

ACUTE UNILATERAL INFECTION OF THE KIDNEY

by

THE BACILLUS COLI COMMUNIS.

Thesis for M.D. degree.

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M.B., C.M., 1887 (Commendation).

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The records of cases of Acute Infection of the Kidney by the Colon Bacillus are not so very numerous, and the following case is chosen for reviewing the more important points in the Symptoms, Diagnosis, Pathology and Treatment, along with a brief summary of some of the Literature.

The patient in this case was a male, thirty-two years of age, unmarried, and a butler by occupation.

He was admitted to the Kirkcaldy Hospital on the 23rd October, 1908, for operation for Appendicitis (acute).

He complained of severe pain across the small of the back, more especially towards the right side, the pain shooting down to the corresponding groin and over the right haunch. He looked seriously ill; his temperature was 102.5 F. and his pulse 130. He had been confined to bed for about a fortnight, and during that time all treatment had failed to relieve the pain or stop the nausea and vomiting.

Family History of the Patient:

Both Father and Mother were alive and well.

The other members of the family had always enjoyed good health.

Nothing further relative to the health of the family need be noted.

Past History:

The patient had not been feeling "quite up to the mark" for the previous eighteen months, although always fit for his duties, which were of a light nature.

He was a good deal subject to irregularity of the bowels, more especially in the direction of constipation, which caused him to be constantly taking aperient medicine, while latterly he had taken to using enemata. He had consulted me a few weeks previous to this illness, in connection with a gonorrhoea which he had contracted about a year previously, and he was then seen to be suffering from a Gleet.

Examination of the patient's urine into separate vessels showed threads, and on standing gave a faint precipitate of mucus; it was strongly acid, with a specific gravity of 1025.

Microscopic examination showed it to contain crystals of Oxalate of Lime.

It appears that some improvement was effected then, as no further medical advice was sought.

The patient next came under my notice in the Hospital as recorded above.

Present Illness:

This began about a fortnight before the date of admission to the Hospital.

Whilst out cycling against a strong head wind, his right foot slipped from the pedal and came to the ground with great force on the toes. He immediately sickened and

felt some pain in his back, but the sickness passing off in a few minutes he again mounted. The pain, however, increased, and the nausea and sick feeling returning, he was compelled to make for home, pushing his machine a distance of about two miles.

For the remainder of that afternoon and evening he felt far from well, but persevered in his duties until bedtime.

On making water previous to retiring for the night, he observed the colour to be rather darker than usual, and on closer examination he considered he had "passed blood along with his water" both intimately mixed. He slept badly that night and on "making water" in the morning it appeared to be in a "similar" condition.

He experienced no pain accompanying the act.

He partook of little breakfast, as he still felt somewhat sick and his back was painful. Being off duty during the forenoon, and thinking that the fresh air would do him some good, he decided to go for a spin.

He found that he was unable to proceed any distance and consequently returned home.

The pain now began to increase in severity, and the sickness and vomiting increasing, he was forced to go to bed.

His Doctor was called in and he appeared to experience difficulty in making out what was wrong, but after a few days' attendance considered the patient to be suffering from acute appendicitis.

Nothing, however, which the patient got seemed to have the slightest effect towards relieving the pain or alleviating the sickness and vomiting.

Patient's Condition on admission to Hospital:

The patient looked very ill, shewing a pinched sallow face and marked emaciation, and there was "something" about the peculiar sallowness not often seen.

He complained of intense pain around the right loin and lumbar region, accompanied with a feeling of nausea and inclination to vomit at the mere sight of food. His temperature was 102.5° F. and his pulse 120, small, compressible, regular, and of low tension, respirations 24. The patient chose to lie on his right side with his thighs flexed on his abdomen.

Physical Examination:

The abdominal muscles were quite lax and moved freely on respiration. There was little tenderness on superficial palpation, but marked hyperaesthesia down to and above the region of Poupart's ligament over an area of two inches corresponding to the twelfth dorsal and first and second lumbar spines and cord segments.

On deep palpation of the right hypochondriac and iliac regions, there was considerable increase of the pain, while the point of maximum suffering was reached as soon as the costo-vertebral angle was approached (posterior renal region).

This pain was still further intensified and became unbearable as soon as the kidney was pressed bimanually. On deep inspiration the kidney was easily felt to descend much lower than normal and was considered to be enlarged, although to no very great extent. During the course of this illness, the kidney could only be palpated occasionally. The left kidney showed no sign of tenderness nor of enlargement, but the spleen could easily be made out to be one and a half inches below the costal margin.

The regions of the appendix, gall-bladder, and stomach were normal, while the muscles during examination showed little tendency to rigidity.

Lungs:

The whole chest moved equally, although respiration was somewhat hurried. Resonance was normal, while towards the base auscultation showed crepitation at both the bases behind, but more especially at the right one.

Heart:

On inspection the apex beat was distinctly diffuse, some enlargement was present but no murmur.

Blood:

A specimen of blood taken from the ear appeared normal, but microscopically examined showed leucocytosis to the extent of 25,000 with 80% polynuclears, haemoglobin 45%, reds 4,500,000.

Urine:

A specimen of the urine taken by catheter smelt pungent and peculiar, was highly acid, with specific gravity 1025. In appearance it was somewhat opalescent, and gave no indication of the presence of blood or of pus by chemical examination.

Microscopical examination revealed a few pus cells and granular casts along with myriads of bacteria moving briskly in the field, and the centrifuged deposit showed these bacteria, on staining with Gram and Carbol Fuchsin, to be the Colon Bacilli. This was corroborated later by Weymouth Reid of Dundee.

Diagnosis of the Condition:

This was considered to be an acute infection of one kidney by the Common Colon Bacillus, accompanied by profound toxæmia, this opinion being confirmed the same evening by Mr Thomson Walker, F.R.C.S., London, who examined the case with me.

From the outset, with the exception of the initial painless hæmaturia (whether blood or hæmoglobinuria, it was impossible to say), there was no other symptom referable to the genito-urinary organs. The amount of urine varied from 25-30 ounces in the 24 hours and throughout showed microscopically the same characteristic condition. The patient's serious illness can be readily appreciated by a reference to the accompanying chart, which shows a wide range of temperature, occasionally reaching 107° Fah.

There were repeated rigors, succeeded by profuse drenching sweats, while the pulse did not show a corresponding rise nor did it bear any direct relation to the temperature. This condition continued unabated by any form of treatment, and the dry glazed tongue, which he had at the beginning, soon gave place to the brown leathery one, with sordes on the teeth and gums, and about the 29th day the patient sank into a typhoid state with low-muttering delirium, only regaining consciousness for a few moments at a time.

He died on the 35th day of his residence in the Hospital and, so far as could be ascertained, the 49th day of his illness.

Treatment:

This was purely symptomatic. It was unfortunate that the affected kidney was not explored and drained, or removed if considered necessary. The patient was very carefully fed every two hours, night and day, his food consisting of peptonised milk, curdled milk, soups and custards, as well as Benger's Food and various meat jellies, while he had as drinks whey, barley and rice water, lemon water, and Contrexville, along with varying amounts of stimulants.

The drug treatment consisted of Morphia injections to relieve the pain, Quinine to allay the fever, and Urotropine with Acid Phosphate of Soda for the urine. While endeavouring to get the urine alkaline with Citrate of Potash, the patient received Hetraline, but

it was impossible to wholly neutralize the acidity.

He received 50 cc. of antistreptococcus serum polyvalent (Park Davis) which effected a slight fall in the temperature after the reactionary period, along with 50 cc. ant.-colon serum of the same make, and about the 7th or 8th day he received a vaccin prepared from the bacilli in the urine, by Weymouth Reid, and although hopes were entertained that this vaccin was going to improve matters, these were short lived. Rectal salines were also given but badly tolerated and had to be given up.

All the sera, as well as the vaccin, were administered subcutaneously.

The vaccin seemed to effect a diminution, so far as could be estimated roughly, in the number of bacilli present in the urine.

The Autopsy:

This was made 18 hours after death and showed a highly emaciated body.

On opening the thorax, the pericardium was found to be somewhat adherent to the anterior thoracic wall and its sac contained about an ounce of serous fluid, while a number of petechial haemorrhages were present below the visceral layer. The heart was somewhat enlarged, but its valves were competent, and there was no evidence of past or recent endocarditis. The lungs were oedematous at their bases, but otherwise were normal.

The right perirenal fat had all but disappeared, while the pericapsular was oedematous and soft. The right kidney was enlarged, weighing 8 ounces. Through the capsule there were seen larger and smaller bulging areas, giving the surface of the kidney a plateau appearance. These areas were found to be soft on removal of the capsule. The latter stripped easily off, bringing along with it these so-called "plateaux" as well as large pieces of the kidney tissue, and leaving depressions, varying in size from that of a pea to a bean, in the kidney cortex. In section these appeared pyramidal in shape, some oval, others round.

Running water washed away the centres of these abscesses, so that the kidney assumed a riddled appearance. Little normal kidney structure was left, and the characteristics of the Malpighian pyramids were well nigh lost.

Microscopical Examination:

The large blank spaces were abscesses in all stages, surrounded by more or less hyperaemia and necrotic tissue. Some of the larger ones occupied the medulla and pyramidal region of the kidney and a few reached towards the hilum, while in the cortical part of the kidney they were round and oval.

The Glomeruli were with difficulty recognised, but when made out were packed with round cells and there was present a dark material resembling broken down red

blood corpuscles. The tubuli contorti presented an abnormal appearance, having lost all their epithelium, while in the straight tubes the epithelium was in the process of disintegration, and the intervening parts of the tubes were filled with leucocytes. Not much could be detected between the pyramids, unless that the abscesses were more rounded, and, in the intertubular spaces, somewhat oval. Now and then little patches of kidney could be recognised presenting the appearance of severe interstitial nephritis. No vessels could be distinctly seen thrombosed.

From all parts of the kidney the Colon Bacillus was obtained, which gave a pure culture.

The left kidney was but slightly enlarged, somewhat oedematous, and weighed 7 ounces. In section the kidney was almost normal, being only somewhat hyperaemic.

The spleen weighed 9 ounces and was intensely hyperaemic.

The other genito-urinary organs, although somewhat inflamed, especially the R-Kidney pelvis, were quite healthy. The bladder was normal and the prostate felt distinctly soft.

No local source of the poison could be detected in any of the other organs, nor was there any urethral stricture.

Analysis of Important Symptoms and Signs.

The patient in this case was a male in the prime of life. Most cases have occurred in the female, so that the female sex is more liable to attack than the male, and the ages have ranged between 20 and 45 years. There may or may not be symptoms referable to the lower genito-urinary tract.

Most authorities say, however, that if proper precautions be taken in the history of such cases, a preliminary cystitis in the form of frequency of micturition and a scalding pain along the urethra can be elicited.

These preliminary symptoms are not mentioned in quite a number of the recorded cases.

In no case, except this one, was there haematuria as one of the first signs.

Whether this was blood or colouring matter of the blood cannot be definitely stated, but it appeared within a few hours after the supposed strain to the side and never returned after the first morning subsequent to the trauma. It was intimately mixed with the urine and there was no pain accompanying the act. A painful feeling of something gone wrong with the side was the first symptom, immediately followed by nausea and sickness and a desire to vomit. Within 24 hours the pain became excruciating, with incessant vomiting, and radiated to the region of the stomach in front, and to the inguinal region and over the corresponding haunch.

In the majority of the recorded cases, pain has been the one symptom most complained of, becoming agonising and almost impossible to relieve by means of the ordinary internal and external medication, and although most severe in the costo-vertebral angle, it has radiated in various directions so as to simulate other acute abdominal affections for which it has been mistaken until the abdominal cavity was opened. Bi-manual palpation of the affected kidney increases the suffering, more especially behind, this differing somewhat from cases of pyelitis, accompanied with pain, which, in the majority of cases, is more severe in front (anterior renal region). Whether this difference in locality is characteristic of truly renal as opposed to pyelitic affections is not easy to affirm, but would appear quite probable. German authorities consider two reflexes of importance in similar conditions - the Uretero-pyelitic and the Vesico-ureteric, corresponding respectively to the Pyelo-vesical and the Vesico-renal of French writers.

The former reflex is made out by pressure with the point of the finger over the anterior region of the kidney pelvis one full finger's breadth from the tip of the ninth rib and in a line joining it with the umbilicus. Here pain is started which extends to the region of the stomach, through to the back, and is accompanied by a desire to urinate.

The latter, the Vesico-ureteric, is brought out

with pressure, through the rectum, on the neck of the bladder when pain darts up in the direction of the ureter to the diseased side, accompanied by a desire to urinate, and, in the case of the male, the prostate seems to share.

The pain is very persistent throughout the period of illness. The cause has been variously interpreted, but is probably due, in the beginning of the illness at least, to the increased tension in the kidney and the parts have not by gradual distension become insensitive.

Gastric symptoms are among the first to be complained of. Vomiting quickly supervenes on the pain, and the constant nausea is highly distressing to the patient. This at the outset may be attributed to the pain, but subsequently it appears to be part of the illness as is the case in other toxic conditions. It lasts for days, the stomach becoming intolerant of any food. The patient looks "very sickly" according to one of the writers on the subject. The tongue, which at the beginning is moist and red, soon becomes glazed or covered with a thick creamy fur, and in time assumes the appearance of washed leather, becoming dry, and, along with the teeth and gums, covered with sordes. Rigors are of frequent occurrence, generally beginning with one well-marked shiver lasting for about half an hour. They are soon followed by others at intervals of from 24 to 36 hours.

They are not so frequent during the first week or ten days. They are most distressing to the patient, who has warning a few minutes before they finally

establish themselves. The shaking is very violent, and the patients usually cover themselves entirely with the bed clothes. These seizures are accompanied by a rapid rise in temperature, mounting on several occasions to 107° F. and followed by profuse drenching sweats. Great prostration follows the rigor and the patient generally falls into a drowsy state lasting for an hour or so, from which he is with difficulty roused. The temperature gradually falls towards the end of the illness as the heat centre becomes incapable of reacting. The pulse varies a good deal but bears no direct relation to the temperature and it soon becomes small and dicrotic.

Urinary Organs:

The diseased kidney, as felt bimanually, has been frequently described as enlarged, but it would appear that this is not always so, as in many of the cases it has never been palpable, at least in the beginning of the illness, and if it had been felt one would imagine that so many mistakes in diagnosis could not have been made. In the case under review it was felt occasionally and never to any marked degree did it extend much below its normal limits nor increase any more in size during the whole course of the illness, so far as could be determined by palpation. No tenderness could be made out down the right ureter but per rectum the patient complained of a pain shooting upwards in that direction, and there was distinct fulness of the

vesicule seminales.

Urine:

That a primary polyuria is present has been remarked on by some observers. Whether it existed in this case there was no means of knowing. Experimentally this condition of polyuria seems to follow the injection of various micro-organisms into the blood.

The quantity of urine gradually diminishes from 35 ozs. in the 24 hours to almost complete anuria shortly before death.

In Colon Bacilluria the presence of colon bacilli can nearly always be recognised by the pungent smell of the urine. Moreover, the urine is as a rule strongly acid, as the reverse condition appears to be inimical to the existence of the bacilli.

The Spec. Grav. varies up to 1025.

On standing there is generally exhibited a deposit and the urine is never clear in colour, being more or less opalescent and having a muddy appearance.

Under the microscope, the centrifugalized deposit may show the presence of red blood cells, few in number if present, along with granular or hyaline tube casts, pus in greater or less quantity, with an amount of albumen varying accordingly. In the present case there was little pus present and a mere trace of albumen detected occasionally.

The chief characteristic of the urine, seen microscopically, is the presence of an immense number of

rod-shaped motile bacilli seen either individually or more often in clumps as they tend to congregate in small clusters. These easily stain with any of the ordinary dyes, but the most satisfactory is Grams to which they are negative and on counter-staining with Carbol-fuchsin they are revealed as beautiful pink rods.

In many of the cases reported, the bacilli appear to have been absent, notwithstanding the careful search that would doubtless be made, and hence the question naturally arises, whether the presence of the bacilli in the urine is to be regarded as a necessary accompaniment of the affection. The above evidence seems to suggest a negative answer.

These bacilli are present as a rule in the so-called pyelitis of pregnancy and also in the same disease as it affects little children, as it is only by their detection in the urine of children that what they are suffering from can be recognised and satisfactorily treated. The same also applies in many cases of pregnancy.

The Spleen:

In my case the spleen was easily detected below the costal cartilages of the left side, and although not always palpable, yet when felt was considered to be distinctly enlarged; this enlargement was present on the first examination in Hospital.

The records of other cases do not mention this

organ as being enlarged, so that it cannot be a very common occurrence. Whether this enlargement indicates a more profound degree of general toxæmia than in the other cases is very difficult to say, although it is my belief that no case could have been much worse than the one under review.

Blood:

The examination of the blood shows in all cases a distinct leucocytosis, in this case to the extent of 30,000 in some of the specimens, while the polymorpho-nuclears ranged as high as 95 per cent. down to 75 per cent. and the haemoglobin between 40 and 50 per cent.

No bacteriological examination was made nor was the agglutinating property tested, so that it cannot be said whether the colon bacilli were present or not.

The causation of this affection is not well understood, but it would appear that lowered vitality, from whatever cause and any condition giving rise to lesions of the lower intestinal mucosa is a predisposing factor. In the majority of cases constipation has been markedly present, requiring strong aperient medicines and finally a resort to enemata.

The use of the enema syringe is attended by considerable danger in the case of constipated people, for it would appear that their lower bowel is more intolerant to its use than in the case of persons who only require occasional purgatives, and it is not uncommon for them to injure themselves with the nozzle of the instrument.

Again, trauma to the kidney region applied direct or indirectly favours the condition, and in some cases has been assigned as the main factor in producing this serious lesion. As regards the sex, the female is more liable to attack than the male, although in the form considered by Sampson as haematogenous he believes that the blood infection is about equal in the sexes, and it is remarkable that the right kidney suffers more often than the left. Many reasons have been assigned for this in the case of the female, although it does not seem to apply with the same force in the haematogenous form. In woman the right kidney is more liable to be moveable and displaced and accordingly to have its circulation interfered with. It is also liable to be pressed on by the enlarged uterus. The ureters may also be injured or be congenitally abnormal, causing ~~the~~ stricture of their lumen, while any abnormal anatomical arrangement may take a share as a predisposing cause. The position of the ureter at the brim of the pelvis has been advanced as the place most likely to be pressed upon by the pregnant uterus, which organ is not only rotated to the right but is obliquely inclined to that side.

Again the presence of pelvic adhesions binding the bowel, the bladder, the uterus and its appendages more or less together, as well as damage to the kidney or the lower end of the ureter resulting from manipulations in difficult full time or premature labours have

all been considered as taking a share as predisposing or exciting causes.

Again haemorrhoids, proctitis, enteritis, retro-colonic abscess may likewise be included under the category of causation, while both Calculi and the Gonococcus are known to cause serious damage to the kidney and perirenal tissue, the former by blocking the urinary outlet, the latter by reason of its specific toxin, thus making the tissue more vulnerable to the inroads of the colon bacillus.

Differential Diagnosis:

The diseases most liable to be confused with this acute infection are other affections of the kidney, appendicitis, cholecystitis, perforated gastric or duodenal ulcer, pneumonia, pleurisy, or the two combined, and renal and ciliary calculi.

The kidney conditions simulating this affection and giving rise, at least in the beginning, to similar symptoms, are those cases of tuberculous kidney where acute inflammation has been grafted upon the chronic disease. Here however there will be a longer or shorter history of ill health, the appearance of the patient will be different, there may or may not be some other focus, as prostate or epididymis, the condition of the urine will show a different microscopic picture, and there will generally be increased frequency of micturition, more marked during the night. There is also the acutely inflamed calculous kidney,

and, without a previous history of stone in this case, it is next to impossible to differentiate, as it is generally the colon bacillus which infects the kidney and gives rise to symptoms similar to those described.

Then there is the congested and hydronephrotic kidney due to excessive mobility, where the size of the organ, the intermittent urination, the condition of the urine, and the previous history of the case assist in making the diagnosis clear. The moveable kidney may simply be congested and swollen; here again the absence of the pyrexial condition with few urinary signs, unless perhaps slight haematuria, will clear up the case. The acute pyelitis of pregnancy is sometimes difficult to diagnose correctly, as this condition may continue for a few weeks with symptoms somewhat similar to those of colic nephritis, although for the first few days at the beginning of the illness the bladder symptoms are more marked and are generally present. Colon bacilli are present in the urine, the general aspect of the patient is not quite so serious, the chills are less frequent, while the pyrexia does not attain the same degree. There is an entire absence of the excruciating lumbar pain in the cases that have come under my care, while in a few cases only bimanual examination brings out the tenderness much more marked in front than behind. In fact, a pyelitis of pregnancy may be described as a long tedious illness accompanied by few signs except gradual emaciation,

pyrexia, loss of strength, sleeplessness, and intense thirst, lasting till the termination of pregnancy, when recovery is marvellously rapid and as a rule complete, neither is the condition liable to occur in succeeding pregnancies. A similar condition may occur shortly after the puerperal state, from the third to the sixth week after a difficult mature or premature delivery, where the kidney or its ureter has been bruised and the patient has been further exposed to damp raw weather. Such cases recover rapidly when treated by a vaccin of their own (autogenous), assisted if necessary by enteroclysis of normal saline.

There is again the acute metastatic abscess arising from a focus in other parts of the body and occurring as part of a general pyaemia. In this case the condition is invariably bilateral and is of most frequent occurrence in ulcerative endocarditis, typhoid and erysipelas. Here the general disease will be a guide in diagnosis, although the kidney implication is not often recognised during life in these cases.

Appendicitis in its many forms has been most often confounded with colic nephritis. There is the sudden agonising pain in the abdomen, referred perhaps to the right iliac region but as frequently to the umbilical and epigastric regions, and radiating over the whole abdomen, sooner or later settling in the right iliac region, accompanied with rigidity of the muscles over the right lower abdomen, and cutaneous hyperaesthesia

between the pelvis and the umbilicus. These symptoms are immediately accompanied by vomiting and sickness and there may be a history of repeated milder attacks.

The bowels immediately previous to the attack may have been irregular, especially towards diarrhoea. The pulse and temperature give no very definite information, at least in the beginning of the illness, but a rectal examination may assist materially, and there is generally a well marked period of repose a few hours after the sudden outburst of symptoms.

Should the appendix be out of its usual situation and be retro-colic, external to the colon, or in the pelvis, there may be considerable difficulty in arriving at a definite conclusion, and this may only be arrived at by operation. In some cases the urine shows the colon bacillus and there may be bladder symptoms as well.

Cholecystitis, whether due to an intestinal condition or to stone in the gall bladder, or to the presence of colon bacilli, or to the gall bladder becoming gangrenous, is difficult to differentiate at the outset from the other acute abdominal conditions.

Here again the history of the case, both past and present, may give material assistance, and it is especially so that in all these acute abdominal conditions the previous history and an accurate account of how the present illness started are often the only means of arriving at a correct diagnosis.

In all liver conditions the pain is confined, more or less, to the upper abdomen, but may radiate through to the back and up to the right shoulder and vary occasionally to the left. There will be a catch in the breath on inspiration, the right rectus will be more or less rigid, and there may be cutaneous hyperaesthesia midway between the umbilicus and the epigastrium.

Perforated gastric or duodenal ulcer or peptic ulcer is characterised by sudden and intense pain in the pit of the stomach, so severe as to cause the patient to fall faint or to be doubled up, a change in the facial expression, and rigidity of the whole upper half of the abdomen. Vomiting and sickness, although generally accompanying, do not last long, and again, as previously, there follows a short period of repose during which all the symptoms subside. The pulse and temperature cannot be much relied on by themselves although nearly always raised. The pulse may be uncountable and the temperature subnormal. Here again emphasis is to be laid on the all importance of the previous history and an accurate account of the initial stage of the present illness.

Pleuropneumonia, or pneumonia preceded by pleurisy, has occasionally been mistaken for acute abdominal conditions but generally speaking within 48 hours the diagnosis becomes clear. The stitch on inspiration resembles some liver affections, especially in their initial stage. There are the well marked rigor, a high temperature, a rapid

pulse, but an altering respiration rate, soon followed by a cough and typical expectoration. There is however cutaneous hyperaesthesia in the epigastric and umbilical regions, and there is a limitation of the movements of the chest on the affected side, as well as a rigidity of the muscles of the right abdominal wall. Other rarer abdominal conditions have to be kept in mind, such as peritonitis from salpingitis, ruptured ectopic gestation, intussusception, haemorrhagic peritonitis, embolism of the mesenteric artery, portal phlebitis, and acute pancreatitis.

The Normal Kidney, its Anatomy and Histology, will be shortly described before entering upon the discussion of the pathology.

The kidney is built up of a large number of compound glands, closely packed, each with its base at the surface of the organ and its apex at the summit of one of the Malpighian pyramids, the whole organ being invested by a strong but thin and transparent fibrous membrane termed the Capsule.

Each kidney tubule commences at Bowman's capsule into which hangs the capillary tuft or glomerulus, the capsule and glomerulus together being known as a Malpighian body or Malpighian Capsule. From the capsule a narrow neck or constriction opens into the proximal convoluted tube which is situated in the cortex in close proximity to its own glomerulus. It then becomes the spiral tube which is less convoluted and

enters a medullary ray in which it descends. At the junction of the cortex and the medulla (boundary zone) it becomes much narrower and passes straight down through the boundary zone of the pyramid as the descending limb of Henles' loop. Near the apex of the pyramid it turns suddenly on itself and passes up again as the ascending portion of the loop which on re-entering the boundary zone again becomes wider.

In the cortex it emerges as the irregular tubule which in turn becomes the distal convoluted tubule. This then enters the medullary ray as the short junctional tube which joins one of the collecting tubules, several of which unite and pass down in the medullary ray.

Near the apex of the pyramid several of these large collecting tubes join to form one of the excretory ducts or tubes, several of which open into one of the calyces of the ureter at the apex of each papilla.

Blood Vessels:

The renal artery divides into four or five branches which pass in at the hilum and proceed into the kidney substance between the Malpighian pyramids and receive the name of arteriae propriae renales.

These pass on to the bases of the pyramids in pairs and run along their sides for the entire length, giving off as they advance the afferent vessels of the Malpighian bodies in the columns. At the bases of the pyramids they make a bend in their course so as to

lie between the bases of the pyramids and the cortical arches, where they break up into two distinct sets of branches devoted to the supply of the rest of the kidney.

The intertubular arteries arise at right angles from these arches and pass directly outwards between the medullary rays (Pyramids of Ferrein) and reach the Capsule where they terminate in the capillary network of that part. In their outward course they give off lateral branches, the afferent vessels for the Malpighian body, in which they break up into little tufts of capillaries which are invaginated into Bowman's Capsule, forming the glomerular tuft or glomerulus. This tuft is loosely covered by a single layer of somewhat polygonal epithelial cells which are essentially different from the cells lining Bowman's Capsule.

The capillaries of the tuft become reunited into a single small vessel, the efferent arteriole, which emerges near the afferent arteriole. These efferent vessels again subdivide into a number of branches which form a dense plexus round the adjacent urinary tubule and is called the intertubular plexus of capillaries. The second set of branches, the arteriolas rectae, is for the supply of the medullary pyramids which they enter at the bases and divide into leashes or pencils of minute vessels, which run down almost parallel with one another to the apices and terminate in the venous plexus found in that region.

The renal veins arise from three sources:-

- (a) Those beneath the capsule,
- (b) The vessels round the tubuli contorti in the cortical arches,
- (c) The plexus situated at the apices of the pyramids of Malpighi.

The veins beneath the capsule are stellate in arrangement, and are derived from the capillary network of the capsule into which the terminal branches of the interlobular arteries break up. These join to form the venae-interlobulares which pass inwards between the pyramids of Ferrein, receive branches from the plexuses around the tubuli contorti, and, having arrived at the bases of the Malpighian pyramids, join with the venae rectae.

The venae rectae are branches from the plexuses at the apices of the medullary pyramids formed by the terminations of the arteriolar rectae. They pass outwards in a straight course between the tubules of the medullary structure, and, joining the venae interlobulares, form the renal veins proper. These renal veins accompany the arteries, running along the entire length of the pyramids, and having received in their course the efferent vessels from the Malpighian bodies situated in the adjacent cortical structure, quit the kidney substance to enter the sinus, where they inosculate with the corresponding veins from the outer pyramids to form the renal vein.

Bowman's Capsule is lined with a continuous layer

of flattened endothelial cells closely resembling bascular endothelium. This layer is situated on a delicate basement membrane which externally is supported by a fine layer of connective tissue.

The proximal and distal convoluted tubes, the secreting or ascending portion of Henle's loop, as well as the spiral and irregular tubules, are lined with very highly endowed columnar secreting epithelium which contains true cell granules.

These cells interlock irregularly, but are distinct from each other. They are much more easily damaged by toxic irritants than either the clear flattened cells lining the descending or narrow part of Henle's loop or the clear cubical or columnar cells of the junctional and collecting tubules or the excretory or uriniferous ducts of Bellini.

The renal artery breaks up into four or five branches, which at the bottom of the renal sinus pass radially through the medullary zone of the kidney, where their further course has been described.

The renal arteries are very subject to variation, and are sometimes reinforced by accessory vessels. These latter are usually given off from the aorta and may penetrate the kidney substance almost at any point on its surface, either in front, behind, above, or below the hilum.

The chief accessory vessel, however, is given off to the lower pole of the kidney, and goes by the name

of the inferior renal artery. The branches of the renal artery in the kidney anastomose very imperfectly with each other and their smaller divisions are regarded as end arteries.

Outside the kidneys there is a free anastomosis between the vessel of the lower pole of the kidney and the ovarian artery which in turn anastomoses with the uterine and these with the vesical.

The veins accompanying the arteries are larger than these vessels and anastomose freely with each other, while the ovarian vein frequently enters the renal directly, both circulations being connected with the bladder.

The Lymphatics:

Since the classical paper by Lindsay Steven in 1884, on the spread of infection from the lower urinary tract to the kidney by means of the Lymphatics, little progress has been made. He considered that there were two sets of lymphatics, a capsular set and a deep set passing outwards from the hilum. Their presence he demonstrated pathologically, as well as by injection of the ureter. More recently Sakata has confirmed these observations. In the ureter the latter found that the lymphatics ran in the muscular layer and outer coats, parallel with the blood vessels. The efferent lymphatic vessels lead to the lumbar nodes which lie alongside the aorta and the inferior vena cava.

The lymph vessels of the lower portion of the

ureter either empty into the hypogastric lymph nodes or unite with the lymph vessels of the bladder.

In the upper portion of the ureter the lymph vessels extending to lymph nodes could not always be demonstrated, but when demonstrated were seen to lead to nodes about the aorta, otherwise the lymph vessels of this portion of the ureter passed into those of the kidney,

The communication between the lymphatics of the bladder and of the kidney was not direct, but existed either by means of the local glands of the bladder and the kidney, or by means of the lymph vessels of the ureter.

As bearing on the spread of infection, it may be advisable to give a short account of the lining of the entire genito-urinary tract. This may be said to consist of an unbroken epithelial tract from the Malpighian bodies to the meatus urinarius. The character of the epithelium varies with its function, being in part excretive, in part secretive, and in part protective or transmissive.

Considering that the renal epithelium is wholly secretory and excretory, it demands extreme contiguity with the blood vessels; hence the unusually close capillary network surrounding each Malpighian body and tubule, hence also the length of each tubule.

As the intact epithelium of the Malpighian body supplies the "head" of fluid which is to drive out the

urinary salts in the tubule excreted by the lining membrane of that part, there is no need for any muscular apparatus, but in order to render the secretory apparatus of the highest efficiency, the secretory layer is reduced to one-cell thickness, the cell being columnar and almost cubical in form.

As regards the other parts, the renal pelvis has a different function to perform, being the collecting area of all the minute tributaries to the main stream and acting as a conduit to the aqueduct which serves to carry the urine from the position of security in which the kidneys are lodged, to the organ which has been evolved in the course of ages for its temporary storage. As neither the renal pelvis, the ureter, or the bladder plays any part in excretion, the epithelium here is different in character, approximating to that of the skin in being several layers in thickness so as to serve as a protection. The ureter and the bladder being transmissive in function, their walls are provided with involuntary muscular fibre.

The epithelium of the renal pelvis is identical with that of the ureter, belonging to the small transitional type, and in transverse section is seen to consist of a layer of cells, four or five thick, of which the superficial are flattened and the deeper ones pear or spindle-shaped.

The epithelium of the bladder belongs to the large transitional type, the individual cells being

larger than those just described, and having usually six to eight superimposed.

The vesical epithelium is continued through the neck of the bladder down to the upper layers of the triangular ligament where it rather abruptly changes to the columnar ciliated type which lines the urethra to the ampulla where the larger transitional squamous epithelium is again found. The columnar ciliated cells are only one deep and the direction of ciliary activity is towards the meatus.

The cells which secrete mucus are found in the renal pelvis, the ureter, and the urethra, none being found in the bladder. The lumen of the terminal collecting tubes is double that at the more truly excretory tubules (Loops of Henle). The renal pelvis has an unusually rich plexus of lymphatics and a very intimate connection with the great sympathetic ganglia.

The submucosa of the ureter is loose and relatively ill supplied with blood vessels, while round the neck of the bladder is the pampiniform plexus of thin-walled blood vessels relatively richer on the inferior than on the superior aspect.

Routes of Infection:

Acute infection of the kidney by the Colon Bacillus can take place probably by one of three channels or by a combination of these.

The prevailing theories regarding the path of

infection to the kidney are:-

- (1) By the blood stream (haematogenous) .
- (2) From the lower urinary organs (urogenous)
- (3) By the lymphatics .

The Haematogenous theory of infection has been most strongly advocated in America; a few in this country support it. How and where the bacilli get into the circulation, and why generally only one kidney, usually the right, should be attacked, are points in this theory that have not been clearly defined. In the majority of cases, it would appear that the local focus of infection was in the lower bowel, and that invasion of the kidney occurred directly by means of the local anastomotic circulation, or that the kidney became invaded through the general circulation, the bacilli having gained entrance to the blood directly or through the intermediary lymphatic channels.

Again, various pathological conditions of the prostate, bladder, uterus or its adnexa where adhesions have formed to the bowel, are all possible sources of infection of the kidney through the local or general blood stream. The bladder itself may become directly infected from the same source, a chronic bacilluria resulting when invasion of the system may take place at any time whenever the conditions become favourable.

It is a remarkable fact that, irrespective of ^{the} focus, whether the source be the blood or the urinary tract, the infection of the kidney is a pure infection.

A principal function of the kidney is to excrete micro-organisms which may have entered the circulation and this is especially true in the case of the micro-organisms of enteric fever, which pass through without causing damage, but which are capable of exerting their pathogenic properties in others.

That there is some local focus, such as the gall-bladder, the appendix, or most probably the bowel from which the blood is replenished would appear to be self-evident.

It is worthy of note, however, that in the usually accepted theory of this infection as having come from a focus in the bowel due to some break in the continuity of its mucosa, constipation has been a marked symptom in all recorded cases, with only one exception where the kidney symptoms were preceded by an attack of diarrhoea. By some writers it is believed that constipation is frequently accompanied by an inroad of colon bacilli into the general circulation.

The belief is gaining ground that, even in the less serious affection of pyelitis in children, but more especially in males, the infection in quite a large number of cases is by the circulation, and in a percentage of such cases a haemorrhagic discharge from the bowel has been noted to take place shortly before the onset of the urinary trouble.

The bladder, the prostate gland, the uterus and its adnexa, are all possible sources of bacterial infection,

and the possibility presents itself of a colon bacillus focus occurring in any of these organs and infecting the kidney, either by way of the general circulation, or through anastomotic channels directly, or through the medium of the lymphatics as already stated.

This focus may arise in many ways; some of these have already been described, while others may result from damage done to the lower urinary organs themselves during operations, or to the adjacent organs, such as the rectum or the cervix. The part played by the non-peritoneal surface, between the kidney at its lower pole and the colon, in causing direct infection by contiguity of surface has never even been thought of unless in the presence of a retro-colonic abscess accompanying appendicitis.

The Urogenous theory is the one mainly held in this country. In it the kidney becomes infected from the bladder, but the question arises, how does the bladder become infected? The usual explanation given by the supporters of this theory is from the cutaneous surface along the urethra, which might well be in the case of the female, but very improbable in the case of the male. It is more likely that there is some local focus in the lower bowel from which the bladder derives its source of bacilli either by the lymphatic circulation or extensive capillary network of blood vessels, or again the uterus or its adnexa from pathological conditions may act as local sources

of infection as well as the prostate in the male.

The advocates of the Urogenous theory consider that their case is strengthened by the presence of bladder symptoms, in the form of frequent and painful micturition with scalding along the urethra for a few days previous to the invasion of the kidney. This argument may easily be met by supposing that these urinary signs are to be taken as the first indication that the kidneys are unable to cope with the toxin of the bacilli which have invaded the kidney structure from the circulation, and that the toxin, possessing highly acrid properties, is acting as an irritant on the whole mucous lining of the genito-urinary tract giving rise to this initial irritability of the bladder and urethra, while in a few days the epithelium too acquires immunity, as these symptoms soon pass off. To uphold the above theory, one must take as the starting point a colon bacilluria. From this point the bacilli may be taken as starting from the bladder, ascending the ureter to the pelvis of the kidney, thence to the surface of the pyramids, and then to the mouths of the uriniferous tubes. The bacilli on arrival at the pelvis of the kidney set up a catarrhal condition giving rise to a pyelitis.

It must not, however, be forgotten, in support of this theory, that it has been proved in pathological conditions that indigo, in powder and in solution, placed at the external meatus urinarius, can be

detected in the divided ureter some hours afterwards.

The bacilli may travel up the ureter against the urinary stream and any retardation or blocking of the flow in the ureter will greatly favour their ascent. It is supposed that they ascend in the periphery of the stream or may reach the kidney along the mucous surface in the current normally present in tubes lined by epithelium. The conditions favouring their ascent are stagnation in the ureter or a reversal of the normal mucous current.

The bacilli, having reached the straight uriniferous tubes, settle chiefly in the cortical parts, giving rise to (a) abscesses in the intralobular area of the kidney, or (b) on ascending to the pelvis of the kidney they find their way to the subcapsular network of lymphatics by travelling through the lymph spaces situated along the vessels, giving rise to abscesses, chiefly in the cortex and subcapsular area comparable to a process of local pyaemia. That this takes place oftener than is supposed cannot be in the least denied. With the exception of this method of kidney lymphatic infection, it has never been shown that the lymphatics take any share in infecting the kidney substance in this acute infection from the bladder, but it has been clearly demonstrated that in chronic bladder conditions, the lymphatics of the bladder and ureter may take a prominent share in carrying infection to the kidney and

limiting their inroads there to the subcapsular lymphatic areas as well as to the cortical part of the kidney where the lymphatics are distributed.

The pathology of this affection has also been much discussed and it is only by an examination of the kidney and its surroundings that a correct solution of how it has become infected can be arrived at. The case, on which this paper is based, could not give much satisfactory information, as the kidney was so much disorganised that little normal tissue was left and its relation to disease could not be made out to any degree of certainty.

Those who uphold the Urogenous method of infection base their arguments on the shape and position of the primary infarctions. They say these are pyramidal in shape with their apices extending towards the kidney pyramids, or, in other words, are to be found in the bundles of tubules forming the lobules and not around the vessels as they ought to be if infection took place from the general circulation, in which case the interlobular vessels would receive the brunt of the attack of the infecting agent and accordingly the infarctions and abscesses would be interlobular in distribution with the apices of the infarctions, in the intermediate zone between the pyramids, whereas in this form of infection the infarctions and abscesses resulting therefrom are intralobular.

When the kidney is examined early in the course

of the disease there is present a good deal of interstitial nephritis with round-cell infiltration and most of all in that condition of infection described as local pyaemia.

In this condition of infection there is no embolus to be found in the vessel near the abscesses, as it is the bacilli themselves that are the infecting agent, and so far this condition differs from the septic emboli which are always found as part of a general pyaemia. Here again the infarction is interlobular, to a greater or less degree, wedge-shaped, and its apex terminates in the intermediate zone between the pyramids.

Conclusions.

It is now clearly recognised that there is a well marked type of acute unilateral infection of the kidney by the Bacilli Coli Communis, ushered in with or without premonitory symptoms in persons apparently in good health and that the first well marked symptom is a severe rigor.

This rigor may indicate the inroad of the bacilli into the general circulation, or the bacilli, having gained entrance into the circulation by whatever means, are for a certain time excreted without producing symptoms; but sooner or later the kidney becomes injured from some of the causes already mentioned, strikes

work, and becomes incapable any longer of excreting the bacilli, which then collect in the terminal branches of the blood vessels, blocking them, injuring their epithelial lining, and producing their pathogenic toxin which, having gained the general circulation, produces arigor as its first definite sign, then follow the other symptoms characteristic of the disease. These are early accompanied by symptoms seen in cases of severe septicaemia or pyaemia and proceed to a fatal termination within seven weeks.

The course of the disease remains uninfluenced by any treatment save a surgical one and this when carried out either in the form of nephrotomy with drainage or nephrectomy is followed by rapid recovery within three or four weeks, the wound rarely if ever showing any sign of sepsis, the blood rapidly becoming immune after the first few days following the kidney invasion, as is evidenced by the rapid recovery when the production of toxin is stopped, by removal of the diseased kidney. It must not be forgotten, however, that the kidney, after the first few hours, will become practically functionless and assist in aggravating the general condition.

No other conclusion can be drawn but that such a condition is an acute blood infection, localising itself on the one kidney.

The reasons why one kidney only should become

infected have never been satisfactorily explained and the pathological evidence, as well as that in the majority of cases the Colon Bacillus can be obtained in pure culture from the kidney after removal or on section and is found in the abscesses connected therewith, is conclusive proof of its haematogenous origin.

It seems very probable that the kidney pelvis may become infected by an ascending infection from the urinary bladder, the bacilli having set up a pyelitis or catarrhal condition remain there, while in other cases, from some unexplainable cause the bacilli find their way to the kidney structure either by ascending the uriniferous tubes or travelling along the lymphatics and give rise to minute abscesses in the subcapsular tissue, cortex and pyramidal regions. It is remarkable how seldom the bacilli have been found in these intralobular abscesses, after removal or incision of the organ. This condition would appear from recorded cases to be little influenced by internal medication, although in a few of the cases recovery is reported, but without operation there is no means of knowing whether abscesses had been present or not. There is evidence that this affection may become subacute or chronic and ultimately end in unilocular or multilocular abscesses requiring surgical treatment, in which case the colon bacillus has been more often absent from the kidney than present.

There is evidence that the condition accompanying pregnancy is a pyelitis of urogenous origin, that the constitutional symptoms arise not only from the toxin of the colon bacillus, but also from some undetermined condition of health incidental to the pregnant state, that there is never any active invasion of the kidney structure by the bacilli but that the toxin is absorbed from the kidney pelvis and uriniferous tubules and thence into the circulation, giving rise to a train of indefinite symptoms, the most important of which is pyrexia.

This condition may or may not be influenced by medical treatment until the pregnancy is ended, when recovery is rapid and complete, and there is always a well marked colon bacilluria.

There is also the pyelitis of little children which may also be either urogenous or haematogenous in origin. Both sexes are affected, the female more so than the male. Here the infection has, up to the present, been considered as Ascending; but now in the case of male children it is believed to be more often haematogenous than urogenous. It is a remarkable point that in the case of female children rigors are common signs and do not occur in the case of male children, whereas in cases of affections of the genito-urinary organs among adults the reverse holds, rigors being very rare in women and common in men. Here again medical treatment is satisfactory, although

recovery is somewhat tedious and colon bacilli are always found present in the urine.

The treatment of the Acute Haematogenous variety as described is purely surgical. Internal medication is of no use. The surgical treatment may be either nephrotomy with drainage or nephrectomy. In quite a number of cases there has been removal of the kidney, following nephrotomy, and this as soon as the diagnosis is made. The patient, after nephrectomy, recovers quickly and completely, care in the place of the nephrotomy incision being all that is necessary.

The following is a short summary of some of the more important papers on the subject:-

Briscoe considers that the bacillus may act in three different ways, but these are really all stages of the same process.

He gives no satisfactory reason why a condition, unrecognisable or devoid of symptoms, should suddenly and without warning develop into a serious one.

He adopts and recognises the following classification:-

- (a) A wide spread infection of the urinary tract with abscess formation in the kidney.
- (b) A continuous passage of bacilli in the urine.
- (c) An intermittent bacilluria.

The two last are often accompanied by headache, malaise, debility, occasional sickness and vomiting. Various cases are reported by him, one of more

especial interest being that of a lady, 60 years of age, with bilateral swelling over each lumbar region accompanied with tenderness, and on removal of a uterine cervical polypus there followed a rapid subsidence in the condition on treatment with a vaccine.

Cases of pelvic troubles such as pyosalpinx, of pelvic-caseous masses around the uterus, of broad ligament suppurating cysts, of appendicitis (discharging), of cholecystitis, all of them containing colon bacilluria, are mentioned as being ultimately cured with vaccine treatment.

This suggests the question as to whether the local suppurative process maintained the general condition or the reverse.

Box discusses concerning the excretion of various micro-organisms by the sound kidney, referring chiefly to those of scarlet fever, measles, diphtheria, pneumonia, and typhoid, and a remarkable point is that, with the exception of the typhoid bacillus, the colon bacillus is the one always found present in the urine. Experimentally it has been shown that the blood can dispose of organisms which have been injected directly into the veins, but it is impossible to say what proportion, if any, of these micro-organisms pass through the kidney into the

urine. Accordingly the number found in the urine bears no relation to the amount either injected or found in the blood. Incidentally he mentions that the washing out of the bladder with normal saline inhibits the growth of the colon bacillus.

Barnard, perhaps the strongest supporter of the Urogenous Theory of infection in this country, cites the case of a male, 27 years of age, in good health, free from venereal disease, and troubled with frequency of micturition and scalding pain along the urethra, along with pyrexia. The urine was turbid and thick. On the third day from the beginning of his illness, he complained of pain in the right loin spreading to the flank. In five days the bladder symptoms were gone, while the general condition steadily grew worse, accompanied with rigors and a temperature of 104° F. The patient looked thoroughly septic. Urine was acid with a Spec. Grav. of 1018 and showed on standing $\frac{1}{8}$ albumen and a few pus cells. Microscopically examined blood was seen to be present along with polynuclear leucocytis, but no mention is made of the presence of bacilli. A tumour was easily palpated behind the ascending colon and was considered a retro-colonic abscess from appendicitis. Laparotomy proved this to be the kidney with subcapsular haemorrhagic spots, while the larger and older spots showed

suppurating centres. The organ was removed and the patient made uninterrupted recovery.

On section the kidney showed masses of wedge-shaped haemorrhagic areas with their apices running into the pyramids. The central parts were pale, necrotic, and suppurating.

There were submucous haemorrhages in the pelvis of the kidney. The areas of inflammation were in the bundles of tubes forming the lobules and not around the vessels. No interlobular vessel was detected as thrombosed, but only the small twigs which entered the necrotic area. No micro-organisms were found. The inflammatory process had started in the tubules. As the cells were swollen they were stained badly and in the centre of the area were distinctly disintegrated.

In the same paper there is reported another case where on section the kidney showed inflammatory changes chiefly in the medulla and cortex and presented innumerable radiating foci of suppuration extending from the medulla to the cortex, some of these forming distinct abscesses. The pelvis of the kidney was acutely congested, but not dilated. There was a typical tubular nephritis with round-celled infiltration in the centre of the tubular tissue. The epithelial cells lining the tubes were swollen and granular. The small vessels were thrombosed, but the infiltration surrounding them was not more marked than in other parts of the field. No micro-organisms

were present.

Barnard then discusses Brewer's published cases and considers that he must have been unaware of such a condition as an ascending infection. He also relates Nature's method of preventing an ascending infection, and concludes by saying that:-

- (1) Most cases begin with a cystitis or urethritis.
- (2) The wedge-shaped areas of inflammation are in the cortex and are intralobular.

As against the Haematogenous method of infection he says:-

- (1) There is no other source of infection in the body.
- (2) The other kidney escapes as well as other organs.
- (3) Rapid cure follows the removal of the diseased organ.

Bond has shown that indigo powder or solution when placed at the external urinary meatus can be detected either in the bladder or in the ureter after a few hours, and he considers this to be due to the mucous currents normally present in the canal lined with epithelium. Accordingly he lays down the following proposition which he considers a necessary predisposing factor for ascending infection, namely, a temporary arrest, partial or complete, in the normal outgoing flow of the natural secretion, thus favouring an ascending mucous stream or current and the probable transport of micro-organisms should

these gain entrance from the exterior to the urethra or bladder. He attacks the Haematogenous theory of infection of the kidney and considers there is no proof for it. Again, the cases he describes had a preliminary cystitis, neither were there any general symptoms pointing to invasion of the circulation by organisms preceding the occurrence of definite local renal symptoms, and if infection had been by the blood stream other organs in the body would be affected. Again nephrectomy cures the patient at once. He considers that it is not necessary for the lining membrane of the urethra or the bladder to show evidence of the passage of micro-organisms as these can quite easily be carried along a healthy mucous canal, but as a result of stagnation of urine or a reversal of the normal mucous current they can locate themselves and commence a rapid and virulent growth.

To prove this, he cites a pneumonoecal peritonitis where the bacilli were traced up the vagina, uterus and Fallopian tubes without giving any sign of invasion or inflammatory reaction in these organs.

French, who is an upholder of the circulatory course of infection, reports two cases of women, both between 5 and 6 months pregnant, who, without possessing preliminary bladder symptoms and with bacilluria present, suddenly were seized with severe

pain in the loin. One recovered under medical treatment. The other had nephrotomy performed, when the kidney was shown enlarged and studded all over with small abscesses mainly through the superficial part of the cortex. Both patients suffered from marked constipation and had been in the habit of using enemata.

Eastes discusses carefully the diagnosis of genito-urinary disease from the clinical pathological aspect and concludes that a much higher percentage of serum albumen is present in diseases of the kidney and its pelvis than in other morbid conditions of the genito-urinary tract. He considers that the common infecting agent is the colon bacillus, that when it produces disease it is an unmixed infection, and that this bacillus plays havoc with the peri-renal tissue and renal pelvis and may be primarily infective in the bladder, urethra, or kidney pelvis.

In Colon Bacilluria he considers that occasionally the infection is spread upwards from without, but as in adults it occurs as a common sequel in appendicitis, mucous colitis, and other intestinal troubles, the lymphatic route must be common.

The manifestations of the colon infections are legion and though pyuria is one of the commonest effects, yet many patients exhibit serious general toxæmia and profound septicaemia in which surgery

is the only treatment that is effective.

Cobb is one of the strongest supporters of the haematogenous theory of infection and in his recent paper he gives details of eight cases, seven of whom were females and one a male, their ages ranging from 21-48 years. The right kidney was involved in five cases and the left kidney in the remainder.

Cobb points out that it is the bacilli themselves that lodge in the terminal branches of the interlobular arteries and capillaries and infect the kidney, and he considers that this illness occurs in persons apparently well, although trauma is a powerful exciting cause.

According to this writer, these cases may become subacute or chronic, developing large abscesses by the coalescing of smaller ones when it may be impossible to be certain whether they are of haematogenous or urogenous origin.

Three of the cases were complicated with calculus, two had a nephrotomy, while nephrectomy was subsequently necessary. Of the six having primary nephrectomy, all recovered, and in the majority of these cases the colon bacillus was found in the kidney. The infection is considered as either coming from the intestinal canal through some local breach in the mucous membrane, or, following severe constipation, the circulation becomes loaded with the bacilli, and he also considers a fruitful source

of the bacilli certain pathological conditions of the male and female reproductive organs.

Brewer also supports the haematogenous mode of infection and reports the case of a female, 22 years of age, with symptoms typical of gall bladder infection. The illness came on suddenly and the urine gave little indication to assist, but contained a trace of albumen, a few hyaline and granular casts, and a negative cystoscopic examination. Laparotomy was performed, showing the right kidney enlarged, the perirenal tissue oedematous, the kidney itself deeply congested and having subcapsular haemorrhages and numerous infarcts. The kidney was removed through the loin and its removal followed by uninterrupted recovery.

He then proceeds to detail his experience in 13 cases, 11 of them female, and 2 male.

In 11, the right kidney was infected; in 2, the left. Four of the cases were ushered in with a chill, the temperature and the pulse rising to 104° F. and 120 respectively. Severe abdominal pain accompanied and was almost coincident with the rigor. In 3 of these cases the abdomen was opened for appendicitis.

Exhaustive experiments were carried out on rabbits, proving that bacteria when injected into the blood passed in quantity through the kidneys without showing any signs of damage, but as soon as

the kidney was bruised or the ureter ligatured, then infection of the tissue followed almost immediately.

McCosh relates the case of a young medical student who took desperately ill with right lumbar pain. Operation revealed the presence of an abscess in both poles of the kidney. Recovery followed their drainage. The urine in this case gave no assistance.

Lilienthal considers that acute multiple abscess of the kidney is rarely diagnosed during life, and more especially when they are embolic in origin and secondary to other infections. These abscesses are nearly always found in the cortex and but rarely in the pyramidal region of the kidney. There may be no pus in the urine and the classical signs of pyelitis or pyelonephritis may be absent. Neither cystoscope nor urethral cathetrization gives much assistance, while the kidneys are not much enlarged, but pain and tenderness may be early marked. In such cases he advises early drainage of the kidney, leaving the pelvis intact to avoid carrying infection to the lower urinary tract.

As showing the effect of necrosis of bone and erysipelas, he reports the case of a Russian lady who, having had two teeth extracted, developed necrosis of the jaw followed by erysipelas, and developed metastatic abscesses in both kidneys.

These were incised and drained and the patient recovered.

Peck reports the case of a female, aged 31 years, who suddenly took ill with the symptoms already described, but with repeated chills. Leucocytosis 34,000.

Polynuclears 92%. The abdomen was opened for appendicitis, when the right kidney was found to be oedematous, with elevated points or specks on its surface which were found to be abscesses. The pus gave a pure culture of Colon Bacilli. The kidney was drained and the patient left hospital, recovered, on the 27th day.

Johnston, in an analysis of the kidney cases admitted to the Roosevelt Hospital between the years 1890-98, says that in only 3 or 4 cases was there the least evidence of infection having taken place through the blood stream. Of 86 cases submitted to surgical interference, 16 had abscesses of the kidney, 13 suppurative nephritis, 1 double pyelonephritis, 2 perinephritic abscesses. Of the 86 cases above, 54 had nephrotomy performed, followed by recovery in the case of 47, equivalent to a mortality of 13%; while 32 had nephrectomy performed, 26 recovering, equivalent to a mortality in this case of 18½%.

It will be seen from the above figures that the total removal of the kidney shows a distinctly higher mortality than simple drainage.

Cabot relates the case of a male patient, aged 41 years, who was suddenly seized with pain shooting down the thigh to testicle and groin, accompanied with high fever, frequent vomiting, and recurring chills. The urine contained pus and albumen in moderate quantities. The kidney was incised and drained, and pus from the cortical abscesses gave a pure cultivation of Colon Bacilli.

He considers that the kidney can become infected:-

- (a) From injury, as for example a punctured wound in the loin, and any injury lowering the resisting power of the organ.
- (b) By extension from adjacent organs, as Colon and Gall Bladder.
- (c) By inflammation of pelvis and through the urinary tubules.
- (d) Through the blood.

McWilliams showed by experiment that the Colon Bacillus can be obtained from the blood in pure culture, and when present can give rise to septic or pyaemic conditions. His classification of the various conditions are Extogenous and Endogenous.

The Extogenous is subdivided into:-

- (a) External causes.
- (b) Prostatic or Vesicular causes.
- (c) Bladder interference resulting from use of instruments and injections.

Here treatment is satisfactory and progress favourable.

The Endogenous condition arises from some part of the organism and passes from the blood, through the kidney, and into the urine. The focus is difficult to trace and cases are rebellious to treatment.

He subdivides this condition as follows:-

- (a) An emigration of the organisms from some neighbouring organs to the urinary tract.
- (b) Absorption into the blood from a primary focus.

In the male he considers the most common route of infection is from the bladder to the prostate, then by the lymphatics into the general circulation, or directly to the kidney lymphatics, or from the lower urinary tract by ascending infection; but he gave no very good reason why the bladder should become affected first unless from emigration into the lower urinary tract from neighbouring organs by contiguity of tissue. He also describes the lymphatic route of the genito-urinary organs as observed by experiment, and states that the lymphatics of the prostate, the seminal vesicles, and the bladder are connected directly with these along the ureter, which in turn communicate with the lymphatics of the hilum of the kidney and again with those of the subcapsular network around the kidney, sending branches into the kidney cortex on the one hand, and to the surrounding fatty capsule on the other. He corroborates the experience of others and states

that when the Coli Bacilli gain entrance into the blood from a primary focus, the kidneys are the first organs to be affected, and from the kidneys as starting points there may be a descending infection to the kidney pelvis and bladder.

Sampson considers that in a number of cases the bladder becomes infected from injury done to neighbouring organs, either accidentally or as the result of operation, and brings forward cases to prove that injury at the ureteral openings in operations on cervix uteri was followed by bacilluria, and the same happened from operative interference on the anus and rectum (i.e. extensions of inflammatory process through the bladder wall). Following on the entrance into the bladder, he discusses both the blood and the ascending method of kidney infection, and in the former case considers that the bacilli enter the veins of the bladder and reach the kidney through the blood stream by the general circulation, or by the blood vessels of the ureter as he has shown that there is a distinct anastomosis between the bladder and the kidney, both arterial and venous.

In the latter method of kidney affection, he discusses an ascending infection along the ureter from organisms travelling upwards and from an influx of urine from the bladder up the ureter.

Bellingham Smith was among the first who drew attention to kidney infection by the Colon Bacillus, and he favoured dissemination by the blood stream and bases his opinions on the sudden appearance of serious symptoms in persons apparently in good health.

Kelly reports a typical case in a female, aged 31 years, who suddenly complained of great pain in the left loin, tenderness, with frequency of micturition. The urine was acid and pus was present. Nephrectomy was performed and showed an enlarged kidney with capsule adherent. Over the surface were large raised nodes which were soft and a few were almost black in colour. These black masses were easily scooped out with the finger and the spaces left extended for nearly one inch into the cortex, while others extended almost to the pelvis of the kidney.

Customs gives details of various infections of the kidney in pregnant women, and a very interesting account of the relations of the ureters to the pregnant uterus at various months. He considers that urinary retention modified the working capacity of the kidney and its excretory canal by lessening the resisting power, and on the other hand causes an increase of the virulence of the Colon Bacillus, which is brought to the kidney by the blood stream,

while cold, fatigue, overwork are strong exciting causes.

The usual history is severe pain in the lumbar region, radiating to the loins and inguinal region, accompanied by rigors and frequent micturition.

Wright reports two cases, which he considers were examples of infection of the kidney by the Colon Bacillus. Female, 33 years of age, with cystitis and typical kidney involvement, being seriously ill. Her kidney was removed and found enlarged, congested, showing microscopically cloudy swelling and degeneration of the epithelium of the convoluted tubes, with an abundant exudation of leucocytes in the stroma particularly surrounding the straight tubules. No bacilli in the kidney, although they were present in the urine. His second case occurred in a girl, 18 years, following measles; she recovered under medical treatment, while the bacilli from the urine gave a pure culture.

Blackadder and Gillies report a rapidly fatal case of general infection by the Colon Bacillus where the kidney showed myriads of bacilli.

A female, 23 years of age, pregnant four months, in good health, was suddenly seized with uterine haemorrhage, pain in lower abdomen, sickness, vomiting, pulse 140, temperature 102° F. On the evening of the same day became delirious

and pulse soon became uncountable. Her skin became brown, resembling that of a dark Indian, and during the night she became cyanotic, with scanty dark coloured urine, highly albuminous, containing red cells, few hyaline, and coarse granular casts and short motile bacilli which gave a pure cultivation of the Colon Bacillus. Blood count 2,704,000 reds, 29,000 whites, 48% haemoglobin, 88% polynuclears; death occurred 36 hours from the first onset of symptoms.

The blood 18 hours before death gave a pure culture of Colon Bacillus, and after death a pure culture was obtained from kidney and spleen. The kidneys were extremely hyperaemic, with no inflammatory reaction, but cloudy swelling of the cells lining the tubules less marked in the collecting tubes than those of the cortex, while a chocolate coloured substance filled the tubes and Bowman's Capsules, which proved to be broken down red blood cells. This case they considered a Colon Bacilli infection through the blood stream from the uterus and was specially characterised with rapid destruction of red blood cells (haemolysis) and haemoglobin-aemia.

Lindsay Steven was the first to show that the kidney can be infected from the lower urinary tract, especially the bladder, by means of the lymphatics, although it is difficult to find any literature

where his results have been confirmed pathologically. In his cases there was obstructed urinary outlet from the bladder and this condition of retention, giving rise to cystitis and damage to the bladder mucosa, allows the organisms to pass through to the lymphatics, then to those of the ureter and the kidney. In such cases the abscesses are generally cortical, being rarely pyramidal. These abscesses are wedge-shaped with a very narrow base showing on the surface, while the length of the wedge may be nearly an inch. They involve the tissue below the capsule quite as much or perhaps more than the renal substance, the whole appearance being strongly suggestive that they have originated primarily in the capsule itself and have subsequently passed into the kidney substance.

Micro-organisms were found in the abscesses, but no indication of embolism leading thereto, as is found in the cases of abscesses resulting from pyaemia.

The German and the French literature mentioned in the Bibliography deals with the subject from the experimental side and it has not been considered necessary to summarise it.

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