, Geiler G. Quantitative Bestimmung von IgA, IgM, IgG und C_3 in Extrakten der Synovialis mit der Laser-Nephelometrie. Dt Gesundh Wesen 1979; 34: 1387-8.

28 Bergmeyer HU, Gruber W, Gutmann I. D-Sorbit. In: Bergmeyer HU, ed. Methoden der enzymatischen Analyse. Weinheim: Verlag Chemie 1974: 1368-75.

29 Blaauwen DH, Poppe W, Tritschler W. Cholinesterase mit Butyrylthiocholinjodid als Substrat: Referenzwerte in Abhängigkeit von Alter und Geschlecht unter Berücksichtigung hormonaler Einflüsse und Schwangerschaft. J Clin Chem Clin Biochem 1983; 21: 381-6.

30 Boggs DS, Kinasewitz GT. Review: pathophysiology of the pleural space. Am J Med Sci 1995; 309: 53-9.

31 Bonnefont JP, Specola NB, Vassault A, Lombes A, Olgier H, de Kierk JB, et al. The fasting test in pediatrics: application to the diagnosis of pathological hypo- and hyperketotic states. Eur J Pediatr 1990; 150: 80-5.

32 Borch K, Renvall H, Lundin C, Wahren B. Evaluation of gastric carcinoembryonic antigen analysis as an aid during screening for gastric neoplasia in atrophic gastritis. Gut 1987; 28: 26-32.

33 Boulat O, Krieg MA, Janin B, Burckhardt P, Francioli P, Bachmann C. Clinical chemistry variables in normal elderly and healthy ambulatory populations: comparison with reference values. Clin Chim Acta 1998; 272: 127-35.

34 Boyer-Neumann C, Bertina RM, Tripodi A, D'Angelo A, Wolf M, Vigano-D'Angelo S, et al. Comparison of functional assays for protein S. European collaborative study of patients with congenital and acquired deficiency. Thromb Haemost 1993; 70: 946-50.

35 Brusilow SW, Gordes EH. Ammonia secretion in sweat. Am J Physiol 1968; 214: 513-7.

36 Büchler M, Malfertheiner P, Uhl W, Beger HG. Diagnostic and prognostic value of serum elastase 1 in acute pancreatitis. Klin Wochenschr 1986; 64: 1186-91.

37 Büscher U, Hertwig K, Dudenhausen JW. Nachweis von Erythropoietin im Fruchtwasser. Geburtsh u Frauenheilk 1996; 56: 243-7.

38 Burkhardt H, Wepler R, Rommel K. Indikationen zur Hydroxyprolinbestimmung im Urin. Dtsch Med Wschr 1976; 101: 1394-7.

39 Campbell J, Wathen N, Macintosh M, Cass P, Chard T, Mainwaring-Burton R. Biochemical composition of amniotic fluid and extra-embryonic coelomic fluid in the first trimester of pregnancy. Br J Obstet Gynaecol 1992; 99: 563-5.

40 Canalis E, Reardon GE, Caldarella AM. A more specific, liquid-chromatographic method for free cortisol in urine. Clin Chem 1982; 28: 2418-20.

41 Castor CW, Prince RK, Hazelton MJ. Hyaluronic acid in human synovial effusions; a sensitive indicator of altered connective tissue cell function during inflammation. Arthritis Rheum 1966; 9: 783-94.

42 Chemnitz G, Schmidt E, Koller PU, Busch EW. Kreatinkinase. Dtsch Med Wschr 1979; 104: 257-60.

43 Chiang CS, Kowalski AJ. cAMP radioimmunoassay without interference from calcium or EDTA. Clin Chem 1982; 28: 150-2.

44 Christ R, Winsel K. Beitrag zur differenzierten Diagnostik chyloser Pleuraergüsse. Z Erkrank Atm Org 1978; 151: 160-6.

45 Cioffi M, Corradino M, Gazzerro P, Vietri MT, Di Macchia C, Contursi A, et al. Serum concentrations of intact parathyroid hormone in healthy children. Clin Chem 2000; 46: 863-4.

46 Cleeman JI. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001; 285: 2486-97.

47 Colombo JP, Peheim E. Physikalische und chemische Untersuchung, Schnelltests (Teststreifen and andere). In: Colombo JP, Hrsg. Klinisch-chemische Urindiagnostik. Rotkreuz: Labolife, 1994; 53-85.

48 Contant G, Nicham F, Martinoli IL. A new functional assay for pai activity based on the use of a viperidae venom. Thromb Haemost 1991; 65: 1266.

49 Cook JF, Hicks JM, Godwin ID, Bailey J, Soldin ST. Pediatric reference ranges for prolactin. Clin Chem 1992; 38: 959.

50 Cremer P, Nagel D, Mann H, Labrot B, Müller-Berninger R, Elster H, et al. Ten-year follow-up results from the Goettingen Risk, Incidence and Prevalence Study (GRIPS). I. Risk factors for myocardial infarction in a cohort of 5790 men. Atherosclerosis 1997; 129: 221-30.

51 Cummings NA, Nordby GL. Measurement of synovial fluid pH in normal and arthritic knees. Arthritis Rheum 1966; 9: 47-56.

52 Da Fonseca-Wollheim F, Heinze K, Lomsky K, Schreiner H. Serum ultrafiltration for the elimination of endogenous interfering substances in creatinine determination. J Clin Chem Clin Biochem 1988; 26: 523-5.

53 Dastych M. Zur Bestimmung von Kupfer und Zink im Stuhl. Ärztl Lab 1990; 36: 330-3.

54 Dati F, Ringel KP. Reference values for serum IgE in healthy non-atopic children and adults. Clin Chem 1982; 28: 1556.

55 Davis ML, Austin C, Messmer BL, Nichols WK, Bonin AP, Bennett MI. IFCC standardized pediatric reference intervals for 10 proteins using the Beckman Array 360 system. Clin Biochem 1996; 29: 489-92.

56 Deller A, Stenz R, Forstner K. Kohlenmonoxid-Hämoglobin bei Rauchern und präoperative Rauchkarenz. Dtsch Med Wschr 1991; 116: 48-51.

57 DeMott WR, Tilzer LL. Hematology. In: Jacobs DS, Demott WR, Finley PR, Horvat RT, Kasten BL, Tilzer LL, eds. Laboratory test handbook, 3rd ed. Hudson, OH: Lexi-Comp Inc., 1994; 517-626.

58 Dhariwal KR, Hartzell WO, Levine M. Ascorbic acid and dehydroascorbic acid measure-

ments in human plasma and serum. Am J Clin Nutr 1991; 54: 712-6.

59 Diener U, Knoll E, Ratge D, Wisser H. Determination of urinary catecholamines by HPLC and amperometric detection. J Clin Chem Clin Biochem 1981; 19: 27.

60 Diedrich K, Hepp S, Welker H, Krebs D, Beutler HO, Michal G. Die enzymatische Lecithinbestimmung im Fruchtwasser zur Beurteilung der fetalen Lungenreife. Geburtsh Frauenheilk 1979; 39: 849-56.

61 Doss M. Haematological disturbances of porphyrin metabolism. In: Gross R, Hellriegel KP, eds. Strategy in clinical hematology. Recent results in cancer research, Vol. 69. Heidelberg: Springer, 1976; 97-109.

62 Drohse H, Christensen H, Myrhoj V, Sorensen S. Characterization of non-maternal serum proteins in amniotic fluid at week 16 to 18 of gestation. Clin Chim Acta 1998; 276: 109-20.

63 Du Bois D, Du Bois EF. A formula to estimate the approximate surface area if height and weight be known. Arch Intern Med 1921; 17: 863-71.

64 Eichner H, Behbehani AA, Hochstraler K. Nasensekretdiagnostik – aktueller Stand – Normalwerte. Laryng Rhinol Otol 1983; 62: 561-5.

65 Elliot BA, Wilkinson JH. The serum α-hydroxybutyrate dehydrogenase in diseases other than myocardial infarction. Clin Sci 1963; 24: 343-55.

66 European Atherosclerosis Society. Prevention of coronary heart disease: scientific background and new clinical guidelines. Nutr Metab Cardiovasc Dis 1992; 2: 113-56.

67 European Diabetes Epidemiology Study Group. Will new diagnostic criteria for diabetes mellitus change phenotype of patients with diabetes? Reanalysis of European epidemiological data. Br Med J 1998; 317: 371-5.

68 Falck M, Stenmans B, Rick W. Die Bestimmung der Aluminiumkonzentration in Körperflüssigkeiten. Internist 1989; 30: 686-94.

69 Fischbach F, Zawta B. Age-dependent reference limits of several enzymes in plasma at different measuring temperatures. Klin Lab 1992; 38: 555-61.

70 Fischer M, Falkensammer C. Hepato-Quick – ein neues Thromboplastinzeitsystem im Vergleich zu Normotest und Thrombotest. Wien Klin Wschr 1974; 86: 577-83.

71 Fly AD, Uhlin KL, Wallace JP. Major mineral concentrations in human milk do not change after maximal exercise testing. Am J Clin Nutr 1998; 68: 345-9.

72 Fujii H, Miwa S. Pyruvate kinase. Assay in serum and erythrocytes. In: Bergmeyer HU, ed. Methods of enzymatic analysis, Vol. 3. Weinheim: Verlag Chemie, 1983; 496-501.

73 Gallistl S, Muntean W, Leschnik B, Meyers W. Longer aPTT values in healthy children than in adults: no single cause. Thromb Res 1997; 88: 355-9.

74 Ganong WF. Lehrbuch der Medizinischen Physiologie. Berlin: Springer, 1979; 742.

75 Garnero P, Gineyts E, Arbault P, Christiansen C, Delmas PD. Different effects of bisphosphonate and estrogen therapy on free and peptide-bound bone cross-links excretion. J Bone Miner Res 1995; 10: 641-9.

76 Gerbes AL, Jüngst D, Paumgartner G. Differentialdiagnostische Wertigkeit der Lipidbestimmung im Aszites. Z Gastroenterologie 1985; 23: 312-3.

77 Gerbes AL, Paumgartner G. Diagnostik des Aszites. Dtsch Med Wschr 1994; 119: 1507-11.

78 Goebell H, Bode C, Horn HD. Einfluß von Secretin and Pankreozymin auf die Calciumsekretion im menschlichen Duodenalsaft bei normaler und gestörter Pankreasfunktion. Klin Wschr 1970; 48: 1330-9.

79 Gozzo ML, Noia G, Barbaresi G, Colacicco L, Serraino A, De Santis M, et al. Reference intervals for 18 clinical chemistry analytes in fetal plasma samples between 18 and 40 weeks of pregnancy. Clin Chem 1998; 44: 683-5.

80 Grabner W, Bergner D, Wermuth G. Mikrozonenelektrophoresen auf Membranfolien. Ärztl Lab 1970; 16: 193-201.

81 Graham SS, Traub B, Mink IB. Automated platelet-sizing parameters on a normal population. Am J Clin Pathol 1987; 87: 365-9.

82 Granerus G, Aurell M. Reference values for 51-Cr-EDTA clearance as a measure of glomerular filtration rate. Scand J Clin Lab Invest 1981; 41: 611-6.

83 Gruhl H, Gilek U. Cadmiumkonzentration im Blut und renale Cadmiumausscheidung bei nierengesunden and nierenkranken Patienten. Ärztl Lab 1987; 33: 186-90.

84 Guder WG, Narayanan S, Wisser H, Zawta B. The quality of diagnostic samples. Discette distributed with the book: Guder WG, Narayanan S, Wisser H, Zawta B. Samples from the patient to the laboratory, 3rd ed. Weinheim: Wiley, 2003.

85 Gustafsson F, Badskjaer J, Steensgard Hansen F, Poulsen AH, Hildebrandt P. Value of N-terminal proBNP in the diagnosis of left ventricular systolic dysfunction in primary care patients referred for echocardiography. Heart Drug 2003; 3: 141-6.

86 Haeckel R, Hänecke P. The application of saliva, sweat and tear fluid for diagnostic purposes. Ann Biol Clin 1993; 50: 903-10.

87 Haeckel R, Walker RF, Colic C. Reference ranges for mixed saliva collected from the literature. J Clin Chem Clin Biochem 1989; 27: 249-52.

88 Hafner G, Ehrenthal W. Universitätsklinik Mainz. Personal communication, 2001.

89 Hafner G, Endler T, Oppitz M, Merten UP, Töpfer G, Dubois H, Hallstein A, Hilger B, Domke I. Effects of standardization with the new international reference preparation for proteins in human serum on method comparability and reference values. Clin Lab 1995; 41: 743-8.

90 Hafner G, Marx M, Müller C, Klein G. Evaluation of a homogenous immunoassay on BM/Hitachi analyzers for the determination of myoglobin. Clin Chem 1996; 42: S165.

91 Hankiewicz J, Swierczek E. Lysozyme in human body fluids. Clin Chim Acta 1974; 57: 205-9.

92 Hannon ZJ, Guzick DS. Tubal pregnancy: significance of serum and peritoneal fluid α-amylase. Obstet Gynecol 1985; 66: 395-7.

93 Hauswaldt C, Schröder U. Differentialblutbilder im EDTA-Blut. Dtsch Med Wschr 1973; 98: 2391-7.

94 Heil W, Grunewald R, Amend M, Heins M. Influence of time and temperature on coagulation analytes in stored plasma. Clin Chem Lab Med 1998; 36: 459-62.

95 Heil W, Heins M, Withold W, Schossow B, Reinauer H. Influence of storage time and temperature on haematological quantities. Eur J Clin Chem Clin Biochem 1995; 33: A82.

96 Heil W, Jachtmann A, Rick W. Zur Reproduzierbarkeit der Ergebnisse des oralen Glucose-Toleranz-Tests. Laboratoriumsmedizin 1990; 14: 440-4.

97 Heil W, Rick W. Lactatbestimmung im Liquor cerebrospinalis zur Differenzierung zwischen bakterieller und viraler Meningitis. Internist 1984; 25: 320-4.

98 Heil W, Rick W. Konkrementanalysen mit Hilfe der Infrarotspektroskopie. Internist 1988; 29: 818-23.

99 Heinrich HG, Adler D, Jung K, Jaroß H, Rose W. Vergleichende Untersuchungen der Konzentrationen von α_1-Mikroglobulin, β_2-Mikroglobulin und Lysozym im Serum, Urin, Schweiß und Speichel bei Gesunden und Nierenkranken. Clin Lab 1991; 37: 377-81.

100 Heins M, Heil W, Grunewald R, Amend M, Withold W, Reinauer H. Preanalytical influence on haemostaseological quantities. Eur J Clin Chem Clin Biochem 1995; 33: A83.

101 Heins M, Heil W, Withold W. Storage of serum or whole blood samples? Effects of time and temperature on 22 serum analytes. Eur J Clin Chem Clin Biochem 1995; 33: 231-8.

102 Heins M, Withold W, Heil W, Fahron U, Perez A, Kullmann W, et al. Influence of nutrition on cardiovascular risk factors. Eur J Clin Chem Clin Biochem 1995; 33: A83.

103 Henry RJ, Cannon DC, Winkelman JW. Clinical chemistry. Principles and techniques. Hagerstown MD: Harper and Row, 1974; 1268.

104 Herbeth B, Siest G, Henny J. High sensitivity C-reactive protein (CRP) reference intervals in the elderly. Clin Chem Lab Med 2001; 39: 1169-70.

105 Herrmann W, Quast S, Ullrich M, Schultze H, Geisel J. The importance of hyperhomocysteinemia in high age people. Clin Lab 1997; 43: 1005-9.

106 Hesse A, Nolde A, Scharrel O. Qualitätsstandard der Urinanalytik zur Nachsorge beim Harnsteinleiden. Klin Lab 1992; 38: 605-10.

107 Hesse R, Tritschler W, Castelfranchi G, Bablok W. Antithrombin III: Referenzwerte mit einem chromogenen Substrat (Chromozym TH). Blut 1981; 42: 227-34.

108 Hicks JM, Bailey J, Bjorn S, Beatey J, Soldin SJ. Pediatric reference ranges for plasma magnesium. Clin Chem 1995; 41: S93.

109 Hicks JM, Cook J, Godwin ID, Soldin SJ. Vitamin B_{12} and folate. Pediatric reference ranges. Arch Pathol Lab Med 1993; 117: 704-6.

110 Hildebrandt G, Gilch G, Gries G. Eine einfache Methode zur routinemäßigen Bestimmung von Vitamin A und Vitamin E im Serum mit HPLC. Laboratoriumsmedizin 1984; 8: 191-3.

111 Hill RM, Terry JE. Human tear cholesterol levels. Arch Opht 1976; 36: 155-60.

112 Hjorth L, Helin I, Grubb A. Age-related reference limits for urine levels of albumin, orosomucoid, immunoglobulin G and protein HC in children. Scand J Clin Lab Invest 2000; 60: 65-74.

113 Hofmann W. Kleinkonferenz „Proteinurie". DG Klinische Chemie Mitt 1991; 22: 78-84.

114 Hoppe B, Jahnen A, Bach D, Hesse A. Urinary calcium oxalate saturation in healthy infants and children. J Urol 1997; 158: 557-9.

115 Hubbuch A. Ergebnisse der multizentrischen Ermittlung vorläufiger Referenzbereiche für Albumin im Urin bei Kindern und Erwachsenen. Wien Klin Wschr 1990; Suppl 189: 48-9.

116 Hubl W. Aldosterone. In: Bergmeyer HU, ed. Methods of enzymatic analysis, 3rd ed., Weinheim: Verlag Chemie, 1985; Vol 3: 256-66.

117 Huizenga JR, Gips CH. Determination of ammonia in saliva using indophenol, an ammonium electrode and an enzymatic method: a comparative investigation. J Clin Chem Clin Biochem 1982; 20: 571-4.

118 Ising H, Bertschat F, Gunther T, Jeremias E, Jeremias A. Measurement of free magnesium in blood, serum and plasma with an ion-sensitive electrode. Eur J Clin Chem Clin Biochem 1995; 33: 365-71.

119 Iyengar V, Wolttiez J. Trace elements in human clinical specimens: evaluation of literature data to identify reference values. Clin Chem 1988; 34: 474-81.

120 Jager J, Tromp A, Hooymans JMM, Reitsma WD, Smit AJ. Reproducibility of vitreous fluorophotometry in patients with type 1 diabetes mellitus. Ophthalmologica 1997; 211: 209-13.

121 Jelkmann W, Wolff M. Bestimmung der Erythropoietin-Aktivität im Serum. Dtsch Med Wschr 1991; 116: 230-4.

122 Johnson TR. How growing up can alter lab values. Diagnostic Medicine (special issue) 1982; 5: 13-8.

123 Jolley RL, Warren KS, Scott CD, Jainchill JL, Freeman ML. Carbohydrates in normal urine and blood serum as determined by high resolution column chromatography. Am J Clin Pathol 1970; 53: 793-802.

124 Josephson B, Gyllensward C. The development of the protein fractions and of cholesterol concentration in the serum of normal infants and children. Scand J Clin Lab Invest 1957; 9: 29-38.

125 Junge W, Abicht K, Goldman J, Luthe HC, Niederau CH, Parker J, et al. Multicentric evaluation of the colorimetric liquid assay for pancreatic lipase on Hitachi analyzers. Clin Chem Lab Med 1999; 37 (Special Suppl.): 499 (abstract).

126 Junge W, Sold G, Wilke B, Halabi A, Klein G. Determination of reference intervals for serum creatinine, creatinine excretion and creatinine clearance with an enzymatic and a modified Jaffé method. Clin Chim Acta 2004; 344: 137-48.

127 Junge W, Troge B, Klein G, Poppe W, Gerber M. Evaluation of a new assay for pancreatic amylase: Performance characteristics and estimation of reference intervals. Clin Biochem 1989; 22: 109-14.

128 Junge W, Wilke B, Halabi A, Jarausch J, Klein G. Reference intervals in collected and random urine using the benethonium chloride method. Clin Chem 2006; 52: A157 (abstract).

129 Junge W, Wilke B, Halabi A, Matouk H, Klein G, Lehmann P. Determination of reference intervals in adults for hemoglobin A_{1c}

(HbA_{1c}). Clin Chem Lab Med 2003; 41 (Special Suppl.): S254 (abstract).

130 Kaiser H, Sold G, Dittmann H, Gründler U, Rumpf KW, Schrader J, et al. Myoglobin im Serum: Referenzwerte und Klinik. Lab Med 1981; 5: 283-9.

131 Kaplan EL, Rothermel CD, Johnson DR. Antistreptolysin O and anti-desoxyribonuclease B titers: normal values for children age 2 to 12 in the United States. Pediatrics 1998; 101: 86-8.

132 Katus HA, Looser S, Hallermayer K, Remppis A, Scheffold T, Borgya A, et al. Development and in vitro characterization of a new immunoassay of cardiac Troponin T. Clin Chem 1992; 38: 386-93.

133 Keil E, Fiedler H. Klinische Chemie systematisch. Bremen: Unimed 2000; 106.

134 Keller H. Klinisch-chemische Labordiagnostik für die Praxis, 2nd ed. Stuttgart, New York: Thieme; 1991.

135 Keller RP, Neville MC. Determination of total protein in human milk: comparison of methods. Clin Chem 1986; 32: 120-3.

136 Kim H, Park C, Jang WI, Lee KH, Kwon SO, Robey-Cafferty SS, et al. The gastric juice urea and ammonia levels in patients with Campylobacter pylori. Am J Clin Pathol 1990; 94: 187-91.

137 Klauke R, Schmidt E, Lorentz K. Recommendations for carrying out standard ECCLS procedures (1988) for the catalytic concentrations of creatinine kinase, aspartate aminotransferase, alanine aminotransferase and γ-glutamyltransferase at 37 °C. Eur J Clin Chem Clin Biochem 1993; 31: 901-9.

138 Klein G, Berger A, Bertholf R, Braun S, Brockett M, Cottenceau D, et al. Multicenter evaluation of liquid reagents for CK, CK-MB and LDH with determination of reference intervals on Hitachi systems. Clin Chem 2001; 47: A30 (abstract).

139 Klein G, Heiduk M, Paege I, Kliem C. Reference intervals for ALAT, ASAT, ALP, GGT, LDH, sTfR, and ferritin from infancy to childhood. Clin Chem 2005; 51 (6): A118 (abstract).

140 Kleine TO, Baerlocher K, Niederer V, Keller H, Reutter F, Tritschler W, et al. Diagnostische Bedeutung der Lactatbestimmung im Liquor bei Meningitis. Dtsch Med Wschr 1979; 104: 553-7.

141 Kleine TO, Stroh J. Fehlermöglichkeiten bei der Aufstellung von Normbereichen der Liquorproteine: Erfahrungen mit einer neuen Mikroelektrophorese für nativen Lumballiquor. Verh Dtsch Ges Inn Med 1975; 81: 631-6.

142 Kolbe-Busch S, Lotz J, Hafner G, Blanckaert NJC, Claeys G, Togni G, et al. Multicenter evaluation of a fully mechanized soluble transferrin receptor assay on the Hitachi and Cobas Integra analyzers. The determination of reference ranges. Clin Chem Lab Med 2002; 40: 529-36.

143 Kosoy J, Trieff NM, Winkelmann P, Bailey BJ. Glucose in nasal secretions. Arch Otolaryng 1972; 95: 255-9.

144 Krafte-Jacobs B, Williams J, Soldin SJ. Plasma erythropoietin reference ranges in children. J Pediatr 1995; 126: 601-3.

145 Kratovil T, DeBerardinis J, Gallagher N, Luban NLC, Soldin SJ, Wong ECC,. Age specific re-

ference intervals for soluble transferrin receptor (sTfR). Clin Chim Acta 2007; 380: 222-4.

146 Kratz A, Lewandrowski B. Normal reference laboratory values. N Engl J Med 1988; 339 (15): 1063-72.

147 Kratzsch J, Fiedler GM, Leichtle A, Brügel M, Buchbinder S, Otto L, et al. New reference intervals for thyrotropin and thyroid hormones based on national academy of clinical biochemistry criteria and regular ultrasonography of the thyroid. Clin Chem 2005; 51: 1480-6.

148 Krause U, Beyer J, Cordes U. Serum C-Peptid – ein neuer Parameter in der Diabetesdiagnostik. Laboratoriumsmedizin 1978; 2: 43-6.

149 Krieg M, Gunßer KJ. Vergleichende quantitative Analytik klinisch-chemischer Kenngrößen im 24-Stunden-Urin und Morgenurin. J Clin Chem Clin Biochem 1986; 24: 863-9.

150 Kruse K, Kracht U, Wohlfart K, Kruse U. Intaktes Serum-Parathormon (PTH 1-84). Dtsch Med Wschr 1988; 113: 283-8.

151 Kruse-Jarres JD, Rukgauer M, Schmitt Y, Beck P, Bauerle-Bubeck A, Moser V, et al. Simultane AAS-Bestimmung von Selen und Zink im Blut und seinen zellularen Bestandteilen, demonstriert am Beispiel der oligoanurischen Niereninsuffizienz. Laboratoriumsmedizin 1995; 19: 117-27.

152 Kühnle HF, Dahl D, Schmidt FH. Die enzymatische Bestimmung von Lactat und β-Hydroxybutyrat. J Clin Chem Clin Biochem 1977; 15: 171.

153 Landon J, Fawcett JK, Wynn V. Blood pyruvate concentration measured by a specific method in control subjects. J Clin Path 1962; 15: 579-84.

154 Langlois MR, Martin ME, Boelaert JR, Beaumont C, Taes YE, de Buyzere ML, et al. The haptoglobin 2-2 phenotype affects serum markers of iron status in healthy males. Clin Chem 2000; 46: 1619-25.

155 Largo R, Heller V, Straub PW. Detection of soluble intermediates of the fibrinogen-fibrin conversion using erythrocytes coated with fibrin monomers. Blood 1976; 47: 991-1002.

156 Ledue TB, Weiner DL, Sipe JD, Poulin SE, Collins MF, Rifai N. Analytical evaluation of particle-enhanced immunonephelometric assays for C-reactive protein, serum amyloid A and mannose-binding protein in human serum. Ann Clin Biochem 1998; 35: 745-53.

157 Lembcke B, Caspary WF. Wasserstoff (H_2) Exhalationstest in der gastrointestinalen Funktionsdiagnostik – apparative und methodische Aspekte. Laboratoriumsmedizin 1982; 6: 261-4.

158 Livesey JF, Donnelly JG, Ooi DS. HPLC screening method for cystinuria. Clin Chem 1996; 42: 1714-6.

159 Lloyd JE, Broughton A, Selby C. Salivary creatinine assays as a potential screen for renal diseases. Ann Clin Biochem 1996; 33: 428-31.

160 Lockitch G. Trace elements in pediatrics. J IFCC 1996; 9: 46-51.

161 Lokitch G, Halstead AC, Quigley G, MacCallum C. Age- and sex-specific pediatric reference intervals: study design and methods illustrated by measurement of serum proteins with the Behring LN nephelometer. Clin Chem 1988; 34: 1618-21.

162 Loraine JA, Bell ET. Hormone assays and their clinical application. Livingstone: Churchill, 1976.

163 Lorentz K, Klauke R, Schmidt E. Recommendations for the determination of the catalytic concentration of lactate dehydrogenase at 37 °C. Eur J Clin Chem Clin Biochem 1993; 31: 897-9.

164 Lorentz K, Lübeck G, Siekmann L. Einführung der neuen Standardmethoden 1994 zur Bestimmung der katalytischen Enzymkonzentrationen bei 37 °C. DGKC Mitteilungen 1995; 26 (6): 290-3.

165 Lotz J, Hafner G, Prellwitz W. Reference values for a homogeneous ferritin assay and traceability to the 3rd international recombinant standard for ferritin (NIBSC Code 94/572). Clin Chem Lab Med 1999; 37: 821-5.

166 Lyon ME, Ball CL, Slotsve GA, Krause R. Pediatric reference ranges for troponin T. Clin Biochem 2004; 37: 470 (abstract).

167 Mackinnon S, Walker ID, Davidson JF, Walker JJ. Fibrinolytic activity in the healthy newborn infant at term. Fibrinolysis 1987; 1: 117-20.

168 Maeder HU. Das Kaliummangel-Syndrom. Fortschr Med 1977; 95: 471-6.

169 Mähr G, Neumann P, Georgi K. Der Glucosegehalt von Speichel und Schweiß bei Gesunden und Diabetikern. Med Klinik 1968; 63: 209-11.

170 Magnussen H. Diagnostik und Therapie beim Pleuraerguß. Dtsch Ärztebl 1987; 84: B2169-76.

171 Manahan KJ, Fanning J. Peritoneal fluid urea nitrogen and creatinine reference values. Obstet Gynecol 1999; 93: 780-2.

172 Mason KE. A conspectus of research on copper metabolism and requirements of man. J Nutr 1979; 109: 1979-2066.

173 Mazzachi BC, Peake MJ, Ehrhardt V. Reference range and method comparison studies for enzymatic and Jaffé creatinine assays in plasma and serum and early morning urine. Clin Lab 2000; 46: 53-5.

174 Meiers HG, Lissner R, Mawlawi H, Brüster H. Hämopexinspiegel bei Männern und Frauen in verschiedenen Lebensaltern. Klin Wschr 1974; 52: 453-4.

175 Meijer F, van Haeringen NJ. Comparison of three techniques for the determination of protein content in human tears. Clin Chim Acta 1992; 209: 209-14.

176 Meillet D, Hoang PL, Unanue F, Kapel N, Diemert MC, Rousselie F, et al. Filtration and local synthesis of lacrimal proteins in acquired immunodeficiency syndrome. Eur J Clin Chem Clin Biochem 1992; 30: 319-23.

177 Meisner M. Procalcitonin: Erfahrungen mit einer neuen Meßgröße für bakterielle Infektionen und systemische Inflammation. Laboratoriumsmedizin 1999; 23: 263-72.

178 Menstell S, Maier H, Adler D, Deeg M. Sialochemische Untersuchungen beim Morbus Sjögren. Laryngo Rhino Otol 1990; 69: 320-1.

179 Mertz DP, Poppe W, Poser G. Über die maximale osmotische Konzentrierung des Magensaftes. Klin Wschr 1968; 46: 85-93.

180 Mezzena G, Giavarina D, Dorrizi RM, Soffiati G. Reference interval of D-dimer in pregnant women. Clin Chem 2000; 46: A130 (abstract).

181 Miles J, Riches P. The determination of IgG subclass concentrations in serum by enzyme-linked immunosorbent assay: establishment of age-related reference ranges for cord blood samples, children aged 5-13 years and adults. Ann Clin Biochem 1994; 31: 245-8.

182 Moalic P, Gruel Y, Body G, Foloppe P, Delahousse B, Leroy J. Levels and plasma distribution of free and C4b-BP-bound protein S in human fetuses and full-term newborns. Thromb Res 1988; 49: 471-80.

183 Moll S, Dietz R. Quick-Wert und INR. Dtsch Ärztebl 1999; 96: C-2114-5.

184 Müller B. Quantitative determination of lysozyme, methods and normal values. Proc 5th Int Symp Clin Enzymol, Venice 1973; abstract no 4.40: 53.

185 Müller-Plathe O. Säure-Basen-Gleichgewicht und Blutgase. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt: TH Books Verlagsgesellschaft, 2005; 468-79.

186 Nakayama T, Yasuoka H, Kishino T, Ohguchi H, Takada M. ELISA for occult faecal albumin. Lancet 1987; no. 8546: 1368-9.

187 Neumann S, Gunzer G, Hennrich N, Lang H. "PMN-elastase assay": enzyme immuno-assay for human polymorphonuclear elastase complexed with alpha 1-proteinase inhibitor. J Clin Chem Clin Biochem 1984; 22: 693-7.

188 Neumeier D. Herz- und Skelettmuskulatur. In: Greiling H, Gressner AM, eds. Lehrbuch der Klinischen Chemie und Pathobiochemie, 3rd ed. Stuttgart, New York: Schattauer, 1995; 768-803.

189 Newcomer AD, Mc Gill DB, Thomas PJ, Hofmann AF. Prospective comparison of indirect methods for detecting lactase deficiency. N Engl J Med 1975; 293: 1232-6.

190 Nilsson-Ehle H, Jagenburg H, Landahl S, Svanborg A, Westin J. Haematological abnormalities and reference intervals in the elderly. Acta Med Scand 1988; 224: 595-604.

191 Norlund L, Fex G, Lanke J, von Schenck H, Nilsson JE, Leksell H, et al. Reference intervals for the glomerular filtration rate and cell proliferation markers: serum cystatin C and serum β_2-microglobulin/cystatin C-ratio. Scand J Clin Lab Invest 1997; 57: 463-70.

192 Nowak-Gottl U, Funk M, Mosch G, Wegerich B, Kornhuber B, Breddin HK. Univariate tolerance regions for fibrinogen, antithrombin III, protein C, protein S, plasminogen and α_2-antiplasmin in children using the new automated coagulation laboratory (ACL) method. Klin Padiatr 1994; 206: 437-9.

193 Nowak-Gottl U, Kreuz WD. 13 Parameter der Gerinnung und Fibrinolyse – hämostaseologische univariate pädiatrische Normbereiche. Monatsschr Kinderheilkd 1991; 139: 403-8.

194 Oellerich M. Pharmaka (Drug monitoring). In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt: TH Books Verlagsgesellschaft. 2005; 1552-68.

195 Oh MS, Carroll HJ. The anion gap. N Engl J Med 1977; 297: 814-7.

196 Parentoni LS, de Faria EC, Bartelega MJLF, Moda VMS, Facin ACC, Castilho LN. Glycated hemoglobin reference limits obtained by high performance liquid chromatography in adults and pregnant women. Clin Chim Acta 1998; 274: 105-9.

197 Parkins FM, Tinanoff N, Moutinho M, Anstey MB, Waziri MH. Relationships of human plasma fluoride and bone fluoride to age. Calcif Tiss Res 1974; 16: 335-8.

198 Patil KP, Rangnekar NR. γ-Glutamyltransferase activity in human milk. Clin Chem 1982; 28: 1724-5.

199 Peled Y, Doron O, Laufer H, Bujanover Y, Gilat T. D-Xylose absorption test – urine or blood? Dig Dis Sci 1991; 36: 188-92.

200 Peters M, Jansen E, Ten Cate JW, Kahle LH, Ockelford P, Breederveld C. Neonatal antithrombin III. Br J Haemat 1984; 58: 579-87.

201 Pilz W. Cholinesterasen. In: Bergmeyer HU, ed. Methoden der enzymatischen Analyse. Weinheim: Verlag Chemie, 1974; 862-83.

202 Piper DW, Fenton BH, Goodman LR. Lactic, pyruvic, citric, and uric acid and urea content of human gastric juice. Gastroenterology 1967; 53: 42-8.

203 Polack B, Pouzol P, Amiral J, Kolodie L. Protein C level at birth. Thromb Haemost 1984; 52: 188-90.

204 Prellwitz W, Kapp S, Dennebaum R. Methodische Untersuchungen und klinische Bedeutung des Blutammoniaks. Med Welt 1976; 27: 1277-80.

205 Raedsch R, Stiehl A, Walker S, Theilmann L, Kommerell B, Waldherr R, et al. Biliary excretion of iron in healthy man and in patients with alcoholic cirrhosis of the liver. Clin Chim Acta 1990; 193: 49-54.

206 Randers E, Krue S, Erlandsen EJ, Danielsen H, Hansen LG. Reference interval for serum cystatin C in children. Clin Chem 1999; 45: 1856-8.

207 Ratge D, Baumgardt G, Knoll E, Wisser H. Plasma free and conjugated catecholamines in diagnosis and localisation of pheochromocytoma. Clin Chim Acta 1983; 132: 229-43.

208 Rathbone BJ, Johnson AW, Wyatt JI, Kelleher J, Heatley RV, Losowsky MS. Ascorbic acid: a factor concentrated in human gastric juice. Clin Sci 1989; 76: 237-41.

209 Rauh M, Koch A. Plasma N-terminal pro-B-type natriuretic peptide concentration in a control population of infants and children. Clin Chem 2003; 49: 1563-4.

210 Rehak NN, Cecco SA, Csako G. Biochemical composition and electrolyte balance of "unstimulated" whole human saliva. Clin Chem Lab Med 2000; 38: 335-43.

211 Reiber H. External quality assessment in clinical neurochemistry: survey of analysis for cerebrospinal fluid (CSF) proteins based on CSF/serum quotients. Clin Chem 1995; 41: 256-63.

212 Reiber H. Liquordiagnostik. In: Thomas L. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 1743-84.

213 Remaley AT, Wilding P. Macroenzymes: biochemical characterization, clinical significance, and laboratory detection. Clin Chem 1989; 35: 2261-70.

214 Rick W. Der Secretin-Pankreozymin-Test in der Diagnostik der Pankreasinsuffizienz. Internist 1970; 11: 110-7.

215 Rick W. Klinische Chemie und Mikroskopie, 6th ed. Berlin, Heidelberg, New York: Springer, 1990.

216 Ries M, Klinge J, Rauch R. Age-related reference values for activation markers of the coagulation and fibrinolytic systems in children. Thromb Res 1997; 85: 341-4.

217 Riesen WF. Fettstoffwechsel. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 225-48.

218 Rizzotti P, Klein G. Evaluation of a specific immunoinhibition method for the determination of pancreatic α-amylase. Eur J Clin Chem Clin Biochem 1994; 32: 97-106.

219 Roberts WL, McMillin GA, Burtis CA, Bruns DE. Reference information for the clinical laboratory. In: Burtis CA, Ashwood ER, Bruns DE, eds. Tietz textbook of clinical chemistry and molecular diagnostics, 4th ed. St. Louis, MO: Elsevier Saunders, 2006: 2251-318.

220 Roche Diagnostics GmbH. Package inserts/ method sheets.

221 Roche Diagnostics GmbH. Reference intervals for children and adults. Elecsys® thyroid tests. Brochure, 2008.

222 Rodger RSC, Laker MF, Fletcher K, White TP, Heaton A, Ward MK, et al. Factors influencing normal reference intervals for creatinine, urea and electrolytes in plasma, as measured with a Beckman Astra 8 analyzer. Clin Chem 1985; 31: 292-5.

223 Rogers K, Roberts GM, Williams GT. Gastric juice enzymes – an aid in the diagnosis of gastric cancer? Lancet 1981; 1124-5.

224 Rodriguez-Palmero M, Koletzko B, Kunz C, Jensen R. Nutritional and biochemical properties of human milk: II. Clin Perinatol 1999; 26: 335-59.

225 Rolles CJ, Kendall MJ, Nutter S, Anderson CM. One-hour blood-xylose screening-test for coeliac disease in infants and young children. Lancet 1973; 2: 1043-5.

226 Rosalki SB, Ying Foo A, Burlina A, Prellwitz W, Stieber P, Neumeier D, et al. Multicenter evaluation of iso-ALP test kit for measurement of bone alkaline phosphatase activity in serum and plasma. Clin Chem 1993; 39: 648-52.

227 Rosemeyer D, Brackmann P, Bablok W, Poppe W, Zawta B. Diagnostik der chronischen Pankreatitis – Untersuchungen im Duodenalsaft nach Stimulation mittels Sekretin-Ceruletid-Test – Entscheidungsgrenzen und Bewertung verschiedener Meßgrößen. Wien Klin Wschr 1992; 104: 272-80.

228 Rükgauer M. Spurenelemente. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/ Main: TH-Books, 2005; 480-504.

229 Rustad P, Felding P, Franzson L, Kairisto V, Lahti A, Märtensson A, et al. The Nordic Reference Interval Project 2000: recommended reference intervals for 25 common biochemical properties. Scand J Clin Lab Invest 2004; 64: 271-84.

230 Sakata T, Yamamura T, Kario K, Katayama Y, Matsuyama T, Kato H, et al. Age- and sex related differences of plasma activated factor VII levels in children. Thromb Haemost 1999; 81: 910-2.

231 Salive ME, Jones CA, Guralnik JM, Agodoa LY, Pahor M, Wallace RB. Serum creatinine levels in older adults: relationship with health status and medications. Age Ageing 1995; 24: 142-50.

232 Schaller KH, Breininger M, Schiele R, Schierling P. Der Quecksilberspiegel für Blut und Urin bei Normalpersonen. Ärztl Lab 1983; 29: 325-34.

233 Scheefers-Borchel U, Scheefers H, Arnold R, Fischer P, Sziegoleit A. Pankreatische Elastase 1: Parameter für die chronische und akute Pankreatitis. Laboratoriumsmedizin 1992; 16: 427-32.

234 Schilling E. Gelenkpunktate: Synovia-Analyse in der Praxis. Diagnostik 1985; 18: 31-5.

235 Schlebusch H, Liappis N, Kalina E, Klein G. High sensitive CRP and creatinine: Reference intervals from infancy to childhood. J Lab Med 2002; 26: 341-6.

236 Scholer A. Niedermolekulare Bestandteile des Urins. In: Colombo JP, ed. Klinisch-chemische Urindiagnostik, Rotkreuz: LABOLIFE-Verlagsgesellschaft, 1994; 165-87.

237 Schramel P, Lill G, Hasse S. Mineral- und Spurenelemente im menschlichen Urin. J Clin Chem Clin Biochem 1985; 23: 293-301.

238 Schreiner H, Göbel-Schreiner B, Durst C, Casper R, Walch S. Homocysteine: reference values. Clin Lab 1997; 43: 1121-4.

239 Schumann G, Dati F. Vorläufige Referenzbereiche für 14 Proteine im Serum (für Erwachsene) nach Standardisierung immunchemischer Methoden unter Bezug auf das internationale Referenzmaterial CRM 470. Laboratoriumsmedizin 1995; 19: 401-3.

240 Schumann G, Klauke R. New IFCC reference procedures for the determination of catalytic activity concentrations of five enzymes in serum: preliminary upper reference limits obtained in hospitalized subjects. Clin Chim Acta 2003; 327: 69-79.

241 Schwartz MK, Bethune VG, Bach DL, Woodbridge JE. New assay for measuring phosphohexose isomerase activity. Clin Chem 1971; 17: 656-7.

242 Schwinger R, Antoni DH, Guder WG. Simultaneous determination of magnesium and potassium in lymphocytes, erythrocytes and thrombocytes. J Trace Elem Electrolytes Health Dis 1987; 1: 89-98.

243 Seeling W, Grunert A, Kienle KH, Opferkuch R, Swobodnik M. Bestimmung von Chrom in menschlichem Serum und Plasma mit der flammenlosen Atomabsorptions-Spektrophotometrie. Fresenius Z Anal Chem 1979; 299: 368-74.

244 Seim H, Thomas L. Carnitin. In: Thomas L. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 273-80.

245 Shieh CC, Chang SC, Tzeng CR, Huang JJ, Svendstrup Nielsen L, Svanegaard J, Klitgaard Nir WJ, Hong CY. Measurement of testosterone in seminal plasma, saliva and serum by solid-phase enzyme immunoassay. Andrologia 1987; 19: 614-21.

246 Siggaard-Andersen O, Thode J, Wandrup J. The concentration of free calcium ions in the blood plasma "Ionized calcium". Copenhagen: IFCC Expert Panel on pH and Blood Gases, Workshop, 1980; 163-90.

247 Sitzmann FC. Normalwerte. München: Hans Marseille, 1986.

248 Soldin SJ, Bailey J, Beatey J, Bjorn S, Hicks JM. Pediatric reference ranges for iron on the Hitachi 747 analyzer. Clin Chem 1999; 45: A22 (abstract).

249 Soldin SJ, Brugnara C, Wong EC. Pediatric reference ranges, 4th ed. Washington, DC: AACC Press; 2003.

250 Soldin SJ, Hicks JM, Godwin ID, Beatey J, Bailey J, Cook IF. Pediatric reference ranges for alpha-fetoprotein. Clin Chem 1992; 38: 959-60.

251 Soldin SJ, Hunt C, Hicks JM. Pediatric reference ranges for phosphorus on the Vitros 500 analyzer. Clin Chem 1999; 45: A22-23.

252 Souberbielle JC, Fayol V, Sault C, Lawson-Body E, Kahan A, Cormier C. Assay-specific decision limits for two new automated para-

thyroid hormone and 25-hydroxyvitamin D assays. Clin Chem 2005; 51 (2): 395-400.

253 Spanuth E, Amiral J. Diagnostische Validität eines neuen Latex-Agglutinationstests zur Bestimmung von Fibrin(ogen)-Spaltprodukten (FDP-Test). Laboratoriumsmedizin 1984; 8: 347-50.

254 Stadil F, Rehfeld IF. Determination of gastrin in serum. Scand J Gastroent 1973; 8: 101-12.

255 Sthoeger D, Nardi M, Karpatkin M. Protein S in the first year of life. Br J Haemat 1989; 72: 424-8.

256 Szasz G. γ-Glutamyltranspeptidase. In: Bergmeyer HU, ed. Methoden der enzymatischen Analyse. Weinheim: Verlag Chemie, 1974; 757-62.

257 Takamiya O, Kinoshita S, Niinomi K, Yoshioka K. Protein C in the neonatal period. Haemostasis 1989; 1: 45-50.

258 Talke H, Schubert GE. Enzymatische Harnstoffbestimmung im Blut und Serum im optischen Test nach Warburg. Klin Wschr 1965; 43: 174-5.

259 Talmage RV, Cooper CW, Toverdu SU. The physiological significance of calcitonin. J Bone Mineral Res 1983; 1: 74-143.

260 Taylor RP, Polliack AA, Bader DL. The analysis of metabolites in human sweat: analytical methods and potential application to investigation of pressure ischaemia of soft tissues. Ann Clin Biochem 1994; 31: 18-24.

261 Terbrack HG, Gürtler KH, Hüls G, Bittner-Dersch P, Klör HU, Lindemann H. Human-spezifische fäkale Pankreaselastase bei Kindern. Monatsschr Kinderheilkd 1996; 144: 901-5.

262 The expert committee on the diagnosis and classification of diabetes mellitus: Report of the expert committee on the diagnosis and classification of diabetes mellitus. Diabetes Care 1997; 20: 1183-97.

263 Thefeld W, Hoffmeister H, Busch EW, Koller PU, Vollmar J. Normalwerte der Serumharnsäure in Abhängigkeit von Alter und Geschlecht mit einem neuen enzymatischen Harnsäurefarbtest. Dtsch Med Wschr 1973; 98: 380-4.

264 Thomas C. Transferrin-Sättigung (TfS). In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 409-11.

265 Thomas L. Anorganisches Phosphat. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 347-54.

266 Thomas L. Bilirubin. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 259-73.

267 Thomas L. Blutglucose. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 193-99.

268 Thomas L. Calcium. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 333-47.

269 Thomas L. Cholinesterasen. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 81-7.

270 Thomas L. Harnsäure. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 280-9.

271 Thomas L. Harnstoff und Harnstoff-N (BUN). In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 544-7.

272 Thomas L, Franck S, Messinger M, Linssen J, Thomé M, Thomas C. Reticulocyte hemoglobin measurement – comparison of two methods in the diagnosis of iron-restricted erythropoiesis. Clin Chem Lab Med 2005; 43: 1193-202.

273 Thomas L, Müller M, Schumann G, Weidemann G, Klein G, Lunau S, et al. Consensus of DGKL and VDGH for interim reference intervals on enzymes in serum. J Lab Med 2005; 29: 301-8.

274 Tietz NW, Shuey DF, Wekstein DR. Laboratory values in fit aging individuals – sexagenarians through centenarians. Clin Chem 1992; 38: 1167-85.

275 Tietz NW, Shuey DF. Reference intervals for alkaline phosphatase activity determined by the IFCC and AACC reference methods. Clin Chem 1986; 32: 1593-4.

276 Triplett DA. Antiphospholipid-protein antibodies: laboratory detection and clinical relevance. Thromb Res 1995; 78: 1-31.

277 Tsunoda T, Eto T, Furukawa M, Nakata T, Kusano T, Lin YQ, et al. Clear and colorless fluid observed during percutaneous transhepatic gallbladder drainage. Gastroenter Jpn 1990; 25: 619-24.

278 Turner GA, Ellis RD, Guthrie D, Latner AL, Skillen AW, Ross WM. Levels of adenosine 3, 5 cyclic monophosphate and guanosine 3, 5 cyclic monophosphate in single urine specimens collected from a large population of healthy subjects. Ann Clin Biochem 1982; 19: 77-82.

279 Uchida K, Matsuse R, Tomita S, Sugi K, Saitoh O, Ohshiba S. Immunochemical detection of human lactoferrin in feces as a marker for inflammatory gastrointestinal disorders and colon cancer. Clin Biochem 1994; 27: 259-64.

280 Valentine VG, Raffin TA. The management of chylothorax. Chest 1992; 102: 586-91.

281 van Rijn JLML, Kruit WHJ, Schrijver J. Haptoglobin typing, is it clinically necessary for a reliable determination of haptoglobin with the single radial immundiffusion technique? J Clin Chem Clin Biochem 1984; 22: 109-12.

282 van Rijn JLML, van Landeghem BAJ, Heima P, Goldschmidt HMJ. Evaluation of ACTH immunoradiometric assays. Clin Biochem 1996; 29: 93-5.

283 Veit S, Sitzmann F, Prestele H. Normalwerte für Lactat- und Glutamatdehydrogenase sowie Leucinarylamidase, erstellt in optimierten Standardansätzen. Klin Padiat 1975; 187: 244-51.

284 Venkatesh B, Boots RJ, Wallis SC. Accuracy of pleural fluid pH and pCO_2 measurement in a blood gas analyser. Analysis of bias and precision. Scand J Clin Lab Invest 1999; 59: 619-26.

285 Vieth R, Bischoff-Ferrari H, Boucher BJ, Dawson-Hughes B, Garland CF, Heaney RP, et al. The urgent need to recommend an intake of vitamin D that is effective. Am J Clin Nutr 2007; 85: 649-50.

286 Voit R. Plasma-Serum-Unterschiede und Lagerungsstabilität klinisch-chemischer Meßgrößen bei Verwendung von Plasmatrennröhrchen. München: Dissertation 1993.

287 Wack RP, Lien EL, Taft D, Roscelli JD. Electrolyte composition of human breast milk beyond the early postpartum period. Nutrition 1997; 13: 774-7.

288 Wanner G, van der Woerd-de Lange J, Weiss L, Hegner N. Partielle Thromboplastinzeit, Aktivitäten von Faktor VIII und Faktor IX bei klinisch unauffälligen Kindern im Vergleich mit gesunden Erwachsenen. Laboratoriumsmedizin 1992; 16: 43-7.

289 Warburton R, Keevil B. Urinary 5-hydroxyindole-acetic acid by high-performance liquid chromatography with electrochemical detection. Ann Clin Biochem 1997; 34: 424-6.

290 Weigl E, Bach H, Krieg D. Serumbilirubinwerte in der gesunden Bevölkerung. Med Klin 1975; 70: 664-9.

291 Weil J, Bidlingmaier F, Sippel WE, Butenandt O, Knorr D. Comparison of two tests for heterozygosity in congenital adrenal hyperplasia (CAH). Acta Endocrinol 1979; 91: 109-21.

292 Weinberg JB, Haney AF, Doly E, Durham VA, Durham D. Extravascular coagulation in humans: fibrin D-dimer levels and macrophage content in peritoneal fluid and plasma in normal and disease states. Clin Res 1989; 37: 551A.

293 Weippl G, Pantlitschko M, Bauer P, Lund S. Serumeisen-Normalwerte und statistische Verteilung der Einzelwerte bei Mann and Frau. Blut 1973; 27: 261-70.

294 Weisshaar D, Gossrau E, Faderl B. Normbereiche von α-HBDH, LDH, AP und LAP bei Messung mit substratoptimierten Testansätzen. Med Welt 1975; 26: 387-90.

295 Wenzel E, Holzhüter H, Muschietti F, Angelkort B, Ochs H-G, Pustai-Markos S, et al. Zuverlässigkeit des Fibrinogen(Fibrin)-Spaltproduktnachweises im Plasma mit Thrombinkoagulase-, Reptilase- und Thrombin-Gerinnungszeit. Dtsch Med Wschr 1974; 99: 746-56.

296 WHO Laborhandbuch zur Untersuchung des menschlichen Ejakulats und der Spermien/Zervixschleim-Interaktion. Berlin, Heidelberg, New York: Springer, 1993.

297 Wichelhaus TA, Hunfeld KP, Brache V. Streptococcus pyogenes-Infektion. In: Thomas L, ed. Labor und Diagnose, 6th ed. Frankfurt/Main: TH-Books, 2005; 1647-50.

298 Wielders JPM, Mink CJK. Quantitative analysis of total thiamine in human blood, milk and cerebral fluid by reversed phase HPLC. J Chromatog 1983; 277: 145-56.

299 Williams WJ, Beutler E, Erslev AJ, Rundler RW. Hematology, 2nd ed. New York: McGraw Hill, 1990.

300 Willms B, Lehmann P. Neuer Fructosamin-Test als Routineparameter in der Diabeteskontrolle. Wien Klin Wschr 1990; 102: Suppl 180; 5-9.

301 Winnefeld K, Schmidt R. Eine einfache und schnelle Methode zur Bestimmung des Proteins im Pankreassekret. Z Med Lab Diagn 1989; 30: 460-2.

302 Wisser H, Stamm D. Untersuchungen zur Bestimmung der 4-hydroxy-3-methoxy-Mandelsäure (Vanillinmandelsäure) im Urin. J Clin Chem Clin Biochem 1970; 8: 21-6.

303 Witt I, Trendelenburg C. Gemeinsame Studie zur Erstellung von Richtwerten für klinisch-chemische Kenngrößen im Kindesalter. J Clin Chem Clin Biochem 1982; 20: 235-42.

304 Wu AHB. Tietz clinical guide to laboratory tests, 4th ed. St Louis, MO: Elsevier Saunders, 2006.

305 Zawta B, Klein G, Bablok W. Temperaturumrechnung in der klinischen Enzymologie? Klin Lab 1994; 40: 23-32.

List of key words