P&G Health

Clinical Application of Micronutrients in Recovery: A Practical Guidebook for Clinicians

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FOREWORD

In clinical practice, we have seen the tremendous impact of nutrition on patient recovery and overall well-being. The role of micronutrients, though known to us for years, remains underutilized and is not applied as effectively as it should be. While the significance of micronutrients in supporting immune function, aiding tissue repair, and enhancing metabolic balance has been acknowledged for years, their potential continues to be overlooked in clinical practice.

Indian Medical Association (IMA) has taken the initiative to develop comprehensive guidelines on the use of micronutrients for recovery in both paediatric and adult populations with medical and surgical conditions.

This evidence-based document is designed to support healthcare professionals in integrating usage of micronutrients in the management of various diseases in daily practice, improving patient outcomes, reducing complications, and enhancing their quality of life. The guidelines provide clear and actionable recommendations, making it easier for clinicians to adopt these strategies in their practice. IMA has developed these valuable guidelines for doctors, helping to bridge scientific knowledge with practical strategies to be implemented across diverse healthcare settings, ranging from outpatient clinics to hospitals.

These guidelines not only emphasize the importance of essential vitamins and minerals but also offer tailored approach to micronutrients supplementation, backed by robust scientific evidence and clinical research. It also highlights the importance of personalized care, ensuring that nutritional interventions align with individual patient needs. These guidelines will serve as a valuable reference in various healthcare settings, assisting clinicians in making optimized nutritional decisions. By prioritizing micronutrient adequacy, we can support better recovery journeys for patients and enhance their quality of life, regardless of age.

Dr. Dilip Bhanushali
National President, IMA

Dr. Sarbari Dutta,
Hony. Secretary General

PREFACE

We, at IMA, a national voluntary organization of doctors practicing modern scientific medicine, have always been committed to advancing medical science and improving public health. Recognizing the critical role of micronutrients in patient recovery and overall well-being, IMA has taken a significant step forward in developing evidence-based guidelines/ recommendations on the use of micronutrients for recovery in both paediatric and adult populations with medical and surgical conditions.

Micronutrients play a crucial role in enhancing recovery and improving overall health, especially in individuals facing acute or chronic illnesses. Optimizing micronutrient intake can significantly support immune function, aid in tissue repair, and improve long-term health outcomes. However, despite their well-established benefits, the role of micronutrients remains underutilized in clinical practice.

There is growing evidence and recognition of the importance of targeted micronutrient support, particularly for patients undergoing surgery, battling chronic diseases, or recovering from acute illnesses. These guidelines aim to bridge this gap by providing evidence-based recommendations on the use of key vitamins and minerals essential for immune modulation, metabolic balance, and tissue repair which enables faster recovery.

A dedicated team of experts, including General Practitioners, Paediatricians, internal medicine specialists, and surgeons, have meticulously reviewed current research, clinical guidelines, and practical applications in medical and surgical recovery to compile this comprehensive resource. Each chapter explores specific micronutrients, their physiological roles, risks of deficiency, and tailored strategies for supplementation, empowering healthcare professionals and caregivers to effectively implement micronutrient management in their clinical practice.

We take immense pride in presenting these Guidelines, which will serve as a valuable reference in various healthcare settings, from outpatient clinics hospitals. By addressing the unique micronutrient needs of patients recovering from acute illnesses and managing chronic conditions, this document aims to support better recovery outcomes and enhance the quality of life for patients of all ages. This collective effort reflects the collaborative spirit of the medical community and reinforces our ongoing commitment to advancing healthcare for the greater well-being of our nation.

Dr. Sarbari Dutta
Hony. Secretary General, IMA

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CHAPTER 1: INTRODUCTION TO RECOVERY

a) Concept of Recovery

Recovery is defined as returning to previous habits and routines with the resolution of symptoms and mental strains caused by surgery or illness.[1]

Figure 1: Two aspects of Recovery, Physiological and Psychological.

Physiological Recovery

- Physiological recovery restores the body to a healthy state after injury or illness.[2]
- Tissue healing needs proper nutrition; proteins aid repair and regeneration.[3]
- Organ recovery relies on specific nutrients, like antioxidants for liver function.[4]
- Systemic recovery requires hydration and electrolytes for cellular and immune balance.[5]

Psychological Recovery

- Physical illness and surgical trauma impact mental health, worsening recovery.[6]
- Chronic diseases increase the risk of psychological disorders due to distress.[7]
- Mental health issues reduce medication adherence, alter behavior, and weaken immunity.[7,8]
- Post-surgery, patients may face anxiety, depression, aggression, or insomnia.[9,10]

A Holistic approach to Recovery

- A holistic approach integrates physical, mental, emotional, and spiritual well-being.[11]
- Recovery requires both pharmacological and non-pharmacological interventions.[11]
- Non-medical strategies like mindset, diet, and exercise support disease management.[11]
- Micronutrients are key in dietary interventions, aiding recovery and disease prevention.[12,13]

b) Key Mechanisms Involved in Recovery

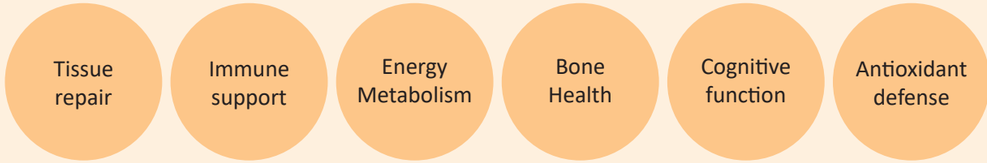

Figure 2: Key Mechanisms Involved in Recovery

Tissue Repair[14]

Efficient tissue repair relies on a well-coordinated series of events divided into three phases:

- Inflammation (1–3 Days)
  - Early Phase: Neutrophils are rapidly recruited to the injury site, persisting for 2–5 days unless infection prolongs their presence.
  - Late Phase: Monocytes transform into macrophages approximately 3 days post-injury, clearing pathogens and debris while promoting healing.
- Proliferation and Repair (4–21 Days)
  - Re-epithelialization: Granulation tissue forms at wound edges, facilitating wound closure.
  - Neovascularization/Angiogenesis: Growth factors stimulate endothelial cell proliferation, leading to new vessel formation supported by pericytes and smooth muscle cells.
  - Granulation Tissue Formation: Fibroblasts generate extracellular matrix (ECM) and collagen, transitioning into myofibroblasts, which later undergo apoptosis.
- Remodeling Phase (21 Days–1 Year)
  - Granulation tissue diminishes, leaving a mature, avascular wound.
  - Collagen replaces earlier structures, and myofibroblasts contract the wound to form scar tissue.

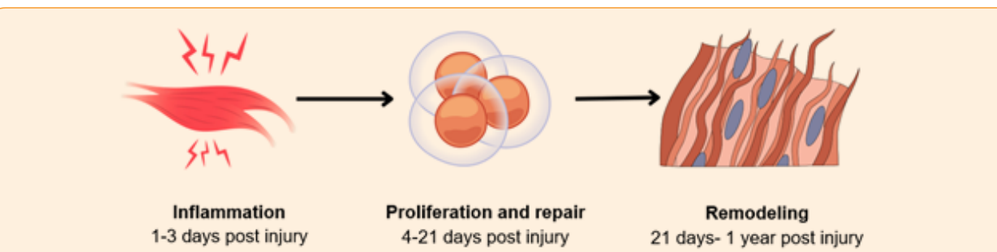

Figure 3: Three Primary phases of Wound Healing and Recovery[14]

Immune Support[15]

The immune system plays a critical role in protecting the body and supporting recovery:

- **Innate Immunity:** The first line of defense includes physical barriers (e.g., skin, gut epithelium) and leukocytes such as neutrophils, macrophages, and natural killer cells. These nonspecific responses help to eliminate pathogens.
- **Adaptive Immunity:** This system is pathogen-specific, involving B lymphocytes (humoral immunity) and T lymphocytes (cell-mediated immunity). It creates immunological memory, enabling rapid responses to subsequent infections.

Adequate intake of micronutrients such as vitamins A, B, C, D, E, selenium, and zinc are essential for optimal immune function. Their deficiencies weaken immunity and increase infection susceptibility.

Energy Metabolism[16]

Energy metabolism is central to recovery, requiring micronutrients for critical biochemical processes:

- **Cofactors in Metabolism:** Trace elements such as zinc and selenium regulate enzyme activity (e.g., zinc supports over 100 enzymes; selenium forms selenocysteine in glutathione peroxidase).
- **Coenzymes in Metabolism:** Vitamins such as riboflavin and niacin participate in the electron transport chain, while folic acid aids in methyl group transfer, ensuring energy and macromolecule synthesis.
- **Genetic Regulation:** Zinc "fingers" control DNA transcription for steroid hormone receptors and other factors.
- **Antioxidants:** Micronutrients like vitamin E and carotenoids neutralize reactive oxygen species (ROS), preventing cellular damage. Enzyme systems such as superoxide dismutase (zinc/copper or manganese dependent) and glutathione peroxidase (selenium dependent) further mitigate oxidative stress.

Bone Health[17]

- Bones provide structure, mobility, and organ protection while constantly remodeling.
- Osteoblasts form bone, osteoclasts resorb it; their imbalance causes osteoporosis.
- Bone density peaks by age of 30, then declines, especially its level decreases rapidly post-menopausal due to low estrogen.
- Calcium, vitamin D, and collagen support bone strength and flexibility.
- Regular exercise, no smoking, and limited alcohol intake help to maintain bone health.

Cognitive Function[18]

- Cognition involves memory, attention, problem-solving, and decision-making.
- Micronutrients regulate energy metabolism, ensuring neurons receive continuous energy supply.

- Antioxidants like selenium, zinc, and manganese neutralize oxidative stress, protecting brain cells.
- Vitamins C and D support immune system, aiding recovery from infections or injury.
- Deficiencies in these micronutrients can impair cognition and increase neurodegenerative risks.

Antioxidant Defense[19]

- The antioxidant system maintains redox balance, regulating immune and metabolic functions.
- Reactive Oxygen Species and Reactive Nitrogen Species aid immunity but, in excess, cause oxidative stress and cell damage.
- Critical illness depletes antioxidants, leading to mitochondrial dysfunction and organ damage.
- Oxidative stress delays recovery, and worsening organ dysfunction in severe conditions.
- Perioperative antioxidant supplementation may reduce inflammation and boost immunity.

Overall, micronutrients support recovery by aiding tissue repair, immunity, and energy metabolism. Hence, adequate intake during illness or stress prevents deficiencies and promotes healing.

CHAPTER 2. MICRONUTRIENTS AND THEIR ROLE IN RECOVERY

Nutrition is a key modifiable factor in health, with balanced intake ensuring optimal physiological function.[13] Macronutrients provide energy and regulate metabolism, while micronutrients support enzymatic reactions and oxidative defense.[13] Deficiencies remain widespread, affecting over 2 billion people globally.[13] Illness depletes nutrient reserves, making adequate intake essential for recovery, tissue repair, and preventing complications.[20] The recommended dietary allowance (RDA) helps to maintain energy balance and meet nutritional needs.[21]

Table 1. Classifications of Macronutrients and Micronutrients[21]

Macronutrients	Micronutrients			
	Vitamins		Minerals	
	Fat-Soluble Vitamins	Water-Soluble Vitamins		
Carbohydrates	Vitamin A (Retinol)	Vitamin B1 (Thiamine)	Calcium	Iron
Proteins	Vitamin D (Cholecalciferol)	Vitamin B2 (Riboflavin)	Phosphorus	Copper
Fats	Vitamin E (Tocopherol)	Vitamin B3 (Niacin)	Sodium	Iodine
	Vitamin K (Quinones)	Vitamin B5 (Pantothenic Acid)	Potassium	Zinc
		Vitamin B6 (Pyridoxine)	Chloride	Fluoride
		Vitamin B7 (Biotin)	Magnesium	Manganese
		Vitamin B9 (Folic acid)	Sulphur	Selenium
		Vitamin B12 (Cobalamin)		Molybdenum
		Vitamin C (Ascorbic Acid)		Cobalt
				Chromium

1. Understanding Vitamins and Minerals

Vitamins are essential for health, growth, and cellular functions but must be obtained through diet.[13] Optimal intake comes from a balanced diet, with supplementation for those at risk.[13] Identifying suboptimal intake is crucial to prevent deficiencies and maintain physiological function.[21]

Table 2: Overview of Functions, Deficiencies, and Toxicities of various Vitamins.[13,21,22]

Vitamin	Functions in Recovery	Deficiency	Hypervitaminosis
Vitamin A	- Regulates immune function - Supports defense against illness and infection	- Night blindness - Xerophthalmia - Bitot spots - Xerosis	- Elevated intracranial pressure - Nausea - Headache - Pain in bones or joints
Vitamin B complex	- B1: Energy metabolism, nerve health - B2: Cell growth, antioxidant - B3: DNA repair, nerve function - B5: Fat metabolism, wound healing - B6: Neurotransmitters, immunity - B7: Skin, hair, metabolism - B9: DNA synthesis, RBC formation - B12: Nerve repair, cognition	- B1: Beriberi, Wernicke syndrome, - Fatigue, nerve damage - B2: Skin rashes, anemia - B3: Confusion, pellagra - B5: Fatigue, burning feet - B6: Peripheral neuropathy, anemia, seizures - B7: Dermatitis, Hair loss, brittle nails - B9: Anemia, birth defects - B12: Numbness, memory loss, Peripheral neuropathy	- B1: Increased heart rate, skin reactions - B2: Yellow urine, light sensitivity - B3: Flushing, liver toxicity - B5: Diarrhoea, digestive issues - B6: Nerve damage, mood swings - B7: Rare, can interfere with certain laboratory tests. - B9: GI issues, skin reactions, neurological problems and can mask B12 deficiency. - B12: Nausea, headache, digestive discomfort, acne rosacea
Vitamin C	- Acts as an antioxidant - Supports wound healing - Maintains skin, blood vessels, bones, and cartilage	- Fatigue - Weight loss - Diarrhoea - Symptoms of Scurvy like swollen or bleeding gums, Arthralgias (joint pains) - poor wound healing	- Rare, but can present with weakness, dizziness, diarrohea, allergic skin rash, insomnia
Vitamin D	- Regulates bone and mineral metabolism - Supports bone, teeth, and muscle health - Influences immune and nervous functions	- Muscle weakness - bone pain - Fatigue - Rickets (in children) - Osteomalacia (in adults)	- Iatrogenic with high daily doses - Hypercalcemia - Nausea,vomiting - Frequent urination - Potential kidney stones
Vitamin E	- Protects cell membranes - Helps to strengthen the immune system - Supports ovarian and placental function	- Gait abnormalities - Impaired reflexes - Loss of proprioception and vibratory sense	- Extremely rare - Risk of bleeding
Vitamin K	- Regulates coagulation enzymes - Supports blood clotting and wound healing - Helps to maintain bone, vascular, and reproductive health	- Bleeding (intracranial, intraabdominal) - Bruising	- Rarely toxic (K1, K2) - Hypervitaminosis K2: jaundice, Hemolytic anemia, hyperbilirubinemia

Table 3: Overview of Functions, Deficiencies, and Toxicities of various Minerals.[13,21,22,23]

Minerals	Functions in Recovery	Deficiency	Mineral Toxicity
Chromium	- Regulates insulin - Increases lean body mass - Helps in reducing body fat percentage - Supports metabolic functions	• Impaired glucose tolerance • Insulin resistance • Weight loss • Peripheral neuropathy • Muscle weakness • Fatigue • Mood changes	- Rare may cause - Higher toxicity in Parenteral Nutrition than Enteral Nutrition
Iron	- Essential for energy and blood production - Transfers oxygen to tissues - Reduces fatigue - Improves physiological functions	- Microcytic hypochromic anemia, fatigue, impaired immune and endocrine function	- Gastrointestinal discomfort, nausea, heartburn, constipation, vomiting (due to supplementation, rare dietary excess)
Selenium	- Helps to boost immune function - Protects cells from oxidative damage	- Impaired immune function, cognitive decline, infertility, fetal development issues, thyroid dysfunction	- Acute: hypotension, tachycardia, tremor, muscle spasms. - Chronic: hair loss, brittle nails, skin rash, joint pain, garlic- breath odor, increased type 2 diabetes risk
Zinc	- Regulates immune processes - Downregulates inflammatory cytokines - Enhances natural killer cell functions	- Hypogonadism, impaired taste, eczematous rash, cheilitis, brittle hair, impaired immune function	- Gastrointestinal disorders - Interstitial nephritis - Respiratory distress - Liver necrosis
Manganese	- Cofactor for metabolic enzymes - Supports immune response - Facilitates tissue repair	- Mild symptoms such as impaired growth, poor wound healing, altered carbohydrate and lipid metabolism.	- Blocks calcium channels - Hypertension - Elevated heart rate
Magnesium	- Cofactor for 300+ enzymes - Regulates muscle/ nerve function, glucose control, energy production	- Muscle spasms, arrhythmias, fatigue, confusion, linked to cardiovascular, metabolic, respiratory, and psychiatric conditions	- Hypermagnesemia: hypotension, bradycardia, coma (rare, mainly from supplements or kidney disease)

Continued

Minerals	Functions in Recovery	Deficiency	Mineral Toxicity
Cobalt	- Facilitates B12 synthesis - Supports red blood cell production - Helps to enhance neurological health	- Rare - Linked to B12 deficiency - Anemia	- Cardiac toxicity - Beer-drinker cardiomyopathy
Copper	- Regulates redox reactions - Supports immune function - Helps to enhance angiogenesis	- Cardiac arrhythmias - Myeloneuropathy - Delayed wound healing - Microcytic anemia - Neutropenia - Osteoporosis - Hair depigmentation	- Rare may cause - Hematemesis - Hypotension - Melena - Coma - Headaches - Behavioral changes - Fever - Diarrhoea - Abdominal cramps - Kayser-Fleischer rings (brown rings around eyes) - Jaundice
Fluoride	- Stimulates bone formation - Helps to prevent dental caries	- Weakened teeth - Dental cavities - Osteoporosis	- Dental Fluorosis - teeth discoloration - Skeletal Fluorosis -pain, stiffness, bone deformities
Iodine	- Regulates thyroid function - Ensures proper metabolic function during healing	- Goiter, impaired neurocognitive development, hypothyroidism, congenital abnormalities	- Rare, may include- - Acute: abdominal pain, nausea, vomiting, diarrhoea, cardiovascular symptoms. - Chronic: thyroiditis, hyperthyroidism
Potassium	- Crucial in acid-base balance - Regulates blood pressure and muscle contractions	- Constipation - Arrhythmia - Fatigue - Muscle weakness	- Excess intake can result in hyperkalemia, affecting heart rhythm and causing muscle weakness.
Calcium	- Bone mineralization - Nerve impulse transmission - Muscle contraction	- Bone loss - Pregnancy complications - Cancer - Cardiovascular disease	- May cause kidney stones, possible myocardial infarction
Phosphorus	- Energy metabolism - Structural role in RNA, DNA, bones, teeth, membranes	- Bone demineralization - Muscle weakness - Neurological symptoms	- Rare, may cause - Chronic conditions like calcification, Cardiovascular disease

Continued

Minerals	Functions in Recovery	Deficiency	Mineral Toxicity
Sodium	- Fluid balance regulation - Nerve impulse transmission - Muscle contraction	- Low intake can lead to hyponatremia	- Rare, may cause - Chronic imbalance associated with adverse health outcomes
Chloride	- Helps in fluid and acid-base balances - Regulates muscle contraction and nervous function.	- Rare in adults - Symptoms found in infants fed with chloride-deficient milk- Hypokalemic metabolic alkalosis - Gastrointestinal symptoms - Growth failure - Lethargy - Irritability - Anorexia - Weakness	- Metabolic Acidosis, dehydration and rapid breathing.
Sulphur	- Component of amino acids (methionine, cysteine) - Supports protein synthesis and detoxification - Involved in antioxidant activity via glutathione	- Deficiency is rare due to adequate protein intake	- Rare may cause gastrointestinal discomfort, difficulty in breathing or swallowing, wheezing

Table 4: Summary of Recommended Dietary Allowances (RDA) of Micronutrients for pediatrics (as per ICMR).[24]

Nutrient	Unit/ day	0–6 months	6–12 months	1–3 years	4–6 years	7–9 years	10–12 years (Boys/ Girls)	13–15 years (Boys/ Girls)	16–18 years (Boys/ Girls)
Calcium	mg	300*	300	500	550	650	850	1000	1050
Iron	mg	-	3.0	8.0	11.0	15.0	16/28	22/30	26/32
Zinc	mg	-	2.5	3.3	4.5	5.9	8.5	14.3/12.8	17.6/14.2
Magnesium	mg	30*	75*	90	125	175	240/250	345/340	440/380
Phosphorus*	mg	200		300	350	400	500	600	600
Vitamin A	µg	350*		390	510	630	770/790	930/890	1000/860
Vitamin D	IU	400*		600					

Continued

Nutrient	Unit/ day	0–6 months	6–12 months	1–3 years	4–6 years	7–9 years	10–12 years (Boys/ Girls)	13–15 years (Boys/ Girls)	16–18 years (Boys/ Girls)
Vitamin E	mg	7.5-10							
Vitamin C	mg	20*	30*	30	35	45	55/50	70/65	85/70
Thiamin (B1)	mg	0.2*	0.4*	0.7	0.9	1.1	1.5/1.4	1.9/1.6	2.2/1.7
Riboflavin (B2)	mg	0.4*	0.6*	1.1	1.3	1.6	2.1/1.9	2.7/2.2	3.1/2.3
Niacin (B3)	mg	2*	5*	7	9	11	15/14	19/16	22/17
Pathothenic acid (B5)*	mg	2		2	3	4	5		
Vitamin B6	mg	0.1*	0.6	0.9	1.2	1.5	2.0/1.9	2.6/2.2	3.0/2.3
Biotin (B7)	µg	4	5	7	9	12	15/16	20	25
Folate (B9)	µg	25*	85	120	135	170	220/225	285/245	340/270
Vitamin B12	µg	1.2		1.2		2.2			
Sodium	mg	500	650	1000	1300	1600	-	-	-
Potassium	mg	900	1100	1750	2250	2825	-	-	-
Iodine	µg	100*	130*	90			100	140	140

*Adequate intake

Table 5: Summary of RDA of nutrients for adults (as per ICMR).[24]

Category		Adult Men >18y			Adult Women >18y			Pregnant woman	Lactation	
Physical Activity Level	Unit/ day	Seden-tary	Mode-rate	Heavy	Seden-tary	Mode-rate	Heavy		0-6 months	6-12 months
Calcium	mg/d		1000			1000		1000	1200	
Magnesium	mg/d		440			370		440	400	
Iron	mg/d		19			29		27	23	
Zinc	mg/d		17			13.2		14.5	14.1	

Continued

Category		Adult Men >18y			Adult Women >18y			Pregnant woman**	Lactation	
Physical Activity Level	Unit/ day	Seden-tary	Mode-rate	Heavy	Seden-tary	Mode-rate	Heavy			
Iodine	µg/d		140			140		220	280	
Vitamin B1	mg/d	1.4	1.8	2.3	1.4	1.7	2.2	2	2.1	
Vitamin B2	mg/d	2	2.5	3.2	1.9	2.4	3.1	2.7	3	29
Vitamin B3	mg/d	14	18	23	11	14	18	13	16	
B6	mg/d	1.9	2.4	3.1	1.9	1.9	2.4	2.3	2.16	2.07
Vitamin B9	µg/d		300			220		570	330	
B12	µg/d		2.2			2.2		2.45	3.2	
Vitamin C	mg/d		80			65		80	115	
Vitamin A	µg/d		1000			840		900	950	
Vitamin D	µg/d		600			600		600	600	

2. Drug-Nutrient Interactions

Drug-nutrient interactions refer to the complex physical, chemical, physiological, or pathophysiological relationships that can arise between medications and nutrients. These interactions often involve multiple, intertwined factors, and medications can impact various stages of nutrient processing.[25]

Table 6: Potential Drug-Nutrient Interactions[26,27]

Drug Category	Micronutrients Affected
Proton pump inhibitors	Vitamin B12, Vitamin C, Calcium, Magnesium, Iron
NSAIDs	Vitamin C, Iron
Anti-hypertensives	Vitamin B1, Magnesium, Potassium, Zinc
Anti-Tuberculosis drugs	Vitamin B6
Hypercholesterolemic	Vitamin D, Vitamin E
Oral hypoglycemics	Vitamin B12, Calcium, Vitamin D

Continued

Drug Category	Micronutrients Affected
Corticosteroids	Vitamin D, Calcium
Bronchodilators	Vitamin D, Calcium
SSRI antidepressants	Vitamin D, Calcium
Oral contraceptives	Vitamin B6, Vitamin B9, Vitamin B12, Magnesium

Contraindications

Table 7: List of Micronutrients and their known contraindications

Micronutrients	Contraindications
VITAMINS	
Vitamin A	Use with caution during pregnancy, lactation, and in individuals with known hypersensitivity to this drug class. Caution is also advised in patients with hepatic or renal disorders, a history of alcoholism, or those diagnosed with acne vulgaris.[28]
Vitamin B1	There are no documented absolute contraindications for vitamin B1. However, individuals with a history of hypersensitivity or allergic reactions to vitamin supplements are advised to use with caution.[29]
Vitamin B2	There are no documented absolute contraindications for vitamin B2. However, individuals with a history of hypersensitivity or allergic reactions to vitamin supplements are advised to use with caution.[30]
Vitamin B3	Use with caution in patients with peptic ulcer disease, arterial bleeding, hepatic disease, or known hypersensitivity reactions.[31]
Vitamin B5	Caution is advised in patients on azithromycin, clarithromycin, erythromycin, or roxithromycin, or those allergic to pantothenic acid.[32]
Vitamin B6	Excessive intake may lead to hypervitaminosis B6. Pyridoxine should be used with caution in women during pregnancy, breastfeeding, or those on oral contraceptives.[33]
Vitamin B7	There are no documented absolute contraindications for vitamin B7.[34]
Vitamin B9	There are no documented absolute contraindications for vitamin B9. However, patients with a history of folic acid allergy should be prescribed with caution.[34]
Vitamin B12	Combined supplementation of vitamin B6 and B9 with B12 in individuals with diabetic nephropathy has been associated with an accelerated decline in renal function and an increased incidence of vascular events.[34]
Vitamin C	Use with caution in patients with G6PD deficiency, thalassemia, sickle cell disease, or hemochromatosis.[35]
Vitamin D	High intake, especially from supplements, may attenuate the efficacy of statins like atorvastatin, lovastatin, and simvastatin due to shared metabolic enzyme pathways. Additionally, thiazide diuretics reduce urinary calcium excretion, while vitamin D enhances intestinal calcium absorption, increasing the risk of hypercalcemia, particularly in older adults and those with renal insufficiency or hyperparathyroidism.[35]

Continued

Vitamin E	Caution is advised in individuals undergoing anticoagulant therapy (e.g., warfarin) or those with vitamin K deficiency, as it increases the risk of bleeding.[34]
Vitamin K	Must be carefully administered in neonates, and patients with hereditary hypoprothrombinemia, kidney dysfunction, over-anticoagulation due to heparin therapy, or hypersensitivity to vitamin K.[36]
MINERALS	
Chromium	Diabetic patients on anti-diabetic medications and insulin therapy should use with caution, as chromium increases insulin sensitivity and the risk of hypoglycemia.[37]
Iron	Caution is advised in patients diagnosed with iron-overloaded states like hereditary hemochromatosis or hemosiderosis, and in those with hemolytic anemia.[34]
Selenium	Prior allergic response to topical selenium application is the only reported concern.[38]
Zinc	Supplementation exceeding the tolerable upper intake level of 40 mg of elemental zinc per day is not recommended for well-nourished pregnant and lactating women.[39]
Manganese	Use with caution in patients with iron deficiency, as decreased iron levels increase manganese absorption, potentially leading to toxicity with prolonged exposure.[34]

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CHAPTER 3: MICRONUTRIENTS IN ADULTS

1. Acute Illness

a. Acute Infections

An acute infection is a sudden and short-term illness. Depending on the route of entry and the affected organs, infections can lead to various illnesses, such as respiratory infections, gastrointestinal disorders, or skin infections. The severity of an infection depends on the number of invading pathogens and the body's ability to fight back.[1,2]

Clinical Presentation[2,3]

1. Fever
2. Sudden weight loss
3. Fatigue and weakness
4. Inflammation and swelling
5. Pain and discomfort
6. Nausea, vomiting, diarrhoea
7. Coughing, shortness of breath
8. Redness
9. Rashes

Role of Micronutrients in Recovery in Acute Infections

- **Vitamin B-Complex, B6 (1.9–3.1 mg/day)[4], B12 (3-7 µg/day)[10]:** Support white blood cell production and maintain overall cellular function.[3,5,8]
- **Vitamin C (6-8 g/day)[7]:** Boosts the immune system and aids tissue repair.[1]
- **Iron (19–29 mg/day)[4]:** Supports oxygen transport and immune function but should be used cautiously during infections.[3,5]
- **Selenium (55-70 mcg/day)[6]:** Improves immune response against viral and bacterial pathogens and counteracts oxidative cellular damage associated with infection and inflammation.[3]
- **Zinc (8-12 mg/day)[5]:** Helps to fight infections.[1]

b. Burns and Wound Healing

Burn injuries lead to significant metabolic stress and hypermetabolism, characterized by increased energy expenditure, exaggerated protein catabolism, and nutrient losses through burn wound exudates. These effects, coupled with a heightened susceptibility to infection, place unique demands on the body for healing and recovery.[1,2,9]

Clinical Presentation[1]

1. Hypermetabolic state: Rapid weight loss, muscle wasting, increased energy demands, and delayed wound healing.
2. Protein catabolism: Signs of protein depletion such as poor wound closure, muscle atrophy, and loss of lean body mass.
3. Fluid and electrolyte imbalance: Dehydration, altered urine output, and signs of electrolyte disturbances such as hyponatremia, hypokalemia, or hypocalcemia.
4. Infection susceptibility: Fever, redness, swelling around wounds, and systemic signs of sepsis.
5. Nutritional deficiencies: Delayed wound healing, fragile skin, or signs of vitamin and mineral deficiencies like brittle hair and nails.
6. Gastrointestinal dysfunction: Anorexia, dysphagia, or signs of ileus.

Role of Micronutrients in Recovery in Burns and Wound Healing

- **Vitamin A (840-1000 µg/d)[4]:** Promotes epithelialization and prevent infections.[1]
- **Vitamin B9 (220-300 µg/day) and Vitamin B12 (2.2–2.4 µg/day)[4]:** Helps to address anemia and support red blood cell regeneration during the recovery phase.[1]
- **Iron (19-29 mg/day)[4]:** May be given to burn patients with anemia to improve oxygen delivery and support red blood cell production.[1]
- **Vitamin C (500–1000 mg/day)[7]:** Supports collagen synthesis, enhances wound healing, and strengthens immune defenses.[1]
- **Vitamin D (600 IU/day)[4]:** Helps to counteract deficiencies caused by extensive skin damage.[1,2]
- **Vitamin E (7.5-10mg/day (as α-tocopherol)[4]:** Reduce oxidative stress and inflammation, promoting better wound healing.[1,2]
- **Zinc (50 mg elemental 1–2xRDA/day)[10]:** Supports immune function, which is essential for wound healing.[9]

c. Diarrhoea

Diarrhoea, as defined by the World Health Organization, involves the passage of three or more loose or liquid stools daily. It results from various factors, including accelerated intestinal transit, reduced enzymatic digestion, decreased fluid and nutrient absorption, increased secretion, or exudative losses.[1]

Clinical Presentation[1]

1. Frequent loose or watery stools
2. Abdominal cramps or discomfort
3. Dehydration (manifested as dry mouth, fatigue, dizziness)
4. Fever or chills (in infectious diarrhoea)
5. Blood or mucus in stools (inflammatory or exudative diarrhoea)
6. Weight loss and malnutrition (chronic diarrhoea)

Since diarrhoea is a symptom, not a disease, the first step in medical treatment is to identify and address the underlying cause. The next priority is fluid and electrolyte replacement, which is crucial in cases of severe diarrhoea.[1]

Role of Micronutrients in Recovery from Diarrhoea

- **Sodium (1725 mg/L), Chloride (2300 mg/L), and Potassium (780 mg/L)[8]:** Essential components of oral rehydration solutions (ORS) to correct electrolyte losses, maintain balance, and prevent complications during severe diarrhoea.[9,12]
- **Zinc (13-17 mg/d)[4,11]:** Supports immune function, helps to restore the intestinal barrier, and reduces the duration and severity of diarrhoea, particularly in children.[9]

d. Fracture

A Fracture is partial or complete break in a bone, which may spontaneously occur or result from a fall or an injury. It can range from a thin crack to a complete break. Bone can fracture crosswise, lengthwise, in several places, or into many pieces.[1,9]

Clinical Presentation[1]

1. Pain
2. Swelling
3. Bleeding
4. Numbness

DEXA scans can identify decreases in bone mineral density before they become apparent on standard X-rays, allowing for the diagnosis of conditions like osteopenia and osteoporosis prior to the occurrence of fractures.[1]

Role of Micronutrients in Recovery in Fracture

In a clinical setting, the following micronutrients are essential to support recovery from Fracture:

- **Vitamin D (60,000 IU/week for 6–8 weeks)[14]:** Helps to achieve serum 25-hydroxy vitamin D levels of at least 30 ng/ml.[1,13]
- **Vitamin K (90-120 µg/day)[14]:** Essential for bone health.[19]
- **Calcium (1000–1500 mg/d)[14]:** Supports normal bone structure and function.[1]

e. Gastroenteritis or GI Infections

Gastroenteritis is the inflammation of the stomach and intestines caused by infections, leading to diarrhoea, vomiting, and dehydration, and posing a major global health risk, especially for children in developing countries.[1,2]

Clinical Presentation[1]

1. Symptoms of Dehydration: Dry mouth, reduced urination, dizziness, and lethargy
2. Severe GI manifestations: Persistent diarrhoea, severe abdominal pain, blood or mucus in stools
3. Fever: High fever
4. Malnutrition indicators: Weight loss, fatigue, and muscle wasting, particularly in chronic cases

Role of Micronutrients in Recovery in GI Infections

- **Vitamin A (840-1000 µg/d)[4]:** Supports the immune system, preserves gut mucosal integrity, and enhances recovery.[1]
- **Vitamins B6 (1.9–3.1 mg/day) & B12 (2.2–2.4 µg/day)[4]:** Helps to combat deficiencies caused by prolonged gastrointestinal inflammation.[21]
- **Vitamin B9 (220-300 µg/day)[4]:** Addresses deficiencies due to chronic malabsorption and supports red blood cell formation.[20]
- **Iron (19–29 mg/day)[4]:** Addresses existing anemia linked to chronic gastrointestinal infections, blood loss, malabsorption, maldigestion, drug-nutrient interactions, and inadequate intake.[21]
- **Zinc (20 mg/d)[1]:** Supports immune function, restores the intestinal barrier, and reduces the duration and severity of diarrhoea.[1]

f. Skin Infections

The skin is the largest organ system in the body. Beyond its physical role, the skin is often the first organ to show signs of nutritional deficiencies, hormonal imbalances, or underlying medical conditions.[6,11]

Clinical Presentation[9,16]

1. Dryness, flakiness, or rough texture
2. Acne and pimples
3. Redness, inflammation, or irritation
4. Oozing or blisters
5. Skin rashes and pain
6. Slow wound healing

Role of Micronutrients in Recovery in Skin Infections

1. **Vitamin A (840-1000 µg/d)[4]:** Promotes skin regeneration and healing.[9,30]
2. **Vitamin B2 (1.9–3.2 mg/day)[4]:** Prevents eczema around the corners of the mouth and red lesions on the lips.[9]
3. **Vitamin B3 (14–23 mg/day)[4]:** Maintains the skin barrier function and is effective in preventing and treating dermatitis.[9]
4. **Vitamin C (65-80 mg/d)[4]:** Enhances collagen production, improves skin elasticity, and protects against oxidative damage.[9,16]
5. **Vitamin E (7.5-10 mg/day (as α-tocopherol)[4]:** Protects the skin from free radicals and UV-induced damage, helping prevent premature aging.[9,16]
6. **Zinc (13-17 mg/d)[4]:** Plays a key role in wound healing and acne prevention, making it beneficial for acne-prone or sensitive skin.[17]

2. Chronic Illness

a. Autoimmune Conditions

Autoimmune conditions occur when the immune system attacks the body's own tissues, causing inflammation and damage.[1]

Common Autoimmune Diseases: Rheumatoid Arthritis (RA), Systemic Lupus Erythematosus (SLE), Multiple Sclerosis (MS), Celiac Disease, Psoriasis & Psoriatic Arthritis, Myasthenia Gravis.[1,15]

Clinical Presentation[1]

1. Chronic fatigue
2. Joint pain & swelling
3. Muscle Weakness & Pain
4. Skin Rashes & Lesions
5. Fever & Inflammation
6. Gastrointestinal Issues
7. Unexplained Weight Loss or Gain
8. Hair Loss

Role of Micronutrients in Recovery in Autoimmune Conditions[1,9,21]

- **Vitamins B6 (1.9–3.1 mg/day), B9 (220-300 µg/day) and B12 (2.2–2.4 µg/day)[4]:** Support immune function and helps to reduce inflammation.[1,21]

- **Vitamin D (600 IU/day)[1]:** Reduces inflammation and regulates immune response.[1]
- **Vitamin E (7.5-10 mg/day (as α-tocopherol)[4]:** Helps to reduce oxidative stress.[1]

b. Cognitive Disease

Cognitive disorders are complex conditions influenced by both physical and psychological factors. These disorders often arise from imbalances in brain structure and function, where nutrition plays a crucial role in brain health.[1]

Clinical Presentation[1]

1. Sudden mood swings or erratic behavior, often linked to blood sugar fluctuations.
2. Cognitive changes like memory issues, difficulty concentrating, or learning challenges.
3. Symptoms related to emotional well-being, including depression, anxiety, or low self-esteem, potentially connected to nutrient deficiencies or imbalances.
4. Neurological symptoms such as headaches, peripheral neuropathy, or muscle dysfunction linked to food intolerances or allergies.
5. Increased susceptibility to psychiatric conditions, such as ADHD, autism, or schizophrenia, often triggered by environmental or dietary factors.[1]

Role of Micronutrients in Recovery in Cognitive Disease

- **Vitamin B Complex (Vitamins B6 (1.9–3.1 mg/day) and B12(2.2–2.4 µg/day)[4]:** Supports nerve function, myelin synthesis, and the production of neurotransmitters.[1]
- **Vitamin D (600 IU/d)[4]:** Important for brain, bone, and skeletal health. Low vitamin D levels have been associated with mood disorders and cognitive impairment.[1]
- **Iron (19–29 mg/day)[4]:** Deficiency can lead to fatigue, depression, and cognitive disturbances, even before anemia is apparent.[1]
- **Selenium (40 µg/d)[4]:** Supports proper immune system function.[1]
- **Zinc (13-17 mg/d)[4]:** Helps to improve mood disorders and may contribute to enhanced cognitive performance and mood stability.[1]

c. Diabetes

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin production, action, or both.[1,9]

Clinical Presentation[1,9]

1. Common Signs

I. Increased thirst (Polydipsia): An increase in thirst due to elevated blood sugar levels.

II. Frequent urination (Polyuria): Excessive urination as the kidneys work to excrete the excess glucose.

III. Excessive hunger (Polyphagia) often a symptom of conditions like diabetes, hyperthyroidism, or hormonal imbalances

IV. Unexplained weight loss: Despite normal or increased eating, weight loss may occur due to the body using fat for energy instead of glucose.

V. Fatigue: Chronic tiredness, as the body is unable to efficiently use glucose for energy.

VI. Blurred vision: High blood sugar levels can lead to fluid changes in the eyes, causing temporary blurred vision.

2. Progressing Complications:

I. Microvascular Complications:

   A. Diabetic retinopathy: Vision problems, including blurred or fluctuating vision, can indicate early damage to the blood vessels in the eyes.

   B. Diabetic neuropathy: Tingling sensation, numbness, or burning sensations in the hands and feet, typically starting in the extremities.

   C. Diabetic nephropathy: Early signs may include proteinuria or swelling in the feet, legs and hands

II. Macrovascular Complications:

   A. Cardiovascular issues: Chest pain, shortness of breath, or irregular heartbeats may indicate cardiovascular complications, which are common in people with uncontrolled diabetes.

   B. Stroke symptoms: Sudden numbness, weakness, or difficulty speaking could be signs of a stroke, another potential complication from diabetes.[1,5]

Role of Micronutrients in Recovery in Diabetes

- **Vitamin A (840–1000 µg/day)[4]:** Reduces inflammation and assists in the preservation of beta cells.[9]
- **Vitamin B9 (220-300 µg/day)[4] and Vitamin B12 (1000 mcg/day)[23]:** Address anemia and normalize gene expression in diabetic patients, particularly those on long-term metformin therapy.[9]
- **Vitamin C (80 mg/d)[4]:** Improves endothelial function, reduces oxidative stress, and helps to prevent diabetic retinopathy.[9]
- **Vitamin D (600 IU/d)[4]:** Enhances insulin sensitivity and reduces inflammation, as deficiency is common in individuals with diabetes.[9]
- **Vitamin E (7.5-10mg/day (as α-tocopherol)[4]:** Helps to reduce oxidative damage in diabetic neuropathy and may support cardiovascular health.[9]
- **Zinc (13-17 mg/d)[4]:** Supports insulin metabolism, improves immune function, and reduces oxidative stress.[1, 9]

d. Hypertension and Cardiovascular Disease

Hypertension is a condition of persistently high blood pressure, increasing the risk of heart, brain, and kidney diseases. Normal adult blood pressure is 120/80 mm Hg. Hypertension is known as a "silent killer," as it often presents with no symptoms but can lead to severe health complications, including heart failure, stroke, and renal disease.[1, 9]

Clinical Presentation[1, 9]

1. Chest pain
2. Headache
3. Dizziness or Lightheadedness
4. Fatigue

Other Symptoms[1, 9]

- Cardiac symptoms: Hypertension may lead to cardiac enlargement, ischemic changes, or signs of left ventricular strain. Myocardial infarction and heart failure may also manifest, particularly in untreated or poorly controlled cases.
- Retinal changes: Retinal exudates and hemorrhages can indicate elevated blood pressure levels and potential end-organ damage.
- Renal symptoms: Impaired renal function, which may be detected through blood tests, is a potential consequence of chronic hypertension.
- Neurological symptoms: Signs of a cerebrovascular accident, including sudden weakness, speech difficulty, or visual disturbances, could point to hypertension-related brain injury.
- Hypertensive crisis: Sudden, severe increases in blood pressure (e.g., DBP >115 mm Hg) may be accompanied by symptoms like headaches, chest pain, or vision disturbances, indicating the need for urgent intervention.

Role of Micronutrients in Recovery in Hypertension and Cardiovascular Disease

- **Vitamin B complex (especially Vitamin B9, 220-300 µg/day)[4]:** Adequate levels help to prevent complications and worsening of cardiovascular diseases.[1]
- **Potassium (3500 mg/day)[1]:** Administer at low doses to maintain serum levels in hypokalemic patients.[1]
- **Sodium (< 2300 mg per day)[1,9]:** Limit intake with a further reduction to 1600 mg/day for individuals not achieving blood pressure targets, especially when following the dietary approaches to stop hypertension (DASH) diet.[1,9]

e. Kidney Disease

Chronic Kidney Disease (CKD)

Chronic Kidney Disease (CKD) is the gradual loss of kidney function over time, potentially leading to kidney failure and requiring dialysis or a transplant. The progression of CKD can be influenced by various factors, including diabetes, hypertension, and glomerulonephritis. Medical nutrition therapy (MNT) plays a crucial role in slowing the progression of CKD and managing the associated symptoms.[1]

Clinical Presentation[1]

1. Edema: Swelling, often around the ankles, feet, or face, due to fluid retention caused by impaired kidney function.
2. Fatigue: A common symptom due to the buildup of waste products in the body.
3. Shortness of breath: Fluid buildup can also affect lung function.
4. Changes in urine output: Reduced urine output, or changes in the frequency and appearance of urine.
5. Nausea and Vomiting: Often caused by the accumulation of toxins in the body.
6. Hypertension: High blood pressure, common in CKD patients, can exacerbate kidney damage.
7. Bone pain: Due to phosphorus imbalance and bone mineral disorders.

Role of Micronutrients in Recovery in Chronic Kidney Disease

- **Water-Soluble Vitamins[4]: B1(1.4–2.3 mg/day)[4], B2(1.9-3.2 mg/day)[4], B6(1.9–3.1 mg/day)[4], B12 (100–200 mcg/day)[24], B9 (1 mg/day)[24]** Supplementation may be necessary to compensate for dietary restrictions associated with CKD.[1]
- **Vitamin D (60,000 IU/week × 6–8 weeks)[24]:** Supports bone health and helps to maintain calcium balance in CKD patients.[1]
- **Iron (100–200 mg/day)[20]:** Recommended for CKD patients with anemia, particularly in stages 3 to 5, ensuring it is not administered in those with acute infections.[1,31]
- **Sodium[4]:** Limit intake to 1500 mg per day to help managing edema and maintaining fluid balance in CKD patients.[1]

End-Stage Renal Disease (ESRD)

ESRD occurs when the kidneys are no longer able to perform their essential functions, including waste excretion, fluid regulation, and hormone production which requires dialysis or transplant. The management of ESRD requires careful attention to nutrition, fluid balance, and electrolyte levels to support patient health and quality of life.[1]

Clinical Presentation[1]

1. Malaise, weakness, and fatigue

2. Nausea, vomiting, and a metallic taste in the mouth
3. Muscle cramps and itching
4. Fluid retention, edema
5. Neurological impairment such as confusion or difficulty in concentration
6. High blood urea nitrogen (BUN) and creatinine levels

Role of Micronutrients in Recovery in ESRD

- **Water-Soluble Vitamins (Vitamin C (60–100 mg/day (avoid >200 mg/day), Vitamin B6 (10–20 mg/day), Vitamin B9 (1 mg/day) and Vitamin B12 (100–200 mcg/day)[24]:** Helps to counteract losses during dialysis, as these vitamins are commonly depleted in dialysis patients.[1,9]
- **Calcium (1000 mg/day) and Vitamin D (60,000 IU/week × 6–8 wks (often active form))[24]:** Help to prevent renal osteodystrophy and maintain calcium balance, as the kidneys' ability to activate Vitamin D decreases.[1,9]
- **Iron (100–200 mg/day)[24]:** Supports anemia management and enhances the effectiveness of erythropoiesis- stimulating agents (ESAs).[8,32]
- **Potassium[21]:** Intake should be reduced to 2300–3100 mg per day, with further reduction to 2000g in anuric patients during dialysis.[32]
- **Sodium[1,6]:** Limited to 1500–2000mg/day, with high-potassium foods avoided to maintain electrolyte balance.[1,9]

f. Liver Disease

Alcoholic liver disease (ALD)

ALD is a major cause of liver-related morbidity and mortality worldwide, characterized by inflammation, jaundice, and liver damage including Hepatic Steatosis (Fatty Liver) and Cirrhosis – End-stage liver disease, often complicated by ascites, jaundice, and hepatic encephalopathy.[1,6]

Clinical Presentation[1,6]

1. **Hepatic Steatosis (Fatty Liver):** Often asymptomatic but may include fatigue, right upper quadrant discomfort, hepatomegaly (enlarged liver).
2. **Alcoholic Hepatitis:** Characterized by hepatomegaly, jaundice, anorexia, nausea, vomiting, abdominal pain, weakness, weight loss, and fever. Serum tests may show elevated transaminases and bilirubin, decreased albumin, and anemia.
3. **Cirrhosis:** Symptoms of liver failure, including ascites, jaundice, gastrointestinal bleeding, hepatic encephalopathy, and portal hypertension. Patients may experience confusion, asterixis (flapping tremor), and altered mental status due to liver dysfunction.

Role of Micronutrients in Recovery in Alcoholism[1,9]

- **Vitamin A (840-1000 µg/d)[4]:** Alcohol impairs its metabolism, and supplementation can help to prevent night blindness and support liver function.[1,34]
- **Vitamin B1 (100–300 mg/d)[27]:** Prevents Wernicke-Korsakoff syndrome, a condition resulting from thiamine deficiency, which is common in alcoholics.[1,34]
- **Vitamin B9 (1–5 mg/d)[27]:** Addresses deficiencies caused by poor intake, impaired absorption, and increased excretion, all of which are common in alcoholics.[1,35]
- **Vitamin B12 (1000 mcg/day)[27]:** Essential for preventing macrocytic anemia and supporting red blood cell formation in patients with ALD.[1,6]
- **Vitamin D (600 IU/d)[1]:** Helps to prevent osteomalacia and supports immune function, both of which are affected by chronic alcohol use.[1,9,35]
- **Magnesium (370–440 mg/day) and Zinc (13.2–17 mg/day)[4]:** Often deficient in alcoholics; supplementation can help to prevent complications such as muscle cramps, seizures, and delayed wound healing.[1]

g. Viral Hepatitis

Viral hepatitis refers to liver inflammation caused by a variety of hepatitis viruses, including A, B, C, D, and E. These infections are transmitted through different routes: hepatitis A and E are primarily spread through the fecal-oral route, while hepatitis B, C, and D are transmitted via blood and body fluids. Minor viruses like Epstein-Barr, cytomegalovirus, and herpes simplex can also cause acute hepatitis.[1]

Clinical Presentation[1]

Viral hepatitis typically progresses through four phases:

1. Incubation Phase: Characterized by vague constitutional symptoms such as generalized fatigue (malaise), anorexia, nausea, and discomfort or pain localized to the right upper quadrant of the abdomen.
2. Pre-icteric Phase: Persistence of systemic symptoms is common during this stage. Approximately 10–20% of patients may exhibit immune-mediated manifestations, including low-grade fever, arthralgia (joint pain), cutaneous rash, and, in some cases, angioedema.
3. Icteric Phase: Defined by the appearance of jaundice, marked by yellow discoloration of the skin, sclerae, and mucous membranes. This phase is often accompanied by exacerbation of systemic symptoms and hepatomegaly.
4. Convalescent Phase: Gradual resolution of jaundice and systemic manifestations is observed.

Infections with hepatitis A and B viruses typically result in complete clinical recovery, whereas hepatitis C virus infection frequently progresses to chronic hepatitis.

While antiviral drugs and supportive therapy remain the primary line of treatment, certain micronutrients play a supportive role in liver recovery and immune strengthening.

Role of Micronutrients in Recovery in Viral Hepatitis

- **Vitamin A (840–1000 µg/day)[4]:** Supports liver function and improves immune response during recovery from viral hepatitis.[1,16]
- **Vitamin B9 (220-300 µg/day)[4]:** Supports cellular regeneration, particularly in pregnant women diagnosed with viral hepatitis.[1,9,16]
- **Vitamin B12 (2.2-2.4 µg/d)[4]:** Improves neurological function, supports liver metabolism, and enhances red blood cell production.[33]
- **Vitamin C (65-80 mg/d)[4]:** Enhances collagen synthesis and boosts immune function.[33]
- **Vitamin D (1,000-2,000 IU/d)[1]:** Supports immune function and improves bone health in patients recovering from viral hepatitis.[1,16]
- **Vitamin E (7.5-10 mg/day (as α-tocopherol)) and Zinc (13.2–17 mg/day)[4]:** Act as antioxidants, reducing inflammation and helping manage oxidative stress in viral hepatitis.[1,9,16]

Metabolic Dysfunction Associated Fatty Liver Disease (MAFLD)

MAFLD is a spectrum of liver conditions marked by the accumulation of fat in the hepatocytes, which can progress from simple steatosis to nonalcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and even hepatocellular carcinoma. It is most commonly associated with obesity, type 2 diabetes, dyslipidemia, and metabolic syndrome[1]

Clinical Presentation [1,2]

1. Steatosis: Simple fat accumulation in the liver without liver inflammation or damage.
2. Nonalcoholic Steatohepatitis (NASH): Characterized by hepatocyte injury, inflammation, and potential fibrosis.[1]
3. Cirrhosis: Advanced liver damage characterized by scarring, impaired liver function, and potential progression to liver failure or hepatocellular carcinoma.[1]
4. Symptoms: Fatigue, right upper quadrant pain, hepatomegaly, and in more advanced stages, jaundice, ascites, and hepatic encephalopathy.[1]

Role of Micronutrients in Recovery in MAFLD

- **Vitamins B (B1 (1.4–2.2 mg/day), B6 (1.9–3.1mg/day), B9 (220-300 µg/day) and B12 (2.2–2.4 µg/day)[4]:** Essential for energy metabolism, DNA synthesis, and liver detoxification processes, helping prevent liver dysfunction.[36]
- **Vitamin C (80 mg/day) and Selenium (40 µg/day)[21]:** Helps to mitigate oxidative stress and inflammation in patients with NAFLD.[1,33]
- **Vitamin D (600 IU/d)[26]:** Addresses the high prevalence of deficiency in MAFLD patients and plays a role in improving liver function.[1,33]

- **Vitamin E (7.5-10 mg/day (as α-tocopherol)[26]:** A first-line treatment for NASH in non-diabetic patients, providing protection against oxidative stress and liver inflammation.[28,33]
- **Magnesium (370–440 mg/day)[4]:** Supports liver function and helps to address deficiencies commonly seen in NAFLD patients.[2]

Cholestatic Liver Diseases

Cholestatic liver diseases are conditions that obstruct bile flow, causing bile buildup, liver damage, cirrhosis, and potential liver failure. Key types include Primary Biliary Cirrhosis (PBC), an autoimmune disease targeting small bile ducts, and Primary Sclerosing Cholangitis (PSC), characterized by bile duct fibrosis and inflammation.[1]

Clinical Presentation[1]

1. **Primary Biliary Cirrhosis (PBC):** Pruritus (itching), fatigue, elevated liver enzymes, and possible signs of cirrhosis such as hepatomegaly, jaundice, and ascites.[1]
2. **Primary Sclerosing Cholangitis (PSC):** Fatigue, pruritus, jaundice, and signs of liver dysfunction; associated with inflammatory bowel disease (particularly ulcerative colitis).[1]

Role of Micronutrients in Recovery in Cholestatic Liver Disease

- **Fat-Soluble Vitamin A (10,000–25,000 IU/d), Vitamin D (60,000 IU/week × 6–8 weeks), Vitamin E (400–800 IU/d), Vitamin K (5–10 mg/week)28:** Patients with cholestatic liver diseases are at risk for deficiencies; supplementation is recommended to prevent complications.[1]
- **Vitamin B9 (220-300 µg/d)[1]:** Supports cellular repair and regeneration, particularly in advanced cholestatic liver disease.[1]
- **Vitamin C (80 mg/d)[4]:** Provides antioxidant support, aiding liver regeneration and immune function.[1]
- **Calcium (1000 mg/d) and Vitamin D (600 IU/d)[1]:** Essential for preventing osteoporosis, a common issue in cholestatic liver disease.[1]
- **Selenium (40 µg/day)[4]:** Helps to reduce oxidative stress and supports liver repair.[1]

h. Malnourishment

1. Malnutrition

Malnutrition is a state of nutrient deficiency or imbalance caused by starvation, chronic disease, or acute illness, leading to impaired recovery and increased health risks.[1,21]

Clinical Presentation[1]

1. Reduced intake: A significant decrease in food consumption due to anorexia, swallowing difficulties, or metabolic changes.

2. Weight loss: More than 5% of body weight lost over a 1-month period, or greater than 10% over 3 months.
3. Muscle wasting: Observable loss of muscle mass or reduced handgrip strength, often linked to the severity of malnutrition.
4. Fluid accumulation: Presence of edema or ascites due to imbalances in fluid and electrolyte regulation.
5. Deficiencies in key nutrients: Especially vitamins B complex, Vitamin A, Vitamin D, and minerals like magnesium and phosphorus.

Role of Micronutrients in Recovery in Malnutrition

- **Fat-Soluble Vitamin A (800-1000 µg/d), Vitamin D (1000 IU/d), Vitamin E (7.5-10 mg/day), Vitamin K (90- 120 µg/d)[4]:** Helps to impaired absorption, particularly in patients with alcohol-related liver disease.[1]
- **Vitamin B complex (Vitamin B1 (1.4–2.2 mg/day), Vitamin B3 (14–23 mg/day), Vitamin B9 (220-300 µg/day))[4]:** Increased needs arise due to metabolic stress and deficiencies caused by chronic alcohol consumption.[1,36]
- **Calcium (1000 mg/day), Magnesium (370–440 mg/day), and Phosphorus (600 mg/day)[4]:** Close monitoring and supplementation may be required to address impaired absorption and organ dysfunction.[1,36]
- **Iron (19-29 mg/d)[4]:** Supplementation is needed in cases of anemia, which is common in malnourished individuals due to chronic blood loss and impaired nutrient absorption.[1]

i. Obesity

Obesity is a complex condition caused by an energy imbalance, influenced by genetic, environmental, and lifestyle factors, increasing the risk of chronic diseases.[1]

Clinical Presentation[1]

1. Excessive fat accumulation: A BMI over 25 is considered obese[37]
2. Excess waist circumference
3. Increased risk of metabolic disorders, infertility, osteoarthritis, and poor immune responses.

Role of Micronutrients in Recovery in Obesity

- **Vitamin D (600 IU/d)[4]:** Regulates insulin sensitivity, inflammation, and fat metabolism.[21,38]
- **Calcium (1000 mg/d)[4]:** Supports bone health and fat metabolism.[38]
- **Vitamin B Complex (Vitamin B1 (1.4–2.2 mg/day), Vitamin B3 (14–23 mg/day), Vitamin B9 (220-300 µg/day))[4]:** Supports energy metabolism, reduces fatigue, and aids nerve function in obesity.[38]
- **Mineral Supplementation:** Necessary if daily caloric intake falls below 1200 kcal for women or 1800 kcal for men. [21]

j. Osteoporosis

Osteoporosis is a systemic bone disease characterized by reduced bone density and deterioration of bone structure, leading to increased fracture risk.[1]

Clinical Presentation[1]

1. Fracture history: Pathological fractures, especially in the distal radius, lumbar vertebrae, and hip, are hallmark signs.
2. Height loss: Significant reduction in height due to vertebral fractures is commonly observed in advanced cases, especially in women.
3. Postural changes: The development of a “dowager’s hump” or kyphosis due to vertebral compression fractures is a common clinical presentation.
4. Low Bone Mineral Density (BMD): Low T-scores below -2.5 SD are diagnostic of osteoporosis, and a T-score between -1.0 to -2.5 SD indicates osteopenia.
5. Osteopenia and osteoporosis can be assessed through bone densitometry using techniques like DXA (Dual-energy X-ray absorptiometry).
6. Pain: Vertebral fractures may present with acute or chronic back pain, often exacerbated by movement or prolonged standing.

Role of Micronutrients in Recovery in Osteoporosis

- **Vitamin D (60,000 IU/week × 6–8 weeks)[18]:** Enhances calcium absorption and supports bone mineralization, especially in those with limited sun exposure.[1]
- **Vitamin K (65-70 µg/d)[4]:** Activates osteocalcin, which is essential for bone mineralization and reducing fracture risk.[1]
- **Calcium (1000–1500 mg/d)[18]:** Supports bone health and reduces fracture risk in osteoporosis patients.[1]
- **Magnesium (370-440 mg/d) and Phosphate (600 mg/d)[1]:** Maintain bone density and optimize calcium metabolism.[1]

k. Polycystic Ovarian Syndrome (PCOS)

PCOS is a hormonal disorder causing reproductive irregularities, metabolic imbalances, and symptoms like infertility, acne, hirsutism, and obesity.[1,9]

Clinical Presentation[1,9]

1. Menstrual irregularities.
2. Hyperandrogenism: Elevated androgens leading to symptoms like excessive hair growth, acne, and male-pattern baldness.
3. Excess weight gain

4. Infertility: Difficulty conceiving due to irregular ovulation.
5. Metabolic issues: Insulin resistance, risk of type 2 diabetes and cardiovascular diseases.
6. Obesity and Sleep Apnea

Role of Micronutrients in Recovery in PCOS

- **Vitamin D (600 µg/d)[4]:** May improve glucose tolerance and insulin secretion in women with PCOS.[1]
- **Chromium (50 µg/day)[4]:** Enhances insulin secretion and improves insulin sensitivity.[1,9]

j. Respiratory Infections

Respiratory infections such as Chronic Obstructive Pulmonary Disease (COPD), asthma, and tuberculosis affect the lungs, causing inflammation and immune challenge that significantly impact public health.[1,9]

Chronic Obstructive Pulmonary Disease (COPD)

COPD is a progressive inflammatory disorder characterized by irreversible airflow limitation, systemic inflammation, and oxidative stress. Micronutrient deficiencies are prevalent in COPD patients due to reduced dietary intake, chronic inflammation, and increased oxidative demands, further aggravating disease progression and recovery challenges.[1,9]

Clinical Presentation[1,9]

1. Frequent exacerbations: Recurrent infections and inflammation despite standard therapy may indicate a micronutrient deficit impairing immune response.
2. Skeletal muscle dysfunction: Muscle weakness or loss (sarcopenia) resulting from oxidative damage and insufficient micronutrient intake.
3. Unexplained fatigue: Persistent fatigue despite adequate sleep and therapy, often linked to deficiencies in iron, magnesium or vitamin B complex
4. Delayed recovery post-exacerbation: Prolonged recovery periods marked by impaired pulmonary function and increased inflammation.
5. Signs of oxidative stress: Early indicators include brittle nails, hair thinning, and heightened susceptibility to infections.

Spirometry assessment should be correlated with nutritional status to identify deficits impacting pulmonary function.

Role of Micronutrients in Recovery in COPD

- **Vitamin C (80 mg/day) and Zinc (13-17 mg/d)[4]:** Essential for reducing oxidative stress and supporting airway remodeling.[1]

- **Vitamin D (600 IU/day)[1]:** Reduces exacerbations and improves respiratory muscle strength.[1,9]
- **Magnesium (370–440 mg/day)[4]:** Helps to mitigate lung oxidative damage and alleviates dyspnea by modulating bronchial tone.[1]

Asthma

Asthma is a chronic inflammatory disorder of the airways characterized by bronchial hyperresponsiveness, reversible airflow obstruction, and airway remodeling. It presents with episodic symptoms such as wheezing, breathlessness, chest tightness, and coughing, which often worsen at night or early morning. Severe, untreated cases can escalate to status asthmaticus, a life-threatening condition requiring immediate intervention.[1]

Clinical Presentation[1,9]

1. Episodic symptoms: Wheezing, coughing, chest tightness, and shortness of breath, especially nocturnal worsening.
2. Recurrent exacerbations: Frequent need for emergency care or hospitalizations.
3. Triggers: Identifiable patterns such as exposure to allergens, exercise, or irritants.
4. Growth impairment in children: Associated with chronic inflammation and malnutrition.
5. Co-morbidities: Gastroesophageal reflux disease (GERD), obesity, and allergic rhinitis often coexist with asthma.

Establish reversible airway obstruction, recurring symptoms, and exclude alternative diagnoses via spirometry and imaging. Observe for nasal polyps, eczema, or allergic rhinitis, and auscultate for wheezing during exacerbations.

Role of Micronutrients in Recovery in Asthma

- **Vitamin C (80 mg/d)[4]:** Alleviates airway inflammation during recovery.[1,9]
- **Vitamin D (600 IU/d)[4]:** Reduces and prevents exacerbation and inflammation.[1]
- **Vitamin E (7.5-10mg/day (as α-tocopherol))[4]:** Reduces oxidative stress during exacerbations.[9]
- **Zinc (13.2–17 mg/day)[4]:** Supports lung function and enhances immune response.[1]

Tuberculosis

Tuberculosis (TB) is caused by Mycobacterium tuberculosis, an intracellular bacterial parasite that grows slowly, thrives in oxygen-rich environments, and induces a granulomatous tissue response in a normal host.[1,25]

Clinical Presentation[1]

1. Persistent cough (lasting more than 2 weeks)
2. Unexplained weight loss

3. Prolonged fever
4. Night sweats
5. Fatigue and weakness
6. Loss of appetite
7. Chest pain or difficulty breathing
8. Blood in sputum (hemoptysis)

Role of Micronutrients in Recovery in Tuberculosis

- **Vitamins A (800–1000 µg/day), D (600 IU/day), and B6 (40–100 mg/day)[29]:** Support epithelial barrier function and improve respiratory health by boosting immunity and enhancing treatment outcomes.[1]
- **Iron (19–29 mg/day)[4]:** Supports the proliferation and activity of immune cells, including T-cells and macrophages, and helps to prevent anemia in chronic TB.[2]
- **Vitamin C (500–1,000 mg/d)[1]:** Reduces oxidative stress and enhances immunity.[1,22]
- **Zinc (13-17 mg/d)[4]:** Boosts immune responses and improves clinical outcomes.[1]

l. Thyroid Disorder

Hypothyroidism

Hypothyroidism, or underactive thyroid, is most commonly caused by Hashimoto's thyroiditis, an autoimmune disorder where the immune system attacks and damages the thyroid gland. Subclinical hypothyroidism often marks the first signs of thyroid hormone dysfunction.[1,39]

Clinical Presentation[1]

1. Fatigue
2. Cold hands and feet
3. Hypercholesterolemia
4. Muscle pain
5. Depression
6. Cognitive deficits
7. Heavy menstrual cycles
8. Dry, coarse hair and skin
9. Hoarse voice
10. Constipation
11. Weight gain

Role of Micronutrients in Recovery

- **Iodine (140 µg/day)[50]:** Essential for proper thyroid hormone synthesis.[1,39]
- **Iron (19–29 mg/day)[50]:** Crucial for thyroid hormone synthesis, particularly for the activity of thyroid peroxidase (TPO), an iron-dependent enzyme necessary for thyroid hormone production.[40]
- **Zinc (13-17 mg/day)[37]:** Aids in the regulation of thyroid function.[41,42]

Hyperthyroidism

Hyperthyroidism, often caused by Graves' disease, is characterized by a diffusely enlarged and overactive thyroid that produces excessive thyroid hormones. Goiter, or thyroid enlargement, is the most common sign of the condition. If untreated, hyperthyroidism can lead to thyrotoxicosis, a serious metabolic imbalance.[19]

Clinical Presentation[1]

1. Enlarged thyroid (goiter)
2. Bulging, puffy and swollen eyes.
3. Excess sweating.
4. Feeling restless, irritable, or hyperactive.
5. Insomnia
6. Menstrual disturbance
7. Unintentional weight loss
8. Tachycardia (Heart rate >90 beats/min.)

Role of Micronutrients in Recovery in Hyperthyroidism

- **Vitamin B Complex (especially B12, 2.2–2.4 µg/day)[4]:** Supports metabolism, energy production, and neurological health in individuals with thyroid dysfunction.[9,42]
- **Vitamin D (600 IU/d)[4]:** Regulates the immune system and supports thyroid health.[42]
- **Iodine (140 µg/d)[1]:** Essential for proper thyroid hormone synthesis.[1]
- **Iron (19–29 mg/day)[4]:** Supports erythropoiesis and prevents anemia associated with chronic thyroid disease.[41.42]
- **Zinc (13-17 mg/d)[4]:** Helps to regulate thyroid function.[1,42]

3. Critical Care

a. Acute respiratory distress syndrome (ARDS)

ARDS is a life-threatening condition causing severe hypoxia, respiratory failure, and lung inflammation, often triggered by infections, trauma, or aspiration.[1]

Clinical Presentation[1]

1. Shortness of breath
2. Fast breathing
3. Respiratory distress
4. Chest pain and discomfort
5. Persistent cough
6. Fever and chills
7. Fatigue and weakness
8. Wheezing

Role of Micronutrients in Recovery in ARDS

- **Vitamin B1(1.4–2.2 mg/day)[4]:** Helps to reduce oxidative stress and support energy metabolism in pneumonia recovery.[1,9]
- **Vitamin C (80 mg/d)[4]:** Reduces oxidative stress and inflammation in lung tissues.[1]
- **Vitamin D (600 µg/d)[4]:** Modulates immune response and reduces inflammation.[1]

b. Sepsis

Sepsis is a life-threatening condition caused by the body's inflammatory response to infection, potentially leading to organ failure.[9]

Clinica Presentation[44]

1. Nausea and vomiting
2. Altered mental status
3. Declining Hemoglobin level
4. Body Temperature – fever (above 38^{O}C) or hypothermic (below 36^{O}C.)
5. Tachycardia (Heart rate >90 beats / min.)
6. Tachypnea > 24 breaths/ min
7. White blood cell count –check out for leukocytosis (>12,00 Cells/µL), leukopenia (<4000 Cells/µL)

Role of Micronutrients in Recovery in Sepsis

- **Vitamin A (840-1000 µg/d)[4]:** Helps to prevent infection and counteracts diminished GI absorption.[9]
- **Vitamin B (Vitamin B1 (1.4–2.2 mg/d), Vitamin B3 (14–23 mg/d)[4], and Vitamin B9 (220-300 µg/d)) [9]:** Supports increased caloric requirements during recovery and improves anemia.[1,6]
- **Vitamin C (80 mg/d)[4]:** Supports immune function and enhances collagen synthesis for wound healing.[46]
- **Vitamin D (600 IU/d)[4]:** Enhances immune response.[9]
- **Selenium (40 µg/day)[4]:** Reduces mortality, mitigates organ dysfunction, and modulates immune response in sepsis.[44]
- **Zinc (13–17 mg/d)[4]:** Reduces oxidative stress and supports sepsis recovery.[6]

c. Trauma

Trauma is the body's physiological response to injury, disrupting homeostasis and requiring rapid recovery through proper nutrition to prevent complications like shock or death.[12,43]

Clinical Presentation[12,43]

1. Ebb phase which may last for 2- 3 days after injury:

I. Bradycardia
II. Low SpO2 (less than 90%)
III. Shock
IV. Hypovolemia
V. Body pressure less than 90/60mmHg

2. Acute phase which may last for 7- 10 days after injury:

I. Tachycardia
II. Body pressure above 140/90 mmHg

3. Adaptive phase (Recovery phase after injury):

I. Decreased hypermetabolism
II. Wound healing

Recommendation for Micronutrients in Recovery in Trauma

- **Vitamin A (840 -1000 µg/day)[4]:** Supports tissue healing.[12]
- **Vitamin C (80 mg/day)[4]:** Supports collagen synthesis, immune function, and antioxidant protection.[43]

- **Vitamin D (600 IU/d)[4]:** Aids bone healing, immune modulation, and muscle function.[44]
- **Vitamin K (65–70 µg/day)[4]:** Essential for blood clotting mechanisms.[1,12]
- **Electrolytes:** Helps to maintain adequate urine output and serum electrolyte balance.[1,44]
- **Iron (19-29 mg/dL)[4]:** Aids recovery from anemia due to blood loss.[45]
- **Magnesium (370–440 mg/day)[4]:** Supports muscle relaxation, energy metabolism, and nerve function.[45]
- **Zinc (13-17 mg/d)[4]:** Promotes wound healing and recovery.[12,44]

4. Surgical Care

a. Bariatric Surgery

Bariatric surgery is a treatment for severe obesity, improving metabolic conditions when non-surgical weight loss fails, requiring lifelong dietary and medical follow-up.[17]

Clinical Presentation[17]

1. Fatigue
2. Nausea and vomiting
3. Anemia
4. Pale skin
5. Fatigue
6. Memory issues
7. Mouth sores
8. Muscle cramps
9. Bone pain
10. Dumping syndrome

Role of Micronutrients in Recovery[21,49]

- **Vitamin B9 (220-300 µg/d)[21]:** Improves anemia and cognitive function.[21]
- **Vitamin B12 (350-500 µg/d orally)[21]:** Prevents neuropathy, cognitive issues, and anemia.[21,49]
- **Vitamin C (80 mg/day) 19:** Enhances wound healing, boosts immune function, reduces oxidative stress, and helps to prevent anemia.[19,46]
- **Vitamin D (3000 IU/d)[19]:** Reduces bone loss, muscle weakness, and fatigue.[49]

- **Vitamin K (90-120 µg/d)[19]:** Supports blood clotting and bone health, especially post-surgery.[19,49]
- **Calcium (1200-1500 mg/d)[19]:** Helps to prevent osteoporosis, bone pain, and fractures.[19,49]
- **Iron (45-60 mg/d)[19]:** Supports recovery from pallor, body weakness, and fatigue.[19,49]
- **Magnesium (370–440 mg/day)[19]:** Aids muscle function, prevents cramps and fatigue.[49]
- **Zinc (8-33 mg/d)[19]:** Prevents hair loss and delays in wound healing.[19,49]

b. Cardiac Surgery

Cardiac surgery is a specialized field focusing on surgical treatment of heart and blood vessel diseases to restore or improve heart function.[11]

Clinical Presentation

1. Sweating[1]
2. Angina or chest pain[11]
3. Shortness of breath[11]
4. Palpitations[11]
5. Fatigue and weakness[1]
6. High blood pressure[11]

Role of Micronutrients in Recovery in Cardiac Surgery:

- **Vitamin B1 (1.4–2.2 mg/d)[4]:** Essential for heart muscle function, especially in patients with heart failure.[1]
- **Vitamin B6 (1.9–3.1mg/day) and B12 (2.2–2.4 µg/day)[4]:** Helps to regulate homocysteine levels, reducing the risk of heart disease.[1,25]
- **Vitamin C (65-80 mg/d)[4]:** Aids in wound healing, collagen synthesis, and reduces oxidative stress.[1,25]
- **Vitamin D (600 IU/d)[4]:** Supports bone health and may help to reduce inflammation.[1]
- **Vitamin E (7.5-10 mg/d)[4]:** Prevents oxidation of polyunsaturated fatty acids (PUFAs) in cell membranes.[1,11]
- **Magnesium (370-440 mg/d)[4]:** Regulates heart rhythm, muscle function, and blood pressure.[1,25]

c. Gastrointestinal Surgery

Gastrointestinal Surgery is a specialized field focusing on surgical treatment of digestive tract and accessory organ diseases through resection, reconstruction, and repair.[1,9]

Clinical Presentation[1]

1. Fever
2. Pain and Tenderness
3. Abdominal Distension
4. Nausea and Vomiting

Role of Micronutrients in Recovery in Gastrointestinal Surgery

- **Vitamin B12 (1000 mcg/day)[51] :** Essential for patients undergoing gastrectomy or terminal ileum resection due to the loss of intrinsic factor, leading to malabsorption.[1]
- **Vitamin D (600 IU/d)[4]:** Supports bone health and helps to reduce inflammation.[11]
- **Calcium (1000–1500 mg/day)[4] :** Prevents osteoporosis; periodic monitoring of serum levels is recommended.[1,6]
- **Magnesium (300–400 mg/day)[51]:** Helps to prevent chronic diarrhoea and malabsorption.[1,9]
- **Sodium (2300 mg/day) and Potassium (600 mg/day)[4]:** Maintain fluid balance, support nerve function, and helps to prevent diarrhoea or excessive ostomy drainage.[4]
- **Zinc (20–40 mg/day)[51]:** Aids in wound healing and helps to prevent diarrhoea.[11,15]

d. Neurological Surgery

Neurological surgery (neurosurgery) treats brain, spinal cord, and nerve disorders through surgical procedures like tumor removal, trauma repair, and aneurysm treatment.[1]

Clinical Presentation[1,48]

1. Neurological changes – Sudden weakness, numbness, confusion, difficulty speaking, or vision problems may indicate a stroke, increased intracranial pressure, or other complications.
2. Severe or worsening Seizures
3. Fever and signs of Infection
4. Excessive drowsiness, agitation, confusion
5. Persistent nausea and vomiting
6. Difficulty breathing or swallowing
7. Weakness or paralysis
8. Slurred or slow speech

Role for Micronutrients in Recovery in Neurological Surgery

- **Vitamin C (65-80 mg/d)[4]:** Reduces oxidative stress and inflammation, promoting neuronal repair.[1]
- **Vitamin D (600 IU/d)[4]:** Supports brain health, immune function, and bone recovery.[17]
- **Magnesium (370–440 mg/d)[4]:** Reduces inflammation and supports muscle and nerve function.[1]
- **Zinc (13-17 mg/d)[4]:** Helps in wound healing, improves immune function, and supports neurological recovery.

e. Orthopedic Surgery

Orthopedic surgery ranges from minimally invasive arthroscopic procedures to complex joint replacements or spinal surgeries, depending on the nature and severity of the condition.[1]

Clinical Presentation[1]

1. Severe pain
2. Deformities or visible abnormalities
3. Fractures or broken bones
4. Numbness or tingling sensation
5. Swelling and inflammation
6. Inability to bear weight
7. Infection or non-healing wounds
8. Disability or loss of function

Role of Micronutrients in Recovery in Orthopedic Surgery

- **Vitamin A (840–1000 µg/day) & Vitamin K (65–70 µg/day)[4]:** Aid in the synthesis of osteocalcin, a protein essential for bone mineralization.[1,47]
- **Vitamin C (80 mg/d)[4]:** Essential for collagen formation, which is a key component of cartilage, ligaments, and tendons. It also aids in wound healing after fractures or surgery.[1]
- **Vitamin D (600 IU/d)[4]:** Enhances calcium absorption from the gut, regulates bone remodeling, and is crucial for bone mineralization.[1]
- **Calcium (1000 mg/d)[4]:** Essential for bone formation and strength, maintaining bone density, and supporting skeletal structure.[1,54]
- **Copper (1.7 mg/day)[4]:** Plays a role in collagen and elastin formation, which are crucial for joint function and bone strength.[1,47]
- **Iron (19–29 mg/day)[4]:** Important for collagen formation and oxygen transport to tissues, supporting the healing process in bones and joints.[1,47]
- **Zinc (13–17 mg/day)[4]:** Supports bone growth, repair, and collagen synthesis.[1,47]

f. Post-surgical Recovery

Post-surgical recovery involves wound care, pain management, early mobilization, and monitoring for complications, tailored to the surgery and patient's health.[1]

Clinical Presentation[1]

Monitoring for post-operative complications is crucial for patient safety and recovery.

1. Fever and chills
2. Tachycardia (>100 bpm)
3. Internal bleeding or drain
4. Rapid breathing (>20 breaths per minute)
5. Severe nausea, vomiting, or bloating

Role of Micronutrients in Recovery in Post-surgical Recovery

- **Vitamin A (840-1000 µg/d)[4]:** Improves immune function and aids in wound healing.[51]
- **Vitamin B9 (400 µg/day)[4]:** Supports red blood cell formation, DNA synthesis, and neurological function.
- **Vitamin C (80-160 mg/day)[51]:** Supports collagen synthesis, enhances wound healing, and boosts immune function.[50,51]
- **Vitamin D (600 IU/d)[4]:** Helps to reduce inflammation and supports overall recovery.[52,53]
- **Vitamin K (65–70 µg/day)[50]:** Essential for blood clotting and bone health.[51]
- **Calcium (1000 mg/d)[4]:** Prevents bone loss and supports muscle function, especially in long-term recovery.[51]
- **Iron (19-29 mg/d)[4]:** Replenishes iron stores lost during surgery and supports oxygen transport.[52]

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CHAPTER 4: MICRONUTRIENTS IN PAEDIATRICS

1. Acute Conditions

a. Acute Hepatitis

Acute hepatitis in infants is sudden inflammation of the liver, often caused by viral infections (such as hepatitis A, B, C, D, E etc.), metabolic disorders, autoimmune conditions, or toxic exposures (e.g., medications or toxins). It leads to liver damage and impaired liver function, which can be temporary or, in severe cases, progress to liver failure.[1]

Clinical Presentation[1]

1. Jaundice
2. Dark urine and pale stools
3. Poor feeding and irritability
4. Vomiting and diarrhoea
5. Lethargy or excessive sleepiness
6. Bruising or internal bleeding
7. Hypoglycemia
8. Dehydration or malnutrition

Recommendation for Micronutrients in Recovery in Acute Hepatitis

- **Fat soluble vitamins like Vitamin A (350-1000 µg/day)[2], Vitamin D (400-600 IU/day)[2], Vitamin E (4-15 mg /day)[2], and Vitamin K (2-75 µg/day)[2]:** Supports immune function and liver health particularly due to fat malabsorption. It also supports maintaining bone health, oxidative stress protection, and blood coagulation.[1]
- **Vitamin B complex B1 (0.2–2.2 mg/day); B2 (0.4–3.1 mg/day); B3 (2–22 mg/day); B5 (2–5 mg/day); B6 (0.1–3.0 mg/day); B7 (4–25 µg/day); B9 (25–340 µg/day); B12 (1.2–2.2 µg/day)[2]:** Supports energy metabolism and liver detoxification.[1]
- **Zinc (Children ≥6 months: 20 mg/day for 10–14 days; Children <6 months: 10 mg/day for 10–14 days)[1]:** Enhances immune function, promotes liver regeneration, and prevents diarrhoea.[1]

b. Acute Respiratory Infections

Acute Respiratory infections are among the most common illnesses affecting children worldwide, ranging from mild upper respiratory tract infections (URTIs) to severe lower respiratory tract infections (LRTIs).[1,3]

Clinical Presentation[3]

1. In URTI – fever, cold, cough breathlessness and enlarged neck lymph nodes
2. In LRTI- severe symptoms are seen such as poor feeding, irritability, cyanosis or breathlessness

Prompt medical evaluation is essential when severe signs appear, as untreated respiratory infections can progress to complications such as pneumonia, sepsis, or respiratory failure.[3]

Recommendation for Micronutrients in Recovery in Acute Respiratory Infections

In acute stage, zinc supplement reduces hospital stay and helps regenerate respiratory epithelial damage.

- **Zinc (Children ≥6 months: 20 mg/day for 10–14 days; Children <6 months: 10 mg/day for 10–14 days)[1.3]**

On follow up

- **Vitamin A (350-1000 µg/day)[2]:** Supports immune function, maintains respiratory epithelial integrity, and reduces infection.[3]
- **Vitamin C (20-85 mg/day)[2] :** Supports immune function and reduces the duration and severity of respiratory infections.[3]
- **Vitamin D (400-600 IU/day)[2]:** Enhances immune response, reduces inflammation, and lowers the risk of severe respiratory infections.[3]
- **Iron (1-3 mg/kg/day)[2]:** In case of iron deficiency anaemia, to support oxygen transport, boosts immune function, and reduces susceptibility to infections.[3]

c. Dengue

Dengue fever is a mosquito-borne (transmitted primarily by Aedes aegypti and Aedes albopictus mosquitoes) viral illness causing high fever, severe body pain, rash, and in severe cases, bleeding and shock.[3]

Clinical Presentation[3]

1. Sudden high fever and severe headache
2. Muscle, bone, and joint pain
3. Skin rash
4. Fatigue and weakness
5. Nausea, vomiting, and loss of appetite
6. Bleeding- petechiae/ecchymosis (in case of Dengue haemorrhagic fever)
7. Shock – hypotension (in case of Dengue shock syndrome)

Recommendation for Micronutrients in Recovery in Dengue

During convalescence phase multivitamins may be given in RDA or double the RDA value as per needed.

- **Vitamin B Complex (B1 (0.2–2.2 mg/day); B2 (0.4–3.1 mg/day); B3 (2–22 mg/day); B5 (2–5 mg/day); B6 (0.1–3.0 mg/day); B7 (4–25 µg/day); B9 (25–340 µg/day); B12 (1.2–2.2 µg/day)[2]:** Supports nerve function, energy metabolism, and immune response.[3]
- **Vitamin C (20-85 mg/day)[2]:** Boosts immunity, has antioxidant properties, and strengthens capillaries to reduce bleeding risk.[3]
- **Vitamin D (400-600 IU/day)[2]:** Enhances immune response and may reduce dengue severity.[3]

d. Dehydration

Pediatric dehydration occurs when excessive fluid loss disrupts electrolyte balance, impairing bodily functions, with higher risk in younger children.[3,4]

Clinical Presentation[4,5]

1. **No Dehydration:** Not enough signs to classify as some or severe dehydration, child drinks normally and not thirsty
2. **Some Dehydration:** Restless and irritable child, sunken eyes, skin pinch goes back slowly, thirsty
3. **Severe Dehydration:** Movement only when stimulated or no movement at all, sunken eyes, skin pinch goes back very slowly, little or no urine output

Recommendation for Micronutrients in Recovery in Dehydration

- **Zinc (Children ≥6 months: 20 mg/day for 10–14 days; Children <6 months: 10 mg/day for 10–14 days)[1]:** Supports immune function and maintains intestinal barrier integrity. Given in cases of diarrhea[1,5]

For infants and children with dehydration, give 75ml/kg of oral rehydration solution (ORS) solution (containing sodium, potassium and chloride) orally over 4 hours, and then reassess the hydration status to continue treatment as needed.[6,7]

e. Diarrhoea

Diarrhoea is characterized by passage of watery stools three or more times in a day or more frequently than normal for an individual)[1]. Clinical types of diarrhoea are:[1,5]

- Acute diarrhoea: present for less than 14 days
- Persistent diarrhoea: present for or over 14 days
- Dysentery: presence of blood in stools

Recommendation for Micronutrients in Recovery in Diarrhoea

- **Zinc (Children ≥6 months: 20 mg/day for 10–14 days; Children <6 months: 10 mg/day for 10–14 days)[5]**: Supports immune function, maintains intestinal barrier integrity, and reduces the severity and duration of diarrhoea. Should be administered along with ORS.[1]
- **Multivitamins and minerals:** In case of persistent diarrhoea multivitamins and minerals are prescribed for 14 days.[5,8]

Chronic diarrhoea may cause malabsorption and may lead to dehydration[5].

Recommendation for Micronutrients in Recovery:

In case of persistent diarrhoea, multivitamins and minerals are prescribed for 14 days.[8]

ORS composition	
21.8g of WHO ORS sachet to be diluted in 1 litre of water.[8]	
Sodium	75 mosm/L
Potassium	20 mosm/L
Chloride	65 mosm/L
Citrate	10 mosm/L
Dextrose	75 msom/L
Total osmolarity	245mosm/L

Additionally, there are different treatment plans as per the severity of dehydration as described below-

According to Plan A (Mild dehydration)[5]		
Child age	**ORS per loose stool**	**ORS per day**
6 months-2 year	50-100 ml	500ml
2-5 year	100-200 ml	1000ml
5-14 year	200ml	1000ml
>14 years	Ad lib (>200 ml)	2000ml

According to Plan B (Moderate dehydration)[5]		
Child age	**ORS after every loose stool**	**ORS in 1st 4 hours**
6 months-2 year	50-100 ml	500ml
2-5 year	100-200 ml	1000ml
5-14 year	200ml	1000ml
>14 years	Ad lib (>200 ml)	2000-4000ml

*Ad lib: as desired

According to Plan C (Severe dehydration)[5]: Treat it quickly with intravenous (IV) fluids

f. Febrile Seizures

Febrile seizures are generalized tonic clonic seizures, lasting < 15 minutes in young children (6 months-6 years of age) with acute fever, without any brain infection or neurological condition.[1,4]

Clinical Presentation[1]

1. High Fever
2. Loss of Consciousness
3. Usually generalized tonic clonic seizures
4. Eye Rolling
5. Frothing at the Mouth
6. Involuntary passage of urine and stool

Recommendation for Micronutrients in Recovery in Febrile Seizures

NOT ROUTINELY GIVEN UNLESS SPECIFIC DEFICIENCY IS FOUND DURING INVESTIGATIONS OR CLINICAL ASSESSMENT.

- **Calcium (300-1050 mg/day)[2]:** Supports nerve transmission and muscle function. Works synergistically with vitamin D.[3]
- **Magnesium (30-440 mg/day)[2]:** Regulates neurotransmission and muscle function, potentially reducing seizure susceptibility.[3]
- **Iron (1-3 mg/kg/day)[2]:** Should be prescribed only if sign of clinical pallor is seen.[9]

g. Malaria

Malaria is a life-threatening disease caused by Plasmodium parasites, transmitted by infected Anopheles mosquitoes, with Plasmodium falciparum causing most severe cases.[3]

Clinical Presentation[3]

1. Fever, chills and rigors
2. Headache and Muscle Aches
3. Fatigue and Malaise
4. Splenomegaly
5. Nausea
6. Vomiting

Recommendation for Micronutrients in Recovery in Malaria

NOT ROUTINELY GIVEN UNLESS SPECIFIC DEFICIENCY IS FOUND DURING INVESTIGATIONS OR CLINICAL ASSESSMENT.

- **Iron (1-3 mg/kg/day)[2]:** In case of iron deficiency, to support oxygen transport, boosts immune function, and reduces susceptibility to infections.[3,10]

h. Measles

Measles is a highly contagious viral disease caused by the measles virus (a member of the Paramyxoviridae family, Morbillivirus genus). It primarily affects children but can occur at any age in unvaccinated individuals. Despite the availability of an effective vaccine, measles remains a significant cause of illness and death worldwide, especially in regions with low vaccination coverage.[3]

Clinical Presentation[3]

1. High Fever
2. Cough, Runny Nose, and Conjunctivitis
3. Koplik Spots
4. Sore throat
5. Muscle aches and Fatigue
6. Severe Diarrhoea

Recommendation for Micronutrients in Recovery in Measles

- **Vitamin A:** Essential for immune function, reducing severity and mortality associated with measles. It is given on day 1,2 and 14.[11]

  A. **Children ≥ 12 months:** 200,000 IU once daily[11]

  B. **Infants 6–11 months:** 100,000 IU once daily[11]

  C. **Infants < 6 months:** 50,000 IU once daily[11]

2. Chronic Conditions

a. Asthma

Paediatric asthma is a chronic hyperactive airway disease affecting daily activities, sleep, and school attendance, requiring individualized treatment based on severity and type.[3,12]

Clinical Presentation[4]

1. Recurrent Coughing
2. Wheezing or palpitation
3. Shortness of Breath
4. Chest Tightness or Pain
5. Audible breathing sounds
6. Disturbed sleep due to persistent coughing

Spirometry is a key diagnostic and monitoring tool for asthma in children over the age of 5, as it measures lung function and helps to assess airway obstruction and reversibility.[4]

Recommendation for Micronutrients in Recovery in Asthma

NOT ROUTINELY GIVEN UNLESS SPECIFIC DEFICIENCY IS FOUND DURING INVESTIGATIONS OR CLINICAL ASSESSMENT.

- **Vitamin C (20-85 mg/day)[2]:** Reduces oxidative stress in the airways and enhances immune response.[13]
- **Vitamin D 2000 IU/day for 3 months OR 60,000 IU/ week for 10 weeks:** Considered to enhance the immune function and reduce airway inflammation. Generally, low levels are linked to increased asthma exacerbations.[13]

b. Hidden Hunger

Hidden hunger is the presence of multiple micronutrient deficiencies (particularly iron, zinc, iodine and vitamin A), which can occur without a deficit in energy intake because of consuming an energy-dense, but nutrient-poor diet and neophobia.[14]

Clinical Presentation[15]

1. Fatigue and Weakness
2. Pale Skin and Brittle Nails
3. Poor Growth and Development in Children
4. Frequent Infections
5. Hair Loss and Skin Issues.
6. Bone Pain or Muscle Weakness
7. Poor Wound Healing
8. Mood swings, Anxiety, and Depression
9. Bleeding gums and tooth decay

Recommendation for Micronutrients in Recovery in Hidden Hunger[3]

- **Iron (1-3 mg/kg/day)[2]:** A key component of hemoglobin for oxygen transport, involved in energy production, cellular respiration, cognitive development, and aids in myoglobin formation for muscle oxygenation.[3,1]
- **Vitamin B1(1-5mg/day), B2(0.4-1.3 mg/day), B6(1-2 mg/day), B9(25-350 µg/day), B12(1.2–2.2 µg/day)[2]:** Supports cell growth and division, reduces infection risk, improves cognitive development and neurological function.[3,15]

c. Malnutrition

Malnutrition in pediatrics refers to a deficiency, excess, or imbalance of energy, protein, and other nutrients, leading to adverse effects on growth, development, and overall health in children. It can manifest as undernutrition or overnutrition.[12]

Types of Pediatric Malnutrition:[12]

Undernutrition:

A. Acute Malnutrition -Low weight-for-height and low weight for age

B. Chronic Malnutrition - Low height-for-age, reflecting long-term nutritional deficits or repeated infections; however, weight-for-height may remain normal.

Clinical Presentationr[12]

1. Weight loss
2. Muscle and fat wasting
3. Signs of Marasmus like, sunken eyes, poor growth, irritability, and apathy
4. Signs of Kwashiorkor like irritability, pedal edema, skin and hair changes.

Overnutrition: Overweight and Obesity

Clinical Presentationr[8]

1. Easy fatigue
2. Weight gain
3. Chances of associated metabolic disorder

Recommendation for Micronutrients in Recovery in Malnutrition[16,27]

Advised vitamin and mineral supplementation during stabilization (1st week) and rehabilitation phase (week 2-6) of recovery from malnutrition[16,27]

- **Vitamin A (Infants-7500-15000 IU/day for 10 days; 1-8yrs 17500-35000 IU/day for 10 days; children >8 years 100000 for 3 days, then 50000 IU/day for 7 days)[5,16]:** Supports vision, immune function, and growth.[11]
- **Vitamin D (if low give 60000 IU/ week for 10 weeks or daily 2000 IU for 3 months)[16]:** Aids bone health, growth, and immunity.
- **Vitamin B complex[16] (Vitamin B1 (1-5mg/day, upto 10-50mg depending upon deficiency level), Vitamin B2 (0.4-3.1 mg/day), Vitamin B3 (10-20mg/day), vitamin B6 (1-2mg/day), Vitamin B9 (25-340 µg/day)[2]:** Supports red blood cell production and DNA synthesis.[11]
- **Vitamin C (50–100 mg/d)[16,27]:** Supports wound healing and immune function.[11]
- **Selenium (1–2 mcg/kg)[16,27]:** Supports enzyme functions in malnutrition.[11]
- **Zinc (Zinc 10 mg (<6 mo), 20 mg (≥6 mo) daily for 10–14 days)[16]:** Enhances immunity, growth, and wound healing.
- **Iron (1-3 mg/kg/day)[2]:** It is given from week 2-7 during rehabilitation phase.[16,27]
- **Calcium and phosphorus (ratio of 2:1)** 250 mg - 500 mg elemental Ca per day.[16,27]

d. Juvenile Diabetes

Type 1 diabetes mellitus (T1DM) is an autoimmune disease, often diagnosed in youth where the body destroys insulin-producing cells and requires lifelong insulin therapy.[1,12]

Clinical Presentation[1,12]

1. Polydipsia (Excessive thirst)
2. Polyuria (Frequent urination)
3. Polyphagia (Increased hunger)
4. Unexplained Weight Loss
5. Fatigue and Weakness

Recommendation for Micronutrients in Recovery in Juvenile Diabetes

Not routinely given unless specific deficiency is found during investigations or clinical assessment.

- Restrict extra-salt intake[17]
- Encourage balanced diet[17]
- Prevention and treatment of associated obesity [17]

e. Gastrointestinal Disorders and Malabsorption

Proper nutritional supplementation addresses various conditions, ranging from common gastrointestinal (GI) issues like constipation and gastroesophageal reflux to more complex diseases such as inflammatory bowel disease (IBD), celiac disease, and liver disorders.[1,3]

Clinical Presentation[1,3]

1. Abdominal Pain and Distension
2. Vomiting and Nausea
3. Diarrhoea
4. Constipation
5. Dehydration
6. Poor Weight Gain or Weight Loss
7. Feeding difficulties, refusal, or food intolerance.
8. Jaundice

There are various causes of malabsorption, such as[18]

1. Pancreatic amylase deficiency
2. Inadequate disaccharidase activity
3. Celiac disease/ IBD/ Autoimmune enteropathy
4. Acrodermatitis enteropathica etc.

Hence, there will be deficiencies including but not limited to deficiencies in vitamin B12, calcium iron, folate, vitamin D, magnesium, carotenoids, thiamin, copper, selenium, and more. The effects of malabsorption of these vitamins, minerals, or trace elements depend on which is deficient and the degree to which they are deficient.[18]

Recommendation for Micronutrients in Recovery in Gastrointestinal Disorders and Malabsorption

Use of multivitamin and minerals varies as per the cause of malabsorption. Vitamins and minerals are commonly used,

- **Fat soluble vitamins16 (Vitamin A (5,000–10,000 IU/d), Vitamin D (400–800 IU/d), Vitamin E (10–20 mg), Vitamin (K 1–2 mg):** Helps to increase mucosal integrity, immune function, calcium absorption, bone health, blood clotting, and in cases of fat malabsorption, IBD, or celiac disease.[1]
- **Vitamin B12 (1–2 mg) and Folic Acid (0.2–0.4 mg; 1–5 mg for deficiency)[16]:** Considered for cell repair, growth, and preventing deficiency, especially in gastrointestinal disorders or when absorption is impaired. B12 may require intramuscular injections.[1]
- **Iron 1–2 mg/kg (maintenance); 3–6 mg/kg (deficiency) for Anemia:[16]** Aids tissue repair, supports wound healing in gastrointestinal recovery.[1]
- **Calcium (500–1000 mg)[16]:** Supports in improving bone health.[16]
- **Zinc (10 mg (<6 mo), 20 mg (≥6 mo) for 10–14 days (given in case of diarrhea); 1–2 mg/kg for immunity as per WHO)[16]:** Enhances iron absorption and manages high ostomy output or diarrhea in gastrointestinal recovery and to boost growth and immunity.[1]

f. Hematological Disorders (Sickle cell anemia and Thalassemia)

Hemoglobin disorders are genetic conditions that affect the structure or production of hemoglobin, the protein in red blood cells responsible for carrying oxygen throughout the body.[12]

Clinical Presentation[12]

1. Chronic Anemia
2. Jaundice
3. Delayed Growth and Development
4. Bone Deformities
5. Splenomegaly

Specific Signs in Thalassemia: Enlarged liver and spleen due to increased red blood cell destruction. Iron overload due to frequent blood transfusions, leading to fatigue, joint pain, and organ damage, skeletal abnormalities.[12]

Specific Signs in Sickle Cell Disease (SCD): Chest pain, cough, and breathing difficulties, resembling pneumonia. Painful swelling of hands and feet in infants and young children. Frequent Infections, sudden weakness, speech difficulties, or seizures due to blood vessel blockages in the brain.[12]

Recommendation for Micronutrients in Recovery in Hematological Disorders

- **Vitamin B9 (500 µg/day)[2]:** Recommended in case of ineffective erythropoiesis. It supports DNA synthesis and erythropoiesis due to increased red blood cell turnover.[12,19]
- **Vitamin C (20-85 mg/day)[2]:** Supplemented only in patients on deferoxamine infusion not exceeding 2mg/kg/day.[19]
- **Vitamin D (400-600 IU/day)[2]:** Supplemented to ensure optimal level, particularly in deficiency cases.[19]
- **Iron (1-3 mg/kg/day)[2]:** To treat associated iron deficiency by monitoring serum iron studies and serum ferritin levels.[12.19]

3. Critical Care

a. Paediatric ICU Recovery

Recovery in the Paediatric ICU involves continuous monitoring, timely interventions, and supportive care to stabilize and restore normal oxygenation and ventilation.[20,21]

Patient may present with one of the following: [20]

1. Shock/ collapse
2. Respiratory failure
3. Meningio-encephalitis
4. Acute renal failure
5. Surgical conditions

Recommendation for Micronutrients in Recovery:

NOT ROUTINELY GIVEN UNLESS SPECIFIC DEFICIENCY IS FOUND DURING INVESTIGATIONS OR CLINICAL ASSESSMENT.

- **Vitamin A (350-1000 µg/day)[2]:** Maintains mucosal barriers in the lungs and reduces the severity of infections.[22]
- **Vitamin B-Complex (B1 (0.2–2.2 mg/day); B2 (0.4–3.1 mg/day); B3 (2–22 mg/day); B5 (2–5 mg/day); B6 (0.1–3.0 mg/day); B7 (4–25 µg/day); B9 (25–340 µg/day); B12 (1.2–2.2 µg/day)[2]:** Aids in energy metabolism, red blood cell formation, and neurological function.[20]
- **Vitamin C (20-85 mg/day)[2]:** Supports collagen synthesis and immune function. 20,21
- **Vitamin D (400-600 IU/day)[2]:** Essential for calcium and phosphorus metabolism and immune function.[20,21]
- **Magnesium (30-440 mg/day)[2]:** Functions as a cofactor for energy metabolism and protein synthesis and maintains cardiovascular and neuromuscular function.[21]
- **Calcium (300-1050 mg/day)[2]:** Supports immune function and cellular growth.[21]
- **Zinc (2.5-3.3mg/d for children <3 years; 4.4-5.9 mg/d for children <9 years; 8.5-14.5mg/d for children < 15 years and 14.5-17.6 mg/day for children above 16 years of age)[2]:** Vital for immune function, wound healing, and cellular metabolism.[20,21]

b. Post-operative Nutrition

Postoperative nutrition refers to the medical and nutritional support given to the patients after surgery to promote healing, prevent complications, and restore normal function. This is due to the high metabolic demands placed on the body during the surgery. [22]

Clinical Presentation[22]

Postoperative monitoring is essential to detect complications early and ensure proper recovery.[14]

In post-operative nutrition micronutrients are recommended to accelerate recovery & repair of tissues; prevent & treat malnutrition.

- **Vitamin B12 (1.2–2.2 µg/day)[2] and Vitamin B9 (25–340 µg/day)[2]:** Aid in red blood cell production, nerve function, and preventing anemia, especially after gastric or intestinal surgeries affecting absorption.[22]
- **Vitamin C (20-85 mg/day)[2]:** Supports collagen synthesis, immune function, epithelial tissue repair, antioxidant defense, blood clotting, and wound healing.[22]
- **Calcium (300-1050 mg/day)[2]:** Supports bone health, muscle and nerve function, immune health, and energy production during recovery.[22]
- **Zinc (2.5-17.6 mg/day)[2] and Iron (03-32 mg/day)[2]:** Promote wound healing, tissue regeneration, immune response, restore blood levels after hemorrhage, and prevent neurological or cardiovascular complications.[22]

c. Prematurity

Prematurity refers to the birth of an infant before 37 weeks of gestation, as opposed to the typical full-term gestation of 40 weeks. Premature infants, also known as preterm infants, are at increased risk for a range of medical complications due to their underdeveloped organs and organ systems.[22]

Clinical Presentation[22]

1. Respiratory Distress: signs like rapid breathing, grunting, flaring of the nostrils, and the use of extra muscles to breathe (retractions).
2. Feeding Difficulties
3. Temperature Instability:
4. Jaundice:
5. Bradycardia and Apnea
6. Low blood sugar levels include jitteriness, lethargy, and poor feeding.
7. Seizures

Recommendation for Micronutrients in Recovery in Prematurity

- **Vitamin D (800 IU per day until 6 months of age)[3]:** Enhances calcium absorption and supports bone health.[22]
- **Calcium (120–140 mg/kg per day) supplementation during the first months of life:[23]** Supports bone mineralization and prevents osteopenia of prematurity.[22]
- **Iron (1-3 mg/kg per day) starting at 2-3 weeks until 12 months of age:[23]** Crucial for red blood cell production and preventing anemia.[22]
- **Vitamin K (1mg/day):** This is provided in case of prolonged antibiotics in children.[22]
- **Vitamin E (50/IU/day):** Prevents oxidation of polyunsaturated fatty acids (PUFAs) in cell membranes.[23]
- **Phosphorus (60–90 mg/kg per day):** Supplementation during the first months of life[23]. Essential for proper bone mineralization.[22]

d. Trauma and Burns

Major burns cause extensive tissue damage, metabolic changes, and systemic inflammation. Immediate fluid resuscitation, infection control, and nutritional support are critical for survival and recovery.[3,22] The severity of a burn depends on its depth, extent and associated complications.[3,24]

Clinical Presentation[3,22]

Signs of superficial burns (Pink-to-red in colour, with or without blistering, dry, and can be moderately painful) and deep burns.[3,22]

Recommendation for Micronutrients in Recovery in Trauma and Burns

- **Zinc (According to American Dietetic Association (ADA), children <3y: 10 mg BD; ≥3y: 20 mg BD):[25,26]** Aids immune function and is crucial for wound healing.[3]
- **Vitamin C (≤10y: 250 mg BD; >10y: 500 mg BD):[25,26]** Essential for collagen synthesis, capillary formation, immunity, and reducing oxidative stress.[3,22]
- **Vitamin A (<3y: 5,000 IU daily; ≥3y: 10,000 IU daily):[25,26]** Promotes epithelialization, improves immune function, and enhances skin integrity.[3]
- **Iron (1–3 mg/kg/day):[25,26]** All burned children also receive a daily multivitamin with iron to support immunity.
- **Magnesium (30–440 mg/day): [25,26]** Replenishes losses from burn wounds.[3,22]

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CHAPTER 5: CONCLUSION

Key Takeaways

- **Micronutrients are essential** for recovery, influencing immune function, cellular repair, metabolism, and overall healing in acute and chronic conditions.
- **In adults,** oconditions like burns, infections, cardiovascular diseases, diabetes, osteoporosis, and post-surgical recovery demands increased nutritional needs, requiring targeted supplementation.
- **In pediatric patients, micronutrients support** growth, immune development, and tissue repair, especially in respiratory infections, malnutrition, and neonatal complications.
- **Premature infants require specialized nutrition** due to insufficient mineral stores at birth, needing supplementation of calcium, phosphorus, vitamin D, iron, and other essential nutrients.
- **Balanced micronutrient intake is crucial**, as deficiencies or imbalances can worsen health conditions, making evidence-based, individualized supplementation vital for optimal recovery.

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