CHAPTER XXXIII

SURGICAL ANATOMY AND PHYSIOLOGY OF THE KIDNEY —EXAMINATION OF THE KIDNEY—ABNORMALITIES OF THE KIDNEY

ANATOMY

Gross Anatomy.—Although familiarity with the minute anatomy of the kidney is an essential part in the equipment of every practitioner, be he physician or surgeon, it is quite impracticable to enter upon this intricate subject here. A brief survey of the gross anatomy of the organ must suffice. The rest we leave to the histologist.

The kidney is ovoidal in shape, flattened antero-posteriorly, and with a deep notch, the *hilum*, in its inner border. The renal vessels and nerves enter the organ through the hilum, the vein lying in front of the artery, while behind these is the *conical pelvis*,[1] terminating below in the ureter. The *sinus* of the kidney is the irregular cavity of which the hilum is the orifice.

The normal kidney is 11 cm. long, 6 cm. wide, and 4 cm. thick. It weighs from 125 to 200 grammes.

The kidney is closely surrounded by a fibrous capsule sending fine processes between the secreting tubules. A thin irregular layer of unstriped muscle lies between the capsule and the kidney. When the organ is healthy its capsule may be stripped from it, but inflammation causes the capsule to become adherent.

A vertical section through the kidney (Fig. 134) shows its secreting structure to consist of two parts: an outer (cortical) portion and an inner (medullary) portion, the latter made up of rounded cones (pyramids) whose apices (papillæ, mammillæ) project into the sinus of the kidney; while between the medullary pyramids the lighter coloured cortical portion of the organ also abuts on the sinus.

[1] Although, strictly speaking, the pelvis is the dilated upper extremity of the ureter, it is customary and convenient to speak of the renal pelvis rather than the ureteral pelvis.

Vessels and Nerves.—The *renal arteries* are given off one from each side of the abdominal aorta, and proceed directly outward to the kidney, lying behind the veins (the right renal artery runs behind the inferior vena cava). As the artery enters the hilum of the kidney it divides into several branches, which enter the cortical substance and are thence distributed throughout the organ.

The *renal veins* accompany the arteries, lying in front of them, and empty into the inferior cava. On the left side, the spermatic, inferior phrenic, and suprarenal veins are tributaries of the renal.

The *nerves* of the kidney are derived through the renal plexus from the solar plexus, the semilunar ganglion, and the lesser and smallest splanchnic nerves. The spermatic plexus is derived from the renal plexus.

The *lymphatics* accompany the blood-vessels and empty into the lumbar glands.

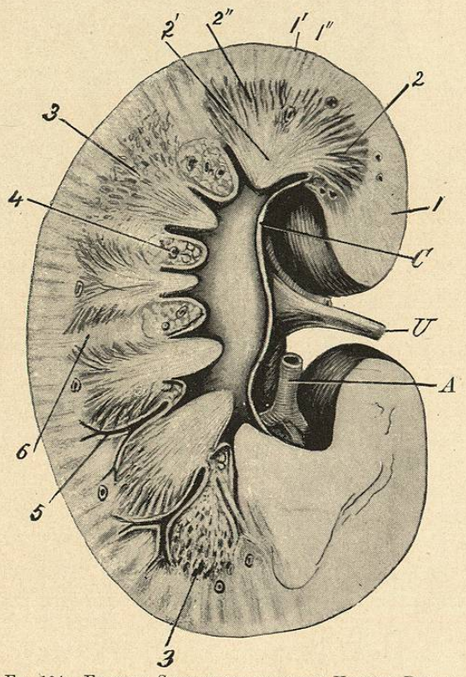

FIG. 134.—FRONTAL SECTION THROUGH THE KIDNEY, PELVIS, AND CALICES (Henle).

A, branch of the renal artery; *U*, ureter; *C*, calyx; *1*, cortex; *2'*, medulla; *2''*, boundary zone; *4*, fat of sinus of kidney; *5*, arterial branches.

Position. — The kidneys lie on each side of the spine in the upper lumbar region, behind the other viscera and outside of the peritoneal cavity (Fig. 135). They rest on the diaphragm and the psoas magnus and quadratus lumborum muscles between the twelfth dorsal and the third lumbar vertebræ. Their upper extremities lie nearer to each other than the lower, and the internal borders face a little downward and forward, the outer borders upward and backward. The right kidney lies rather lower than the left on account of the position of the liver above it (Fig. 136).

The average normal variation in the position of the kidneys is well expressed by Brewer's [1] statistics obtained in the dissecting-room. He found the upper end of the right kidney opposite the eleventh rib in 78 cases, opposite the twelfth rib in 62 cases, and lower still in 9 cases. The upper end of the left kidney was opposite the tenth rib in 1 case, opposite the eleventh in 100 cases, opposite the twelfth in 43 cases, and below the ribs in 6 cases. Yet it must be borne in mind that during life the kidneys move up and down with every respiration, and are peculiarly susceptible to downward displacement.

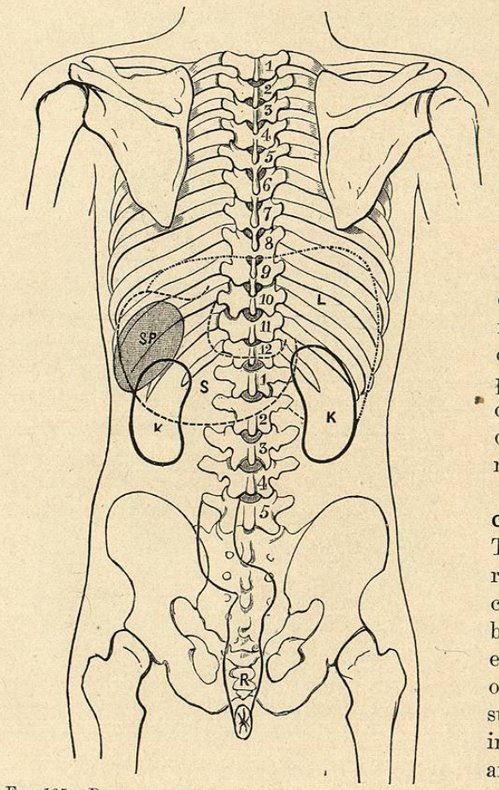

Fig. 135.—Diagram showing Relation of the Viscera to the Parietes, Posterior View (Treves).

S, stomach; *L*, liver; *K*, kidney; *SP*, spleen; *R*, rectum.

Fatty and Fascial Envelope.—The kidney, surrounded by its fibrous capsule and topped by the adrenal, lies embedded in a mass of loose cellular tissue, usually containing a considerable amount of fat, and calculated to permit slight changes in its size and position. This fatty envelope (perirenal fat) quite fills the hollow of the loin, and is surrounded and held in place by a distinct fascia. This fascia has been studied by Zückerkandl, Gerota, and Glantenay and Gosset.[2] It completely surrounds the kidney, the suprarenal capsule, and the perirenal fat. In front it blends with the subperitoneal fascia, internally it adheres to the vertebral column, and above to the diaphragm. It sends a few fibres to the aponeurosis of the quadratus lumborum which lies immediately behind it. It thus forms a distinct sac firmly anchored to the diaphragm and the spine. It is everywhere closed, except at its lower extremity, where the posterior layer thins out and sends only a few fibres across to the subperitoneal fascia. (Were it not for this hiatus floating kidney would be impossible.) Below and behind this fascial envelope lies another mass of fat, practically continuous with the perirenal fat, but distinguished by the Germans as the "pararenal" fat.

[1] Med. News, 1897, lxxi, 129.

[2] Guyon's Annales, 1898, xvi, 113.

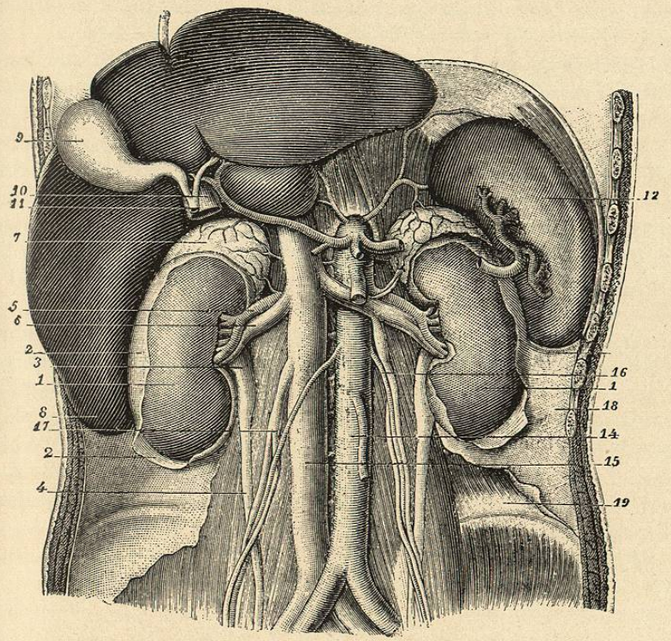

Fig. 136.—Situation, Direction, Form, and Relations of the Kidneys (Sappey).

1, 1, the two kidneys; *2, 2*, fibrous capsule; *3*, pelvis; *4*, ureter; *5*, renal artery; *6*, renal vein; *7*, suprarenal capsule; *8*, the liver lifted up; *9*, gall-bladder; *12*, spleen; *14*, abdominal aorta; *15*, inferior vena cava; *16*, left spermatic artery and vein.

Relations.—Behind, the kidney is in relation with the diaphragm and the psoas and quadratus muscles. The last dorsal nerve runs transversely between the muscles and the perirenal fascia, and the pleura usually descends between the ribs and the diaphragm low enough to cover the upper third of the organ.

In front of the right kidney lie the duodenum and the ascending colon. A fold of peritoneum separates kidney and liver above the colon, while lower down a peritoneal fold separates colon and duodenum.

The left kidney is crossed by the tail of the pancreas and lower down by the descending colon, while its upper portion is separated from the stomach by the lesser sac of peritoneum.

The upper extremity of each kidney is capped by the adrenal. In fetal life this is closely adherent to the kidney and almost completely envelops it, but after birth the adherence becomes slight.

The Pelvis of the Kidney.—The pelvis belongs anatomically to the ureter, of which it is the dilated upper extremity, but surgically to the kidney, of whose secretion it is the reservoir and in whose surgical diseases it participates.

At the bases of the renal pyramids the epithelium of the uriniferous tubules joins with the fibrous covering of the cortex, the one to form the inner, the other the outer, coat of a tube surrounding one or more papillæ, and called a *calix* (infundibulum). The calices unite to form the pelvis, an irregularly funnel-shaped pouch which protrudes from the lower and back part of the hilum, whence it runs downward, narrowing rapidly to become the ureter proper at a level with the lower end of the kidney.

The structure of the pelvis resembles that of the ureter (p. 469).

PHYSIOLOGY

The physiology of the kidney, in so far as it interests the surgeon, may be studied under three divisions:

I. Estimation of the Renal Function.
II. Renal Reflexes.
III. The Effect of Anesthetics upon the Kidney.

Estimation of the Renal Function

The surgery of the urinary organs would be an exact science were we able accurately to estimate the functional capacity of the kidneys. Renal insufficiency, be it in the form of an acute suppression of urine or of a slowly progressing uremia, is the most elusive, the most threatening element of post-operative prognosis. In every operation from urethrotomy to nephrectomy we are taught by bitter experience that however careful the preparation, however minute the asepsis and antisepsis, however brilliant the execution, however promising the outlook, suppression or uremia may claim the victim. We are becoming expert in urinary bacteriology and antisepsis. Our

ideas grow more incisive, our fingers more adept, but now and again the kidneys trick us still. Wherein does our knowledge fail? We can estimate accurately the quantity and quality of the renal secretion. We can recognise the clinical picture of urinary toxemia and septicemia. We can even delve into urinary toxicity, cryoscopy, and the phloridzin and pyoktanin tests. By these means we can learn with considerable accuracy what the kidneys *are doing*, and hence we may make certain fairly correct inferences. But what the kidneys *will do*, how they will bear the shock of anesthesia and operation, how much reserve energy they have, we are far from comprehending. I make no attempt to discredit the present trend of scientific investigation in this department: on the contrary, I hope as fervently as any one that we are on the right track. But as yet the experimental stage has not been passed. While all are agreed that the estimation of specific gravity, urea, etc., affords very inadequate evidence of functional activity of the kidneys, the newer methods have yet to show that they are much better for the surgeon's purposes.

Methylene Blue and Phloridzin.—In 1897 Achard and Castaigne proposed to test the permeability of the kidneys by means of subcutaneous injections of methylene blue. After the injection of 1 c. c. of a 5% solution, they found that if the kidneys are normal the blue appears in the urine within a half hour, reaches its maximum concentration in about two hours, and gradually diminishes, disappearing at the end of twenty-four to forty-eight hours. The elimination of the methylene blue is accompanied, sometimes preceded, sometimes followed, by the elimination of a colourless chromogen, which is detected by acidulating with acetic acid and boiling.

It was at first believed that the elimination of both the blue and its chromogen was retarded by any disease which interfered with the excretory power of the kidneys (producing the so-called renal insufficiency). But further experience has shown that while, as a rule, the excretion of methylene blue is retarded by interstitial nephritis, it is accelerated by parenchymatous nephritis; while in a fair proportion of cases the opposite is true, interstitial change hastens and parenchymatous change retards elimination. Albarran and Bernard [1] have studied, by the aid of ureteral catheterism, the elimination of methylene blue in surgical diseases of the kidney.

On the other hand, it has long been known that the subcutaneous injection of phloridzin would cause a temporary glycosuria. This fact has been utilized as a test of renal permeability. If 5 mgm. of phloridzin are injected subcutaneously, sugar should appear in the

[1] Guyon's Annales, 1899, xvii, 336, 465.

urine within an hour and disappear within four hours, the total amount of sugar excreted varying from 0.5 to 2.5 grammes. Disease, especially interstitial disease, retards and decreases the glycosuria or even prevents it completely. In other cases the glycosuria is excessive.

Cryoscopy.[1]—Cryoscopy is the determination of the freezing point of fluids containing certain substances in solution. Urinary cryoscopy consists in determining the relation of the freezing point of the urine to that of the blood. The most important studies in these relations have been made by Koranyi. Urinary cryoscopy has been applied to the study of renal permeability, cardiac disease, and physiological metabolism. It is currently stated that with the reduced elimination of urinary insufficiency the urinary freezing point falls. But the case is by no means so simple. The theory is based upon a series of chemical formulæ and hypotheses that cannot be familiarly handled by any but a trained physiological chemist; while as an evidence of the delicacy of the technic we may adduce the testimony which Huddleston [2] offers in his able review of this subject—viz., that his earlier experiments were rendered useless by instrumental inaccuracy, in spite of the great care which he evidently bestowed upon every detail.

Comparison of Methods.—When one endeavours to compare the relative values of the different tests of renal permeability, one is confronted by a remarkable discrepancy of authorities. We learn that the results of the methylene blue and the phloridzin tests are neither consistent with nor conformable to each other. A happy, though possibly incorrect, elucidation of these discrepancies appears in the theory that either test measures only the renal permeability to a single substance, not to all substances—a selective, not a general permeability. Again, while all award to cryoscopy a pre-eminent precision, Casper [3] claims that the phloridzin test always accords with the findings of cryoscopy, while Achard [4] proclaims the supremacy of the methylene-blue test. And finally, Bernard [5] confesses that there is no stable relation between uremia and impermeability, and Vaquez adds that the absence of any sign of reduced permeability or of reduced freezing point does not preclude the possibility of uremia.

From these diverse opinions several conclusions may be drawn. In the first place, it is evident that none of these new methods is infallible, while, unhappily, the most promising of the lot—viz., cryoscopy—is the most difficult to carry out accurately, and can only be performed by a trained chemist with special apparatus. It is also obvious that any one of the methods may hint at an important renal insufficiency, which other methods of diagnosis might fail to show; and yet that very insufficiency need not necessarily indicate an impending uremia. Finally, it is an open question whether the routine observance of the daily excretion of urea, the presence or absence of polyuria or anuria, and above all a broad-minded estimate of the patient's general condition, of the presence or absence of urinary toxemia or septicemia, do not give surer results than a too close technical examination by methods whose value is as yet only vaguely determined. I confess a greater confidence in the older familiar methods until such time as we can apply the newer elimination tests with greater precision than is as yet attainable.

[1] *Cf.* La Cryoscopie des urines. H. Claude et V. Balthazard, Paris, 1901.
[2] Phila. Med. J., 1901, vii, 1246.
[3] Berlin. klin. Wochenschr., 1900, xxxvii, 643.
[4] Semaine méd., 1900, xx, 247.
[5] Guyon's Annales, 1901, xix, 206 *et seq.*

Renal Reflexes

Here, again, we enter a field that merits further exploration. So vague is our knowledge of renal reflexes that the description of them resolves itself into the enumeration of a series of disconnected facts and opinions. We may consider reflexes concerning the secretion of urine and painful reflexes.

Reflexes concerning the Secretion of Urine.—The function of the kidneys is regulated by the nervous system. Roughly speaking, the excretion of solid matter (in solution) by the kidney depends upon the amount of such matter in the blood and the health or the disease of the renal cells. But the amount of water excreted varies widely with the nervous condition of the individual, as is best exemplified by the phenomena of hysterical polyuria, and nocturnal polyuria.

Hysterical Polyuria.—Hysterical polyuria occurs almost exclusively in young adults. By day the attacks occur as follows: the subject urinates naturally, emptying his bladder completely. Within a short time, perhaps within fifteen or twenty minutes, he is surprised by a desire to urinate—often an imperious desire. In relieving himself he notices a scalding in the perineum and along the urethra, which is the more remarkable since the urine is almost clear water. But the most startling feature of the case is the amount of urine passed. More than a pint of this clear limpid fluid may be secreted by the kidneys within a half hour. These attacks are purely neurotic, of short duration, and irregular in recurrence. They are indicative either of an acute nervous strain or of a chronic state of nervous tension and weakness. Beyond this they have no significance.