Lactic Acid & Buffering Your Blood

BIG LAC ATTACK

By Dr. T. P. Turner

Where was I? Oh well, I guess that's a better question than "Where am I?" What were we talking about before I landed on my head and went off on that Giro tangent? Oh yeah, we were talking about the stresses of cycling ... with the rubber side on the bottom.

I want to start with the best-known stressor of them all, lactic acid. We all know that lactic acid is produced during hard efforts. We know what it feels like to have our legs burn and our chest feel like it's on fire.

We also have the idea that lactic acid makes us sore after hard efforts and is the reason we feel tired. Right? Well, no. Actually lactic acid has gotten a bad rap all around. We need to examine the whole process to understand lactic acid's role in energy production.

The energy for muscle contraction comes from breakdown for ATP (adenosine triphtosphate).

[Adenosine-P04~P03~P03]

The bonds represented by the "little squiggles" on the last two phosphate radicals are "high energy bonds". When these bonds are broken, there is a release of about 11,000 calories of energy/mole for each bond or 22,000 calories in all.

Breaking the first bond, converts ATP into ADP (diphosphate). Breaking the second bond converts ADP into AMP (monophosphate). There is only enough ATP hanging around in the muscles to fuel maximum muscle power for about 5 or 6 seconds. New ATP has to be formed continuously. there are three systems for producing new ATP.

1) Muscle stores of phosphocreatine

[Creatine ~ P03]

Notice the high-energy phosphate bond. This bond stores even more energy than the bonds of ATP. When this bond is broken, the energy released is used to reconstitute AMP to ADP and ADP to ATP. This takes only a small fraction of a second.

The muscle stores of ATP and phosphocreatine combined are called the phosphagen energy system. This system can provide maximum muscle power for about 10 - 15 seconds. This system requires no oxygen, but the time is only accurate when the stores are completely full. Running the 100 yard dash is a good example. It is hard to equate directly to cycling because we rarely get to sprint when fully recovered.

2) The aerobic system involves the combining of glucose, fatty acids and amino acids with oxygen in the mitochondria of our cells to release energy to convert AMP and ADP to ATP. The aerobic system can theoretically provide energy as long as the nutrients last. It is relatively slow however, compared to the phosphagen system. The aerobic system can reconstitute ATP at a maximum rate of about 1 mole/minute 9all day long) while the phospagen system can reconstitute at a rate of 4 moles/minute (but only for about 10 seconds).

3) The glycogen-lactic acid system can reconstitute ATP at a rate of about 2.5 moles/minute. It can sustain maximum muscle power for about 30 - 40 seconds. This system along with the phosphagen system can provide the well-trained athlete with 50 - 60 seconds of maximum anaerobic power. this equates to running the 400 meters or to cycling the kilo. It can provide sub maximum power for an hour or more depending on the rate and relative fitness of the athlete, of course.

Muscles and the liver store glucose as glycogen. To produce energy, glycogen is first broken down into glucose. Glucose is split into 2 pyruvic acid molecules by a process called glycosis. This is split releases energy to reconstitute ATP. Pyruvic acid ordinarily enter the mitochondria and combines with available oxygen to form still more ATP 9the aerobic system). When there is not enough oxygen to go around, the amount of pyruvic acid in the cell begins to rise.

The law of mass action says that as the end of products of a chemical reaction builds up in the reacting medium, the rate of reaction approaches zero. that means that if the pyruvic acid was allowed to build up in the cell, we should stop producing energy in a very few seconds. So, most of this excess pyruvic acid is converted into lactic acid.

The lactic acid diffuses out of the muscle cells into the fluids between the cells and into the blood. This allows the breakdown of glucose for energy to continue. The big limiting factor in the use of this system is the amount of lactic acid we can stand. You all know how it feels. When the lactic acid levels get high enough, the burning and fatigue just shut you down. Can you say bonk?

So, although lactic acid levels do limit the amount of anaerobic energy we can produce, it does allow us to produce more than we could without it. it also saves the end products of glycosis for reuse.

When oxygen becomes readily available again, the pyruvic acid being produced is oxidized and the conversion to lactic acid reverses itself and the lactic acid again becomes pyruvic acid. Some of this pyruvic acid is used for energy to reconstitute ATP and the rest is converted back into glucose and into glycogen. Most of this reconversion happens in the liver.

Once oxygen is readily available, lactic acid has a half-life in the system of about 30 minutes. This means that within an hour or two it has all been eliminated from the body. So, although lactic acid causes us considerable suffering during hard efforts it is not around the next day to cause the residual muscle soreness it gets blamed for. Well, it it's not lactic acid in the muscles that makes us sore, what is it? To tell you the truth, I don't know for sure. It's not a done deal. There are only theories. The most popular one is that the soreness following exercises is from micro tearing of muscle fibers and connective tissue. This idea makes sense when talking about weight lifting but I'm not sure I buy it for most cycling workouts. Let's look at some of the facts.

1) I can get sore after easy rides if they are long enough. There is not much stress to cause tearing, but there is a whole lot of aerobic energy production. 2) An easy recovery ride the next day significantly reduces the soreness. Tearing would just take time to heal. 3) Massage helps reduce soreness a lot. (See no.2) 4) The soreness is a burning type of pain. This is fairly subjective but most people seem to agree. The neurological mechano-receptors that send

the signals to our brains that are interpreted as burning are called nociceptors and are stimulated by noxious chemicals and not by micro tears. 5) I have checked the urine of lots of sore athletes and that all have very acid urine.

My pet theory about soreness is based on the fact that when we produce energy by any system there are a great many hydrogen ions produced. Hydrogen ions seriously acidify the tissues. There are a lot more produced in anaerobic metabolism and when then lactic acid is reconverted into pyruvic acid much of this acid byproduct is left behind.

The sodium bicarbonate buffering system is our first line of defense if neutralizing this acid. Our kidneys are responsible for ridding the body of the excess ions we can't neutralize. The kidneys can only dump hydrogen ions at a rate that will lower the pH of the urine to 4.5. This makes the process a slow one. It often takes the urine two or three days to return to normal pH (6.5 - 7).

When there are too many ions to neutralize with available sodium bicarbonate the body will switch to the protein buffering system as back up. This system produces ammonia, which is an effective buffer but has some side effects. You know those afternoons after a long or really hard efforts when you feel all fuzzy headed and have a hard time getting of the couch. That's ammonia!

In his book Road Racing Technique and Training, Bernard Hinault suggests that after long hard races "detoxification' is the first priority. The first thing he recommends is sodium bicarbonate. I have found that 1/2 to 1 teaspoon of baking soda in water after hard efforts generally eliminates soreness and greatly reduces fuzzy headed couch time. So, my theory is that it is the hydrogen ions and not lactic acid that produces soreness. Hey, it's just a theory. Put those rocks down.

To test this idea, test your urine pH after hard efforts. It will be 4.5. Also test your salivary pH, it will either be a little acidic or if the effort was hard enough to create ammonia it will be 8 (very alkaline). Take the baking soda. The urine will generally not change but if the saliva was 8, it will usually drop to 6 or so within an hour.