Amino Acid Balance (Pool)

THE AMINO ACID BALANCE

The circulation of amino acid throughout the organs and cells of the human body. We divide amino acid balance into:

• Systemic amino acid balance

• Cellular amino acid balance

From a systemic standpoint, we'll address…

• Digestion and absorption of the essential amino acids via protein digestion and absorption.

• Passage via the portal vein to the liver, which is the major organ that metabolizes amino acids and manages their ammonia and carbon skeletons.

• Passage into systemic arterial circulation into key extra– hepatic organs (eg, muscle and kidneys).

From a cellular standpoint, we'll address…

• Amino acid uptake via amino acid– specific transporters.

• The concept of the amino acid pool – the pool of amino acids within the cytoplasm, which distributes to proteins synthesis and the biosynthesis of small molecules, including the nucleic acids necessary for the formation of DNA transcription.

SYSTEMIC AMINO ACID BALANCE

• Draw a head and neck, stomach, proximal small intestine, and pancreas.

• Show that dietary protein enters in its folded state.

• Indicate that the highly acidic pH of the stomach (~2) from the HCL denatures (uncoils) the protein.

• Show that proteases (aka peptidases), which operate in a more neutral environment (pH ~6), from the bicarbonate of the pancreas, cut up the long stands of polypeptides into oligopeptides (short peptide chains).

• Now, draw the liver and connect the liver to the GI tract via the hepatic portal vein.

• Show that oligopeptides are absorbed as amino acids through the epithelial lining of the proximal small intestine (the enterovilli), and pass via the hepatic portal vein to the liver.

• Show that the liver is the major organ responsible for amino acid metabolism in that it is responsible for:

– Transamination reactions (via aspartate aminotransferase (AST) and alanine aminotransferase (ALT) (we review transamination at the end). – The degradation of amino acids into their carbon skeletons for the purpose of energy production in mitochondria. – The management of ammonia via the urea cycle, which involves mitochondria.
Ammonia is a toxic waste product in amino acid metabolism and must be excreted.

• Draw the kidneys and show that urea is excreted from the body in the urine via this excretory pathway.

• Take a moment and show that fecal nitrogen excretion is the corollary for ammonia waste via the feces, which is a small percentage of protein intake.

• Next, draw the rest of the systemic circulation and show some key organs for amino acid metabolism: muscle, kidney, brain, and the red and white blood cells.

Don't lose sight of the fact that amino acids are distributed to all organs throughout the body – cells need amino acids for the formation of proteins!

• Now, show that transamination occurs in these organs in addition to the liver.

– Thus, although clinically we call AST and ALT "liver enzymes", they are found in many organs other than simply the liver.

• Finally, conclude our diagram of systemic amino acid circulation with some endogenous protein being shuttled via systemic circulation to the stomach where its recycled.

– In fact, just as much protein (100 grams) enters the stomach via endogenous means as it does via the diet.
CELLULAR AMINO ACID BALANCE

Next, let's move inward in the body and in our diagram to tackle cellular amino acid balance.

• Draw a cell and include the cytoplasm.

• Include the cell nucleus.

• Show that amino acids enter the cell via amino acid transporters, which are often sodium– dependent.

Amino Acid Pool

• Indicate that these amino acids form what is referred to as the amino acid pool.

– The pool of amino acids that exist within the cytoplasm and can be used for various processes.
Nuclei Acid Synthesis

• Start with their role in nuclei acid synthesis: the purines and pyrimidines.

• Show that protein synthesis starts with DNA, which undergoes transcription to pre– mRNA; it undergoes RNA processing to mRNA, and the mRNA leaves the nucleus for translation via ribosomes to produce protein.

Next, let's see how amino acids are further responsible for synthesis of that protein!

Protein Synthesis

• Draw an enlarged ribosome.

– Include the mRNA and the tRNA ribosomal binding sites. – Show that the tRNA carries amino acids from the amino acid pool into the ribosomes for protein formation.

• Next, show that the protein is folded (coiled) and in some instances will leave the cell to enter systemic circulation and be broken down within the stomach (if that's its fate).

Biosynthesis of Small Molecules

• Now, show that the amino acid pool can directly involve the building of small molecules with the help of various co–factors.

– Key small molecules include the nucleic acids we already showed but also include histamine, thyroxine, nitric oxide, and the catecholamines.

Metabolism for Carbon Skeletons

• Finally, show that in periods of fasting, amino acids can be shuttled back into circulation from the amino acid pool in, for instance – muscle, to be metabolized for their carbon skeletons in liver for glucose production.

TRANSAMINATION

Throughout this tutorial, we discussed transamination, so let's explore what this means at a chemical level.

• First show that that transamination is the transfer of an amino group from an amino acid to an alpha– keto acid.

• Draw alanine.

• Show that via alanine amino transferase, the amino group is transferred off the alanine and it becomes its keto– acid counterpart: pyruvic acid.

LABORATORY VALUES

Finally, let's consider some of the key laboratory values that are used to measure clinical activities pertaining to amino acids:

• Aspartate Aminotransferase (AST)

– Indirect measurement of liver and muscle inflammation/toxicity.

• Alanine Aminotransferase (ALT)

– Indirect measurement of liver inflammation.

• Blood Urea Nitrogen (BUN)

– Indirect measurement of kidney efficiency.

• Fecal Nitrogen Excretion

– Indirect measurement of GI efficiency.

• Serum Ammonia Level

– Indirect measurement of liver efficiency.

FULL-LENGTH TEXT

• Here, we'll learn about amino acid balance, which is the circulation of amino acid throughout the organs and cells of the human body.

• To begin, start a table.

• Denote that we divide amino acid balance into:

- Systemic amino acid balance (which refers to their systemic circulation).

- Cellular amino acid balance (which refers to their cellular circulation).

• From a systemic standpoint, we'll address:

- Digestion and absorption of the essential amino acids via protein digestion and absorption.

- Passage via the portal vein to the liver, which is the major organ that metabolizes amino acids and manages their ammonia and carbon skeletons.

- Passage into systemic arterial circulation into key extra-hepatic organs (eg, muscle and kidneys).

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- Amino acid uptake via amino acid-specific transporters.

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