LECTURE 12

RENAL PATHOPHYSIOLOGY

While reviewing renal physiology in the previous lecture, a limited exposure to renal pathophysiology was presented. Many more disorders exist and a selected few of the more important ones will be described in this lecture. For ease of understanding, renal disorders will be grouped, according to their cause, into the following categories: (1) Prerenal (before the nephron); (2) Intrarenal (within the nephron); and (3) Postrenal (beyond the nephron and within the urinary tract).

Skim read Chapters 33 and 34, then look up each disorder treated in the various subheadings below (highlighted in blue) in your textbook and read in detail about its pathophysiology prior to proceeding through each lecture section.

Prerenal Pathophysiology

According to the approach described above in the introductory paragraph, ***prerenal disorders*** will be used to refer to any disruption on the cardiovascular side of the nephron. Specifically, anything that originates in the circulatory blood supply of the nephron that impairs its function will be classed as ***prerenal***.

Chronic Hypertension and Benign Nephrosclerosis. Because of the large number of small diameter blood vessels associated with the kidney, kidney function is extremely sensitive to high blood pressure. Elevated pressures can cause blood vessel damage as plasma leaks into the artery wall under pressure. This plasma infiltration begins an inflammatory response that thickens the artery walls with resultant renal ischemia. Renal ischemia, in turn, can further damage the kidney through the renin-angiotensin response and its resultant exacerbation of hypertension.

Left-Sided Heart Failure. Recall the definition of heart failure being any condition in which cardiac output is insufficient to meet body needs. One of those "needs" in systemic circulation is adequate kidney perfusion to keep filtration function and waste removal within normal limits. Admittedly, with left CHF blood backs up into the lungs causing respiratory problems. But, it is the diminished output into the aorta from the failing heart that lowers kidney perfusion "downstream" and can result in renal failure with its associated low urine output and accumulation of wastes in circulating blood and body fluids.

Glomerulonephritis. In this condition, antibody complexes resulting from a recent infection collect on the glomerular membrane on the circulatory side and cause a secondary glomerular inflammation. This glomerular inflammation can cause permanent nephron damage by fibrous connective tissue infiltration which interferes with the glomerular filtration process. Streptococcal infections are notorious as causative agents of acute glomerulonephritis. Consequently, something as simple as a "strep throat" can have serious consequences.

Intrarenal Pathophysiology

With ***intrarenal*** disorders, the problem arises from within the nephron tubules themselves, at some point from the proximal tubule to the collecting duct. It is difficult to imagine damage so specific as to damage the inner nephron without affecting either end unless attention is given to bacterial toxins and accidentally ingested materials, such as pesticides, herbicides, heavy metals, antifreeze, certain cleaning fluids, and nephrotoxic drugs.

Toxins (Acute Tubular Necrosis, ATN). Many bacteria, especially certain strains of *Escherichia coli*, secrete toxic materials that can be damaging to the host. In humans, these toxins may exist in circulating blood at levels too low to cause problems until they are filtered into the nephron across the glomerulus. Once filtered into the nephron, tubular reabsorption results in these toxins being concentrated in the nephron, eventually reaching a concentration high enough to damage nephron tubule cells (tubular necrosis). A recent event involving a recreational water park in north Atlanta gained notoriety when fecal contaminants containing *E. coli* were ingested with inadequately chlorinated water. The affected children experienced varying degrees of renal impairment.

A similar situation exists with the other accidentally ingested materials listed in the introductory paragraph. And, the etiology of the resultant kidney dysfunction in these situations is comparable.

Postrenal Pathophysiology

Postrenal disorders are those that originate in the urinary tract "downstream" from the nephrons of the kidney. These disorders can involve the renal pelvis, the ureters or the bladder and urethra.

Renal Calyx (Kidney Stone). Kidney stones result from crystalline materials that occur in urine in concentrations sufficient to cause aggregate crystals that grow into stones within the renal pelvis. Once formed, these stones can move into the ureters and lodge causing intense pain until they are passed naturally or are removed surgically or disrupted by ultrasound treatments. A common kidney stone develops from calcium oxylate salts in people with high calcium and oxalic acid in their diets. Such stones are prevalent in people in the South. In fact, southerners have triple the incidence of other regions. Calcium comes primarily from dairy products and leafy green vegetables, both of which

are common in southern diets. Oxylates come from plant extracts (coffee, tea, and cola), which are also common in southern diets. Considering both of these factors, when combined with dehydration as is common in southern climates, it is not surprising that the rate among Southerners is so high.

Pyelonephritis. Pyelonephritis is a condition which develops when infectious microorganisms establish in the urinary tract and migrate upward into kidney tissue. The incidence is particularly high in individuals who contaminate the urethra with fecal material containing *E. coli* as a result of poor hygiene or are unable to completely void the bladder for some reason. The urinary retention leads to excess microbial growth and eventual spread into the kidneys.

Renal Failure

No treatise of renal disease would be complete without a discussion of renal failure. Renal failures can be **acute**, lasting only for a short time, or **chronic**, developing over and continuing for an extended period of time. Chronic renal failures result when over 70% of nephrons are permanently lost and require dialysis to sustain life. From the point at which dialysis or transplantation is required to sustain life, the condition is termed ***end stage renal failure***.

Basically, the etiology of any type of renal failure can be quite varied and depends upon the particular event that initiates the kidney damage. If uncorrected, any of the events described above can lead to renal failure. One type of renal failure is relatively rare and termed "nonconcentrating" in which reabsorption fails and high urine output results in danger of dehydration and loss of essential nutrients. This type will not be considered here.

The most common category of renal failure is one in which urine production fails and urine output drops below 30 cc per hour. Under these conditions, fluid expansion occurs with elevated blood pressure and wastes accumulating to dangerous levels. ***Azotemia*** is the accumulation of nonprotein nitrogenous wastes, such as urea, uric acid and creatinine. The condition of existing azotemia is termed ***uremia*** or ***uremic poisoning***. In uremia, these wastes along with other accumulated salts are excreted in sweat and deposited in soft tissues of skin. With sweat evaporation, these salts accumulate on the surface of the skin resulting in ***uremic "frosting"***.

REVIEW QUESTIONS:

1. Explain why clients with renal problems are put on low protein diets.
2. Why isn't all of blood calcium lost in the urine?
3. Why is the ingestion of poorly washed fruits and vegetables risky?

4. Review each of the renal disorders in this lecture and explain why they are classed as pre-, intra-, or postrenal by cause.

DISCUSSION QUESTIONS: (Post answers to the "Patho Discussion Group")

1. Describe step-by-step how a sore throat could lead to dialysis.

2. How (step-by-step) could renal failure lead to left CHF and vice versa.