A Course of Lectures ON URINE, URINARY DEPOSITS, AND CALCULI.

DELIVERED AT THE PATHOLOGICAL LABORATORY,
DURING THE SESSION 1857-58.

BY

LIONEL BEALE, M.B., F.R.C.P., F.R.S.,

PHYSICIAN TO KING'S COLLEGE HOSPITAL; PROFESSOR OF PHYSIOLOGY
AND OF GENERAL AND MORBID ANATOMY IN KING'S
COLLEGE, LONDON; ETC.

LECTURE VI.

THE ANATOMY OF THE KIDNEY. ITS ACTION IN HEALTH AND DISEASE. *Cortical and Medullary Portions of the Kidney. Pelvis. Mammilla. Infundibula and Calyces. Artery. Vein. Nerves. Lymphatics. Secreting Apparatus. The Uriniferous Tube. Of the Circulation in the Kidney. Epithelium. Of the Basement Membrane of the Tubes and of the so-called Matrix. On some Points connected with the Physiology of the Kidney. ON THE FORMATION OF CASTS OF THE URINIFEROUS TUBES. Of the Cast. Circumstances under which the Renal Secretion may be altered in Quantity or Quality. On the Absorption of Substances from the Stomach, and their Excretion in the Urine. MORBID CHANGES AFFECTING THE STRUCTURE OF THE KIDNEY. Of Bright's Disease. Dr. Johnson's Investigations.*

GENTLEMEN,—I propose to devote some time this evening to the consideration of the anatomy and physiology of the kidney, and I hope to be able afterwards to give you a short account of some of the most important morbid changes to which this gland is liable.

As the kidney is essentially concerned in the removal of soluble substances resulting from the disintegration of tissue, the accumulation of which in the blood would materially interfere with the action of other important organs, it must necessarily form an interesting subject of study for the physician. It is not too much to say that, without a good knowledge of the anatomy and physiology of the kidney, it is impossible to form an accurate idea of the nature of a large class of diseases. A thorough acquaintance with the physiological changes occurring in this organ will alone enable us, to the greatest advantage of our patients, to suggest and apply remedies in various cases of disease. The subject is so extensive that I cannot hope to do more than offer some very brief remarks; and I shall omit discussing many points connected with the pathology necessary to make the subject complete, because your practical knowledge of disease renders such a minute description superfluous.

The general anatomy of the kidney is shown in section in the diagram (Fig. 11). Each kidney is enclosed in a capsule composed of fibrous tissue, but abundantly supplied with blood-vessels, and with lymphatics. At the hilus or notch, the capsule is continuous with the areolar tissue which surrounds the large vessels, and extends in intimate relation with them for a certain distance into the interior of the organ.

The *cortex* or *cortical portion* of the kidney consists of a layer about half an inch in thickness, forming the surface of the entire organ, and dipping down often to the depth of an inch between the pyramids.

The *medullary portion* lies immediately within the cortex, and is directly continuous with its inner surface. It is composed of from ten to fifteen pyramids, their bases being continuous with the cortex; their apices free, and projecting

into the cavity in the interior of the organ (*pelvis of the kidney*).

Pelvis: Mammilla: Infundibula: Calyces. The mucous membrane, with the fibrous and muscular tissue externally, forms a dilated cavity in the interior, called the *pelvis*. From

Fig. 11 shows the general structure of the kidney as seen upon section.

The *ureter* traced upwards is continuous with the *pelvis* of the kidney. From the *pelvis*, narrow funnel-shaped prolongations (*infundibula*) are observed. These extend to the *pyramids*, being reflected around the apex of each to form a cup-shaped depression (*calyx*). The apices of some pyramids are also seen opening into the infundibula towards the observer. The *cortex* extending round the kidney and passing inwards between the pyramids, is easily distinguished from the *medullary portion*, by the irregular granular appearance it presents to the unaided eye, and by the numerous minute points (*Malpighian bodies*) seen in it. The medullary portion is composed of the pyramids, which consist of tubes which are nearly straight, and converge to the apex or *mammilla*, when they open by about fifteen or twenty orifices. Portions of arteries and veins are observed between the infundibula, and smaller vessels are seen in the section between the cortex and medulla. These give branches in two directions, *outwards* to the cortex, and *inwards* to the pyramids. The drawing is about two-thirds of the natural size. The scale at the side is divided into four spaces, representing inches.

the *pelvis*, passing towards the apices of the pyramids, are several tubular prolongations, forming funnel-shaped channels (*infundibula*), usually not more than twelve in number. In many cases, two pyramids open into one infundibulum. Each of these funnel-shaped prolongations forms a cup-like cavity round the tip of the pyramid (*mammilla* or *papilla*), called a *calyx*. Lastly, the mucous membrane, after forming this reduplication, is firmly adherent to the *mammilla*, and immediately continuous with that lining the tubes, which open by orifices varying from ten to twenty or more in number upon the summit. Some of the free extremities of the pyramids are thin, and extend in a longitudinal direction perhaps for the distance of a quarter of an inch or more. The term *mammilla* or *papilla* can hardly be properly applied to these.

The *pelvis* is dilated at the notch or hilus, where it leaves the kidney, and soon contracts to a tube with muscular parietes (*ureter*), which opens into the bladder—one on each side of this viscus, at its posterior aspect.

Artery. Outside the mucous membrane of the *pelvis* of the kidney, the artery, entering at the hilus behind the vein, divides into branches, which are distributed to the organ. The branches of the artery do not anastomose, but radiate outwards as they divide and pass towards the cortex of the organ. Arrived at a point between the cortical and medullary portions

of the kidney, many branches pursue for some distance a more or less horizontal, or rather curved course, corresponding to the bases of the pyramids. From these radiate outwards in the cortex a number of nearly straight branches, which give off on all sides little vessels which terminate in Malpighian

Fig. 12.—Thin section of a portion of the kidney. a. Cortical, b. Medullary portion. c. Pelvis. d. Infundibulum. e. Opening of an infundibulum into pelvis. f. Calyx. g. Pyramid. h. Mammilla or papilla. i. Adipose tissue. k. Large veins divided in making the section. Small arteries are also seen cut across in different parts of the section, some large branches being situated between the cortex and medullary portion of the organ.

bodies. The great bulk of the blood carried by the artery to the kidney is distributed by Malpighian bodies; but a few small arterial branches pass straight through the cortex, and supply the capsule; others are distributed upon the external surface of the pelvis, and ramify amongst the adipose tissue in the neighbourhood; while some (*vasa recta*) are given off from the vessels that lie between the cortex and medulla, many branches of which, I have shown, anastomose with each other, and pass in the substance of the pyramids towards their apices.

The *emulgent or renal vein* is formed by the union of a number of smaller trunks which receive the blood from the capillaries. Numerous large branches may be seen in the intervals between the cortex and medulla. They converge from all points, receiving the blood distributed by the artery as above described, and at length form one large trunk, which emerges at the hilus at its anterior part, and opens into the inferior cava.

Nerves. The nerves are branches of the sympathetic, and are distributed upon the coats of the artery. They may be traced for a considerable distance into the interior of the gland, always accompanying the subdivisions of the artery. I have seen branches on the Malpighian arteries, but have not been able to ascertain how they terminate. It is possible that small branches may pass into the Malpighian tuft.

Lymphatics. There are numerous lymphatic vessels distributed to the kidney. They leave the organ at the hilus, where the large vessels enter. I have not succeeded in injecting these lymphatics as I have in the case of the liver, where they exist in great number, and are found both in the substance of the capsule and in the portal canals. The capsule of the kidney is probably also supplied with lymphatics, although it is not easy to demonstrate them by injection.

Secreting Apparatus: Uriniferous Tubes. The secreting apparatus consists of tubes lined with epithelium. The tube commences in a small flask-like dilatation, which embraces the capillary vessels of the Malpighian tuft (Fig. 13). In continuation with this is the tube which, in the greater part of its extent, is very much convoluted, being frequently bent upon itself; so that a great length of secreting tube occupies but a very small space. The convoluted tubes are so closely packed, that it is impossible to trace the course of one individual tube for any great distance; and, in thin sections of the cortex, segments of the windings of different tubes are seen divided in all directions.

The tubes, as they are about to leave the cortex, pursue an almost straight course; and here commences the ductal portion of the urinary apparatus. A certain number of these straight tubes extend nearly to the surface of the kidney, and carry off the secretion from the tubes which lie most superficially. These may be seen lying in the cortex, at certain intervals. In

the pyramids, the tubes are straight; and as they converge, they unite together, and become fewer in number; while their calibre greatly increases as they pass towards the apex of the pyramid, where they open as before described. Some of these orifices are figured in Plate XXX, Fig. 5, vol. i, *Archives of Medicine*, 1859.

The *cortex* of the kidney, then, is composed of Malpighian bodies, the flask-like dilatations and convoluted portions of the uriniferous tubes with capillaries, the arrangement of which will be presently considered, branches of arteries and veins, with a certain amount of transparent and fibrous tissue.

The *medullary portion* is composed of the pyramids, which are formed of the straight portion of the uriniferous tubes, with capillaries, bundles of small straight branches (*vasa recta*) from the arteries, and numerous straight branches of small veins; the majority of these nearly straight vessels, however, consist of vessels resulting from the division of the efferent vessels of the Malpighian bodies situated nearest the pyramids (Fig. 14). There is also an intervening material containing nuclei and having a very firm consistence.

Fig. 13.—The arrangement of the secreting structure and vessels of the kidney of man, magnified about 50 diameters. a. Malpighian body. b. Malpighian artery or afferent vessel. c. Efferent vessel. d. Capillary network, into which the blood passes from the efferent vessel. e. Small venous radicle, which carries off the blood after it has traversed the capillaries just alluded to. f. Commencement of the uriniferous tube by a dilated extremity, which embraces the vessels of the tuft. g. The tube; near the point where it opens, joins others, h. to pursue a straight course towards the pyramids of the kidney. i. Another tuft, the vessels of which are empty and shrunken. k. Portion of a tube cut across, showing the basement-membrane. The attention of the reader is particularly directed to this figure.

Circulation in the Kidney. By the aid of Fig. 13, we may now trace the course of the circulation in the kidney. Starting from the arterial branches between the cortex and medullary portion of the organ (Fig. 12), the blood pursues two directions—*outwards* towards the external surface, and *inwards* towards the apices of the pyramids.

Of the blood which passes *outwards*, a little is distributed to the capsule and membrane of the pelvis, but by far the larger proportion is carried to the Malpighian bodies. Arrived at the Malpighian body, the trunk of the little artery divides into three or four dilated branches, each being as wide as the artery itself, which subdivide into capillary loops having their convexity towards the uriniferous tube, and which lie uncovered by epithelium within its dilated commencement; so that fluids passing through the membranous walls of these capillaries, and, indeed, everything escaping from them when they are ruptured, must at once pass into the uriniferous tube. The blood is collected from the capillaries by small venous radicles which lie in the central part of the tuft, which there unite to form a single efferent vessel that emerges usually at a point very close to that by which the artery entered. In some

specimens, I have seen two and even three efferent vessels, but these are not common.

The efferent vessel of the tuft pursues a short course, and then divides into an extensive network of capillaries, in the meshes of which the tubes ramify. It is from the blood, which, after passing through one system of capillaries in the tuft, thereby losing much of its water, slowly wanders in a more concentrated state, through this second extensive capillary system, that the solid constituents of the urine are separated by the agency of the epithelial cells lining the tubes. The water transuding from the capillaries of the Malpighian body is made to traverse in succession the epithelial cells lining the tube, and dissolve the different substances which they have separated from the blood. It becomes richer and richer in solid constituents as it approaches the straight portion of the tube. From the network of capillaries above alluded to, the blood is collected by small venous radicles, which at last pour their contents into the renal or emulgent vein.

Of the comparatively small quantity of the blood which passes *inwards* towards the apex of the pyramids, a very small portion passes into vessels which supply the walls of the pelvis and adipose tissue. The remainder is conducted towards the apex of the pyramid by the *vasa recta*, or branches resulting from the division of small trunks of the artery, one of which is represented at *a*, Fig. 14. These *vasa*

Fig. 14 represents the so-called *vasa recta*. Some of these straight vessels are seen to spring immediately from small arteries, but the greater number are formed by the division of the efferent vessels of the Malpighian tufts situated near the medulla.

recta terminate in a capillary network, in the longitudinal meshes of which the straight portions of the tubes lie. I have shown that the *vasa recta* have the structure of small arteries; and, in disease, their coats are found much thickened, and the circular fibres very distinctly marked. It must not be concluded, however, that all the straight vessels in the pyramids are *vasa recta*; for the efferent vessels of those tufts near the pyramids divide into long and nearly straight branches, which pour their blood into this system of capillaries, from which it is collected by radicles which also pursue a straight course, and unite together to form small trunks, which open into branches of the vein lying between the cortical and medullary portions of the kidney. It should be mentioned, that the intertubular capillaries are everywhere continuous; and from this network venous radicles arise at certain intervals. The arrangement of the capillaries is well shown in the frontispiece of the *Illustrations of Urine, Urinary Deposits, and Calculi*. Virchow seems to consider that all, or very nearly all, the straight vessels consist of *vasa recta*; but I have shown by transparent injections that many of these vessels are the efferent vessels from Malpighian bodies, as Bowman long ago stated. Some, however, certainly come directly from arteries (Fig. 14). ("On the *Vasa Recta* in the Pyramids of the Kidney," by the author—*Archives of Medicine*, No. iv, 1859.)

Epithelium. The epithelium of the kidney is represented in the annexed cut. That in the convoluted portion of the tube is described as being polygonal; it extends into the tube to the extent of one-third of its calibre. That in the straight portion of the tube is flatter, and approaches to the scaly variety of epithelium. Although the convoluted portion of the tube is much wider than the straight portion, the diameter of the channel is much wider in the latter position than in the former, owing to the much greater thickness of the epithelium in the secreting portion of the tube.

In healthy human kidneys, I have never seen the outline of the

cells so distinctly as figured in various works, or in the upper part of my own figure. The round body usually termed the *nucleus* is very clear and well defined, and this seems to be surrounded

Fig. 15.—Epithelium from the convoluted portion of the uriniferous tube. *a*. Treated with acetic acid. X215.

by a quantity of soft granular matter. I think it very doubtful if there is a cell-wall external to this. In many cases of disease, the round central body is all that can be made out; and sometimes these are found in great number in the urine. By the action of acetic acid, nucleoli may be observed. It would seem as if the granular matter external to the rounded granular body (nucleus) was altered in character under certain circumstances. From numerous observations, I feel compelled to dissent from the descriptions generally given both of the kidney and liver epithelium, inasmuch as the appearance of a cell-wall can only be seen under certain circumstances; and in many animals there is undoubtedly no such structure. I would rather say that the so-called nuclei are imbedded in a granular material, by which they are separated from each other by nearly equal distances, as represented in the lower part of Fig. 15.

Fig. 16.—Epithelium from the pelvis of the kidney.

Fig. 17.—Epithelium from the ureter.

The epithelium in the straight portion of the tube is much flatter than that in the convoluted part, and probably serves the office of a protective covering. It is doubtful if it takes part in secretion.

Fig. 18.—Section of cortical portion of a healthy kidney washed in water and examined in the same medium. The capillaries are not injected, and, being collapsed and shrunken, exhibit the fibrous appearance which is considered to depend upon the matrix.

Fig. 19.—Section of another part of the same kidney in which the vessels were injected. The nuclei on their coats are seen, but no fibrous matrix is distinguishable.

The Basement-Membrane of the Tubes and the so-called Matrix. The basement-membrane is easily demonstrated by washing a thin section of the kidney, so as to remove the epithelium. It is much stronger and thicker in the pyramids than in the cortex (Fig. 20, *b*).

The so-called matrix described and delineated by Goodsir, Kölliker, Dr. G. Johnson, and others, I have not succeeded in demonstrating to my satisfaction; for, when the capillaries of the kidney have been distended with transparent injection, I have failed to demonstrate any fibrous structure between the wall of the tube and that of the vessels. The appearance considered to be fibrous matrix is easily seen in any thin section which has been washed and examined in water; but in such a section it is impossible to distinguish the walls of the tubes, those of the capillaries, and the so-called fibrous matrix, from each other. It has been figured by many as a distinct structure; and Fig. 18, representing a section which has been washed in water, gives its appearance most distinctly. Fig. 19 represents an injected specimen

from the same kidney, which does not exhibit any indication of fibrous tissue existing between the vessels and the tubes. Here and elsewhere, as I have shown, the stretched and crumpled capillaries produce an appearance resembling fibrous tissue or matrix of the kidney (*Archives of Medicine*, No. III, 1858).

This so-called matrix has been compared to the ultimate ramifications of Glisson's capsule; and it has been considered necessary as a support to the structures of which the gland is composed. I have never seen fibrous tissue in the situation described in health in either gland; and it is quite obvious that the structures do not require any supporting tissue, as they mutually support each other; and any matrix would tend to increase the distance between the secreting cells and the blood, while we certainly find in these organs every arrangement to reduce this as far as possible consistently with strength. If this matrix exists, it ought to be developed as a structure distinct from the tubes and vessels; but, as far as I know, it has not been demonstrated in the embryo at an early stage of development of the kidney, by any one; and, in a careful examination of embryonic structures, one cannot fail to be struck with the absence of this fibrous tissue, which is by some regarded as an essential part of every organ. The morbid changes are surely explained as well by supposing the effusion of a new material between the walls of the tubes and those of the vessels, and by a thickening or other change in one or both of these structures, as by attributing them to an alteration in the matrix or intertubular areolar or fibrous tissue (*Bindegewebe*).

Fig. 20.—Thin section of healthy human kidney slightly washed in water. *a*. Convoluted portion of uriniferous tube. *b*. A portion of a tube stripped of its epithelium. *c*. Outline of tube and crumpled capillaries, having a fibrous appearance—the so-called matrix. *d*. Malpighian body. *e*. Loops of vessels shrunk, showing cells in thin walls. X 215.

The conclusions to which I have arrived, from numerous investigations on this subject, may be summed up as follows:—

1. In the cortical portion of the kidney there is no evidence of the existence of a "fibro-cellular matrix".
2. The fibrous appearance observed in thin sections of the kidney which have been immersed in water is due to a crumpled, creased, and collapsed state of the membranous walls of the secreting tubes and capillary vessels.
3. A small quantity of a transparent and faintly granular material, with distinct nuclei, the nature of which has not yet been determined, is to be demonstrated between the walls of the tubes and the capillary vessels.
4. The changes met with in disease can be fully explained without supposing the existence of a fibrous matrix.

[To be continued.]

THE MILITARY MEDICAL PROFESSION IN FRANCE. By an imperial decree dated June 18th, the relative ranks of the medical officers of the French army are to be regulated as follows:—An inspector ranks with a general of brigade; a principal surgeon, first class, with a colonel; second class, with a lieutenant-colonel; a surgeon-major, first class, with a *chef de bataillon*; second class, with a captain; assistant-major, first class, with a lieutenant; second class, with a sub-lieutenant.

Lettsomian Lectures

ON

THE OPHTHALMOSCOPE AND ITS APPLICATION.

DELIVERED BEFORE THE MEDICAL SOCIETY OF LONDON.

By HAYNES WALTON, Esq., F.R.C.S., Surgeon to St. Mary's, and to the London Ophthalmic Hospitals, etc.

LECTURE I (concluded from page 453).

FOR the examination, the patient sits by the side of a table on which the lamp is placed close to his head, and the flame put to a level with the eye, from which it is screened by a little metal plate fixed to the burner; but his hand may be used as a screen. The observer takes his position directly in front, and sits slightly elevated, holds the ophthalmoscope close to his own eye, in an oblique position, to receive the light from the lamp, and at about eighteen or twenty inches from the patient's eye, on which he must throw the reflection. Looking through the central aperture, he moves the instrument forwards, and endeavours to get the focus. A diffused reddish glare shows that the interior of the eye is illuminated. With a little more adjusting backwards and forwards, the retinal vessels or the optic disc may be seen. The exact focus is now obtained. If, however, it should be desired to illuminate the eye still more, or to magnify the parts at the fundus for examination, the lens must be used. It should be held before the eye at its focal range, and the ophthalmoscope and it manœuvred till the desired definition is acquired.

Easy as all this appears in description, the majority of persons have difficulty in accomplishing it, and do not succeed till after many trials.

As might naturally be expected, ingenuity has not been asleep in endeavouring to devise an easier way of getting the focus, and of maintaining it when found, for in truth the method in ordinary use is like making a microscopic examination with the lenses held in our hands. I have seen and used many instruments devised for this purpose, yet I have met with but one that has answered, Leibreich's. It is of German invention. It consists of the mirror and the lens set in a tube, to each of which is attached an adjustment; the whole is clamped to a table. The patient's head is fixed, partly by resting on the end of the table, and partly by a chin support, which is screwed to the table.

Nothing can be more satisfactory than an examination in this way when the focus is got; it is just the thing for the uninitiated to look through, after an experienced observer has made the arrangement. Such an instrument greatly facilitates ophthalmoscopic drawings; but it possesses, as far as I know, no other practical use, and its machinery renders it inapplicable for ordinary application. The simple instrument, once learned, is enough for our purpose. All that we need in an inspection is a general idea of the interior of the eye; and, for the most part, we get at a glance all that can be of use to us. I suspect that it would avail us little, as regards treatment, if we could obtain a microscopic view of the morbid anatomy of the diseased tissues.

The optic disc is the first and chief object to be examined, and, as it is on the nasal side, may generally be readily found if the patient turn his eye inwards. I always desire him to look at the tip of my ear, on the side farthest from the eye examined. It is in early life a pinkish white disc, more or less circular, set as it were in a field of red. This disc is the termination of the optic nerve; there is a question about its prominence in life. A very slight shadow around parts of its circumference, when the light is thrown in certain positions, tends to support the affirmative. In death there is a slight perceptible rising at the margin, while the centre is rather depressed. As age advances, the circular figure is less certain, and even the size varies. Besides this, it may be white, and all of which differences are compatible with perfect sight. But the examiner must be prepared for apparent differences in size if he uses ophthalmoscopes and lenses of different foci; hence the prudence of keeping to the same.

The central artery of the retina and the vein perforate the