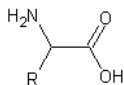


Parenteral Amino Acids



PARENTERAL AMINO ACIDS,
AND THE NON-AMINO ACIDS
GLUTATHIONE, TAURINE,
CARNITINE



INTERNATIONAL
IV NUTRITIONAL THERAPY
GLOBAL PHYSICIAN EDUCATION

Pfeiffer's Law

"We have found that if a drug can be found to do the job of medical healing, a nutrient can be found to do the same job. When we understand how a drug works, we can imitate its action with one of the nutrients."

Amino acids have many applications under Pfeiffer's Law

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Before the Infusion

- Tailor the formulation to the patient's condition
- Obtain baseline lab testing: Comprehensive metabolic panel, CBC & urine dip
- Safe and effective use of parenteral nutrition requires nutritional knowledge and the ability to recognize and treat potential complications

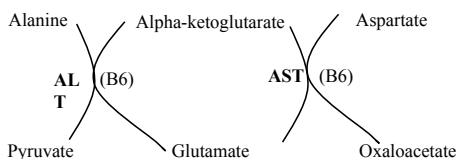
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Vitamin-Amino Acid Interactions

B vitamins required for all amino acid formulations

- B vitamins all contain an amino group - nitrogen
- Pyridoxine, B6, is most important vitamin for amino acid metabolism
- B6 is cofactor for transaminase enzymes which metabolize amino acids
- Riboflavin, B2, is required by GSH reductase
- Niacin, B3, is synthesized from tryptophan
- Others will be covered with specific amino acids

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Amino Acid Metabolism Review

- Amino acids that are not used for protein synthesis can be used for energy, either as sugars (glycogenic) or fats (ketogenic)
- Most amino acids are glycogenic, leucine is ketogenic and four are both: isoleucine, lysine, phenylalanine and tyrosine
- Amino acids also exhibit complementary or antagonistic relationships

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Amino Acid & Nutrient Relationships

Amino Acid	Complementary	Antagonistic
Arginine	Aspartate Citrulline Ornithine	Lysine
Carnitine	Lysine, Taurine Niacin	Tyrosine Vanadium
Cysteine	Methionine Taurine	Lysine, Copper Zinc

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AA & Nutrient Relationships

Amino Acid	Complementary	Antagonistic
Phenylalanine	Tyrosine Methionine Copper	Tryptophan
Taurine	Alanine, GABA Glycine	Aspartic acid Glutamic acid
Tryptophan	Niacin, Zinc Pyridoxine	Phenylalanine Tyrosine
Threonine	Arginine Proline, Glycine	Copper

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Neurotransmitter Precursors

Amino Acid	Neurotransmitter(s)
Cysteine	Cysteic acid
Glutamine	GABA, Glutamate
Histidine	Histamine
Lysine	Pipecolic acid
Phenylalanine	Dopamine, Norepinephrine, Epinephrine, Tyramine
Tyrosine	Dopamine, Norepi, Epi
Tryptophan, 5-HTP	Serotonin, Melatonin

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Amino Acids as Neurotransmitters

Amino Acid	Function
Alanine	Inhibitory or calming
Aspartic acid	Excitatory
GABA	Inhibitory or calming
Glutamate	Excitatory
Glycine	Inhibitory or calming
Taurine	Inhibitory or calming

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Brain Neurotransmitter Physiology

- Uppers:
 - Serotonin
 - Acetylcholine
 - Norepinephrine
 - Histamine**
 - Epinephrine
 - Dopamine
 - Glycine**

- Downers:
 - GABA
 - Nitric Oxide
 - Histamine**
 - Neurosteroids
 - Glycine**

Balancing / Leveling: Serotonin – Glycine - Acetylcholine

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Amino Acid Infusions, Crystalline Combination Products

Examples

- Plenamine 15%
- Aminosyn , Aminosyn II, Aminosyn-PF
- FreAmine III
- Novamine
- Travasol
- Trophamine

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Note – Caution with severe liver disease

- Some patients with severely compromised liver function may experience increased blood ammonia levels on receiving amino acids
- This can result in severe encephalitis and can require treatment with dialysis

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Plenamine 15%

Essential Amino Acids in mg/100 ml

Isoleucine 740	Tryptophan 250
Leucine 1.04 gms	Valine 960
Lysine 1.18 gms	
Methionine 749	
Phenylalanine 1.04 gms	
Threonine 749	

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Plenamine 15%

- mOsm/ml 1.38 (1358 per liter)
- pH 5.6

Non-essential Amino Acids in mg/100 ml

Alanine 2.17 gms	Arginine 1.47 gms
L-Aspartic acid 434	Glycine 1.04 gms
Histidine 894	Proline 894
Serine 592	
N-Acetyl-L-Tyrosine 39	
L-Glutamic Acid 749	

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Aminosyn II, 8.5%

Essential Amino Acids in mg/100 ml

Isoleucine 561	Tryptophan 170
Leucine 850	Valine 425
Lysine 893	
Methionine 146	
Phenylalanine 253	
Threonine 340	

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Aminosyn II, 8.5%

Non-essential Amino Acids in mg/100 ml

Alanine 844	Arginine 865
L-Aspartic acid 595	Glycine 425
Histidine 255	Proline 614
Serine 450	
N-Acetyl-L-Tyrosine 230	
L-Glutamic Acid 627	
(Remember Glutamate and Tyrosine are excitable!)	

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FreAmine III, 10%

Essential Amino Acids in mg/100 ml

Isoleucine 690	Tryptophan 150
Leucine 910	Valine 660
Lysine 730	
Methionine 530	
Phenylalanine 560	
Threonine 400	

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FreAmine III, 10%

Non-essential Amino Acids in mg/100 ml

Alanine 710	Arginine 950
Cysteine 16	Glycine 1400
Histidine 280	Proline 1120
Serine 590	

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FreAmine III, 10%

Non-amino acid constituents per 100 ml

- Phosphoric acid NF 120 mg
- Sodium bisulfite < 100 mg
- SWUSP qs
- pH adjusted with glacial acetic acid USP to pH 6.5 (6.0-7.0)
- Calculated osmolarity 950 mOsm/L
- Aminosyn II 920 mOsm/L

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Amino Acid Infusions, Crystalline Combination Products

Indications & AA formulation based on condition:

- Total parenteral nutrition (TPN) for patients who cannot or will not eat
 - Nutritional support for cachexia, e.g. cancer patients
- Nutritional support for patients with hepatitis, cirrhosis, hepatic encephalopathy
- Nutritional support for patients with renal failure

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Amino Acid Infusions, Crystalline Combination Products

Action

- Provides substrate for protein synthesis
- Enhances conservation of existing body protein

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Combination Product Dosing For TPN

This information is available in the PDR and Nurses drug handbook.

- There are special formulations available for:
 - Liver disease
 - Renal disease
 - Patients on dialysis
- These formulations are used in in-patient settings or by home care nursing services
- Discussion of these applications is not appropriate for outpatient clinics

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Amino Acid Infusions, Crystalline Combination Product Dosing

Nutritional IV Therapy

- Common dosage is 100 ml 10% FreAmine III or (115 ml) Aminosyn II, 8.5% solution
- Provides 8.5-10 grams AA
- Limit peripheral infusions to 2.5% AA (Nurses Drug Handbook 2000, p. 1140)
- 100 ml 10% diluted in 400 ml sterile water, is a 2.0% AA solution

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Amino Acid Infusions, Crystalline Combination Product Adverse Reactions

- CV: thrombophlebitis, thrombosis, edema
- GI: nausea
- GU: glycosuria, osmotic diuresis
- Hepatic: increased liver enzymes
- Skin: flushing
- Other: hypersensitivity reactions, hyperglycemia, metabolic acidosis

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Amino Acid Infusions, Crystalline Combination Product Adverse Reactions

- Other: alkalosis, hypophosphatemia, hyperammonemia, electrolyte imbalances, fever, weight gain
 - Hyperosmolar hyperglycemic nonketotic syndrome
- Drug-drug interactions: tetracycline may reduce protein sparing effects of infused AA due to its antianabolic activity

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Combination Amino Acid Infusions

Contraindications: patients with anuria or inborn errors of amino acid metabolism

- 68 inherited disorders at last count (Kelly's Textbook of Internal Medicine, 4th ed.)

Administration considerations:

- Use caution in patients with renal insufficiency, cardiac disease, hepatic disease

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Combination Amino Acid Infusions

Administration considerations:

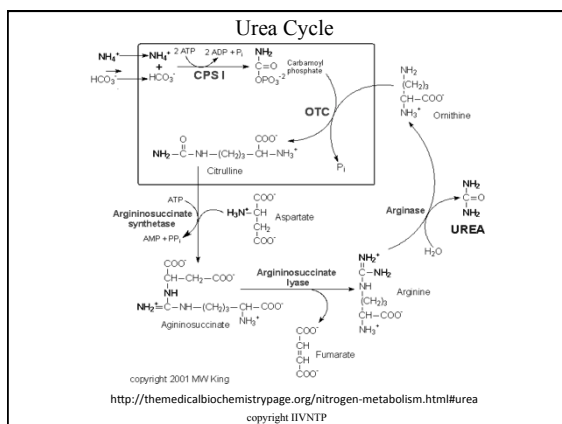
- In diabetic patients insulin may be required to prevent hyperglycemia
- If patient has chills, fever or other signs of sepsis, stop infusion and retain bottle and IV tubing for microbiological culture – this is true for all IV infusions

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Single Amino Acid Infusions Introduction

- See Therapeutic Application of Amino Acid Therapy page for clinical uses
- Commonly available AA's
- Commonly available concentrations
- Safe dosing for single amino acids given IV has a very wide safe range
- Gram doses are noted in literature
- Practicality and cost lead to mg or low gram dosing

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L-Arginine

- 50 mg/ml
- Conditionally essential AA
- Precursor to neurotransmitter nitric oxide
- Arginine stimulates carbamyl phosphate synthetase, which initiates urea cycle
- IV doses of 20-35 grams releases growth hormone, glucagon and insulin
- Chelates ammonia

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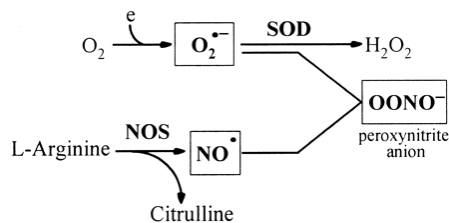
A short history of nitric oxide

- Vasodilators, such as acetylcholine and bradykinin, do not exert their effects upon the vascular smooth muscle cell in the absence of the overlying endothelium. When acetylcholine (or bradykinin) binds its receptor on the surface of endothelial cells, a series of steps leads to the release of intracellular stores of Ca^{2+}
- The elevation in Ca^{2+} leads to the liberation of endothelium-derived relaxing factor (EDRF) which then diffuses into the adjacent smooth muscle, leading to smooth muscle cell relaxation
- Quite unexpectedly, EDRF was found to be the free radical diatomic gas, **nitric oxide, NO**
- So important was the elucidation of the pathway to and actions of NO that Drs. Murad, Ignarro and Furchgott were awarded the Nobel Prize in 1998 for their work on this system

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Peroxynitrite formation

- CAUTION in patients with high oxidative stress.

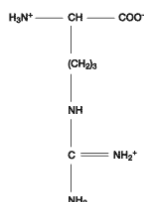


Picture taken from:

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<http://www.bloodjournal.org/content/97/11/3521?sso-checked=true>

L-Arginine



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L-Carnitine

- 60 to 200 mg/ml
- Optimal health requires 250-500 mg in diet daily
- IV: 500mg/L caution in Thyroid suppression
- Carnitine is an amine and an alcohol
- Has been described as vitamin, amino acid, and essential metabolite
- Not used in construction of proteins

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L-Carnitine

- Increases rate at which liver burns fats, creates energy
- Primary role is regulation of fat metabolism
- Acts by carrying fat across mitochondrial membrane – dose dependent
- Very important in providing energy to muscles, including heart
- Prevents cachexia
- Lysine loading raises Carnitine levels

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L-Carnitine

- Lysine to Carnitine conversion requires methionine, niacin, pyridoxine (increases metabolism), vitamin C and iron
- Strict vegans are often deficient in Carnitine
- Elevated insulin levels can inhibit optimal Carnitine activity, e.g. high CHO diet
- Omega-3 fats improve Carnitine utilization

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L-Carnitine

- **IV is best until you know your patient!!**
- Cleveland clinic has found that L-Carnitine can contact certain bacteria in the intestines which converts Carnitine to TMA. In the liver there is an enzyme that makes TMAO (Trimethylamine-N-oxide)
- TMAO forms vascular inflammation and unstable plaques in the arterial walls.

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L-Cysteine

- 50 mg/ml
- Amino acid combined with thiol group
- Thiol compounds serve as reducing agents, e.g. help prevent oxidation of sensitive tissues, cysteine is oxidized in process
- Two oxidized cysteine residues link via disulfide bridge to form cystine

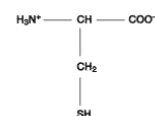
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L-Cysteine

- Cysteine is major amino acid that will support-increase Glutathione levels
- It is the rate limiting substrate in glutathione production
- Large amounts of Phenylalanine and Tryptophan can lead to decrease in Cysteine levels – antioxidant levels decrease

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L-Cysteine



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N-Acetyl-Cysteine

- 100 mg/ml
- Closely related to L-Cysteine
- Water solubility is higher than Cysteine
- Increases intracellular Glutathione
- Enhances antitumor responses by Interleukin 2
- Helpful in detoxification of chemotherapy agents post treatment
- Antidote for arsenic and acetaminophen poisoning

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N-Acetyl-Cysteine

- Acetaminophen overdose – usual treatment is oral dosing within 24 hours
- 140 mg/kg initially
- 70 mg/kg every 4 hours for 17 additional doses
- NAC increases GSH levels in liver, helps prevent oxidative drug damage

Ref: Davis Drug Guide for Nurses, 8th Ed. p. 1180

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N-Acetyl-Cysteine

- NAC is a weak chelator of heavy metals (HM)
- Transport mechanisms exist for movement of NAC:HM complexes both into and out of the brain
- Whey protein, and the amino acids Leucine and Methionine, help protect the BBB from HM movement into the brain during detoxification programs

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N-Acetyl-Cysteine

- 400 mg NAC b.i.d. for a total of 800 mg daily p.o. has been recommended for patients at high risk for brain deterioration due to HM toxicity and oxidative damage
- Typical dosage recommendations are in the range of 250-1500mg of NAC daily for the majority of therapeutic benefits.
- 3-5 grams dosing for children with ADHD

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N-Acetyl-Cysteine

- There is scientific confirmation that NAC supplementation does increase levels of glutathione in the liver, in plasma, and in the bronchioles of the lungs (ref last two bullets: <http://www.nutritioninstituteofamerica.org/research/NutrientReview/N-Acetylcysteine.pdf>)
- NAC is a useful mucolytic agent – has the ability to reduce disulfide bonds in mucoproteins found in mucus, leading to a thinning of viscous mucus

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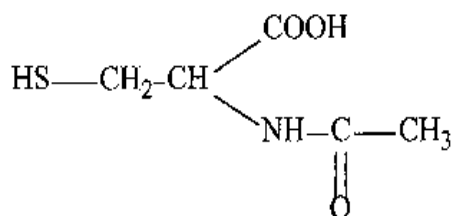
N-Acetyl-Cysteine: Research Overview

(<http://www.nutritioninstituteofamerica.org/research/NutrientReview/N-Acetylcysteine.pdf>) 10/17/04

- | | |
|---|---|
| 1. Is an antidote for acetaminophen poisoning | 09. May reduce carcinogenic effect of tobacco smoke |
| 2. Prevents liver damage | 10. Decreases ulcerative colitis |
| 3. Is a free radical scavenger | 11. Limits susceptibility to HIV infection |
| 4. Is an antioxidant in methanol intoxication | 12. Reduces heavy metal toxicity |
| 5. Is effective in chemoprevention | 13. Enhances glutathione (GSH) |
| 6. Reduces endothelial dysfunction | |
| 7. Prevents cartilage erosion | |
| 8. Prolongs transplants | |

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NAC



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L-Glutamine

- 30 mg/ml
- Most common AA in body
- Primary fuel source for immune system, intestines and colon
- Maintain and support GSH levels
- Conditionally essential amino acid
- Contraindicated in lymphatic cancers

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L-Glutamine

- Glutamine is known to enhance replications of cancer cells
- Tumors did not grow but more tumor cell division took place, in spite of this it is used to:
 - Enhance chemotherapy effectiveness
 - Prevent development of mucositis during chemotherapy
 - Significantly lower infection rates in bone marrow transplant patients

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L-Glutamine & The Brain

- Glutamine is a derivative of glutamic acid, chemical name glutamic acid 5-amide
- Glutamine can more easily pass through the blood brain barrier than glutamic acid
 - Glutamine + glutamate synthetase → glutamate
- Glutamate is the most common neurotransmitter in the brain and is always excitatory
- If patients receiving glutamine can't sleep, they may be over expressing the conversion to glutamate
 - This tendency can be decreased by giving organic lithium, e.g. Lithium orotate, 20 mg q.d.

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L-Glutamine & The Kidneys

- Glutamine is a major Nitrogen carrier in the kidney.
- The kidney can use glutamine to shuttle NH₃ residues to be oxidatively deaminated where the NH₃ joins local H⁺ and is secreted into the tubular system for removal from the body.
- This process is B6 dependent

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Glutamine Depletion

- Glutamine Peptides to Prevent Protein Loss After Surgery American Family Physician
Date: July 1, 1989
 - Catabolic stress, such as surgery, trauma or infection, lead to nitrogen loss
 - This loss is thought to come from muscle protein breakdown, which leads to the transport of glutamine to visceral organs
 - Results in profound intramuscular glutamine depletion

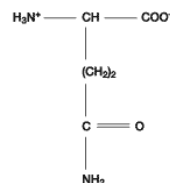
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Glutamine Depletion (2)

- Muscle glutamine concentration strongly correlates with rate of protein synthesis
- Glutamine is known to promote protein anabolic processes
- Parenteral nutrition containing glutamine would likely conserve protein and promote healing

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L-Glutamine



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Glutathione

- 60 to 200 mg/ml
- A tripeptide synthesized from Glycine, Glutamic acid and Cysteine
- Primary intracellular antioxidant – essential to life
- Useful to prevent radiation injury before during and after treatment
- Important chelator of lead, mercury, cadmium, arsenic

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Glutathione

- Can prevent or reverse alcohol induced fatty liver, cirrhosis, hepatitis, liver tumors
- Inhibits chemical induced carcinogenesis
- Improves prognosis of stroke victims
- Useful in any condition where there is risk for oxidative damage

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Glutathione (GSH)

- 500 mg is a reasonable starting dose for conditions benefiting from GSH
 - MCS patients may do better starting at 100-200 mg
- Evaluate how patient tolerates dose before giving high doses, e.g. build up dose over time incrementing 500 mg per infusion
- Protocols for the treatment of Parkinson's Disease use from 2400-3600 mg
 - This dose has been as high as 10,000 mg

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Glutathione & Parkinson's Disease

- David Perlmutter, MD, has done extensive work with Parkinson's patients and finds GSH essential
- Dr Perlmutter's protocol
 - Typically starts GSH at 2400 mg twice weekly
 - Some patients require 3600 mg GSH daily
 - Given by push over 5-8 minutes following a nutritional IV

*Personal communication June 2007

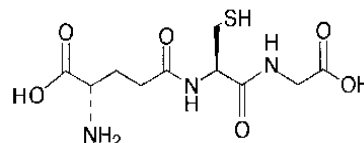
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Glutathione

- Important role in immune function via white blood cell production and is a potent anti-viral agent
- It is one of the strongest anti-cancer agents made by the body
- Glutathione levels decrease with age. It is involved in cellular differentiation and slows the aging process

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Glutathione Gamma-glutamyl-cysteinyl-glycine



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L-Glycine

- 50 mg/ml
- Key metabolic agent
 - Helps in synthesis of nucleic acids, glycerol, phospholipids, cholesterol esters, skin proteins
 - Required for GSH synthesis
 - Enters into Krebs cycle via pyruvate
 - Encourages glycogenolysis
 - Required for creatinine synthesis
 - Required for glycine conjugation in phase 2 detox
 - Oral: sweetner

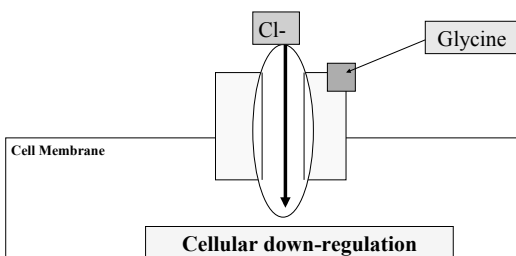
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Glycine Receptor

- CNS Activity:
- Receptor agonist: Glycine – AND - NMDA Receptors
 - Glycine is also agonist to NMDA receptor
 - **Contraindicated in Bipolar Disorders.**
 - Glycine receptor is cross regulatory mechanism for the excitatory receptor class generally minor with exception in manic dx (major)

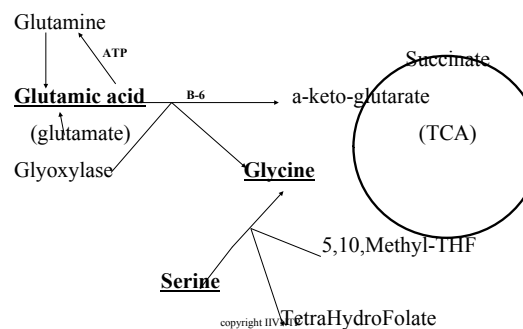
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Glycine Receptor



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Glutamate and Glycine: CNS Metabolism



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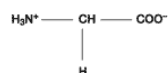
L-Glycine

- Dosing
 - 1-4 grams
 - Caution
 - Manic episodes

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L-Glycine



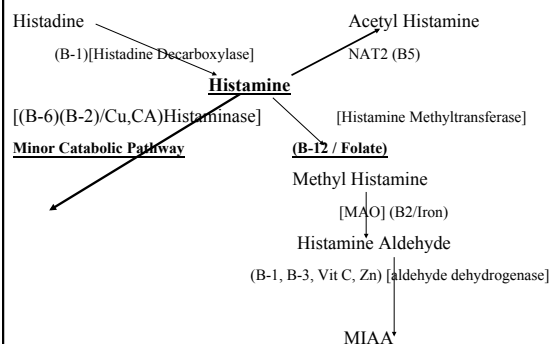
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L-Histidine

- Not readily available currently
- 50 mg/ml
- Can be synthesized from Glutamic acid, Carnosine, possible Biotin
- Precursor of histamine, neurotransmitter in brain and autonomic nervous system
- Low levels found in serum and synovial fluid of patients with rheumatoid arthritis
 - Treatment with 1 gram or more daily resulted in improved grip strength and walking ability

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Histamine Metabolism



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Histamine in the Brain

- H-1 (Stimulating)
 - Causes increased depolarization in hypothalamic and limbic areas
- H-2 (Stimulating)
 - Slows potassium conductance, increasing excitation in the hippocampus, amygdala and basal nuclei
- H-3 (Inhibiting)
 - Blocks calcium channels in the basal nuclei decreasing histamine release
- “H-4” (Inhibiting)
 - Slows / modulates NMDA receptor complex

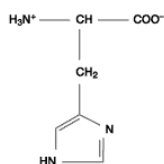
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L-Histidine as Histamine Precursor

- | | |
|--|---|
| <ul style="list-style-type: none"> • Low histamine has been seen in: <ul style="list-style-type: none"> – Aphthous stomatitis – Low libido and slow sexual response – Tension headaches – Grand plans but easily frustrated – Suspicious, paranoia – Ringing in ears – Low tolerance for medications – Frequent irritability | <ul style="list-style-type: none"> • High histamine has been seen in: <ul style="list-style-type: none"> – Hyperactivity – Obsessive-compulsive – Chronic depression with strong suicidal tendencies – Phobias – Low pain tolerance – Rapid metabolism with lean build – Excess sweating – Seasonal allergies – Frequent URI's |
|--|---|

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L-Histidine



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L-Lysine

- 50 mg/ml
- Metabolized by B2, B3
- Iron and ascorbate required to incorporate into collagen
- Lysine, along with zinc, vitamin C suppress clinical manifestation of herpes virus
- Large doses IV, 1.9 gm/kg in rats was non-toxic unless aminoglycoside antibiotics were concurrently administered (renal tox.)

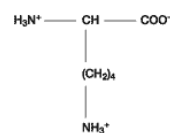
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L-Lysine

- Supports enzyme action of collagen development, inhibits breakdown and metastases. M.Rath MD

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L-Lysine



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L-Methionine

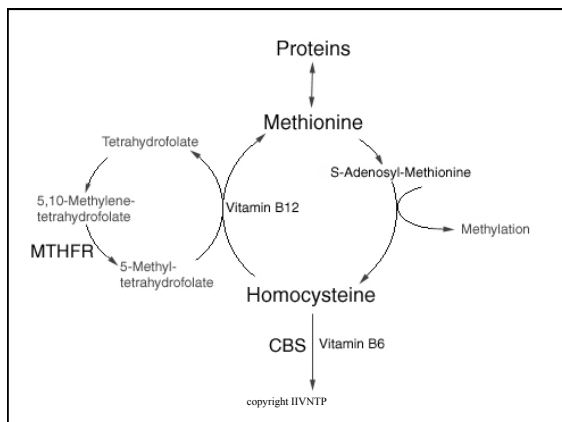
- 50 mg/ml
- Essential sulfur containing AA
- Serves 3 major roles in body:
 - As a methyl donor for synthesis of many body compounds
 - Sulfur donor, e.g. phase 2 sulfation
 - Precursor for other sulfur AA
- Deficiency leads to temporary folate deficiency, folate is trapped in liver, important in allergic patients (high histamine)

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L-Methionine

- Critical to take adequate B6, B12, Folate when supplementing Methionine, otherwise homocysteine levels rise
- Methionine is useful as part of a program for lowering high histamine levels
- Depression – S-Adenosyl L-Methionine (S-AdoMet) is synthesized in the body after supplementation of methionine
 - Study found IM injection of 45 mg S-AdoMet had beneficial effect on depression, suicidal tendency and brain performance

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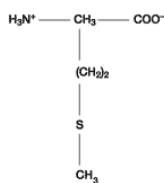


L-Methionine

- S-Adenosyl-Methionine (SAME) is a cofactor for the neurotransmitter, epinephrine
 - Epinephrine opens up the blood supply to the heart, skeletal muscles and liver
 - Insufficient SAME results in nor-epinephrine being formed leading to hypertension
- SAME required for synthesis of carnitine

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L-Methionine : Important methyl donor



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L-Proline

- Not readily available currently
- 50 mg/ml
- Collagen is major Proline reservoir
- Vitamin C deficiency leads to increased Proline loss in urine
- It is useful in wound healing, injuries to ligaments, tendons
- Contraindicated in depression, seizures

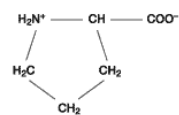
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- A non-essential amino acid that is synthesized from GLUTAMIC ACID. It is an essential component of COLLAGEN and is important for proper functioning of joints and tendon.
- Responds to stress signaling, reduces need for ornithine and arginine

J Nutr. 2008 Oct;138(10):2008S-2015S. The metabolism of proline as microenvironmental stress substrate. Phang JM Pandhare J, Liu Y

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L-Proline



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Taurine



- 50 mg/ml
- Sulfur containing organic acid, not incorporated into muscle protein, present in all cell membranes
- Major role in normal functioning of brain, other electrical excitable tissues (heart)
- Promotes pumping action of heart
- Useful for CHF: 3-5 grams (oral) + 200- 300 mg COQ10 daily

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Taurine



- Taurine is a master osmolyte in the body – osmolyte function allows transport of excitable ions to the preferred side of the cell membrane (Na / Ca / Cl outside, Mg / K inside).
- Taurine is required in the cell membrane as well as in circulation to be effective as an osmolyte.
- Deficiency creates sub-optimal osmolyte activity

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Taurine

- Useful in patients who show increase of arrhythmias from IV magnesium
- Heart
 - Modulates activity of C-AMP which activates many cardiac enzymes
 - Contributes to muscle contractility
 - May affect entry of Ca into heart muscle cells
 - May be useful in treating arrhythmias

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Taurine

- Found in high concentrations in eye, useful for macular degeneration
- Required for synthesis of taurocholic acid one of the primary bile acids
- Mercury can significantly interfere in the trans-sulfuration pathway at many different locations, leading to a deficiency or reduction in available taurine

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Taurine

- Cysteine and B6 support synthesis in body
- Zinc enhances Taurine effects
- Zinc + vitamin A deficiency leads to loss of Taurine in urine – depleted tissue levels
- Has potent and long-lasting anticonvulsant action
- 15-20 grams IV given without toxicity

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Taurine: Research Overview

- | | |
|---------------------------------------|-------------------------------------|
| 1. Slows development of heart failure | 6. Improves endothelial dysfunction |
| 2. Prolongs life in those with CHF | 7. Prevents cell membrane damage |
| 3. Prevents EtOH induced hypertension | 8. Decreases serum cholesterol |
| 4. Improves glucose tolerance | 9. Antihypoxic |
| 5. Improves insulin utilization | 10. Decreases aortic lesions |
| | 11. Helps prevent atherosclerosis |

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Taurine: Research Overview

- | | |
|---------------------------|-----------------------|
| 12. Controls seizures | 16. Protects against |
| 13. Treats EtOH induced | reperfusion injury |
| amnesia | 17. Reduces adrenal |
| 14. Helps cystic fibrosis | gland adrenaline |
| fat absorption | output |
| problems | 18. Taurine is second |
| 15. Prevents cataract | only to GABA as |
| development | inhibitory NT |

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Taurine: Research Overview

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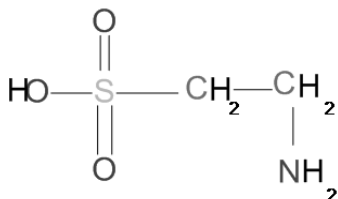
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Taurine



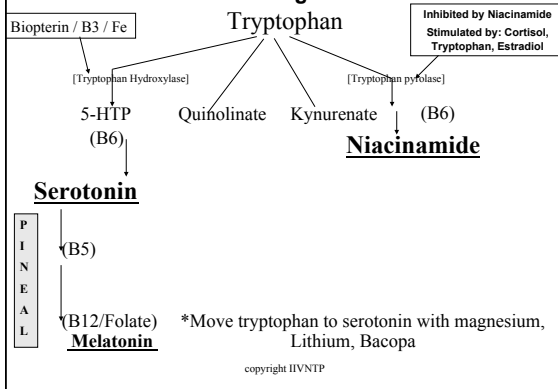
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Tryptophan

- Not readily available currently
- 30 mg/ml
- Essential AA
- IV administration supports production of serotonin
- Provides a calming effect on the brain
- CNS and peripheral effects
- Caution in people on serotonin medications
 - Monitor for serotonin syndrome.
 - Fever, Hyperreflexia, HTN, Coma, Death
- Required for synthesis B6, B3, B5, B12, Folate

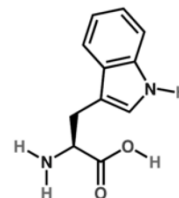
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Serotonin Augmentation



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Tryptophan



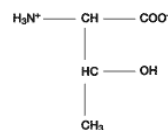
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L-Threonine

- Not readily available currently
- 50 mg/ml
- Essential AA
- IV administration raises Glycine and Threonine concentration in brain and spinal cord – 1 g bid orally for depression
- Threonine is essential for normal GABA receptor function
- B6 essential to metabolism
- Most studies found that Threonine is an immunostimulant, specific requirement by thymus

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L-Threonine



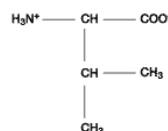
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L-Valine

- Not readily available currently
- 50 mg/ml
- Essential branched chain AA
- Cofactors for metabolism: B1, B2, B6, Mg, Cu, Glutamic acid
- Useful in treatment of liver disease (5 mg/kg), muscle building (5-10 g daily, oral dose)

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L-Valine



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The Bottom Line

Practicalities

- Freamine III/Aminosyn II is good to replace those individual AA not used frequently in your clinic
- Essentials to have on hand
 - Glutathione
 - Taurine
 - Proline,
 - Carnitine
 - NAC
- Purchase others for specific patient applications

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