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The American Board of Pediatrics®

PRCP

Program for Renewal of Certification in Pediatrics

Guides for Record Review

Seizures

Supplement to Pediatrics in Review

The American Board of Pediatrics
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This guide has been prepared by the American Board of Pediatrics (ABP) as an integral part of the record review required for renewal of certification in general comprehensive pediatrics. Its purpose is to provide the pediatrician with criteria for assessing patient records dealing with specific problems. Important elements to be included in the record appear in bold-face type in the margins; other elements to be considered are printed in italics. Please note that these guides do not purport to articulate standards of care. They are designed solely to address record keeping issues.

The guides focus on the elements of the history and physical examination relevant to specific problems and are not meant to discourage a more thorough history and physical examination as appropriate for the patient and the particular circumstances.

The guides will be updated periodically. Because of rapid changes in knowledge about drugs and their availability, drugs and dosages included in these guides should be verified in current sources.

A table of international units is included in each guide.

The guides are planned, written, and reviewed by an ABP committee composed primarily of practicing pediatricians. Appropriate subject experts are consulted during the preparation of the guides.

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INTRODUCTION

Seizures are among the most common disorders of childhood. If one includes the simple febrile seizure, at least 3% of children will experience a seizure at some time. The incidence and type of seizure vary according to the age of the child. During the neonatal period, post-asphyxial cerebral hypoxia, intracranial hemorrhage, congenital malformation of the central nervous system, metabolic derangements and infection are prominent causes; drug withdrawal following long- term maternal use of narcotics or recent maternal use of cocaine also may be responsible. During later infancy and childhood, febrile convulsions, central nervous system infections, trauma, neoplasm, or drug ingestion become important factors. During later childhood and adolescence, idiopathic or cryptogenic seizures are most common,[1,2] although head trauma continues to be an important cause. The current classification of seizures is summarized in Table 1.

Birth date

Immunizations

Drug allergies

This discussion will be restricted to seizures beginning after 3 months of age, and will not take into account seizures due to metabolic causes such as hypoglycemia, hypocalcemia or hypernatremia, seizures due to intoxications or seizures related to increased intracranial pressure or acute trauma.

Birth date should be present on all charts. An up-to-date record of all immunizations should also be part of each child's medical record. Any or all of these variables may be important factors in developing an appropriate differential diagnosis, interpreting laboratory and radiologic data, and determining the safety, efficacy, and appropriate dose of medications.

Because of the frequency of drug therapy in children, it is essential that any confirmed drug allergies be noted prominently on the chart so that inadvertent prescription of the drug can be avoided. However, the absence of such a notation does not relieve the physician of the responsibility for inquiring about drug sensitivity before prescribing any medication.

HISTORY

Age of onset

Clear description of seizure

Date of last seizure

Frequency

Previous therapy

Response to previous therapy

Complications:
Pregnancy
Perinatal

CNS insults

Growth and development

School performance

Behavior

Family history of seizures

Because the age of onset is an important clue to etiology, the date of the first seizure should be recorded.[3] The initial classification of the seizure is determined largely on the basis of the clinical manifestations[4]; thus, it is essential that a clear description of the seizure(s) be noted; this should include the presence of an aura, the type of motor activity (tonic, clonic, akinetic, etc.), and any behavioral changes or automatisms. The duration of the seizure, the state of consciousness, and the presence of any life-threatening problems such as cyanosis or laryngospasm should be noted. It is helpful to note the presence of bowel or bladder incontinence, as well as the type and duration of any postictal manifestations. The presence of any focal component may indicate an underlying neurologic/anatomic abnormality. Factors such as illness or fever, emotional disturbance, or immunization which occur in a temporal relationship to seizures must be described. Other details such as relationship to sleep, exercise, or excitement may provide helpful clues to management. The type, dose and duration of treatment, if given, and its effectiveness, should also be recorded. The previous medical history should include a search for the etiologic factors. Most important of these are a history of the pregnancy and delivery, a careful review of growth and development, and, for school children, the presence of any learning disorder or unexplained motor dysfunction which could be attributed to an earlier central nervous system injury. Change in behavior may be related to an underlying lesion, to partially controlled seizures, or to anticonvulsant medication. Meningitis or encephalitis, cranial trauma, and lead poisoning are examples of problems which have the potential for permanent brain injury. Such problems should be noted in the patient's chart. It is important to remember that most seizures in infants beyond the early months after birth are not associated with a definable etiology (idiopathic seizures). These have a good prognosis, providing that central nervous system function is otherwise normal.

A number of conditions can be confused with seizures; most of these can be eliminated on the basis of a careful history. These include breath-holding spells, simple syncope, hyperventilation, day dreaming, and psychogenic pseudoseizures.[1,2]

The family history should be reviewed for evidence of seizures in other family members, and for genetic disorders that may be associated with seizures, such as tuberous sclerosis or metabolic disorders.

The presence in the home of drugs that may have been accidentally ingested, or the possibility of exposure to a toxic substance such as lead, should be considered.

PHYSICAL EXAMINATION

Temperature

Blood pressure

Weight

The extent of the initial examination depends on the patient's condition. If a seizure is occurring, attention must be given to emergency management. This includes maintenance of the airway, administration of supplemental oxygen, and precautions to reduce the risk of self-inflicted injury. If the seizure does not appear to be subsiding spontaneously, an intravenous catheter should be inserted and anticonvulsant drugs administered. Blood should be withdrawn for laboratory studies to confirm the suspected etiology. A complete physical and neurologic examination should be done, as well as an examination of the cerebrospinal fluid if infection is a consideration.

Head circumference/ size

Fundi

Skin

Anomalies or dysmorphic features

Neurologic examination

Developmental assessment

Because fever is a common trigger factor, the temperature should be recorded as soon as possible after the seizure is controlled. The head circumference should be measured because anatomic abnormalities of the central nervous system may cause seizures or may be associated with small or increased head size. Weight should be recorded because poor growth may provide a clue to an underlying metabolic disorder, perinatal brain injury, or certain genetic syndromes. The blood pressure should be recorded because severe hypertension may cause an encephalopathy; hypertension may also provide a clue to advanced increased intracranial pressure, renal disorders, or a vascular malformation. Development should be carefully assessed; delayed development may accompany seizures, especially those associated with underlying congenital disorders.[5] Developmental regression suggests a metabolic or degenerative disorder. Inspection of the fundi may reveal evidence of infection, developmental anomalies, certain genetic disorders, or intracranial hypertension. Careful examination of the skin may disclose evidence of café-au-lait spots, depigmented nevi, adenoma sebaceum, shagreen patches, neurofibromas, or other clues to one of the neurocutaneous syndromes. The presence of a major anomaly, or of multiple minor anomalies, increases the likelihood of an organic or anatomic cause for the seizures, and may point to the diagnosis of a specific syndrome. In the presence of a cardiovascular abnormality, one should think of syncope, embolism, and similar rare causes of central nervous system symptoms. Hepatomegaly may indicate a possible metabolic cause such as hypoglycemia.

A careful and thorough neurologic examination is essential in the evaluation of a patient with seizures. Particular attention should be paid to any focal abnormality, but gait disturbances, abnormal motor or sensory function, cranial nerve abnormalities, and reflexes should be evaluated.

DIAGNOSTIC PROCEDURES

EEG

Examination of the CSF

Imaging studies

With the exception of a careful history and physical examination, further diagnostic evaluation is usually not indicated in a child with a simple febrile seizure unless there are atypical features.[6] The criteria for febrile seizures include age between 6 months and 5 years, a history negative for a neurologic or developmental disorder, the absence of neurologic abnormalities on physical examination, and a seizure that is brief and nonfocal in character.[7] Often, there is a family history of similar seizures. A diagnosis of febrile seizure should be made only in the presence of significant fever.

In most other children with seizures, or in those suspected of having seizures, some diagnostic studies are indicated. The nature and extent of the evaluation will depend upon the age of the child, the type of seizure, and the likelihood of an underlying disorder, as disclosed by the history and physical examination. Electroencephalography (EEG) is the most useful single test, although up to 15% of patients with seizure will have normal EEGs, and minor abnormalities of the EEG may exist in the absence of clinical seizures. Results of EEG help to determine whether a seizure has recently occurred and the active site of epileptiform discharge. It can also help to differentiate between seizure types which have similar clinical presentations. For some types of seizures, the EEG can be diagnostic; for example, a classic hypsdysrhythmia pattern is seen in patients with infantile spasms, and a 3/sec spike and wave pattern in absence seizures. When the diagnosis is in doubt, or in unusual situations such as when pseudoseizures are suspected, EEG with video monitoring for prolonged periods may be helpful.[7] The results of EEG should be recorded in the patient's chart.

If treatment with an anticonvulsant drug that has possible hematologic effects is being considered, a complete blood count should be done as a baseline. In addition, some hereditary disorders may cause classic changes in the complete blood count, or there may be evidence compatible with lead poisoning.[8] Urinalysis should be done if the patient has hypertension so that glomerulonephritis will not be missed. Some anticonvulsant drugs are nephrotoxic and a baseline urine study may be helpful for future comparison. In patients with the early onset of seizures or who have findings suspicious of a metabolic disorder (eg, persistent metabolic acidosis), urinary studies for amino acids, organic acids and other evidence of metabolic disease are indicated. Determinations of blood glucose and serum calcium, phosphorus and electrolyte concentrations, though not indicated in every patient, may be appropriate if the clinical pattern is consistent with a metabolic disorder.[1,2]

An examination of the cerebrospinal fluid (CSF) should be done in every child in whom central nervous system infection cannot be confidently ruled out on the basis of findings on physical examination. In the uncommon patient with evidence for degenerative central nervous system disease, special studies of CSF may be helpful in making a specific diagnosis.

Although computed tomography (CT scan) of the head is commonly done in adults with seizures, it is not routinely indicated in infants and children unless a cerebral abnormality is suspected, if increased intracranial pressure is a concern, or if there is evidence of progressive central nervous system dysfunction. CT scan may also be helpful in patients with atypical seizures, particularly if they are unresponsive to anticonvulsant therapy. All patients with focal seizures, focal abnormalities on neurologic examination, or a slow-wave focus on EEG should have CT scans to rule out anatomic abnormalities.

In the patient being evaluated for possible seizures manifested by unexplained syncopal episodes, an electrocardiogram may assist in ruling out a cardiac dysrhythmia.

TREATMENT

Anticonvulsant therapy

The management of the child with an acute seizure will be discussed only in general terms. Although seizures provoke substantial fear and anxiety in patients and their parents, most seizures stop spontaneously in a few minutes. Prolonged seizures are probably detrimental to the central nervous system. Thus, it is important that continuous seizures lasting more than 30 minutes (status epilepticus) be stopped as soon as this can be safely accomplished; parenteral treatment is required to accomplish this. The drugs of choice for treatment of the acute seizures are diazepam, phenytoin and phenobarbital. During the effort to bring the seizure under control, it is essential that an adequate airway is established, that fever is controlled, that metabolic derangements are corrected, that adequate fluids and glucose are administered, and that the patient is monitored in an intensive care setting.

Dosage

Frequency of dosage

The long-term management of seizures requires the administration of the drug(s) which is/are most specific for the type of seizure (Table 1). The usual dosage range and important side effects for the most frequently used anticonvulsant drugs are listed in Table 2.[1,2,4] As noted, children who have had a simple febrile seizure need not be given anticonvulsant therapy, but continuous treatment with anticonvulsant drugs is indicated if repetitive seizures occur. Phenobarbital is the drug of choice, although other drugs may be used in patients who do not tolerate phenobarbital.[6,8,9]

Certain principles of drug management are applicable to the use of most anticonvulsant drugs. In general, treatment should be started with a single drug, and, if seizures are not well controlled, the dosage of this drug should be increased to the maximum tolerated without side effects before a change to anther drug is considered. Knowledge of the pharmacokinetics of the drug is essential if one is to make appropriate changes in the dose at appropriate times to maximize efficacy and minimize toxicity. Measurement of serum drug concentrations is particularly valuable in the management of patients whose seizures are not controlled after initiation of therapy or recur after a seizure-free period. If a trial of several drugs given singly fails and a second drug must be added, the physician should be aware of any interactions which will influence the serum concentrations of either drug; in general, patients taking more than one drug will have lower serum concentrations than if they were taking the same dose of a single drug, but other interactions are possible. Likewise, anticonvulsant drugs may affect the metabolism of other drugs, such as theophylline. Other drugs, such as erythromycin, may alter the metabolism of certain anticonvulsants. Finally, many anticonvulsant drugs are potentially toxic to the liver, the hematopoietic system, or the kidney. Periodic assessment with appropriate laboratory tests may be indicated (Table 2). To facilitate compliance, the dosage interval for anticonvulsant drugs should be as long as possible. Phenytoin, because of its long half life, can be given twice daily; phenobarbital can be given once a day. Tablets or capsules are often less expensive than liquid preparations and the dosage is more precise. The use of phenytoin suspension is discouraged because active drug may settle to the bottom of the bottle if it is not shaken thoroughly.

In general, patients should take anticonvulsant drugs until they have been free of seizures for approximately two to four years[10-13]; this may need to be modified depending upon the type of seizure and its etiology. Reduction in dosage should be gradual because sudden termination of medication may precipitate status epilepticus.

Most pediatricians would be comfortable in the management of the child with typical seizures who responds to treatment with one or two drugs and who has no evidence of a focal neurologic abnormality or of degenerative disease of the central nervous system. Consultation with a pediatric neurologist is indicated, however, if the child has seizures that respond poorly to treatment or if multiple drug therapy seems warranted. Likewise, the child with infantile spasms who may require treatment with ACTH or prednisone and has a poor prognosis deserves neurologic evaluation at the time of diagnosis. The rare patient in whom a ketogenic diet may be indicated or in whom surgical therapy is contemplated should be evaluated and managed on a regular basis by a pediatric neurologist.

MANAGEMENT OF ASSOCIATED PROBLEMS

Children with recurrent seizures have an increased incidence of mental retardation, learning disabilities, and psychologic or behavioral problems. The presence of seizures and the need for long-term treatment may be disruptive or stressful for the family. Management of these problems may require consultation with a psychologist or psychiatrist, cooperation with the school system and considerable family counseling.[14]

Follow-up evaluation

Liver function tests

Complete blood/ platelet counts

Serum drug concentration

Neurologic consultation

Patient education

FOLLOW-UP EVALUATION

All patients with seizures, except simple febrile seizures, should be scheduled for follow-up examinations; the interval will depend upon the degree of seizure control, the anticipated need to modify the anticonvulsant regimen, and the need to monitor serum drug concentrations and possible drug toxicity (Table 2).

PATIENT EDUCATION

Considerable time is required from health personnel for education of the patient with seizures and his or her family. The importance of compliance with long-term drug therapy, the risks of abruptly stopping medications, the need for monitoring serum drug concentrations, and the possibility of side effects[15] or drug interactions must be carefully explained. Families obtaining immunizations from other sources should be informed that in patients with infantile spasms, uncontrolled seizures, or associated progressive neurologic disease, pertussis immunization should be deferred.[16] Each family should know what to do in the event of a seizure, particularly in regard to maintaining the airway and to reducing the body temperature, and when to notify the physician or to seek emergency care. Families may need assistance in dealing with peers and teachers who are fearful of the possibility that the patient may have a seizure in their presence. The young athlete with seizures may need help in deciding what activities are appropriate, and coaches may need instruction regarding any special needs of the child.[17] Unsupervised swimming is unsafe for any child, but must be strictly prohibited in the patient who may have a seizure if he or she hyperventilates or becomes hypoxic as a result of swimming under water. The patient and parents need to be made aware of precipitating factors such as fatigue, flashing lights, drinking alcohol, and so forth. Adolescent patients will need to know the state laws regarding disclosure of diagnosis when applying for a driver's license.

It is important that the patient and his or her family have an optimistic outlook, especially for the child with an idiopathic seizure disorder. The prognosis is excellent for many seizure disorders such as febrile seizures[6] and absence attacks.[18] The tendency of parents to over-protect the child should be avoided, and the possibility that the child may use his or her disease to control the parents must also be guarded against. With the knowledge that good control of seizures is usually possible, and that prognosis in most cases is favorable,[10-13] most patients and their families can learn to live comfortably with the diagnosis of a seizure disorder and look forward to a relatively normal life.

REFERENCES

1. Huttenlocher PR: The child with a convulsive disorder, in *Nelson Textbook of Pediatrics*, ed 13, edited by Behrman RE, Vaughan VC III. Philadelphia, WB Saunders Co, 1987, pp 1285-1295

2. Wright FS: Epilepsy in childhood. *Pediatr Clin North Am* 31:177, 1984

3. Ellenberg JH, Hirtz DG, Nelson KB: Age at onset of seizures in young children. *Ann Neurol* 15:127, 1984

4. Nellhaus G, Stumpf DA, Moe PG: Neurologic and muscular disorders, in *Current Pediatric Diagnosis and Treatment*, ed 8, edited by Kempe CH, Silver HK, O'Brien D, et al. Los Altos, CA, Lange Medical Publications, 1987, pp 658-660

5. Ellenberg JH, Hirtz DG, Nelson KB: Do seizures in children cause intellectual deterioration? *N Engl J Med* 314:1085, 1986

6. Consensus Development Panel, National Institute of Neurological and Communicative Disorders and Stroke: Febrile seizures: Long-term management of children with fever-associated seizures. *Pediatrics* 66:1009, 1980

7. Mizrahi EM: Electroencephalographic/polygraphic/video monitoring in childhood epilepsy. *J Pediatr* 105:1, 1984

8. Lascari AD: *Hematologic Manifestations of Childhood Diseases*. New York, Thieme-Stratton Inc, 1984, pp 235-264, 297-334

9. Camfield C, Chaplin S, Doyle A, et al: Side effects of phenobarbital in toddlers: behavioral and cognitive aspects. *J Pediatr* 95:361, 1979

10. Shinnar S, Vining EPG, Mellits ED, et al: Discontinuing anti-epileptic medication in children with epilepsy after two years without seizures. *N Engl J Med* 313:976, 1985

11. Thurston JH, Thurston DL, Hixon BB, et al: Prognosis in childhood epilepsy: additional follow-up of 148 children 15 to 23 years after withdrawal of anticonvulsant therapy. *N Engl J Med* 306:831, 1982

12. Hirtz DG, Ellenberg JH, Nelson KB: The risk of recurrence of nonfebrile seizures in children. *Neurology* 34:637, 1984

13. Camfield PR, Camfield CS, Dooley JM, et al: Epilepsy after a first unprovoked seizure in childhood. *Neurology* 35:1657, 1985

14. Marshall RM, Cupoli JM: Epilepsy and education: the pediatrician's expanding role. *Adv Pediatr* 33:159, 1986

15. American Academy of Pediatrics, Committee on Drugs: Behavioral and cognitive effects of anticonvulsant therapy. *Pediatrics* 76:644, 1985

16. American Academy of Pediatrics: *Report of the Committee on Infectious Diseases, 1988 Red Book*, ed 21. Elk Grove Village, IL, American Academy of Pediatrics, 1988, pp 321-322

17. American Academy of Pediatrics, Committee on Children with Handicaps and Committee on Sports Medicine: Sports and the child with epilepsy. *Pediatrics* 72:884, 1983

18. Holmes GL: Therapy of petit mal (absence) seizures. *Pediatr Rev* 4:150, 1982

19. Glaze DG, Hrachovy RA, Frost JD Jr, et al: Prospective study of outcome of infants with infantile spasms treated during controlled studies of ACTH and prednisone. *J Pediatr* 112:389, 1988

20. Vining EPG, Mellits ED, Dorsen MM, et al: Psychologic and behavioral effects of anti-epileptic drugs in children: a double-blind comparison between phenobarbital and valproic acid. *Pediatrics* 80:165, 1987

21. Wolf SM, Forsythe A, Stunden AA, et al: Long-term effects of phenobarbital on cognitive function in children with febrile convulsions. *Pediatrics* 68:820, 1981

TABLE 1.
CLASSIFICATION OF SEIZURES AND DRUGS OF CHOICE

I. Partial seizures*	
A. Simple (no alteration of consciousness)	Carbamazepine (Tegretol®); phenytoin (Dilantin®); phenobarbital
1. Motor signs 2. Somatosensory symptoms 3. Autonomic signs/symptoms	
B. Complex (consciousness impaired)	Carbamazepine; phenytoin; phenobarbital
II. Generalized seizures**	
A. Absence (petit mal)	Ethosuximide (Zarontin®); valproic acid (Depakene®) or divalproex (Depakote®)
B. Myoclonic***	Valproic acid
C. Atonic	Valproic acid
D. Tonic-clonic (grand mal)	Phenytoin; phenobarbital; carbamazepine; valproic acid
(Febrile)	Phenobarbital (after more than two to three seizures)

* Partial seizures begin in a localized area of the brain as documented by electroencephalography. Clinically they are characterized by a focal onset. They may remain focal or may rapidly generalize. An aura is sometimes present. The finding of transient postictal focal neurologic abnormalities implies that the seizure was focal in onset.

** Generalized seizures are characterized by a seizure discharge which begins over all portions of both cerebral hemispheres simultaneously as documented by electroencephalography. The initial feature of the seizure is loss of consciousness; no aura is present. Convulsive movements are bilateral and symmetrical; focal postictal neurologic abnormalities should not be present.

*** For infantile spasms with hypsdysrhythmia, a trial of ACTH or prednisone therapy is recommended.[19]

TABLE 2.
USUAL STARTING DOSE AND SIDE EFFECTS OF COMMONLY USED ANTICONVULSANT DRUGS

Drug	Usual Starting Dose/Day (mg/kg)	Side Effects	
		Common	Rare
Phenobarbital	2-3	Rash; drowsiness; sleep disturbance; hyperactivity[9,20,21]; behavior disorder	Stevens-Johnson syndrome; blood dyscrasia
Phenytoin	5-8	Gum hyperplasia; hirsutism; lymph-adenopathy; coarse facies; ataxia; nystagmus	Stevens-Johnson syndrome; hepatic necrosis; rickets; blood dyscrasia
Carbamazepine	10-15	Drowsiness; leuko-penia; abdominal pain	Aplastic anemia; thrombocytopenia (monitor CBC, especially first 3 months)
Valproic acid	10-20	Drowsiness; alo-pecia; abdominal pain	Hepatic failure*; pancreatitis (monitor enzymes first 6 months)
Ethosuximide	10-20	Drowsiness; nausea	Blood dyscrasia

*Highest risk is in children younger than 2 years of age.

CONVERSION TABLE TO STANDARD INTERNATIONAL (SI) UNITS

I.	Hematology	
	Hemoglobin g/dL x 0.155	= mmol/L
	Platelets/mm^3	= count/μL = 10^6 cells/L
	Leukocytes/mm^3	= count/μL = 10^6 cells/L
	Erythrocytes/mm^3	= count/μL = 10^6 cells/L
	Hematocrit % x 0.01	= vol RBC/vol whole blood
	Reticulocytes % x 0.01	= (1)
II.	Blood Pressure mm Hg (torr) x 1.333	= mbar
III.	Blood Gases 1 mm Hg = 133.322 Pa	$PC0_2$ mm Hg x 0.1333 = kPa
	Base excess mEq/L = mmol/L	$P0_2$ mm Hg x 0.1333 = kPa
	pH value = same	
IV.	Blood Chemistries	
	Acetone mg/dL x 0.1722	= mmol/L
	Acetaminophen μg/mL x 6.62	= μmol/L
	Albumin g/dL x 144.9 or g/L x 14.49	= μmol/L
	Aldosterone ng/dL x 0.0277	= nmol/L
	Ammonia mgN/dL x 0.714	= mmol/L
	Bicarbonate mEq/L	= mmol/L
	Bilirubin mg/dL x 17.10	= μmol/L
	Blood urea nitrogen mg/dL x 0.357	= mmol urea/L
	Calcium mg/dL x 0.25	= mmol/L
	Carotene IU x 0.6	= μg
	or μg/dL x 0.01863	= μmol/L
	Ceruloplasmin mg/dL x 0.0662	= μmol/L
	Chloride mEq/L	= mmol/L
	Cholesterol mg/dL x 0.0259	= mmol/L
	Complement component (C3) mg/dL x 0.01	= g/L
	Copper μg/dL x 0.157	= μmol/L
	Cortisol μg/dL x 27.59	= nmol/L
	Creatine mg/dL x 76.26	= μmol/L
	Creatinine mg/dL x 88.40	= μmol/L
	Digoxin ng/mL x 1.28	= nmol/L
	Enzymes	
	Alanine aminotransferase (ALT, SGPT) U/L	= U/L
	Aldolase Sibley-Lehninger units/mL	= U/L
	Amylase Somogyi units/dL	= U/L
	Aspartate aminotransferase (AST, SGOT) U/L	= U/L
	Creatine kinase (CK) U/L	= U/L
	Phosphatase	
	Bodansky units/dL	= U/L
	King-Armstrong units/dL	= U/L

Fatty acids mg/dL x 0.0354	= mmol/L
Ferritin ng/mL x 1	= µg/L
α_1-Fetoprotein ng/mL x 1	= µg/L
Fibrinogen mg/dL x 0.01	= g/L
Folic acid µg/dL x 22.65	= nmol/L
Glucose mg/dL x 0.0555	= mmol/L
Glycerol mg/dL x 0.1086	= mmol/L
Haptoglobin mg/dL x 0.01176	= µmol/L
17-Hydroxycorticosteroids mg/d x 2.759	= µmol/d
Insulin IU x 0.04167	= mg
or µU/mL x 1.0	= mU/L
Iodine µg/dL x 78.8	= nmol/L
Iron µg/dL x 0.1791	= µmol/L
Iron binding capacity µg/dL x 0.1791	= µmol/L
17-Ketosteroids mg/d x 3.467	= µmol/d
Lead µg/dL x 0.0483	= µmol/L
Lipoprotein mg/dL x 0.01	= g/L
Magnesium mg/dL x 0.4114	= mmol/L
or mEq/L x 0.5	= mmol/L
Phosphorus mg/dL x 0.3229	= mmol/L
Potassium mEq/L	= mmol/L
Prednisone mg x 2.79	= µmol
Protein g/dL x 10	= g/L
Salicylate mg/dL x 0.0724	= mmol/L
Sodium mEq/L	= mmol/L
Theophylline µg/mL x 5.55	= µmol/L
Thyroid-stimulating hormone µU/mL x 1	= mU/L
Thyroxine µg/dL x 12.87	= nmol/L
Transferrin mg/dL x 0.01	= g/L
Triglycerides mg/dL x 0.01	= g/L
Triiodothyronine ng/dL x 0.0154	= nmol/L
Urea nitrogen mg/dL x 0.357	= mmol urea/L
Uric acid mg/dL x 59.48	= µmol/L
Vitamin A µg/dL x 0.0349	= µmol/L
Vitamin B_{12} pg/dL x 0.738	= pmol/L
Vitamin C mg/dL x 56.78	= µmol/L
Vitamin E µg/dL x 2.322	= µmol/L
Xylose mg/dL x 0.0667	= mmol/L
Zinc µg/dL x 0.153	= µmol/L

V. Urine or Stool

Coproporphyrin µg x 1.53	= nmol
Epinephrine µg/d x 5.458	= nmol/d
Vanilmandelic acid mg/d x 5.046	= µmol/d
Homovanillic acid mg/d x 5.489	= µmol/d

VI. Energy

Kcal x 4.1868	= KJ (Kilojoule)
Rad x 0.01	= Gy (Gray) (joule/kg)

VII. Radionuclide Activity

Curie (Ci) x 37	= GGq (Gigabecquerel)

NOTES