Ionized Magnesium

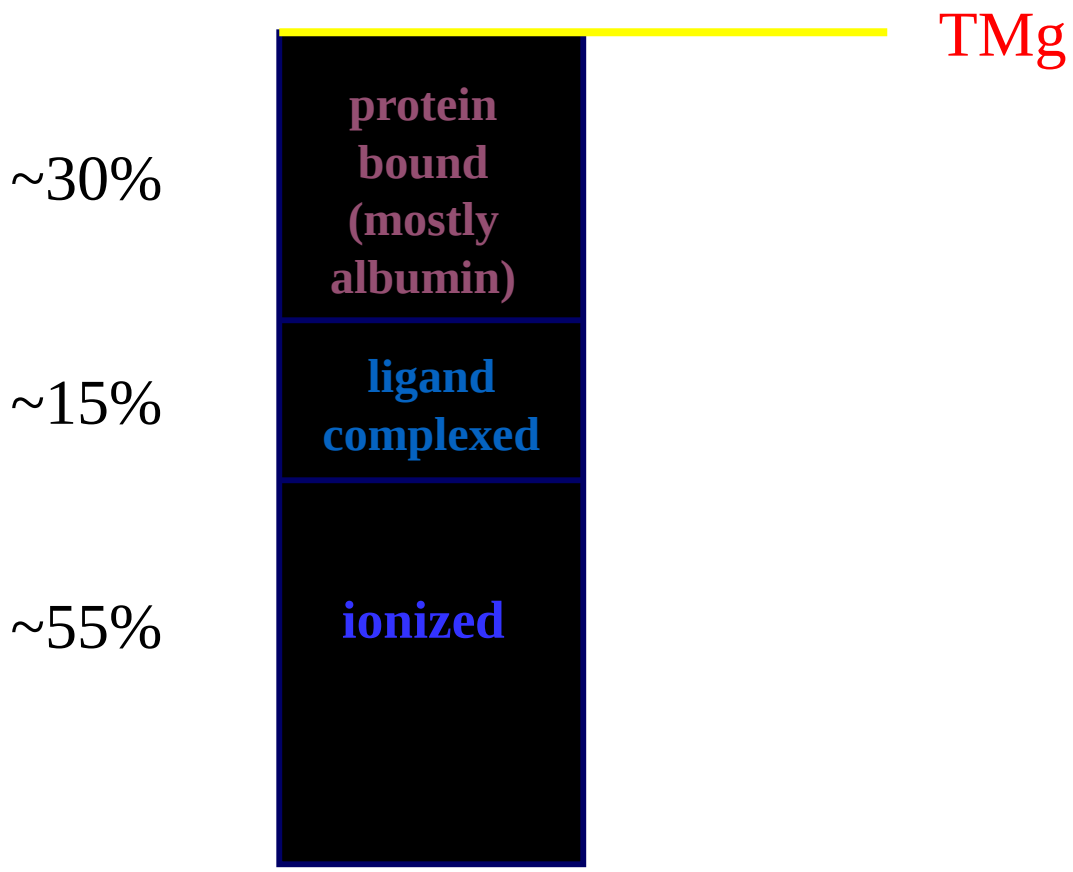
An Essential Part of the Critical Care Profile

Key Role of Magnesium

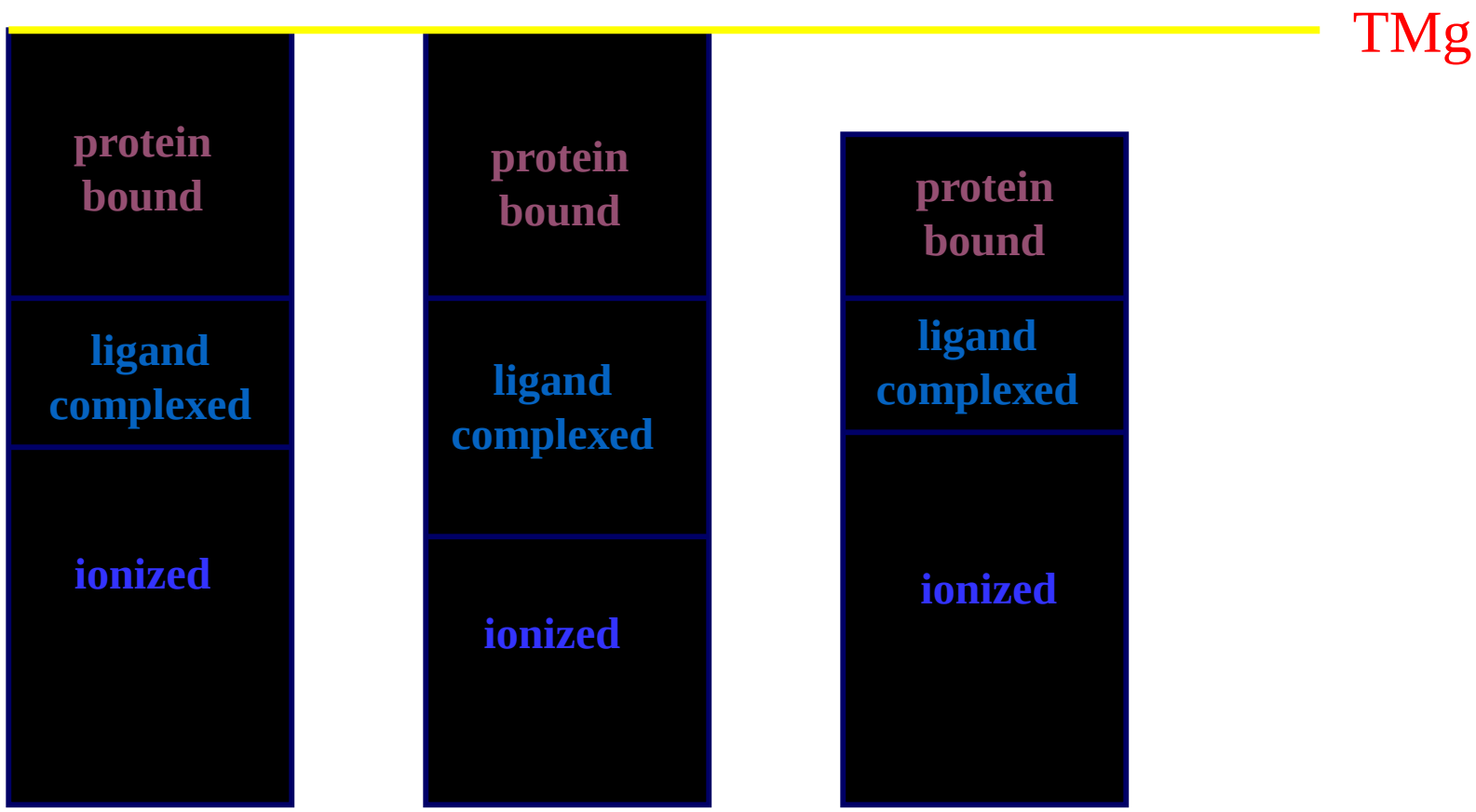
iMg essential for activity of >300 enzymes and many biological processes:

- Operation of membrane Na, K, Ca pumps
- Regulation of vascular smooth muscle tone
- Skeletal and cardiac muscle excitability and contractility
- Second messenger systems and signal transduction

Components of TMg



TMg v. iMg


TMg
protein bound
ligand complexed
ionized
protein bound
ligand complexed
ionized
protein bound
ligand complexed
ionized

Lack of Correlation

- CPB patients

Significantly reduced iMg levels despite increase in TMg

- Severe head trauma patients

Significant decreases in iMg but not TMg

- Type 2 diabetes patients

iMg significantly reduced but not TMg

- Critically ill children

60% had low iMg; of these, 60% had normal TMg

Lack of Correlation

- Intestinal and liver disease patients

14% were false positive with respect to functional hypomagnesemia (low TMg, normal iMg)

- Renal disease patients

20% were false positive with respect to functional hypomagnesemia

Frequency of Abnormalities

Critical Care Setting	% Patients with Abnormal Mg
Surgical ICU	49% at completion of CPB; 64% 24 hours later
Medical ICU	65% of patients with creatinine < 1.1 mg/dL
	26% pediatric patients
Neonatal ICU	31% of all patients
Emergency Department	22% of all patients
	56% of patients with chest pain using diuretics
Coronary Care Unit	45.9% of patients admitted to rule out AMI
	38% of patients with unstable angina
	34% of patients with ischemic heart disease

Clinical Manifestations

Hypomagnesemia

Arrhythmias
Hypertension
Cardiac insufficiency
Coronary vasospasm
Heart failure and sudden death
Decreased pressor response
Digitalis sensitivity, toxicity
Respiratory muscle weakness
Tetany and seizures
Hypokalemia
Hypocalcemia

Hypermagnesemia

Hypotension
Bradycardia
Inhibition of platelet aggregation, clotting
Respiratory paralysis
Heart block
Cardiac arrest

Associated Morbidity/Mortality

Critical Care Setting	Associated Morbidity and Mortality
Surgical ICU	Higher mortality rate Increased frequency of dysrhythmias Prolonged ventilatory support
Medical ICU	Increased frequency of dysrhythmias, MI, respiratory failure Higher mortality rates, more rapidly fatal course
Neonatal ICU	Increased support from mechanical ventilation
Emergency Department	Arrhythmias refractory to standard therapy Normal Mg required for successful resuscitation
Coronary Care Unit	Increased dysrhythmias, tachycardia, fibrillation
Medical Ward	Higher mortality rates

Associated Electrolyte Abnormalities

Electrolyte abnormality	% patients with hypomagnesemia
Hypokalemia	38-42%
Hypocalcemia	22-23%
Patient population	**% patients with hypokalemia**
Hypomagnesemic ED patients with chest pain	43%
Hypomagnesemic AMI patients with increased arrhythmias	30%
Patient population	**% patients with hypocalcemia**
Hypomagnesemic patients one day after CPB	55%

Danger of Hypermagnesemia

- Hypotension
- Bradycardia
- Inhibition of platelet aggregation/clotting
- Respiratory paralysis
- Heart block
- Cardiac arrest

Salem, et al., recommend serial iMg determinations during therapy to prevent hypermagnesemia. Continued monitoring at the conclusion of therapy avoids redevelopment of hypomagnesemia.

Danger of Hypermagnesemia

- The kidneys are primarily responsible for control of serum magnesium concentrations

- Essentials of Critical Care Pharmacology recommends assessing renal function prior to therapeutic use of magnesium to reduce risk of hypermagnesemia

The Problem with TMg

- Not available as part of stat critical care panel
- Cannot be performed on whole blood
- Requires large sample volume
- May be normal despite changes in iMg concentrations
- Does not correlate with iMg concentration
- Does not distinguish among protein-bound, ligand-complexed, and ionized
- May not properly identify patients at risk

Why iMg is Preferable

- Available as part of stat critical care profile
- Can be performed on whole blood
- Requires small sample volume
- Measures only physiologically active fraction
- Effectively identifies patients at risk

Critical Citings

- Indications for measurement of magnesium include unexplained hypocalcemia and instances in which hypokalemia is unresponsive to potassium supplementation. *(Laboratory Test Handbook, Williams and Wilkins)*

- Patients with severe hypomagnesemia have a higher mortality rate than similarly ill patients with normal magnesium levels. *(Chest 93:391; Critical Care Medicine 21:203)*

- Patients with hypomagnesemia have increased frequency of ventricular dysrythmias, myocardial infarction, and respiratory failure. *(Abstract, 1995 Critical Care Medicine Meeting)*

Critical Citings

•Hypomagnesemia is probably the most underdiagnosed electrolyte deficiency in current medical practice. *(American Journal of Medicine 82:24)*

•Magnesium deficiency is increasingly recognized in critical care patients and may be present despite normal total serum magnesium. *(Annals of Thoracic Surgery 64:572)*

•Magnesium depletion alters normal cellular and end-organ physiology and predisposes patients to clinically important morbidity. *(Critical Care Clinics 7:225)*

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