CHAPTER XIII

THE URINE

A PROPER understanding of the pathological processes in the kidneys is facilitated by recalling certain physiological facts. The unit of the kidney is the nephron, comprising the glomerulus, the absorbing tubules and the collecting tubule. Under the pressure of the blood in the glomerular capillaries, the glomeruli filter a fluid similar to blood plasma, minus its proteins. The greater part of this fluid is reabsorbed into the blood stream from the tubules ; a concentrated residue of urine is left, containing the waste products. To accomplish this, only a few nephrons are in action at a time for short periods. In diseased conditions there may be a generalised inflammation or degeneration of the nephrons (nephritis or nephrosis), or a patchy destruction of groups of them owing to narrowing or obliteration of their blood supply (arterio-sclerosis).[1] Such is the enormous reserve power of the kidneys that a large part may be destroyed and yet the remainder can carry out the necessary work ; but the reserve power is diminished. With further destruction each remaining nephron is called into continuous activity. To maintain the action of the glomeruli, the blood pressure rises. The blood is still cleared of waste products (*e.g.*, urea) to a normal extent, but, as the power of the absorbing mechanism of the tubules is diminished, a larger volume of the dilute urine passes down them. With still further damage to the nephrons, less fluid is secreted by the glomeruli, and so the blood now contains an excess of waste products (uræmia) and the volume of urine falls.

When the glomeruli are inflamed, albumen and even blood leak into the urine, as in acute nephritis. Some forms of renal disease are associated with general œdema and with intense albuminuria ; modern research suggests that the primary defects are not in the kidneys, but in the composition of the blood and in the semipermeability of the capillaries throughout the body (in which the renal capillaries share). The loss of such a large quantity of albumen from the blood may so lower the osmotic pressure of the blood plasma that fluid is attracted from the blood into the tissues. The cardinal features of renal disease are therefore best seen by examination of the urine, aided later by examination of the blood and the tissues. In practice it is not always possible to separate kidney diseases proper from disorders of other parts of the urinary tract, because changes

[1] Richard Bright in 1836 described the acute and chronic forms of inflammation of the kidneys, associated with albuminuria and hyperpiesia. Unfortunately the term chronic Bright's disease is still sometimes loosely and incorrectly applied to high arterial pressure and its associated symptoms, and so is better avoided.

in the urine are common to them all. It will be necessary, therefore, to refer to disorders of the bladder, prostate, and urethra for diagnostic purposes, though their treatment is often mainly surgical.

PART A. SYMPTOMATOLOGY

§ **368.** One of the chief functions of the kidneys is the elimination of nitrogenous waste. When this is interfered with by structural or functional disease, a toxic condition results, which is known as uræmia. Other functions are the removal of water, acid products and excess of sugar from the blood, and to maintain the optimum salt concentration in the tissues.

As a consequence of the deep-seated position of these organs, the local symptoms referable to the kidney are, except in cases of Tumour or Displacement, of subordinate importance. The most constant and CARDINAL SYMPTOM of kidney disorders is some **Alteration in the Urine,** which, as an indication of renal disease, corresponds to the physical signs in other organs, and is dealt with in PART B. of this chapter. The cardinal symptoms next in order of importance are **Pallor of the Surface** and **Dropsy. Pain** and **symptoms connected with the passing of urine** are often present. **General Symptoms,** due to toxæmia resulting from the retention of nitrogenous waste generally accompany these diseases.

Pallor of the Surface and Malaise are very constant features of all organic kidney diseases. To the experienced eye the pallor differs from that of anæmia in a manner somewhat difficult to describe. The skin has a "waxy" hue, a simile which is still further exemplified when dropsy is present. It affects the whole body, but is always most evident in the face. In chronic interstitial nephritis the pallor has a greyish hue. The diagnosis from other causes of pallor will be found in Chapter XVI, § 535.

§ **369. Renal Dropsy** is of *general* distribution, in which respect it differs from cardiac dropsy, which starts in the *legs* or most dependent parts, and from hepatic dropsy, which starts in the *abdomen* (§ 29). It is, however, most evident in the loose cellular tissue—*e.g.*, around the eyelids, where it is most marked on first waking in the morning. Towards evening the ankles become œdematous, or, as the patient may express it, "a ridge is present around the top of the boot." In severe cases the eyes may be almost closed by the swollen lids (Fig. 106), and at the same time there may be signs of dropsy in the serous cavities—the peritoneum, pleura, and pericardium. Œdema of the solid organs also occurs in severe cases, and death may be produced by pulmonary œdema. Œdema glottidis is another serious though less frequent complication.

Dropsy is not an equally constant feature in all diseases of the kidney. In *acute nephritis* it is often present, and it is seen in *subacute parenchymatous nephritis* and in *nephrosis.* But in *chronic nephritis* and *lardaceous kidney* it is comparatively rare; in the former it may occur late in the course of the disease, when it is generally due either to cardiac failure, to

recrudescence of the subacute nephritis, or to secondary inflammation of the serous membranes. In uncomplicated *pyelitis* and *neoplasms* dropsy is not present.

§ **370. Pain in the Kidney.**—Many serious diseases of the renal substance are unaccompanied by any pain or local symptoms. A sense of dull aching in the loins may be present at the onset of acute nephritis and is frequent with pyelitis, pyelo-nephritis, pyonephrosis and oxaluria. Pain may be very severe when a renal calculus is present (Renal Colic, §§ 246, 408). Various tumours of the kidney are accompanied by pain, and perinephric abscesses are associated with lumbar pain and tenderness. A pain of gradually increasing intensity in the renal area on one side, which finally becomes very severe, but is relieved suddenly with the passage of a large quantity of urine, suggests Dietl's crisis. (§ 414.) A dull, dragging pain in the lumbar region, relieved by rest in the recumbent posture, occurs with movable kidney; it is usually on the affected side, and is liable to acute exacerbations resembling renal colic. The lumbar pain of renal disease must not be mistaken for the backache due to congestion of the female generative organs, nor for lumbago, in which the pain is usually of sudden onset, is not confined to one side, and may be accompanied by other signs of rheumatism. Less frequent causes of lumbar pain are dealt with in § 457.

Symptoms *connected with the passing of urine* are: increased frequency of micturition (§§ 422 and 456), incontinence of urine (§ 422), inability to pass urine (retention § 420, suppression § 421), the passage of large quantities of urine (§ 414) or the passage of blood (§ 406).

§ **371.** A large number of **General Symptoms** are consequent on failure of renal function. These may be divided into (1) early symptoms, (2) late symptoms (uræmia).

(1) *Early Symptoms* ("incipient uræmia"). These are mainly due to hypertension and its associated vascular changes. To compensate for the renal damage the blood pressure rises so as to produce an increased filtration pressure in the glomeruli. Changes in the vessel walls follow; thickening of the arteries due to hypertrophy of the muscular coat is followed by degenerative changes in the vessel walls. In consequence the following symptoms arise: (i.) Breathlessness. At first present only on exertion, it is associated with hypertrophy of the left ventricle and an accentuated aortic second sound. Later, signs of left ventricular failure may occur (§ 55), the resulting pulmonary œdema aggravating the breathlessness. (ii.) Headache accompanies most forms of renal disease, especially that which terminates in uræmia: chronic interstitial nephritis is one of the most frequent causes of headache in advanced life. (iii.) Mental disturbances such as lack of power of concentration, forgetfulness and irritability may be present as early symptoms. (iv.) Vertigo, tinnitus and various neuralgias may also be complained of. (v.) Insomnia in the aged is another common symptom of chronic renal disease. The patient readily drops off to sleep, but as readily awakes, and may do so a dozen

times every night. (vi.) Hæmorrhages sometimes occur in chronic renal disease, a consequence of the high pressure, combined in most cases with a diseased state of the blood-vessels. Epistaxis may be the first symptom which leads to the discovery of chronic renal disease. Bleeding from the stomach or intestines, and purpura, sometimes occur. *Cerebral hæmorrhage is the most frequent cause of death* in chronic interstitial nephritis. (vii.) Ocular changes may be so characteristic that a diagnosis may be made by their presence. Albuminuric retinitis is diagnosed by typical alterations in the fundi, with loss of visual acuity—œdema and swelling of the retina, papillitis, flame-shaped hæmorrhages, and white areas of degeneration. Changes in the arteries may also be seen (Plate V). (viii.) Even though the patient remains at work, there is loss of mental and physical vigour, and wasting of muscular and subcutaneous tissues.

§ **372.** (2) *Late Symptoms.*—**Uræmia** is a term used to describe the symptoms which arise from retention within the body of those constituents which, under normal circumstances, are secreted in the urine. Originally intended to indicate the retention of nitrogenous products, it is now used to include a large variety of symptoms present in renal failure: as a result toxæmia ensues. There is a retention of nitrogenous bodies (urea, uric acid, creatinine); of acids (especially sodium acid phosphate), causing respiratory symptoms; of phosphate (with a rise in blood phosphate and often a lowering of calcium), producing neuro-muscular irritability and even tetany; and added to these are the cerebral changes consequent on hyperpiesis—cerebral œdema, vascular spasm or occlusion (see hypertensive cerebral attacks, § 94) producing convulsions, amaurosis, headaches, drowsiness, etc. The term uræmia therefore is used to indicate a symptom complex which may show many different features, depending on the chemical state of the blood and the condition of the cerebral vessels.

Symptoms.—(i.) Persistent headache. (ii.) Restlessness, twitching and muscular tremors are frequent: the latter may be complained of by the patient or noticed by the doctor. True tetany is sometimes seen. (iii.) Drowsiness during the day, with sleeplessness or "cat-sleeps" (dropping off for a few minutes at a time) at night. Stupor and later uræmic coma often supervenes, with or without muttering delirium. Sometimes convulsions occur before death. (iv.) Uræmic dyspnœa is in part due to the cardio-vascular changes mentioned in § 371, and also due to retention of acid products together with an altered sensitivity of the respiratory centre. The various types are: (*a*) *Paroxysmal*; the attacks coming on chiefly at night, and resembling asthma ("uræmic asthma"). The patient sits up in bed gasping for breath, but there is no cyanosis, and the mind is clear. The breathing is often noisy, with a characteristic hissing quality (Addison). (*b*) *Continuous*, or continuous alternating with paroxysmal. (*c*) *Cheyne-Stokes' Respiration* (§ 28) may last for weeks. The pulse slows in the apnœic periods, and there is alternate contraction and dilatation of the pupil, the contraction occurring during

the period of apnœa. (v.) Gastro-intestinal disturbances such as thirst, anorexia, nausea, vomiting, and often epigastric pain may be present, and diarrhœa, sometimes with ulcerative colitis, may occur towards the end. These lead to still further (vi.) Wasting, which is often extreme in the terminal stages. (vii.) There is often a uriniferous odour in the breath and a metallic taste in the mouth. (viii.) Præcordial pain due to dry pericarditis is not unusual. (ix.) A severe grade of anæmia (even to 20 per cent. hæmoglobin) is common. This is mainly due to a toxic effect on the bone marrow, but is aggravated by hæmorrhages from the nose (epistaxis), gums, bronchial mucosa and gastro-intestinal and urinary tracts. (x.) The ocular changes (§ 371 and Plate VI) become more advanced. (xi.) A low form of bronchitis or pneumonia is a common complication of nephritis. (xii.) Renal disease may be complicated by various skin affections other than dropsy and the cellulitis which is liable to affect dropsical limbs. Amongst these may be mentioned eczema, urticaria, and various forms of erythema and purpura. Undoubtedly the most fatal is an epidemic form of exfoliative dermatitis.

An acute fulminating form of uræmia occasionally occurs. It may supervene at any stage of the foregoing or may come on abruptly in an apparently healthy person (small white kidney, § 402, 2 (*b*)). Its leading symptoms are (i.) low muttering delirium, (ii.) stupor, passing into coma, with or without convulsions, (iii.) a hissing type of respiration.

Etiology.—Renal failure and uræmia may occur in almost any disease of the kidney. In acute, subacute, and chronic glomerulo-tubular nephritis it is the usual mode of death ; in tuberculous, calculous, and polycystic disease, in hydronephrosis and consecutive nephritis, in active or passive congestion, and in lardaceous disease (rarely), mentioned in order of frequency, it is also apt to supervene. Moreover, complete suppression of urine may produce death associated with symptoms of what is called *latent uræmia* (§ 421), in those relatively rare cases of removal of a solitary kidney, or obstruction of both ureters. In severe alkalosis, as may be seen with the administration of large doses of sodium bicarbonate in the treatment of peptic ulcers, occasionally in cases of repeated vomiting and following a severe hæmatemesis, uræmia may occur, especially in elderly persons, even if the kidneys are fairly healthy (*extrarenal uræmia*, *gastric uræmia*).

Diagnosis.—The presence of any albumen with casts in the urine indicates renal damage. The earlier stages of renal failure are best diagnosed by performing one or more of the renal efficiency tests (§ 389) : in the later stages examination of the blood, especially for its urea content, will decide the diagnosis, a value over 120–150 mgms. per cent. usually being diagnostic. The differential diagnosis of uræmic coma is dealt with in §§ 711, 716.

Prognosis.—This depends on the extent of renal damage and how far it can be removed. In chronic nephritis where the kidneys are permanently and irremedially damaged, the prognosis is grave : whereas if

uræmia is secondary to obstruction (*e.g.*, enlarged prostate) or some other cause which can be removed, the prognosis is correspondingly improved. Untoward symptoms are a greatly reduced diurnal quantity of urine, severe anæmia, emaciation, drowsiness, uræmic dyspnœa, toxic myocardial changes, vomiting or diarrhœa, and a blood urea which is rising in spite of treatment. A safe rule is that once retinal changes are present, the patient will not survive more than 18 months.

Treatment.—This depends on the symptoms and signs present. With incipient uræmia, the treatment is that of chronic interstitial nephritis (§ 403). In the later stages the main object is to eliminate or neutralise the toxic effects. To aid elimination from the blood, sweating may be induced with hot packs, or a hot air or vapour bath: also a high colon washout may be used, but brisk purges are better avoided as they exhaust the patient too much. In view of its depressant effects, pilocarpine is no longer used to induce sweating. Provided œdema is not present, copious fluid drinks (at least 5 pints a day) with added glucose must be administered. For convulsions and coma, especially in persons under 30 with increased intracranial pressure as indicated by papillœdema, lumbar puncture is essential: in older persons with hyperpiesis, venesection ($\frac{1}{2}$–1 pint) should be used unless anæmia is present, and if need be, the subsequent transfusion of normal saline solution will compensate for the loss of fluid by venesection or purgation. Chloral and potassium bromide, morphia in small doses, or a general anæsthetic will help to control or to prevent the occurrence of convulsions. For uræmic dyspnœa, the same sedatives, combined with bicarbonate of soda (60–120 grains a day until the urine is faintly alkaline), are necessary: and for the neuromuscular irritability, especially in the presence of a low blood calcium, calcium salts administered—even uræmic convulsions may be benefited. It is unwise to restrict the fluid intake or to lower the blood pressure excessively in uræmia, as these defeat the attempt at compensation by the kidneys. In those cases where the heart shows evidence of failure, supporting measures must be undertaken.

PART B. PHYSICAL EXAMINATION

§ 373. The **Examination of the Urine** corresponds, in renal diseases, to the physical examination of other organs.

We examine it by (*a*) observing its *physical characters* (§ 374)—viz., its appearance (*i.e.*, its colour, and whether it is clear or cloudy)—its odour, reaction, specific gravity; the presence and characters of any deposit; and its diurnal quantity. (*b*) Then by *chemical analysis* (§ 379) we ascertain the presence or absence of albumen, the presence or absence of sugar, and other substances, according to circumstances. (*c*) A *microscopic examination* (§ 391) has to be made of any deposit which may be present. (*d*) The *kidney efficiency* tests consist in part of examination of the urine, and in part of examination of the blood. The blood examinations are usually

conducted by skilled laboratory workers (§ 389). They are of special value in the detection of kidney disease where albuminuria is slight or sometimes absent. It is important in all cases—not only in cases of suspected renal disease—to observe *and to record* the condition of the urine when the patient is first seen, even when the symptoms do not suggest renal disease.

(*a*) *Physical Characters of the Urine*

§ 374. Appearance.—The colour of the urine depends upon the proportion of pigments present. The chief pigments are urochrome and urobilin, the antecedents of which are the blood and bile pigments; but there are many others.

The urine varies from a pale yellow to a deep amber, according to the DEGREE OF DILUTION of the pigments; and, as the latter are fairly constant in quantity, a *dark urine* is commonly associated with a smaller diurnal quantity and a higher specific gravity than a pale urine. The urine is dark in excessive perspiration, acute nephritis, pyrexial states, and with diminished fluid intake, as in diarrhœa or vomiting. On the other hand, in certain diseases with *polyuria* the urine is *pale*, as in chronic nephritis, and in diabetes. With a large intake, in diabetes insipidus, and other conditions, the urine may be as colourless as water.

The colour of the urine may be altered by MORBID PRODUCTS—*e.g.*, *a dark orange colour to brown* is due to the presence of bile pigments or urobilinogen (§ 383). A *red* colour, which may be a dark red or porter colour or only a mere "smokiness," is due to the presence of blood (§ 382). *Blackish brown* colour may be due to melanin and certain oxyacids, which cause the urine to darken on exposure (§ 386). A *bright green* urine may be associated with chloroma. Intense *grass-green* fluorescence follows the ingestion of fluorescein dye (fluoresceinuria). *Milky* urine is found with chyluria and multiple myeloma. Various DRUGS affect the colour of the urine. A *dark olive-green* or *black colour* may be due to the absorption of carbolic acid—as when this is used for dressings; or it may appear after administration of creosote, salicylates, salol, tar, resorcin, or naphthol. The colour is explained by the presence of hydroquinone, which turns crimson on the addition of ferric chloride. A *reddish-brown colour* may be due to rhubarb, senna, or chrysophanic acid taken internally—all these turn red on the addition of alkali. A *bright yellow colour* follows the administration of mepacrine and santonin. A *colourless* urine is said to result from tannin taken by the mouth, and a *reddish* hue from hæmatoxylin. A *coloured* urine, from the presence of eosin, methylene blue, or other dye, may result from coloured sweets or cakes or certain proprietary pills. *Black* urine may follow the ingestion of black cherries or bilberries.

Urinary Deposits and Cloudiness will be described in § 390.

§ 375. Reaction.—The urine should be tested soon after being passed. In normal urine an *acid reaction* is usual from the presence of acid phosphate of sodium. On standing decomposition takes place, the urea being transformed into ammonium carbonate $(NH_2)_2CO + 2H_2O = (NH_4)_2CO_3$, and hence the reaction becomes alkaline. The same change takes place within the bladder in many cases of chronic cystitis. *Alkalinity* occurs in normal urine on waking and after meals—the "alkaline tide"—due to the disodium phosphate (Na_2HPO_4) replacing the acid salt, or when alkalies are administered. A *neutral* reaction may occur under the same conditions. The reaction of the urine is often expressed in terms of pH values, and varies in health from pH 5·5 (acid urine) to pH 8·0 (alkaline urine), the neutral point being at pH 7·2.

§ 376. Specific Gravity.—The average specific gravity of the urine in health varies between 1015 and 1025. It depends chiefly upon the percentages of urea and salts (especially chlorides) present. Extractives and pigments play only a small part; and —since the salts are fairly constant—the specific gravity, *in the absence of sugar*, gives

a fair measure of the urea present in a given sample. The specific gravity is low in granular, lardaceous, and polycystic kidney disease; high in acute and subacute nephritis, passive congestion and with glycosuria. The specific gravity is most conveniently measured in the specimen passed on waking, as it has been collecting over a period of 8–10 hours. The instrument, a urinometer (Fig. 89), must not touch the sides of the vessel, and the graduated stem should be read along the surface of the fluid, not at the place where it is raised along the stem by capillarity. When enough urine is not obtainable, and a glass bead urinometer is not accessible, mix the urine with one, two, or three times its own bulk of water and multiply the last two figures of the specific gravity by two, three, or four, respectively. For example, a mixture of one ounce of urine with *three* ounces of distilled water gives a specific gravity of 1005; the specific gravity of the urine is 1020($0{\cdot}005 \times 4 = 0{\cdot}020$).

FIG. 89. — URINOMETER, made of metal, and with flanged foot.— The flanges steady it while in the urine, and form a stand when not in use.

§ **377.** The normal **odour** of freshly-passed urine is described as "aromatic"; it is very different from the ammoniacal odour of decomposing urine. The resinous portions of copaiba, cubebs, and other balsams are excreted by the urine, and impart their characteristic odour to it. Turpentine gives an odour said to resemble violets. It may smell of volatile sulphides due to the presence of some bacteria, notably *B. coli communis*, and also when cystinuria is present, especially after the urine has stood for awhile.

§ **378. The Diurnal Quantity** varies considerably within the range of health. Normally, 40 to 50 ounces (1½ litres) are passed per diem, but the quantity depends upon the amount of fluid drunk, the action of the skin, and the activity of the renal circulation. In order to estimate the quantity of urea, and for some other purposes, it is necessary to collect all the urine passed in twenty-four hours—say, for example, from 8 A.M. Monday to 8 A.M. Tuesday. The patient should pass water *at* 8 A.M. *on Monday morning*, and this should be thrown away. All that is passed after that hour, together with what is passed *at* 8 A.M. *on Tuesday*, should be collected in one clean vessel. During the whole time it is necessary to pass water *before* going to stool, and to add this to the total collected. At 8 A.M. on Tuesday, after passing urine and adding it to that previously passed, the whole should be stirred and measured. A specimen from this should be put into a clean bottle (say, 10 ounces), and this should be labelled with the name of the patient, the date, and the total quantity passed in twenty-four hours, and sent for examination immediately. A few drops of chloroform or toluene will preserve it.

(*b*) *Chemical Examination of the Urine. Abnormal Constituents.*

In disease the most important abnormal substances for which the urine has to be tested chemically are albumen, sugar, blood, bile, aceto-acetic acid, acetone, and pus.

§ **379. Albumen** is the most frequent of the pathological constituents of the urine. The variety of "albumen" usually present is serum albumen and serum globulin. Their relative amounts are of no clinical significance. The chief tests for albumen are: (1) boiling; (2) cold nitric acid; (3) Esbach's Test.

1. *Boiling.*—After testing with litmus, adjust the reaction (by the addition of alkali or 2 per cent. acetic acid) until slightly acid; then boil.

A generalised white precipitate forms on boiling if albumen is present, and is not dissolved by further addition of acetic acid. It is always best to boil the upper part of a column of urine to compare it with the lower.

The *Fallacies* of this test are: (i.) Phosphates may be precipitated by heat alone if the urine be faintly acid, neutral, or alkaline, but the acetic acid dissolves these whereas it increases the albuminous precipitate. (ii.) Excess of acid redissolves the albumen; undue natural acidity may have the same effect; all of which prove how essential it is to adjust the reaction correctly in the first place. (iii.) In acid urines a cloud sometimes appears, not on boiling only, as albumen would do, but when the acid is added, due to mucus. (iv.) Copaiba and other resins may give a precipitate insoluble in acid, but their odour is characteristic. (v.) If the urine is not quite clear, it may be necessary to filter it. If turbid from bacteria, add a trace of NaOH, and a deposit of phosphates occurs which carries the bacteria down with it. Filter and acidify again before testing.

2. *Cold Nitric Acid Test.* Pour some strong non-fuming nitric acid into the bottom of the test-tube, hold the tube in a very sloping position, and let the urine gently flow upon the top; a haze of precipitated albumen will appear at the line of junction. It is necessary to wait a few seconds for the haze to appear, when the albumen is very small in quantity; and the tube should be gently heated at the junction.

The *Fallacies* of this test are not serious. (i.) Mucin, or urates, may form a precipitate, but it occurs *above* the line of junction; (ii.) in a very concentrated urine, a haze of tiny crystals of nitrate of urea may form, but this may readily be dissolved by heat; (iii.) copaiba and other resins give a haze in a similar position, but the odour is characteristic; (iv.) the haze due to the presence of albumoses disappears on heating, and reappears on cooling; (v.) both pus and blood contain albumen, and if present in the urine, give this reaction, apart from the presence of free albumen.

3. *Esbach's Test.*—Add Esbach's solution [1] to the urine by a pipette. A precipitate indicates the presence of albumen. Alkaloids and albumoses may also be precipitated, but disappear on heating.

The *quantitative estimation* of albumen may be roughly determined by boiling as above, setting aside the test-tube for twenty-four hours, and reading off the proportion. It may be more precisely calculated by means of Esbach's albuminometer, a tube graduated for measuring the percentage of albumen. Urine taken from twenty-four hours' collection is poured into the tube up to the mark U, and the reagent is added up to the mark R. After mixing the tube is set aside for twenty-four hours, and the precipitate falls to the bottom. The level to which this reaches is then noted, and the number on the glass indicates the grammes per litre of albumen present. *Fallacies.*—(1) This method is not reliable if the specific gravity of the urine is over 1015. The urine should be diluted to 1015 or below, and a calculation made afterwards by multiplying the result by the number of times of dilution. (2) If the patient is taking alkaline salts, the urine must be first acidified before adding the reagent.

§ **380. Mucin** is precipitated, as above mentioned, by adding dilute acetic acid which precipitates it in the cold; the precipitate is not redissolved by excess of acetic acid. Mucin is dissolved in alkaline urine. Excess of mucus indicates irritation of the bladder or genito-urinary tract, or a vaginal or uterine discharge.

§ **381. Sugar** is present in normal urine to the extent of 0·1 per cent., but the reagents used to detect an abnormal amount do not give a reaction with this normal trace of sugar. Glycosuria (sugar in the urine) is most

[1] Picric acid, 1 part; citric acid, 2 parts; water, 100 parts.

commonly due to the presence of glucose (dextrose), as in Diabetes Mellitus (§ 416), but may be due to lactose in certain cases.

QUALITATIVE TESTS FOR GLYCOSURIA (glucose, lactose or pentose).

(1) *Benedict's Test.*—The reagent consists of copper sulphate 17·3 G. sod. cit. 173 G. sod. carb. (anhyd.) 100 G. aq. dest. ad. 1000 c.c. Add 8 drops urine to 2 c.c. of the reagent and boil for 2 minutes. If a reducing sugar is present a red or greenish-yellow precipitate forms. When the test is done in this manner, a reduction is only given by a reducing sugar.

(2) *Fehling's Test.*—Fehling's solution consists of an alkaline solution of potassio-tartrate of copper, so prepared that 10 c.c. is reduced by 0·05 gramme of glucose. As it will alter on keeping, it should be boiled before using, to make certain that no precipitate forms before adding the urine (it is better to keep the copper solution and the alkali solution in separate bottles, mixing them just before using). Add to it a few drops of urine and boil again: and then continue adding till equal quantities of urine and Fehling are used. If on further boiling the solution is still clear, no noteworthy quantity of sugar is present. The Fehling's solution must always be in excess, and the boiling must not be too prolonged. If glucose or some other readily oxidisable substance is added, the blue cupric hydrate on gentle heating is reduced, and falls as a *red* or *yellow* precipitate of cuprous hydrate (Cu_2O, H_2O), which on longer boiling becomes red cuprous oxide (Cu_2O).

Fallacies.—(i.) The urine to be tested must be freed from albumen, and (ii.) it must not be ammoniacal. (iii.) Other reducing agents may occasionally give the reaction. After the administration of chloroform, chloral, morphia, and some other drugs, a reaction is obtained resembling that due to sugar, but is due probably to the presence of glycuronic acid. Lactose, uric acid and urates, ammonium salts, hippuric acid, creatinine, oxyacids and the products of certain drugs, such as carbolic or benzoic acids, may be sources of fallacy. To avoid these it is best to control by the Fermentation Test, or to filter a few drachms of the urine through a charcoal filter seven or eight times, to remove all reducing substances other than sugar.

(3) The *Clinitest Method* avoids the need of external heat and is useful to diabetic patients when travelling.

Lactose is only present in the urine during the later months of pregnancy, and during lactation. To distinguish between glucose and lactose, two tests may be used: (1) *Fermentation Test.*—Glucose is the only substance occurring in urine which is fermented by yeast. Lactose is not fermented. See that the urine is acid. Pour it into a test-tube, and insert a piece of German yeast; invert the tube over a saucer of water (or mercury) and place in a warm place (*e.g.*, on the mantelpiece). Have a control tube beside it with normal urine and a piece of yeast. If glucose is present, bubbles of CO_2 form and collect at the top of the tube. (2) *Phenyl-Hydrazine Test.*—To a third of a test-tube of urine add enough phenyl-hydrazine hydrochloride to cover a sixpence, sodium acetate to cover a shilling, and a few drops of glacial acetic acid; boil in a water-bath for half an hour. Cool by placing the tube in cold water. In the case of glucose a mass of yellow crystals forms, which under the microscope appear as fine yellow needles arranged as in a "wheatsheaf." In the case of lactose, yellow balls with fluffy edges are seen.

Pentosuria, due to a rare error of metabolism, causes a reduction of the alkaline copper solutions, but does not give the fermentation test, and the crystals found with phenyl-hydrazine hydrochloride are different from those produced by glucose and lactose. It may be tested for by Bial's reagent.

QUANTITATIVE ESTIMATION.—An approximate estimate of the amount of glucose present in urine may be formed if it is remembered that the specific gravity of a 1 per cent. solution is 1003. Thus, if from the depths of pigments present, it is judged that the specific gravity should be 1010, whereas the urinometer shows it actually to be 1031, the amount of sugar present is approximately $\frac{1031 - 1010}{3} = 7$ per

cent. (1) *Fehling's Method.*—The urine should be a sample taken from the total collection in twenty-four hours. Fill a burette with urine, diluted if necessary, and have 10 c.c. Fehling's solution in a porcelain dish, diluted with water. Boil the solution, and while boiling run in drops of urine, stirring all the while. Urine must be added from the burette till the fluid is just colourless; this is difficult to decide unless the dish be tilted so that it shows against the white background apart from the red precipitate at the bottom. Read off the amount of urine required for complete reduction, and calculate. Suppose 60 c.c. of urine, which has been diluted twenty times, are required to decolorise the 10 c.c. Fehling's solution (representing 0·05 gramme glucose), then 60/20 = 3 c.c. urine contain 0·05 gramme glucose. From this the percentage of glucose present can easily be calculated. Carwardine's Saccharimeter may be employed if an ordinary laboratory burette is not accessible.

(2) *Benedict's Method* is a modification of Fehling's method. The cuprous oxide formed on reduction reacts with potassium thiocyanate and forms a white precipitate of cuprous thiocyanate. 25 c.c. of Benedict's *quantitative* solution are measured into a conical flask; 4 G. of anhydrous sodium carbonate are added, and the urine (diluted if necessary) is run into the boiling solution until the blue colour is discharged. The solution must be kept boiling between each addition from the burette. 25 c.c. of Benedict's solution are reduced by 0·05 gramme glucose. The advantage of using Benedict's solution is that (as in qualitative testing for sugar in urine) it is not reduced by many other reducing substances present in urine.

If lactose is the reducing sugar present, when calculating the results remember that 10 parts of lactose have the same reducing power as 7 parts of glucose.

§ **382. Blood** in the urine imparts a characteristic smoky colour and may be present largely (*a*) in the form of red blood corpuscles (hæmaturia), some usually being broken up by the acidity of the urine, or (*b*) only in the form of free hæmoglobin (hæmoglobinuria). A darker colour of different shades may also be imparted to the urine by Methæmoglobinuria, Hæmatoporphyrinuria, Alcaptonuria, and Carbolic Acid. The most delicate test for hæmoglobin is the spectroscopic test (see Plate IV).

Chemical Test for Blood.—Add a few drops of freshly-prepared tr. guaiaci to the urine (which has been previously boiled and cooled) and shake; then add excess of ozonic alcohol or ozonic ether. A blue line appears at the junction of the fluids. The same reaction may be obtained by using filter or blotting-paper. Allow a drop of each of the reagents to fall on the paper beside a drop of the urine, noticing the colour at the junction of the three drops. *Fallacies.*—Saliva gives the same reaction, and so do iodides, in patients taking these salts. Pus gives a green-blue colour with guaiacum alone. Tincture of guaiacum must be freshly prepared, and it is best to dissolve a little of the resin in rectified spirit just before use.

Hæmoglobinuria is always present with hæmaturia, because the corpuscles break up. Its presence *alone* is rare, and can only be proved by examining the centrifugalised deposit of absolutely fresh urine under the microscope and finding *no red cells*, although hæmoglobin is present. Some of the hæmoglobin is converted into methæmoglobin. (See also § 409.)

Methæmoglobinuria.—The characteristic smoky colour of the urine in hæmaturia of renal origin depends largely on methæmoglobin, a substance formed from hæmoglobin by the action of acid urine. (See § 409.) It is recognised by the spectroscope.

Hæmatoporphyrinuria (Iron-free Hæmatin in the Urine).—The urine has a dark cherry-red colour like port wine, but gives no guaiacum reaction, as no iron is present. Usually albumen is absent. It is found in rare congenital conditions, and after excessive amounts of sulphonal and trional, and is an indication for at once stopping the drug and giving alkalies freely. It is known by its spectroscopic bands

(Plate IV). If these cannot be detected, the hæmatoporphyrin should be extracted with acetic ether or amylic alcohol, after adding a few drops of acetic acid.

Hæmosiderinuria occurs in some forms of severe acute hæmolysis. The tobacco-yellow deposit gives in part the reactions for iron and consists of pigment partly free and partly incorporated in leucocytes and epithelial cells.

§ **383. Bile** is present in the urine in cases of obstructive jaundice, and can be detected even before the skin becomes yellow. Both bile pigments and bile salts are present early in jaundice, but later only the pigments are present in many cases, probably because the liver ceases to manufacture the salts. A greenish-orange colour of the urine betrays the presence of bile if in more than slight amount.

Bile pigments may be tested for by: (1) *Gmelin's Test.*—Run fuming nitric acid down the side of a test-tube containing urine. As the bile-pigment oxidises, rings of colour form red, violet and green at the top; the green indicates bile. (2) *Marechal's Test.*—Add a few drops of very diluted solution of iodine to the surface of the urine in a test-tube; a green reaction is obtained. *Bile Salts* are tested for by *Hay's Test.* Sprinkle flowers of sulphur on the surface of the urine in a wide-mouthed vessel (not a test-tube). If bile salts are present, the sulphur sinks, instead of floating as on normal urine, because the surface tension of a fluid containing bile salts is lowered. For the same reason urine containing bile salts gives a yellow or greenish froth when shaken in a test-tube.

Urobilinogen is present in small amounts in normal urine, but in cases of hepatic deficiency or of hæmolytic anæmia is in excess of normal, giving the urine a brighter yellow or yellowish-brown tinge. It rapidly disappears in urine on standing, being converted to urobilin.

To test, fresh urine must be used. Use Ehrlich's aldehyde reagent (p. dimethyl-aminobenzaldehyde 10 G., conc. hydrochloric acid 100 c.c., distilled water to 300 c.c.). To 10 c.c. urine add ½ c.c. reagent, and if urobilinogen is in excess of normal a cherry-red colour develops within three minutes: this is hastened by gently warming.

Urobilin is absent in normal urine, but is slowly formed from urobilinogen on standing: when large quantities of urobilinogen are passed in pathological conditions, some urobilin probably accompanies it.

To test.—The colourless chromogen is converted into urobilin by 2 drops of liq. iodi mit. (B.P.): after acidifying with HCl, the spectroscope will detect an absorption band between the green and blue.

§ **384. Acetone** and **Aceto-acetic acid** (often called diacetic acid) are present together in the urine in cases of ketosis. Small amounts are detected by Rothera's test and large amounts by Gerhardt's test.

Rothera's Test.—Add to 5 c.c. urine a small crystal of sodium nitro-prusside and a few drops of liq. ammon. fort., shaking well: a permanganate colour appears and gradually deepens. The sensitiveness of the reaction is greatly increased by saturation of the urine with crystals of ammonium sulphate.

Gerhardt's Test is performed by adding a few drops of a strong aqueous solution of ferric chloride, until in excess of the amount required to precipitate the phosphates, when a Burgundy-red colour appears. This same colour is given by salicylates. When urine gives a positive Gerhardt's test, Rothera's reaction develops very quickly due to the large amount of ketone bodies present.

Diacetic acid and acetone have long been known to be present in the urine in many cases of diabetes mellitus. One or both are also present in starvation and inanition, prolonged vomiting and gastro-intestinal diseases which prevent assimilation, severe acute diseases of the liver (such as acute yellow atrophy, delayed chloroform poisoning and eclampsia), in febrile states, in cases with an ill-balanced diet with a large excess of fat and insufficient sugar, and also in sea-sickness and cyclical vomiting in children (§ 271), even before the vomiting commences. In ketosis there is a deficiency in the utilisation of carbohydrates; the subsequent incomplete oxidation of fats leads to the formation of oxybutyric acid, aceto-acetic acid and acetone. **Acidosis** signifies a decrease in the fixed bases in the blood and tissues; though the blood remains alkaline, the amount of base present, as measured by the bicarbonate reserve, is diminished. It is therefore not always due to diacetic acid, although this is the commonest cause. Acidosis may also be caused (1) by the presence of other acids (as in acute rickets); (2) in kidney disease, by interfering with acid excretion; (3) by taking excessive quantities of acids by the mouth—HCl, acid phosphate of sodium—and ammonium chloride which is converted into urea and HCl. The normal ratio of acid to base in the blood and tissues is upheld by the elimination of CO_2 by the lungs and of acid by the kidneys, by the neutralisation of acid by ammonia, and by the intake of bases with food. In acidosis (whether due to ketosis or to other causes), much of the nitrogen excreted appears in the urine as salts of ammonia instead of the normal urea. Hence, the ammonia nitrogen/total nitrogen coefficient is increased from the normal 5 to as much as 30 to 50 per cent.

The clinical *symptoms* of acidosis are: (1) hyperpnœa or dyspnœa (air-hunger), without cyanosis. If it is due to ketosis, there is (2) an ethereal odour to the breath, and (3) the presence of ketone substances may be shown in the urine. Chemical tests reveal the presence, but not the degree of the ketosis. The normal urine is rendered alkaline after a dose of about 60 gr. of bicarbonate of soda, but in ketosis the urine may not become alkaline till about 1 oz. has been taken.

Treatment of Acidosis and Ketosis.—Bicarbonate of soda is given with the idea of raising the bicarbonate reserve of the blood. Water aids the elimination of the acids. Glucose must be administered in large quantities by mouth, or in the form of a 5 per cent. solution per rectum every four hours. In severe cases, the most rapid results are given by intravenous injection of 250 c.c. of sodium bicarbonate (4 per cent.) and dextrose (5 per cent.), and should be used with insulin. When the ketosis occurs with diabetes mellitus, see §§ 416, 417.

Alkalosis is the reverse of acidosis, and signifies an increase in the basic constituents of the blood (particularly $NaHCO_3$). If it occurs slowly, it is compensated for by a retention of acids, especially H_2CO_3; if rapidly, the blood actually becomes more alkaline, and so a condition of *alkalæmia* results. The usual *symptoms* are headache, nausea, vomiting, abdominal pain, thirst, mental irritability; in severe cases symptoms of tetany ensue (§ 778), ushered in with tingling of the fingers and toes; coma may lead to a fatal issue. On examination the patient looks ill, usually has a flushed dehydrated face, a furred tongue and suffused conjunctivæ; the urine may contain a trace of albumen and in severe cases acetone occurs. *Causes.*—(1) After excessive vomiting, as with pyloric and high intestinal obstruction; (2) after excessive doses of alkalies by mouth, especially $NaHCO_3$; (3) with hyperpnœa due to mountain climbing, forced breathing at rest or exposure to a hot moist climate, with excessive loss of CO_2, and therefore of H_2CO_3 from the blood.

Treatment.—The cause must be removed, vomiting allayed, the lack of chlorides compensated by large doses of normal saline solutions by mouth, per rectum, or intravenously, and acid administered in the form of ammonium chloride (50–100 gr.) or dilute hydrochloric acid by mouth, or calcium chloride (15–30 gr.) intravenously.

§ **385. Pus** in the urine is detected by the microscope: chemical tests should not be used, as they only show the presence of large amounts of pus. The presence of one or two leucocytes in the deposit of a fresh

specimen of urine is normal. When pus comes from the *kidney*, the urine is, at any rate when first passed, acid, and the pus is uniformly disseminated through the urine, and remains so for some time. When it comes from the *bladder*, the urine is usually alkaline or neutral, and the pus soon collects into a creamy layer at the bottom of the glass.

When in *very considerable quantity*, pus may be detected by the addition of an equal quantity of liq. potassæ to the deposit. A ropy gelatinous mass is formed, which pours from one test-tube to another like a fluid jelly. Another test is by the addition of a few drops of tinct. guaiaci, when a greenish-blue colour appears. *In small quantities* it is essential to examine the deposit microscopically for pus cells.

§ **386. Other constituents** sometimes met with in urine are albumoses, homogentesic acid, melanin, indican and skatol.

Albumosuria occurs in many different conditions, *e.g.*, with abscess formation, during the resolution of pneumonia, with acute yellow atrophy of the liver, with asthma and with some cases of nephritis. It is only clinically significant in the form of *Bence-Jones' protein*, which is present in about half the cases of multiple myelomatosis or Kahler's disease.

Tests.—Slightly acidify 50 c.c. urine with 33 per cent. acetic acid. To 5 c.c. urine in each of 3 test-tubes, add 0, 1, and 2 drops of 33 per cent. acetic acid and place in a water bath with a thermometer. When Bence-Jones' protein is present, the urine suddenly becomes turbid at a temperature between 40–55° C. On boiling, in at least one tube the protein redissolves. Bradshaw's test depends on a dense white ring forming at the junction of urine and concentrated HCl in a test-tube. (Other proteins when in large quantities give a faint white ring.)

Alcaptonuria is a condition where the urine darkens from the surface downwards on standing exposed to the air or on addition of alkalies, due to the presence of *homogentesic acid*. It is due to an inborn error of metabolism, and has no known clinical significance. Its only importance lies in the fact that it reduces Fehling's solution and simulates glycosuria. (See § 653. XI.)

Melanuria occurs when there are extensive deposits of melanotic sarcoma. Fresh urine is usually colourless (melanogen) but becomes dark on standing (melanin).

Test.—To 5 c.c. of urine add 3–4 drops of freshly prepared sodium nitro-prusside solution, and 10–12 drops of 40 per cent. caustic soda and shake. Then add sufficient 33 per cent. acetic acid to acidify, when a Prussian-blue colour develops.

Indicanuria.—Indican is found where there is undue intestinal putrefaction; usually where bacterial infection is present above the cæcum. *Test.*—To 5 c.c. urine add 5 c.c. Obermayer's reagent (ferric chloride 2 parts, hydrochloric acid 1000 parts) and 2 c.c. chloroform. Shake a few times and in the presence of excess of indican the chloroform assumes an indigo-blue colour.

Fallacy.—Iodides and bile pigments also give this reaction.

Normal Constituents of the Urine.

Normally the urine consists of water containing about 4 per cent. of solids by weight, of which urea comprises from 2·5 to 3 per cent. of the total urine, amounting to about 30 grammes per diem.

§ **387. Urea.**—A healthy male adult, weighing, say 140 pounds, excretes daily an average of 1200 to 1500 c.c. urine (42 to 53 ounces), containing 30 grammes of urea. These figures vary widely in health, and are much less for a lighter person taking less food. If the kidneys are acting well, the urea output is dependent on the intake of nitrogenous

food, but it is considerably diminished after vomiting or diarrhœa. A specimen for estimation should be taken from the urine of twenty-four hours, mixed and measured (§ 378). Deficient elimination of urea (with a rise in blood urea) occurs sooner or later in nearly all renal diseases (see Uræmia, § 372), in certain hepatic diseases, in myxœdema, Addison's disease, and melancholia. (See Kidney Efficiency Tests, § 389.)

Estimation of Urea.—On an average mixed diet, the urea excretion is about 30 grammes per diem, *i.e.*, just over 2 per cent. in the urine. For accurate results it is necessary to determine the *total nitrogen* in the urine; but since the greater proportion is in the form of urea, it is most convenient to estimate the urea excretion.

The apparatus usually employed is Gerrard's Ureameter or some modification of it. It is fitted up as shown in Fig. 90. 25 c.c. of freshly-prepared solution of sodium hypobromite are placed in the wide-mouthed jar (A). Then a small tube containing 5 c.c. of urine (B) is carefully introduced so that it stands up against the side of the wide glass jar, which is tightly stoppered. Next, the reservoir (C) is filled with water; the stopcock (E) of the cylinder (D) is opened and the reservoir raised till the water in the cylinder is at zero and level with that in the reservoir: the stopcock (E) is closed. Then the jar (A) is tilted so that the urine mixes with the hypobromite. Effervescence occurs as the liberated nitrogen enters the cylinder and displaces water, driving it into the reservoir. After allowing to cool for ten minutes, the reservoir is moved until the water in it and the cylinder are level; then the amount of gas is read. The cylinder is graduated in percentage of urea.

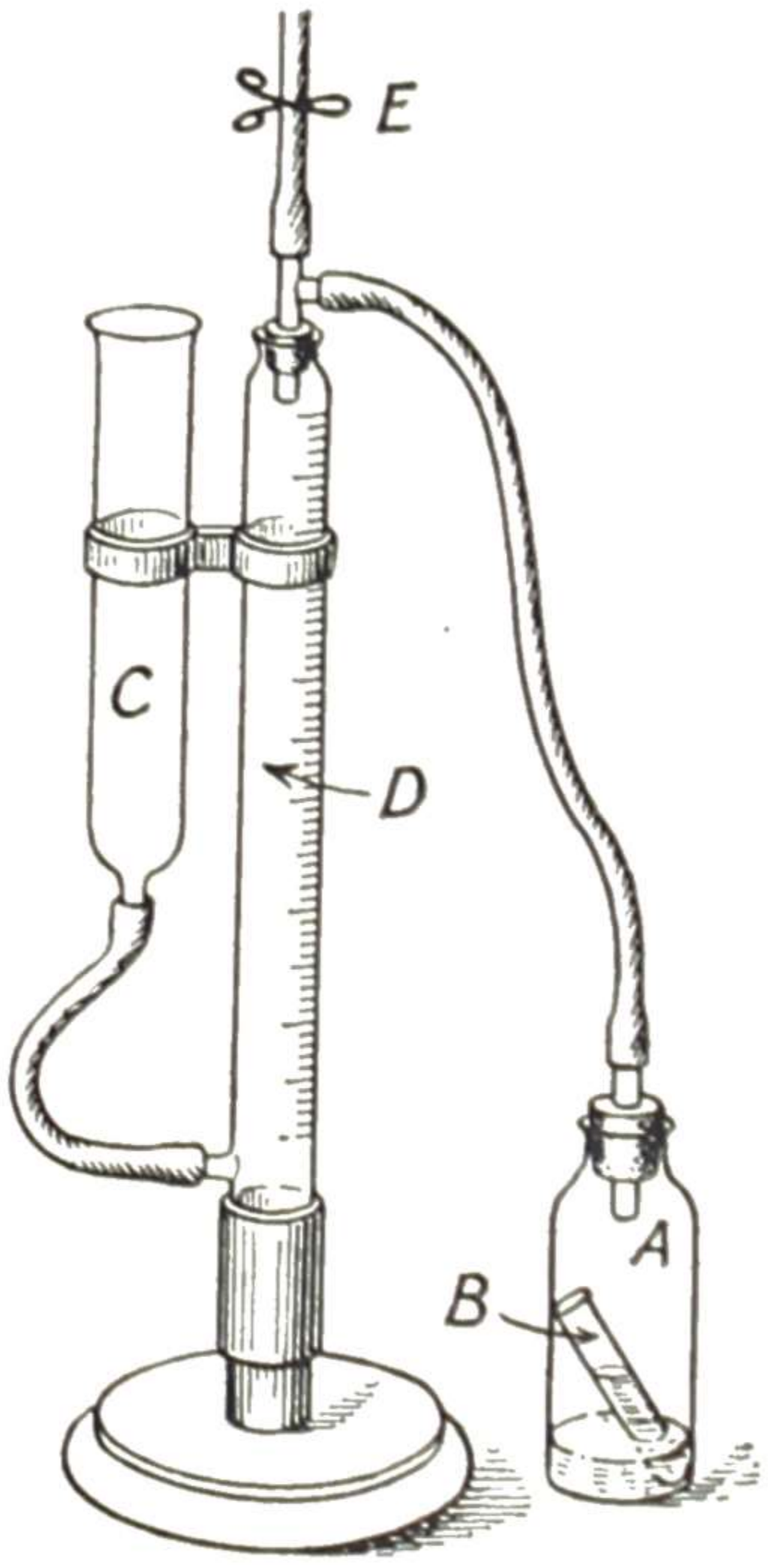

FIG. 90.—GERRARD'S UREAMETER.

§ 388. **Uric acid,** either free or combined in the form of urates, is normally present in a sample from a day's collection of urine to the extent of 0·04 grammes per cent. (or 0·7 grammes excreted per diem). Uric acid and urates separate out as a cloudiness or deposit (§§ 390 and 393) when there is high acidity. This dissolves on warming with alkali. Their chemical quantitative estimation is difficult.

CHLORIDES.—The chlorides found in the urine are principally salts of sodium, and vary in *health,* according to the food taken, from about 11 to 15 grammes daily. In *disease,* the chlorides are increased during convalescence from fevers, during the absorption of œdema or other forms of serous exudations, and in diabetes insipidus. Except in malaria, they are diminished in acute fevers, especially in pneumonia (reappearing 2 or 3 days after the crisis), in renal diseases with albuminuria, during vomiting and in anæmic conditions.

Test.—Add a few drops of HNO_3 to the urine, and an equal bulk of 3 per cent. solution of $AgNO_3$. A curdy precipitate follows if the chlorides are normal in quantity; if the urine only becomes milky, they are diminished.

PHOSPHATES (§ 393) occur in two groups: the alkaline phosphates, salts of potassium, sodium and ammonium; and the earthy phosphates, salts of calcium and magnesium. The former are readily soluble; the latter are readily deposited when the urine is neutral or alkaline, especially when heated.

Tests.—In an *alkaline* or neutral urine, the earthy phosphates form a cloudy precipitate, which is increased on boiling, but disappears on acidifying the urine. If present in an alkaline urine the deposit is distinguished from pus by being dissolved by acetic acid. The microscope enables us to distinguish between pus and phosphates, and is indispensable when, as often happens, the two deposits occur together.

SULPHATES are also normally present in the urine, and there is an increase with increase of protein in the diet or in fever. Two forms exist: (*a*) as potassium or sodium sulphate (*inorganic sulphates*); (*b*) as combinations of cresol, phenol, indol, skatol, etc. (*organic or ethereal sulphates*). A relative increase of the latter group occurs when phenol or allied substances are given as drugs, and with intestinal putrefaction.

§ 389. Kidney Efficiency Tests.—Certain tests yield invaluable evidence as to the condition of the kidneys. These have usurped the position of the older tests for the amount of urea in the urine, which was formerly regarded as the chief source of information. Several of these tests should be confided to the skilled laboratory worker. This is true especially of the examination of the blood for protein and non-protein nitrogen.

1. *Estimation of Blood Urea.*—The most accurate method is by means of urease in the soya bean, but for practical purposes a much more rapid method is by means of sodium hypobromite. *Ambard's Method.*—Into a 25 c.c. measuring flask deliver approximately 10 c.c. of 20 per cent. trichloracetic acid. To this add 10 c.c. of blood, and make up to the 25 c.c. mark with water. Filter off the coagulated protein, and take a measured quantity (10–15 c.c.) of the clear filtrate. Pour this into the urea apparatus by squeezing some air out of the rubber bag, filling the cup with the solution, and introducing this into the apparatus by releasing the pressure on the rubber. Add a few drops of phenolphthalein and sufficient strong caustic soda to

FIG. 91.—AMBARD'S APPARATUS FOR ESTIMATING BLOOD UREA. (½ scale.)

make the contents alkaline. By pressing on the rubber bag, drive all the air from the apparatus to the top of the tap. Then fill the cup to the level of the neck with sodium hypobromite, and release this into the apparatus, taking care that no air enters. Invert the apparatus several times till all the nitrogen has been evolved, and measure the quantity of this by releasing the bag from the apparatus in a cylinder of water, and measuring the quantity of gas when the levels of fluid are the same inside and outside the apparatus. Suppose 13 c.c. of filtrate were used, and evolved 0·8 c.c. of nitrogen. This amount of filtrate was derived from $\frac{13 \times 10}{25}$ c.c. of blood. Knowing that 1 gram of urea liberates 354 c.c. nitrogen at N.T.P., the amount of urea present in the blood is readily calculated. Normally the blood has 20 to 50 mgms. of urea per 100 c.c. In renal diseases it rises considerably higher; about 100 mgms. per 100 c.c. blood may be taken as definitely pathological. A high blood urea may occasionally occur without renal disease (§§ 372 and 387); then the prognosis varies with the cause. In doubtful cases the urea excretion should be measured.

The urea concentration test and the urea clearance test will help to decide whether the condition is due to disease of the kidney. Usually there is urea retention in the blood with chronic interstitial nephritis but not with subacute parenchymatous nephritis.

2. *The Urea Concentration Test* introduced by Maclean is a valuable guide to the function of the kidney. The bladder is emptied, and the patient drinks 15 G. urea dissolved in 100 c.c. water. The urine passed at the end of 1, 2 and 3 hours is separately collected, measured and the urea percentage in each specimen estimated. The volume in the first hour may be increased by the diuretic effect of urea, and if it exceeds 120 c.c. the result should be discarded. The second sample is often the more important because of this diuresis. Above 2·5 per cent. urea in any sample means normal concentration. In chronic interstitial nephritis there is less; serious cases show a concentration of only 1·0 to 1·5 per cent. urea. The fallacy of this test is that it may not show even severe grades of renal insufficiency in certain cases, particularly in subacute parenchymatous nephritis, because the urea is concentrated, owing to the small output of fluid. This is partly overcome by estimating the total urea excretion in each hour. In at least one period 10 per cent. of the ingested dose of urea is secreted by the normal kidneys. More accurate estimation is by the urea clearance tests.

3. *Van Slyke's Method for Determining Urea Clearance.*—The test is best performed between breakfast and lunch. Before the test, vigorous exercise must be avoided, and the previous meal must have been moderate and without coffee. Just prior to the test, and again 1 hour later, a glass of water is given. At a noted time, the bladder is emptied; at the end of the first hour a sample of blood is taken for blood urea estimation; at about the end of the first hour, urine is passed, the time recorded, and the whole specimen put into a labelled bottle. At the end of a second hour urine is again passed, and the whole specimen put into another labelled bottle.

For persons over 16 years, and of average build, the following methods are used to calculate the results (in others, correction factors have to be applied).

$$\text{The Maximum Clearance} = \frac{\text{per cent. urea in urine (U}}{\text{per cent. urea in blood (B)}} \times \frac{\text{Vol. of urine in c.c.}}{\text{per minute (V)}}$$

is used where the output exceeds 2 c.c. per minute, the normal values being 64–99.

$$\text{The Standard Clearance} = \frac{\text{U.}}{\text{B.}}\sqrt{\text{V.}}$$

is used where the output is less than 2 c.c. per minute, the normal values being 40–68.

4. *The Phenolsulphonophthalein test* can also be used to detect whether the kidney function is impaired. After the patient has drunk 300 c.c. water, inject intramuscularly 6 milligrammes of the dye, and examine the urine 70 and 130 minutes after. If 40 to 50 per cent. of the dye is excreted in an hour, and 70 to 90 per cent. in two hours, the kidneys are not diseased.

(c) *The Urinary Deposit.*

§ 390. Cloudiness of the Urine (naked-eye examination).—In healthy urine there is no deposit, but many of the normal constituents, and some abnormal substances, may become evident as a sediment or turbidity after the urine has cooled.

(1) A bulky pinkish turbidity and deposit in an acid urine, which form when the urine cools, indicates the presence of *urates*. It is the commonest of urinary deposits. (2) *Uric Acid* is evident to the naked eye as a sandy deposit resembling red cayenne pepper. (3) A white flocculent turbidity in an alkaline or neutral urine indicates the presence of *phosphates*, which are cleared at once by the addition of a few drops of 2 per cent. acetic acid. (4) *Calcium oxalate* gives a typical "powdered-wig"

deposit of fine white points seen on the surface of a mucous cloud. (5) A fine cloud of *vesical mucus* is normally present in the urine, although it is only visible when the entangled débris and epithelial cells are sufficiently plentiful. (6) *Pus* forms a deposit which resembles phosphates to the naked eye, but it is readily distinguished under the microscope. (7) *Prostatic threads* (" floaters ") are elongated fine white threads which float in the urine and indicate chronic prostatitis. (8) Urine is sometimes cloudy from the presence of *bacteria*, and this cloudiness cannot be cleared by boiling or the addition of acids.

§ **391. Specimens** of the deposit must always be examined **microscopically** in cases of suspected renal disease. The urinary deposit is best examined after the urine has stood for some hours in a conical glass, or after the specimen has been centrifugalised. Take a pipette, close it at the top with the right forefinger, pass it to the bottom of the glass, allow a small quantity of the sediment to enter, withdraw the pipette, wipe its exterior with a cloth, place the point on a slide, then surround the pipette with the palm of the left hand, the warmth of which will cause a drop to exude. Cover the drop with a cover-glass, and examine first under a $\frac{1}{3}$ or $\frac{1}{2}$ inch objective, then under a $\frac{1}{8}$ or higher. The deposit normally contains foreign substances, such as cotton and woollen fibres, etc., and a few bladder (and in women nearly always a few vaginal) epithelial cells, which are recognised by their large and nucleated appearance. Inquiry should always be made as to the sex of the patient, and in women if any leucorrhœa is present. If so, it is very desirable to draw off a specimen of urine by the catheter.

The urinary deposit may contain ORGANISED SUBSTANCES (§ 392), or CRYSTALLINE and inorganic substances (§ 393).

§ **392.** The **Organised Constituents** of the urinary sediment are of far more serious import than the crystalline substances. They comprise TUBE-CASTS (which are the most important), EPITHELIAL CELLS, PUS CELLS, BLOOD CELLS, spermatozoa, and certain rarer structures such as bacteria, fat cells, etc.

Tube-casts and renal **Epithelial Cells** are present in all renal maladies attended by shedding or destruction of the renal epithelium. The casts are composed of blood cells or renal epithelial cells moulded together in the convoluted tubules during the absorption of water. When tube-casts are abundant in the urine microscopic examination of the sediment permits of their ready detection. But if, on the other hand, they are present only in small numbers, they may be easily overlooked, especially when, as in chronic interstitial nephritis and in amyloid disease, the urine is abundant and of low specific gravity, so that any suspended matter is deposited only slowly and incompletely. Moreover, these are the exact instances in which the casts are apt to be of the hyaline variety, and their almost transparent character renders them inconspicuous objects in the microscopic field. To detect the presence of casts a fresh specimen of urine is often essential, as they rapidly disappear in alkaline or decomposing urine.

THE SEARCH FOR TUBE-CASTS must be conducted with great care if the risk of a false conclusion is to be avoided. One of the best methods, after settlement or centrifugalisation of the deposit, is to examine it with a moderately low power of the microscope, using a narrow diaphragm and shading the light so as to have the field

only feebly illuminated. Any suspicious-looking object can be brought into the centre of the field and examined with a stronger lens. In this way casts may be detected which in a strong light would readily be missed, and if several slides have been prepared and examined in this manner the detection of any casts present in the urine is rendered fairly certain. But the examination should be repeated on several occasions in any urine containing albumen before a negative conclusion is finally arrived at. The addition of a few drops of methylene blue to the urine before centrifugalisation is of assistance. The casts do not stain at first, but in those containing cells the nuclei stain; and the casts stand out against the pale blue background of the fluid.

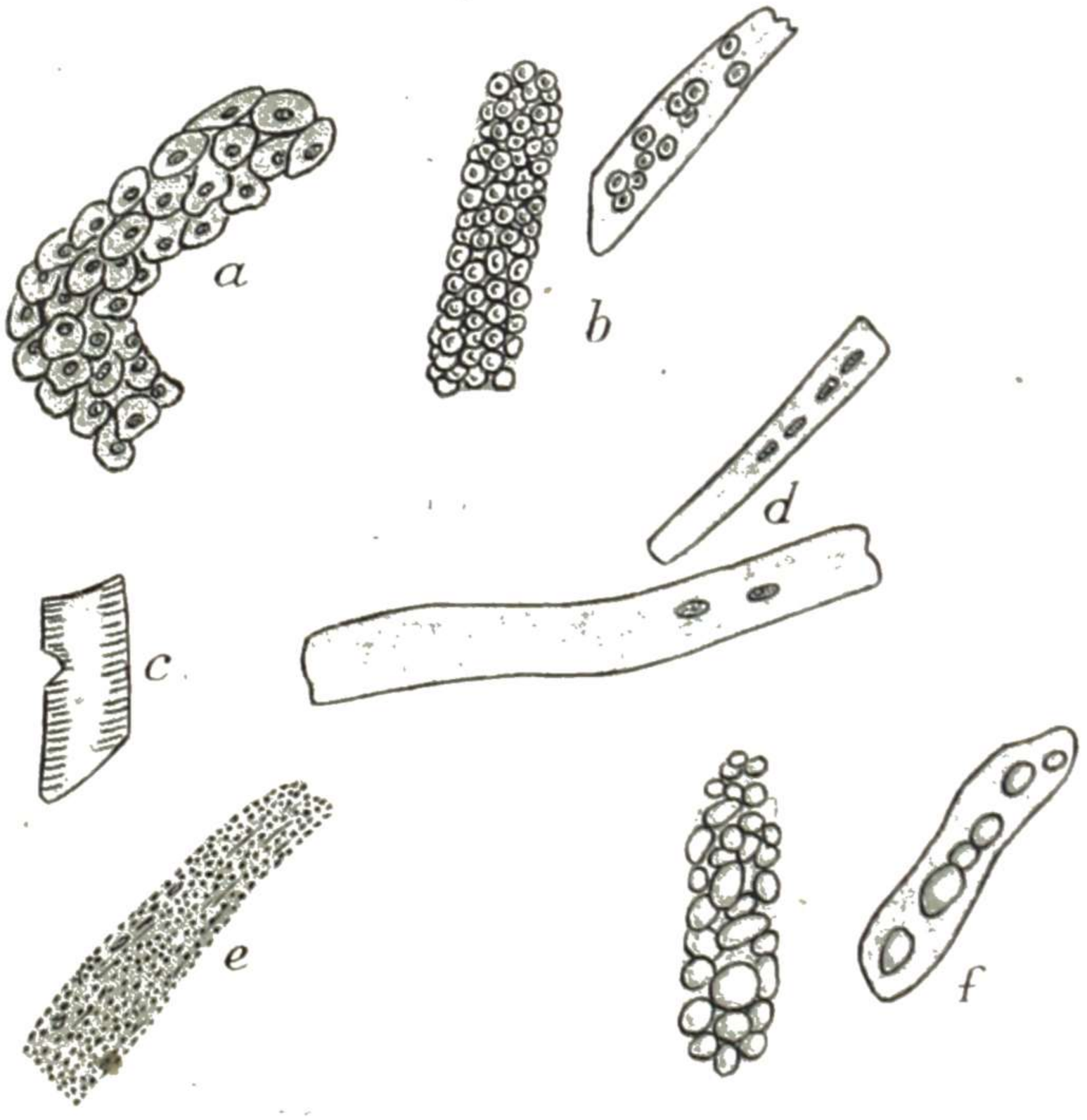

FIG. 92.—RENAL TUBE-CASTS.—*a*, epithelial casts; *b*, blood casts; *c*, waxy cast; *d*, hyaline casts; *e*, granular cast; *f*, fatty casts.

The clinical importance of tube-casts in the urine is that, with but few exceptions, they definitely indicate disease of the renal epithelium. Thus, when found in a urine containing albumen, they indicate that the albuminuria is a result of some structural change in the kidney. Similarly in cases of pyuria and hæmaturia the detection of tube-casts not only suggests that the pus and blood are of renal origin, but that the kidney is affected. It must be remembered that more than one part of the urinary tract may be diseased at one and the same time. In the urine of patients who are jaundiced, tube-casts may often be found without, either at the time or subsequently, any evidence of renal disease.

In general terms, *epithelial casts* and *blood casts* are indicative of the earlier and more acute stages of nephritis. *Waxy casts* are not peculiar to lardaceous kidney, but occur in other forms of long-standing renal disease. These and *fatty casts* indicate that the inflammatory process is passing to a degenerative stage. *Granular casts*

are more abundant in chronic renal disease. *Hyaline casts*, which must not be confused with waxy casts, occur in all forms of nephritis, both acute and chronic. The relative proportion of epithelial, granular, and hyaline casts (Fig. 92) is affected by the condition of the urine. In highly acid and in alkaline urine the casts tend to be hyaline ; in acid urine, granular. Tube-casts in abundance always form a serious symptom, but one or two hyaline casts occur in normal urine. They are more abundant in the acute than the chronic forms of renal disease. Their *absence* does not count for very much, as they may be easily missed or undergo disintegration in the urine. The continued presence of hyaline and granular casts is more serious than the temporary appearance of other types.

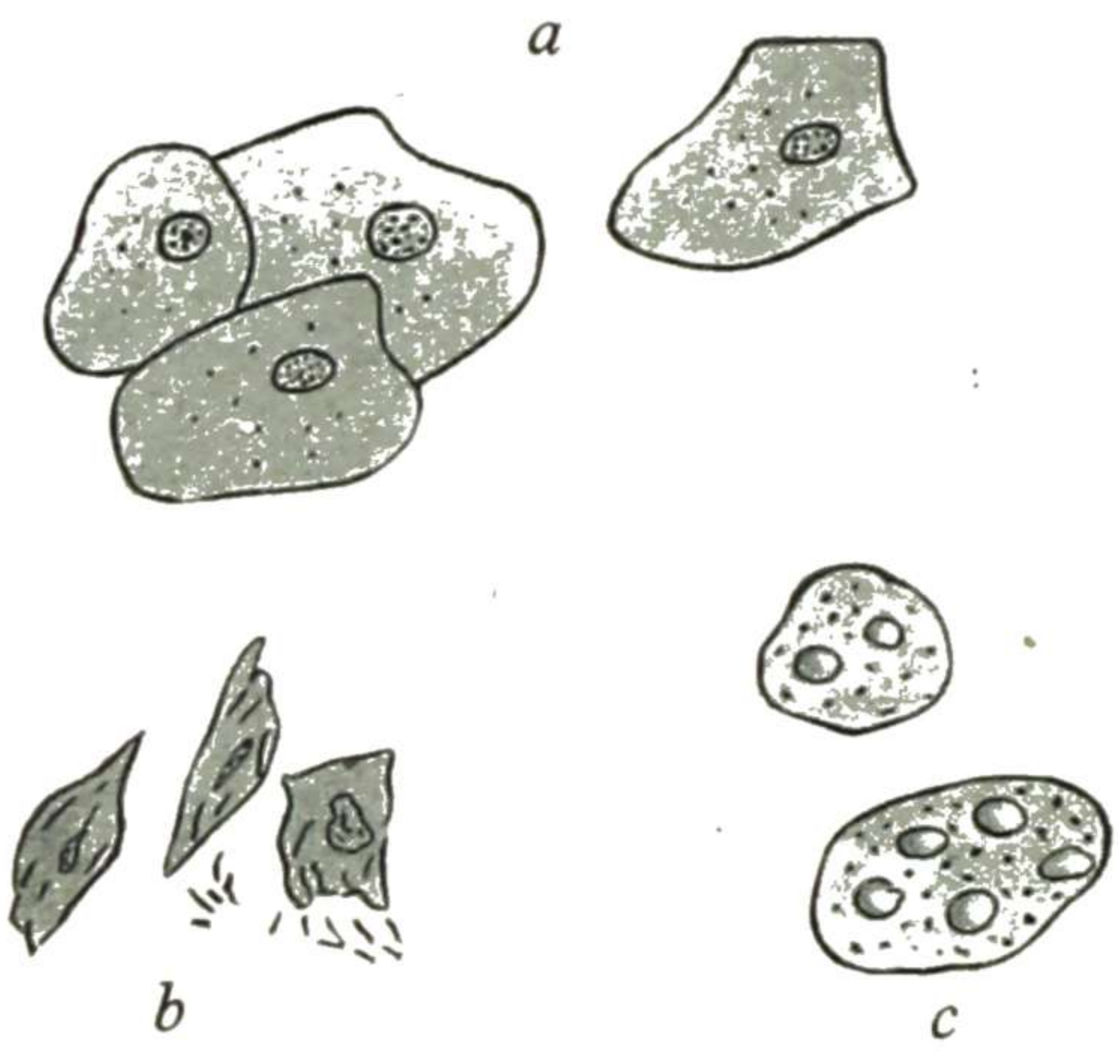

FIG. 93.—RENAL EPITHELIUM—*a*, normal ; *b*, disintegrating ; *c*, fatty.

Renal Epithelium (Fig. 93). —The detection of renal epithelium in a urinary deposit has much the same significance as the presence of tube-casts. The cells are *spherical* and rather smaller than bladder or vaginal epithelium. They may be seen isolated or in small groups. In acute nephritis they may be found in an unaltered condition, but in chronic disease they become degenerated, and may thus appear crowded with fat globules. BLADDER or VAGINAL EPITHELIUM (Fig. 94) is met with as collections of squamous cells ; transitional, spindle-shaped, and other forms of epithelium may also be derived from the bladder. TAILED EPITHELIUM may be derived from the pelvis of the kidney : the

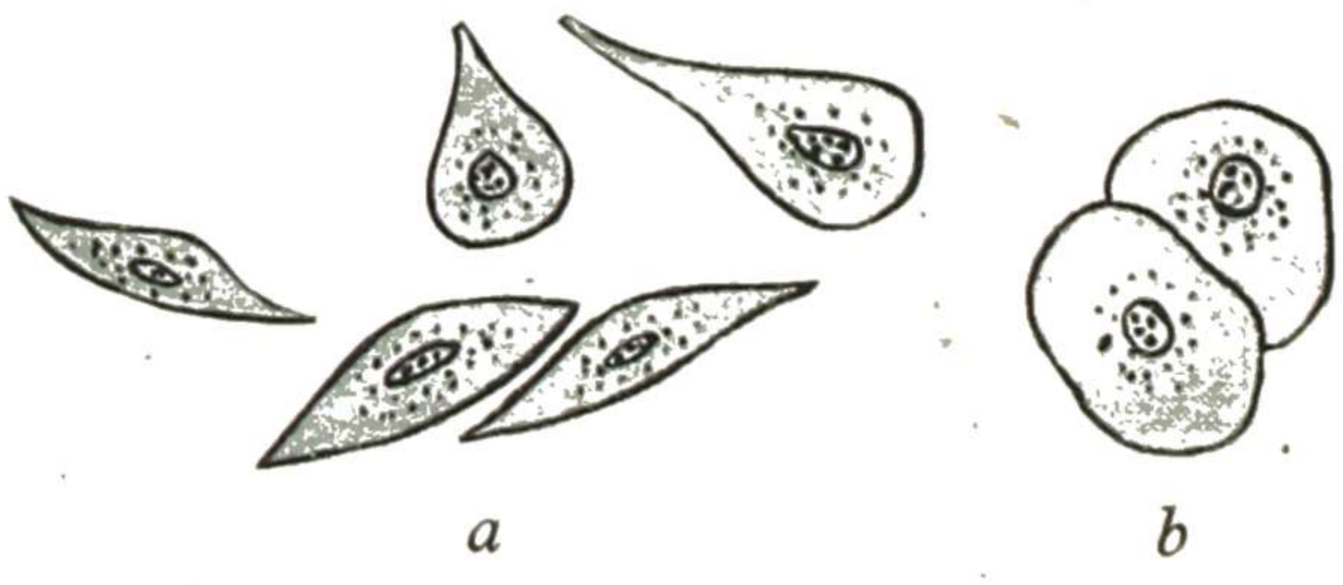

FIG. 94.—TAILED EPITHELIUM (*a*) from the pelvis of the kidney ; and BLADDER EPITHELIAL CELLS (*b*).

male urethra and the prostate gland yield epithelium practically identical with this.

Pus Cells, under the microscope, are of globular form with a diameter about one-third larger than that of a red blood cell : they are opaque and granular, but when treated with acetic acid they clear, and a nucleus is seen (Fig. 95, *d* and *e*). Pus cells may or may not accompany bacilli in the urine.

Red Blood Cells.—The detection of red blood cells in a urinary deposit

is conclusive evidence of the presence of blood. When only in small numbers, they may be seen microscopically, but do not give the chemical reactions (§ 382). In most fresh urines they are readily distinguished, as they retain their bi-concave form and the outline shows a double contour (Fig. 95, *a*). But sometimes the cells become much changed. Thus in a very dilute urine they are apt to become distended by imbibition, and then are seen as circles having sharp delicate outlines (*c*). In other instances they become crenated, shrunken, and deformed (*b*).

Spermatozoa may occasionally be found in the urine. Each has a minute oval or pear-shaped head, from the larger extremity of which there passes a long and delicate tail. The total measurement of the spermatozoon is about $\frac{1}{600}$ inch in length.

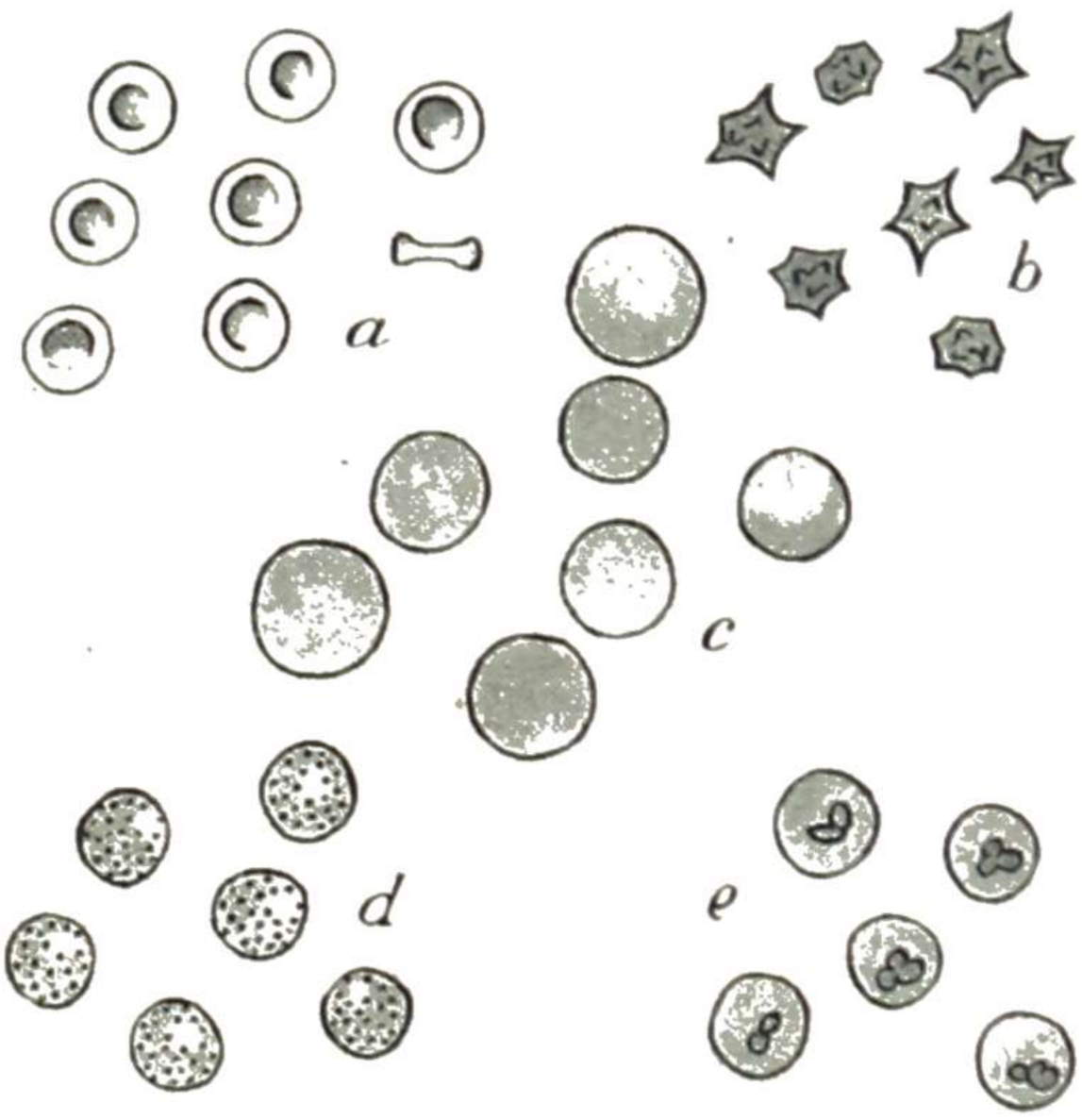

FIG. 95.—Various appearances of RED BLOOD CORPUSCLES and PUS CELLS in the URINE.—*a*, normal red blood corpuscles; *b*, crenated; *c*, in hypotonic solution; *d*, pus cells; *e*, pus cells + acetic acid. In very pale, watery urine the red corpuscles may be so pale as to escape detection (*c*). They may then be revealed by adding a solution of iodine in potassium iodide.

Micro-organisms.—Numerous organisms are found in the urine, especially when decomposition has occurred within the bladder. *B. Coli* is much the commonest (§ 412): other organisms found are *B. proteus*, *B. pyocyaneus*, *B. subtilis*, streptococci, staphylococci and occasionally gonococci, and tubercle bacilli (see § 411). The *Typhoid bacillus* may be abundant in cases of typhoid fever, and long after health is restored it may remain a potent source of infection to others.

The *Tubercle bacillus* may be found in tuberculous disease of the bladder or of the kidney, and is therefore a sign of great value. In appearance under the microscope it resembles the smegma bacillus. Its presence should always be suspected when pus cells are abundant and yet the urine remains sterile on culture. Its special staining reaction is given in § 921. It is difficult to find in the urine early in the disease and the deposit of a 24 hours' specimen should be examined. In obscure cases a guinea pig should be inoculated or a culture made (§ 919).

§ **393. Crystalline and Inorganic Deposits** in urine are usually of less serious import than the organised substances above noted.

In ACID URINES we meet chiefly urates, uric acid, oxalates, and, more

rarely, stellar phosphates, cystin, xanthin, hippuric acid, tyrosin, and leucin.

In neutral or ALKALINE URINES we meet chiefly triple phosphates (occasionally ammonium urate and calcium carbonate).

In urines of EITHER REACTION amorphous deposits of potassium or ammonium urate and phosphates and carbonates of the alkaline earths may be met.

1. URATES, chiefly of sodium, potassium, or ammonium, when in excess are deposited as an amorphous brick-coloured deposit after the urine has become cold. On heating or on the addition of caustic potash, the deposit clears, both tests distinguishing urates from phosphates. The characteristic forms are shown in Fig. 96.

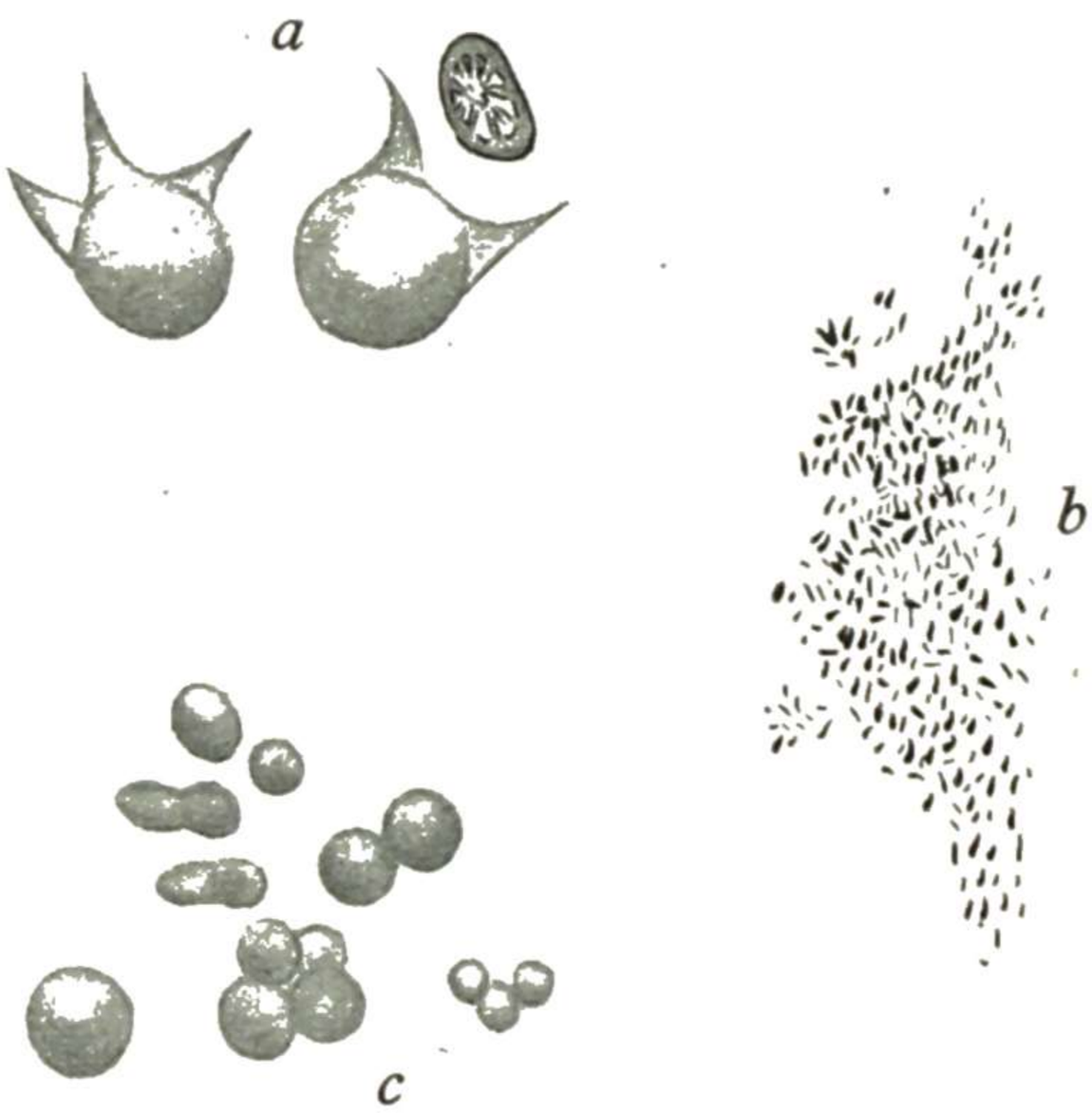

FIG. 96.—URATES.—*a*, "Hedgehog" crystals of sodium urate; *b*, amorphous urates; *c*, ammonium urate crystals (found in alkaline urine).

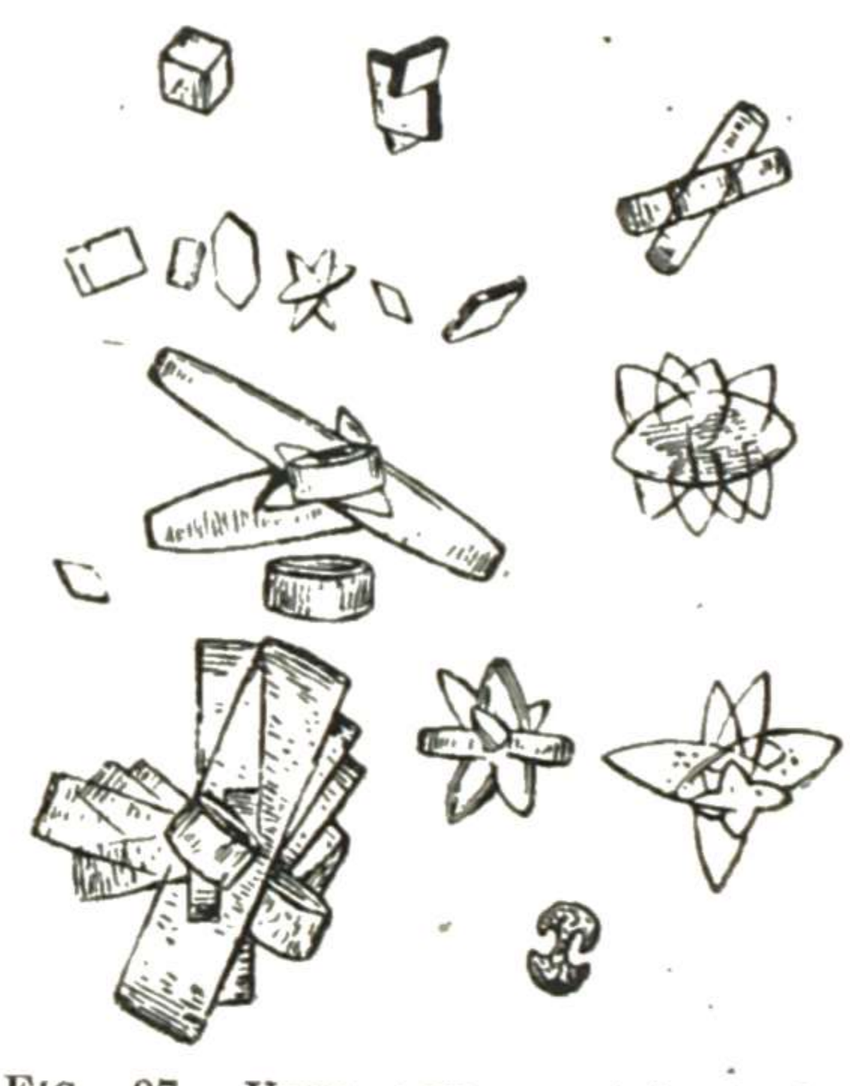

FIG. 97.—URIC ACID crystals (red-brown).—The two top rows show, from left to right, the evolution in a colloid medium of the "lozenge-shaped" crystal from the primary rhombic prism. In the lower right-hand corner is the "dumb-bell" form occasionally met with.

An occasional deposit of urates in a concentrated urine is of no importance. When they are *constantly* present a calculus may form in the kidney or bladder.

2. FREE URIC ACID is deposited when the urine is very acid or poor in salts and in pigment, and is therefore found chiefly in dilute pale urines with deficiency of salts. The red deposit of uric acid closely resembles cayenne pepper to the naked eye. It may be detected in the urinary deposit under the microscope by the *colour* and *shape* of the crystals. It occurs in the form of *red-brown crystals* (the only coloured crystals commonly found in the urine) (Fig. 97). Uric acid assumes many different shapes, owing to the presence of the colloid substances in the urine. This deposit is soluble in caustic potash, insoluble in dilute acetic acid, the converse of phosphates.

In health uric acid is increased with a highly nitrogenous diet, after much exercise, after meals, and during the "alkaline tide" of the morning. It is also increased after any excess of purin intake, in most fevers, in liver diseases, and during and after acute gout. It is diminished in chronic gout, especially just before the acute exacerbations and in chronic nephritis.

3. PHOSPHATES occur as a white deposit or flocculent turbidity in FEEBLY ACID, NEUTRAL, OR ALKALINE urine, in three different forms, which in order of frequency

are (1) *Amorphous phosphates of calcium* form the thick white deposit that is apt to be mistaken for pus, but which is more readily shaken up in the urine. These and all other phosphates are soluble in acetic acid (which distinguishes the deposit from pus). (2) *Triple phosphate* of ammonium and magnesium (Fig. 98) is found in urine which has undergone alkaline fermentation. In markedly ammoniacal urine "feathery phosphates" are found. (3) *Basic magnesium phosphate* occurs in large rhombic plates, not grouped, but scattered. (4) *Neutral or dicalcium phosphate* occurs in neutral or alkaline urine as "stellar phosphates" (Fig. 100). They decompose on the addition of ammonia. The constant presence of phosphate deposits may be

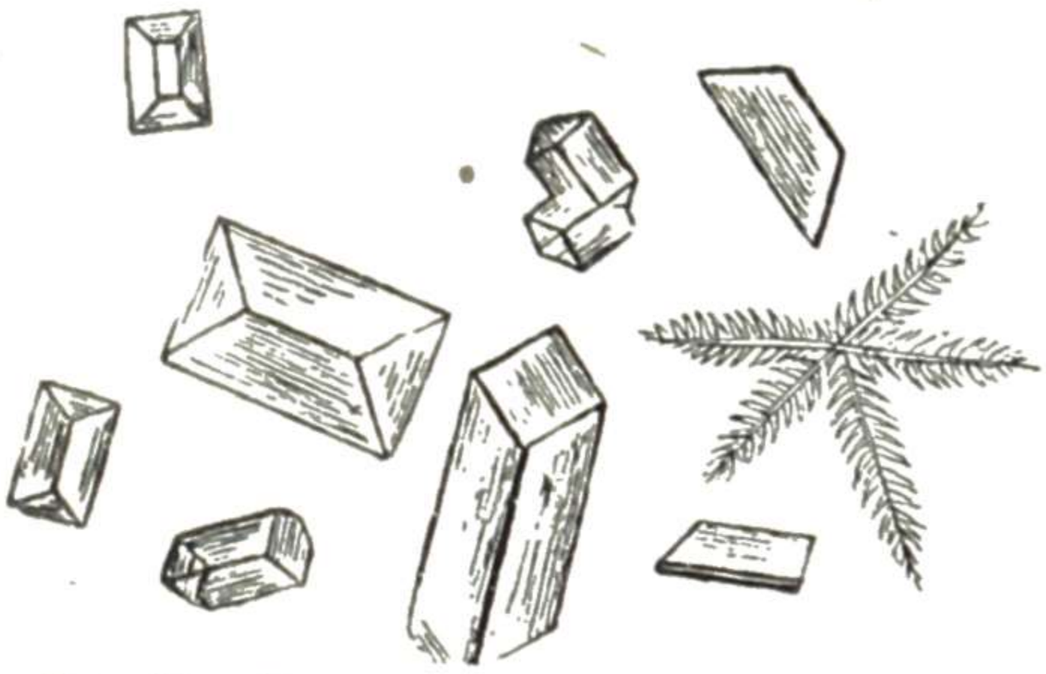

FIG. 98.—TRIPLE PHOSPHATE—"house-top" and "feathery" crystals.

FIG. 99.—*a*, TYROSIN, in bundles of needle-shaped crystals; *b*, CYSTIN (clear six-sided plates) is a rare urinary deposit due to an inborn error of metabolism. It may form renal calculi; *c*, LEUCIN, spherical crystals with concentric markings, found in the urine in rare cases of acute yellow atrophy of the liver.

associated with symptoms of phosphaturia (§ 423), and usually does not indicate excess eliminated, but only alkalinity of the urine. *Monocalcium phosphate* occurs chiefly in acid urines.

4. OXALATES are chiefly met as *calcium oxalate* (Fig. 101). They are soluble in hydrochloric acid, insoluble in acetic acid or caustic potash. The presence of crystals of calcium oxalate is not necessarily indicative of an excess (OXALURIA, § 423); their presence may suggest the nature of a calculus.

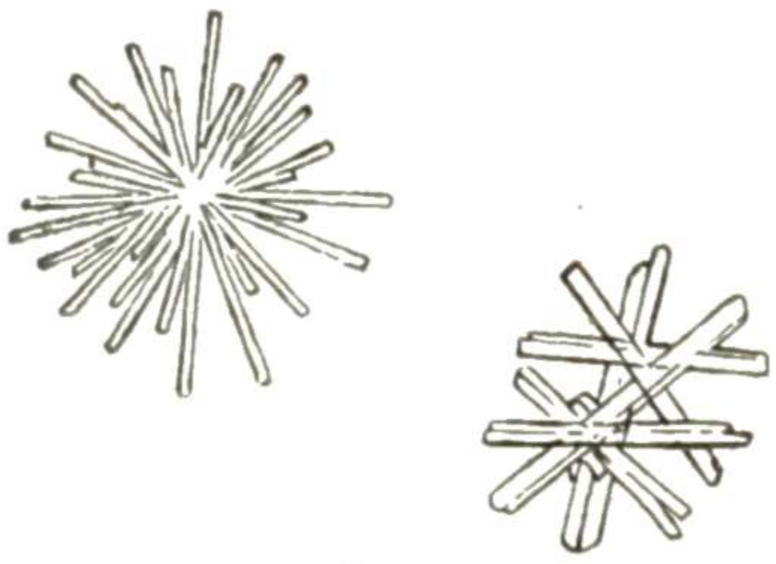

FIG. 100.—NEUTRAL OR "STELLAR" PHOSPHATE.

FIG. 101.—CALCIUM OXALATE—"envelope" and "dumb-bell" crystals.

5. *Calcium Carbonate* is a rare deposit, consisting of tiny spheres and dumb-bells, or of amorphous granules, effervescing and dissolving in acetic acid. The *Carbonates of the Alkaline Earths* are rarely found as tiny amorphous granules or concretions. Calcium sulphate and carbonate may take part in the formation of vesical calculi, especially in the aged, but otherwise they have no clinical significance. Their presence indicates the composition of a calculus.

When a patient is taking crystalline drugs, such as potassium acetate and sodium phosphate, or even liquor ammoniæ, crystals without pathological significance sometimes appear in the urine. After giving sulphonamide drugs, characteristic crystals are seen. Moreover, after a reagent has been added to urine (*e.g.*, Esbach's solution for estimating albumen), and it has been set aside, crystals may appear which have no clinical significance.

6. *Certain rare and less important deposits*, which occur chiefly in acid urines, are as follows: *Hippuric Acid* occurs as four-sided prisms, either scattered or in groups. It is present after the ingestion of benzoic acid in large doses, cranberries, and other fruits. *Calcium Sulphate* occurs either as amorphous granules, or, very rarely, as long colourless needles or elongated tables with truncated ends. It is detected by being insoluble in ammonia and acids. *Leucin* occurs as laminated spheroids, and *Tyrosin* as bundles of acicular crystals (Fig. 99). Both occur occasionally in the urine in phosphorus poisoning, acute yellow atrophy of the liver and other causes of liver destruction. *Cholesterin* (Fig. 86) is only occasionally found among urinary deposits. It forms laminated plates with longitudinal striæ, and a notch at one end. *Cystin* occurs as hexagonal plates soluble in ammonia (Fig. 99), in large amount in congenital cystinuria.

PHYSICAL EXAMINATION OF THE KIDNEYS

§ **394.** A dull "sickening" pain is usually felt on firmly compressing the kidney with both hands, but there is no tenderness in a healthy organ. Tenderness may be elicited in cases of calculus and other forms of pyelitis, perinephric inflammation, abscess, or tumour of the organ, and in "dropped kidney" in neurotic subjects. Kidney tumours tend to grow forwards, where there is least resistance, pushing the resonant colon *in front* of them. When, therefore, the palpating hand encounters resistance and swelling in the lumbar region *posteriorly*, it is probably due to a peri- or extra-renal, rather than to a renal condition (see Fig. 41). The diagnosis of renal swellings from other abdominal tumours has been given in § 263. An extra-renal tumour may press the kidney backwards, so that the apex of the tumour may be due to the displaced kidney.

In the majority of renal disorders the physical examination of the kidney is of secondary importance to the examination of the urine. The kidneys are situated on either side of the spine, about 3 inches from the middle line; the right is slightly lower than the left, owing to the position of the liver just above it. The upper end of the right kidney reaches to the *lower* edge of the eleventh rib; the left kidney reaches as high as the *upper* edge of the eleventh rib. The kidneys lie partly in the hypochondriac and partly in the lumbar regions, and are therefore much higher than is commonly supposed, with reference to the anterior abdominal wall. The lower end of the right kidney is 1 inch and that of the left kidney 1½ inches *above* the level of the umbilicus.

Palpation.—Even in normal conditions the lower border of the right kidney may be palpable in thin people. In those whose abdominal walls are lax—in women who have borne children, for instance—it is surprising how frequently the right kidney can be palpated. The patient should lie on the back, with the abdominal muscles relaxed. The physician, standing on the right of the patient, should place his left hand beneath the patient's back, close under the ribs, just external to the quadratus lumborum. The right hand is laid flat over the anterior surface of the abdomen, in the mid-clavicular line, with the fingers pointing upwards, just below the liver. Pressure backwards, as if to meet the left hand, is made by the right hand. The patient should then be asked to draw a deep breath, and as he does so the rounded lower edge of the kidney is felt to slip between the opposing hands. When the ligaments of the kidney are relaxed—*movable kidney*—the fingers of the right hand may be able to palpate the upper border of the organ, and to retain it during expiration. A kidney is said to be "*floating*" when it can not only be readily palpated, but can be pushed below the umbilicus or freely moved about in the abdominal cavity.

FIG. 102.—NORMAL RETROGRADE PYELOGRAPHY.

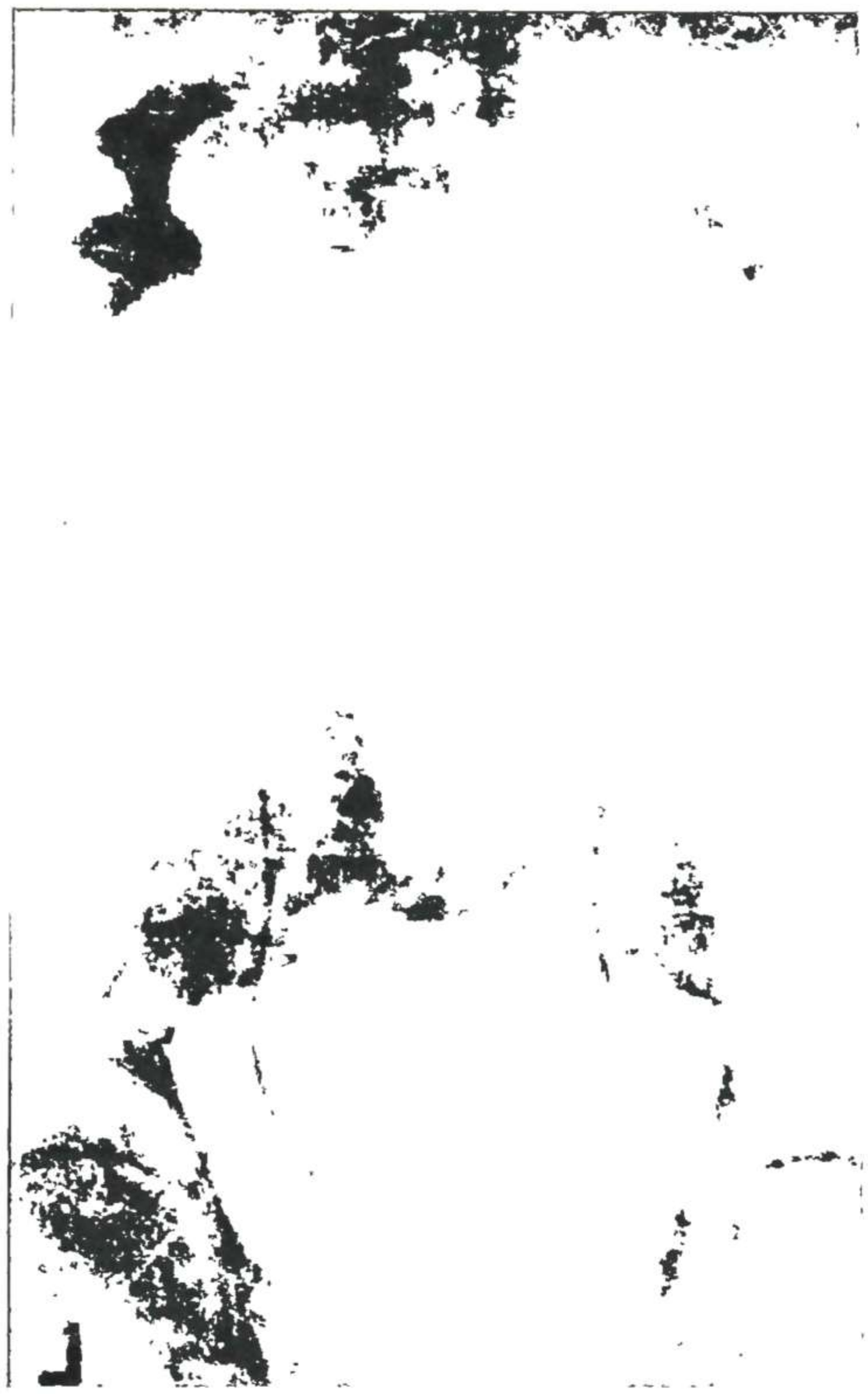

FIG. 103.—LARGE BILATERAL BRANCHED RENAL CALCULI ("coral calculi"), with ureteric catheters in position.

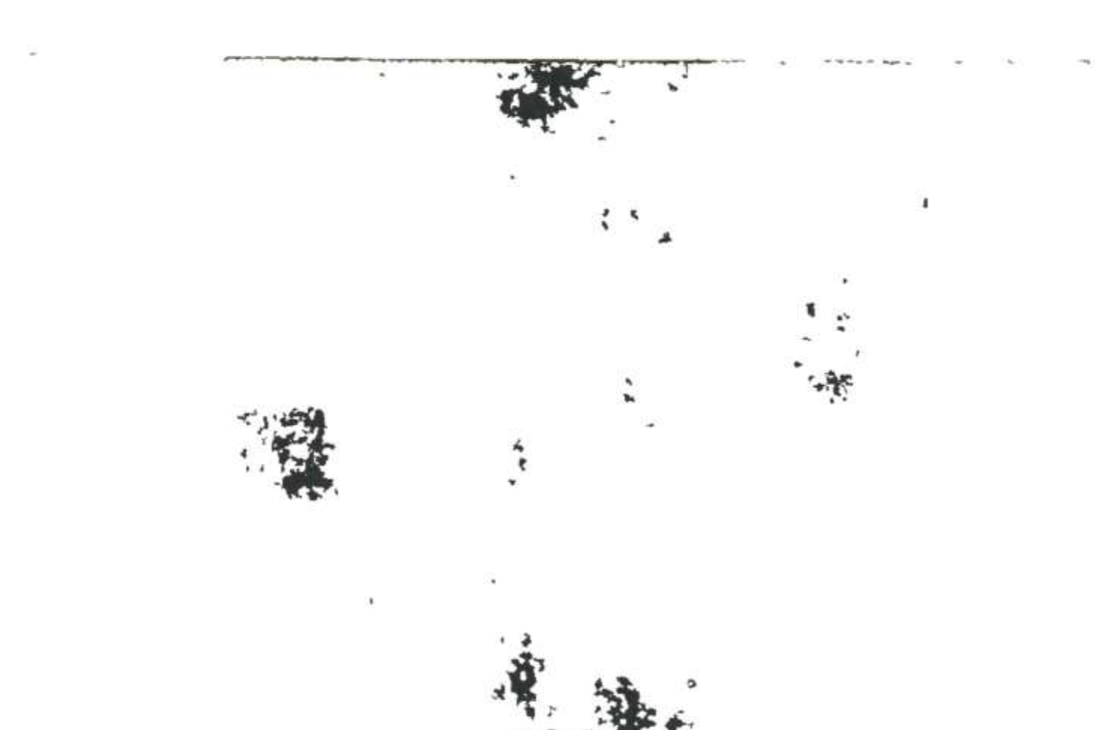

FIG. 104.—BILATERAL POLYCYSTIC KIDNEYS, demonstrated by retrograde pyelography.
(X-Rays kindly supplied by Dr. J. Russell-Reynolds.)

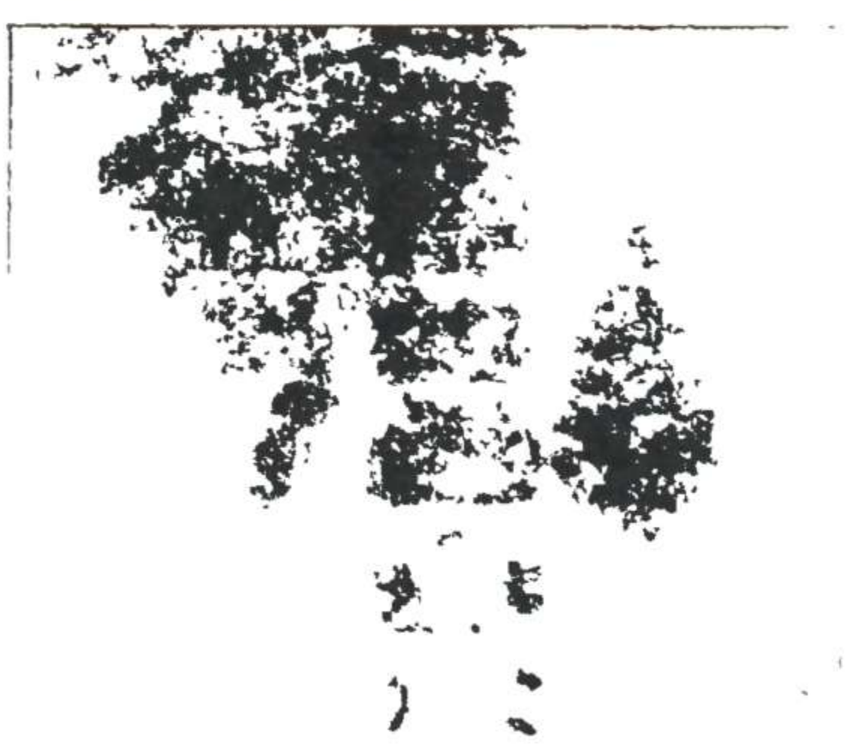

FIG. 105.—BILATERAL HYDRONEPHROSIS in a child, with demonstration of renal pelves with iodoxylum (excretion urography).

Percussion does not enable us to define the margins of the kidney, for the organ is too deeply seated. The feature of primary importance in this connection is its relation to the colon, which is pushed forward by enlargement or tumour of the kidney. Consequently the anterior surface of such growths is always resonant, there being dulness at the side which is continuous with that at the back; whereas with enlargements of the spleen or gall-bladder there is dulness anteriorly and resonance at the side.

Radiography is often of great help. In cases of doubtful renal calculus a *radiogram* usually settles the diagnosis. By *pyelography* an outline of the pelves of the kidneys, and of the ureters can be obtained. In retrograde pyelography, a 10–15 per cent. solution of potassium iodide is injected through a ureteric catheter, and on X-ray examination an opaque shadow is thrown where the solution has penetrated (Fig. 102). With *excretion urography* iodoxylum B.P. (uroselectan B.) is injected intravenously in doses of 15–20 c.c. of a 75 per cent. solution in water, and X-ray examination 5, 10, 30 and 50 minutes later gives information as to the secreting power of the kidneys and a picture of the outline of the whole renal tract (Fig. 105). Care must be taken that no drop enters the tissues round the vein. Diodone (B.P.) is a new preparation for intravenous or intramuscular injection.

Cystoscopy reveals the condition of the bladder and of the ureteric orifices: the orifices may be the seat of congestion or ulceration. The previous injection of indigo-carmine or methylene blue may make the differences of the flow from the orifices more obvious (*chromo-cystoscopy*). Through the cystoscope the ureters may be catheterised and a separate specimen of urine obtained from each kidney.

PART C. URINARY DISORDERS, THEIR DIAGNOSIS, PROGNOSIS, AND TREATMENT

§ **395. Routine Procedure and Classification.**—*First*, having ascertained that the patient's LEADING SYMPTOM refers to the urinary apparatus; and, *secondly*, the data of his ILLNESS, particularly as to whether it is of an ACUTE or CHRONIC nature; we proceed, *thirdly*, to examine the urine. The ROUTINE EXAMINATION of the URINE in everyday practice consists of Inspection, Reaction, Specific Gravity, Tests for Albumen and for Sugar. The subsequent more detailed examination depends upon circumstances. As stated, the examination of the urine stands in relation to renal disease, as the local signs do to diseases of other organs. Few diseases, certainly no common disorders of the kidneys, are unattended by some change in the urine. On the other hand, the LOCAL EXAMINATION of the kidney, by palpation, percussion and by radiography, is more difficult, but should never be omitted in any case which is at all obscure.

Classification.—We will deal with urinary disorders under their respective cardinal symptoms as follows:

§ **396. Albuminuria.**—The causes of albuminuria come under these groups:

A. The ALBUMEN IS ASSOCIATED with BLOOD and CASTS and the disease is **acute**: Acute nephritis (§ 397).

B. The ALBUMEN IS PERSISTENT and is ASSOCIATED with CASTS; BLOOD is present microscopically, and ŒDEMA may be marked; the disease is **subacute**: Subacute parenchymatous nephritis: § 398.

(*a*) With marked œdema.
(*b*) Without marked œdema.

C. The ALBUMEN is ASSOCIATED with CASTS; BLOOD is USUALLY ABSENT and the disease is **chronic**: § 399.

(*a*) Secondary contracted kidney.
(*b*) Chronic interstitial nephritis.
(*c*) Amyloid disease (§ 404).

D. The ALBUMEN is NOT USUALLY ASSOCIATED with CASTS or BLOOD; it may be INTERMITTENT, and the condition is usually **chronic**—I. physiological; II. orthostatic; III. kyphotic; IV. toxæmic; V. pregnancy; VI. drugs; VII. endogenous poisons; VIII. chill to the surface; IX. mild renal congestion; X. chronic gout and arteriosclerosis; XI. urinary calculi and crystals; XII. leaky kidney or residual albuminuria; XIII. anæmia; XIV. obscure causes (§ 405).

E. The ALBUMEN IS ASSOCIATED with BLOOD, and CASTS are SCANTY or ABSENT—Hæmaturia (§§ 406–409).

F. The ALBUMEN IS ASSOCIATED with PUS—Pyuria (§ 410).

A. *The illness came on recently and is* **acute**; *the urine contains a considerable quantity of* ALBUMEN *and* TUBE-CASTS: *it is or has been* "SMOKY" *from the presence of blood. The disease is* ACUTE NEPHRITIS.

§ **397. Acute Nephritis** (Synonym: Acute glomerulo-tubular nephritis; formerly called Acute Bright's Disease).—In this disease the inflammation begins and predominates in the glomeruli and to a less extent in the tubules (the parenchyma) of the organ. The condition usually lasts five or six weeks, and may terminate in recovery or pass into a subacute condition. The disease exists in two forms: (*a*) acute diffuse glomerulo-tubular nephritis; (*b*) acute focal glomerulo-tubular nephritis.

(*a*) **Acute diffuse glomerulo-tubular nephritis** is due to an intoxication of the kidney, usually one to three weeks after an acute hæmolytic streptococcal infection. The diffuse involvement causes temporary renal failure.

Symptoms.—(1) The albumen is often in considerable quantity, and the urine may even "go solid" on boiling. (2) The other characters of the urine are: (i.) It is scanty, sometimes only 10 or 20 ounces a day, or less. Consequently, the specific gravity is high, although the diurnal quantity of urea is diminished. (ii.) It varies from a turbid or "smoky" to a dark brown hue from the presence of blood. (iii.) Epithelial, hyaline, and

blood casts, free renal epithelium, and red and white blood-corpuscles are present. (3) Dropsy is usually moderate in extent and severity, and is first noticed in the loose areolar tissue below the eyes, in the legs and back and in the genitals. There may be collections of dropsical fluid in the serous cavities. (4) There is a waxy pallor of the skin. (5) A degree of malaise, with discomfort and even pain in the loins or abdomen, may be present, but there is only a slight elevation of temperature for about four or five days: mild anæmia is common. (6) Uræmic symptoms may come on early—*e.g.*, (i.) occasional vomiting, (ii.) headache, (iii.) drowsiness, (iv.) some shortness of breath, (v.) the blood urea is often raised. (7) In the course of a few days the blood pressure may become high, and the second aortic sound accentuated.

Etiology.—(1) Acute infection is the commonest cause. The micro-organism is usually streptococcus hæmolyticus, commonly found in the tonsils, rarely in the respiratory passages, nasal sinuses or middle ear, or in the skin (*e.g.*, erysipelas). This explains its common occurrence with scarlet fever. Other acute infections are influenza, typhoid, malaria, cerebro-spinal fever, staphylococcal infection and trench fever. (2) Hidden foci of sepsis, cholecystitis, empyema, etc. (3) Sudden chill may predispose. (4) A family tendency is common.

Prognosis.—Acute nephritis will terminate (1) usually in complete recovery in a few weeks, when treatment and hygienic surroundings are good (80 per cent. of cases). This is usual with children; with adults complete recovery is not so common, unless the original focus of infection rapidly subsides. (2) Partial recovery. If the disease lasts longer than two months, it develops into the condition known as large white kidney (Subacute Parenchymatous Nephritis, § 398). (3) Death may occur from uræmia, from dropsy into the serous cavities, or from other complications. The chief *complications* are: (*a*) Uræmia; (*b*) hypertensive encephalopathy; (*c*) inflammations of the *serous* membranes, such as pleurisy, pericarditis, or peritonitis, which are usually latent—*i.e.*, attended by little or no pain; and (*d*) infections of the *mucous* membranes, such as bronchitis, broncho-pneumonia, gastro-enteritis; (*e*) œdema of the lungs or of the glottis; (*f*) cardiac dilatation and left ventricular failure with pulmonary œdema; (*g*) erysipelas, cellulitis, and various other *skin diseases* are very prone to attack patients with acute nephritis. The prognosis, therefore, of acute nephritis is grave in proportion to (i.) the persistence of œdema, oliguria, gross albuminuria, and hypertension beyond two weeks; (ii.) the development of uræmic symptoms; and (iii.) the nature and severity of the complications.

Treatment.- The indications are to relieve the kidney by giving it as little to do as possible; to increase the action of the skin and bowels; and to lessen local congestion. (i.) The diet should consist at first of 1½–2 pints of fluid daily, with added glucose (see diet in § 297, VIII, Stage I) unless the blood urea is over 100 mgms. per cent., when more fluid is essential. After 3-4 days the hæmaturia has often diminished, the

blood pressure fallen, and the volume of urine increased ("critical diuresis"), when further quantities of fluid and more carbohydrate may be added (Stage II). About the 10th–14th day it is usually possible to give a still more liberal diet (Stage III). It is unwise to restrict the diet for too long a period as this undermines the patient's resistance. (ii.) To obviate the danger from exposure to cold, the patient must be kept strictly confined to bed till all red blood cells have disappeared from the urine. Cases of scarlet fever should be kept in bed during convalescence, because they are so apt to develop this disease. Diaphoretics may be needed, liquor ammoniæ acetatis, warm baths, wet packs, and hot-air baths. Mild purgatives are indicated; saline purgatives are especially useful when there is much dropsy. Diuretics are contraindicated in the early stage only. Alkalies such as sodium or potassium bicarbonate, citrate, acetate, and bitartrate may be given to prevent an acid urine still further damaging the inflamed renal epithelium. (iii.) Local depletion by wet or dry cupping is especially indicated when the volume of urine is low. Counter-irritation over the kidneys, with poultices, antiphlogistine, or leeches, has a similar effect. Digitalis can be given if the heart is feeble. The effect of penicillin injections is on trial. During *convalescence*, tonics, especially iron, must be given. In the treatment of renal disease two drugs are contraindicated—cantharides and turpentine. Mercury is generally added to these and mersalyl should certainly be used with caution. For the treatment of Uræmia, see § 372.

In scarlet fever albuminuria frequently comes on between the sixteenth and twenty-sixth day, at which time also acute nephritis may supervene. To avoid this risk, scarlet fever patients should be kept in bed a month, and the urine kept alkaline (Osman).

(*b*) **Acute focal glomerulo-tubular nephritis** arises during the height of the acute stage of an infection, again usually due to streptococcus hæmolyticus. Only a certain number of the glomeruli are involved; probably the micro-organisms produce minute emboli in them, and so signs of renal failure are usually absent.

Symptoms.—(1) The condition is commonest in children. (2) Hæmaturia and cylinduria are present; the bleeding may be profuse; the amount of albumen is such as can be accounted for by the bleeding, or little in excess of this. (3) Dull aching in the loins is common. (4) There is no renal failure; symptoms and signs of uræmia are absent, there is no œdema, no rise in the blood urea or blood-pressure. (5) Relapse may occur with recurrence of the original infection. The *prognosis* is almost invariably excellent; chronic nephritis ensues rarely. The *treatment* is as for the diffuse variety, except that there is no need for restriction of fluids, and not so much need to restrict the protein.

B. *The albumen is* PERSISTENT *and is* ASSOCIATED WITH CASTS; BLOOD *is present microscopically and* ŒDEMA MAY BE PRESENT; *the disease is* **Subacute parenchymatous nephritis.**

§ **398.** When the symptoms and signs of acute nephritis do not subside within 6–8 weeks, the disease has entered the subacute phase. A large number of patients are first seen at this stage, occasionally because they have neglected to obtain advice, or more usually because there is no initial acute infection and the disease has been insidious from the commencement. There are two extremes of this clinical condition: (*a*) In

the usual variety œdema is the most prominent feature; (*b*) in rare cases œdema may be largely absent: intermediate cases are often seen. In either case, if the disease persists, it usually passes into the stage of secondary contracted kidney (§ 400).

(*a*) *The illness has been present for two or more months, and the general symptoms of renal disease pronounced;* GENERALISED DROPSY IS MARKED; *the* URINE IS SCANTY, *and* ALBUMEN *and* CASTS ARE ABUNDANT. *The disease is* SUBACUTE PARENCHYMATOUS NEPHRITIS (nephrotic type).

Subacute Parenchymatous Nephritis (synonyms: Large White Kidney, Subacute Glomerulo-tubular nephritis, formerly called Chronic Parenchymatous Nephritis) usually develops insidiously.

Symptoms.—(1) The albuminuria is considerable, $\frac{1}{4}$ to $\frac{1}{3}$ of the volume of the urine: the daily loss may be 20–30 G. (2) The other characters of the urine are: (i.) the diurnal quantity is diminished, (ii.) the specific gravity tends to be high, (iii.) it is often turbid with urates, (iv.) all forms of casts are met with (§ 392), (v.) blood is rarely absent but is usually only detected microscopically: relapses temporarily increase the amount of blood. (3) Generalised dropsy is a marked feature. At first it is most marked in the face, giving a general puffiness: soon it appears in all the loose cellular tissues of the body, and the serous cavities become involved, causing a general anasarca. The amount of œdema varies at different times, so that the patient may lose or gain many pounds in weight in the course of a few weeks. (4) A marked degree of anæmia is present sooner or later, the hæmoglobin falling to $\frac{1}{2}$–$\frac{1}{3}$ the usual values. (5) Lassitude and digestive disorders are common. (6) The blood pressure and the blood urea are very little raised. (7) The blood proteins are markedly lowered (below 5 per cent.), but the blood cholesterol is high. (8) After many months the œdema may subside. It is rare for the condition to be cured: more often the blood pressure and the blood urea are found to increase simultaneously with the disappearance of the œdema, renal function tests show progressive impairment of function, and the condition becomes chronic (secondary contracted kidney).

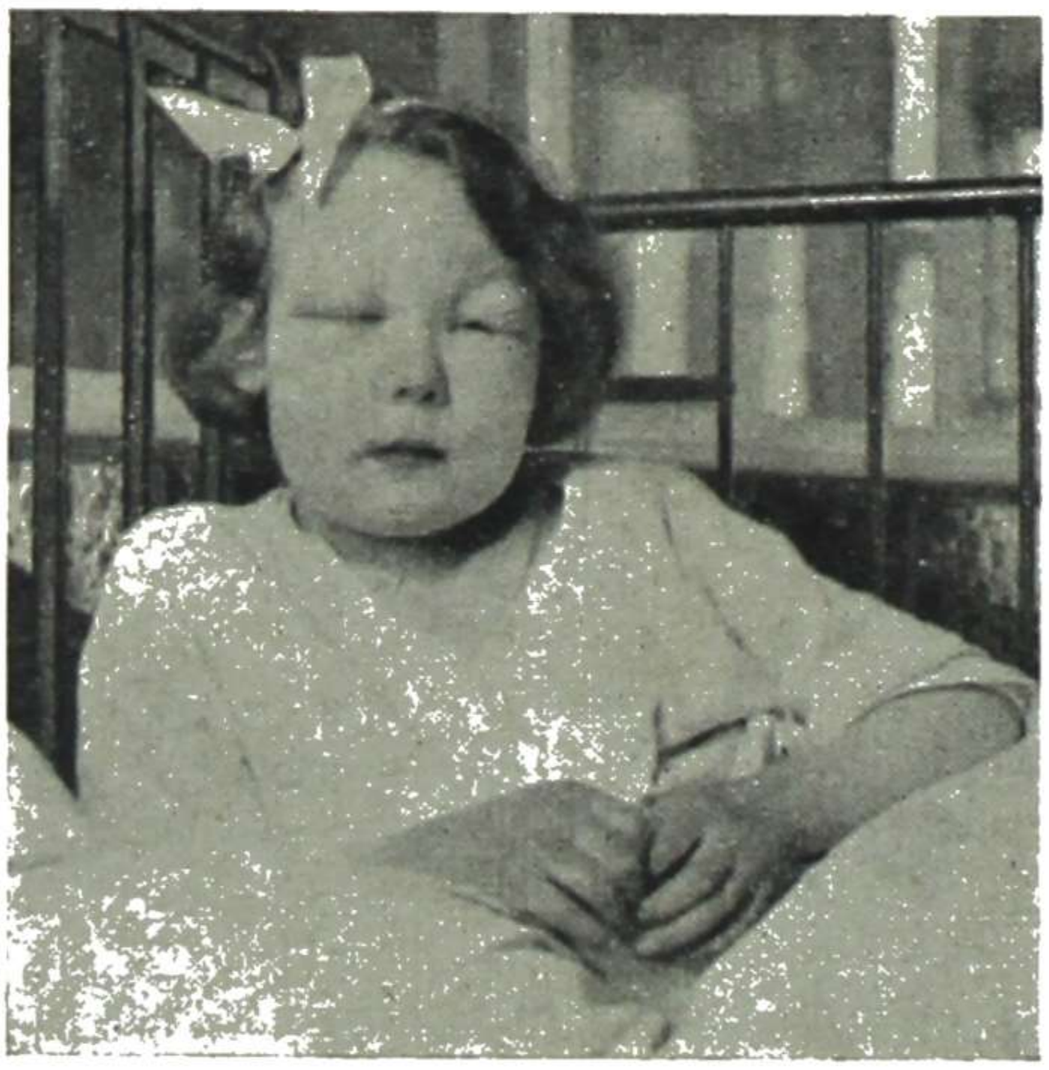

FIG. 106.—A case of Subacute Nephritis with Anasarca.

(*b*) *The illness is subacute, the urine containing* ALBUMEN, TUBE CASTS *and* RED CELLS: *the patient is* PALE, *shows occasional* PUFFINESS OF THE FACE, *and renal function tests show* PROGRESSIVE IMPAIRMENT OF RENAL FUNCTION. *The disease is* SUBACUTE NEPHRITIS WITHOUT MARKED ŒDEMA.

This variety is more commonly overlooked than the nephrotic variety, on account of the slight degree of œdema. The *symptoms* are: (1) The urine invariably contains a small quantity of albumen, and hyaline and granular casts. Microscopically, red cells are almost invariably present, indicating that the inflammatory process is still active. (2) Periodically, slight œdema may appear, especially in the face. (3) Symptoms of general debility, lassitude, anæmia, and headaches are present. (4) The blood pressure is raised, the systolic pressure being commonly 20–50 mm. above normal. (5) The blood urea is raised and kidney efficiency tests give a poor result. (6) The nephrotic type may supervene later.

Etiology of Subacute Nephritis.—The cause is usually not known. However carefully a septic focus is sought, according to Ellis it is rarely found. The insidious onset over a period of weeks or months makes the search more difficult. The average age of onset is later than in the acute varieties. Occasionally tertiary syphilis is causal.

Diagnosis of Subacute Nephritis.—When the insidious form occurs in young women it is often mistaken for *simple anæmia ;* in all such cases, examine the urine for albumen and tube casts. In the later stages it may be mistaken for *chronic interstitial nephritis* ; but in that disease the patient is usually older, and see Table XXII (p. 490). In certain cases which present *both renal and cardiac* symptoms, it may be very difficult to say *which condition is the primary* one.[1] In such cases it is important to note the following points: (i.) If there is a *history* of rheumatic fever and previous attacks of dropsy, it is probable that the cardiac condition is primary. (ii.) The presence of *other than mitral* systolic murmurs points to cardiac disease ; a mitral regurgitation murmur *alone* might be due to the cardiac failure following renal disease. (iii.) The *urine*, when there is any difficulty in diagnosis, is in both cases scanty and albuminous. Many tube-casts, and an appreciably raised blood urea, point to renal disease ; the rapid clearing up of the dropsy and improvement of the urine after a short period of rest in bed points to heart disease. (iv.) A *hard pulse* favours kidney disease, but an irregular soft pulse is found with cardiac failure secondary both to renal and to cardiac disease.

Prognosis.—It is rare for the disease to be arrested, but the prognosis is better in the non-œdematous variety. It is not uncommon for acute relapses to occur. A useful guide to the prognosis is furnished by successive renal function tests every six months. Death occurs with complications of uræmia, or as with acute nephritis. The prognosis is grave in proportion to (1) the amount of dropsy and albuminuria ; (2) diminution of urine and of nitrogen excretion ; (3) the height of the blood pressure. When this rises progressively the outlook is grave, whereas if the pressure remains the same or falls, the prognosis improves correspondingly. (4) Uræmic symptoms.

[1] It is well to bear in mind that when both cardiac and renal disease are present, they may be associated in three ways : (*a*) Cardiac disease may produce renal disease (§405. IX). (*b*) Renal disease may produce cardiac disease, as when acute or chronic nephritis lead to cardiac hypertrophy and failure. (*c*) They may both be the result of a common cause—*e.g.*, gout.

If a source of infection is found and removed, the outlook improves. When the stage of contraction sets in, life may be prolonged with care.

Treatment.—So long as subacute inflammation is present, the patient should be confined to bed, and this is essential when œdema is present. The main objects are (i.) to reduce or abolish œdema, (ii.) to remove septic foci, (iii.) to relieve the kidneys as far as possible. (i.) *Diet.* When œdema is present, the kidneys do not secrete sodium chloride and water, the urinary volume remains at a low figure, but on the other hand an enormous amount of albumen (often 10–25 grammes daily) is lost in the urine. The rational line of therapy is to limit the amount of fluid ingested to that which the kidneys can secrete per day, and salt should be avoided as far as possible : at the same time the protein intake should be of a high order, and this is of additional value for the urea so produced is a valuable diuretic (Maclean). A diet meeting these needs is given (§ 297. VIII. B.). If benefit is to be obtained with such a diet it should show itself in 6–8 weeks, and it is useless to continue it otherwise. In this case an ordinary diet can be resumed, with some restriction of total fluid and salt intake. It is unwise to use a high protein diet if the blood urea is already raised, and in any case weekly blood urea estimations are desirable : in these circumstances the Karell diet is often used (§ 297. VIII. B.). When there is little or no œdema, these strict diets are unnecessary and may be harmful by lowering the patient's resistance. The Stage III diet of acute nephritis is then useful. *Diuretics* may aid the elimination of fluid. Maclean found a remarkable diuretic effect can be obtained with 15 G. of urea dissolved in water, 2–3 times daily. Thyroid gr. 3–5 a day helps to reduce œdema. Another method is to give citrate and bicarbonate of potassium in the ratio 1 : 2 ; these act by raising the alkali reserve of the blood, antagonising the sodium salts in the tissues and acting as diuretics.

So long as the urea elimination tests give good results, these salts should be given in frequent small doses sufficient to make the urine strongly alkaline to litmus and to give a faint pink tint to 4–5 drops of phenolphthalein (*i.e.*, to pH 8·2). Often 200–300 grains a day are necessary and after a week a profuse diuresis frequently sets in and eliminates the anasarca.

Intramuscular injections of mersalyl are now used more freely than was once thought possible : the toxic effects on the renal tubules are usually very transitory, but need careful watching. This drug must never be given intravenously in nephritis, for in cases with a low plasma albumen sudden myocardial failure may occur.

Effusions in the serous cavities may have to be tapped if they are producing pressure symptoms, but scrupulous care must be taken to avoid infection. *Decapsulation* of the kidneys has been performed in resistant cases. (ii.) Septic foci must be searched for and carefully removed. The author has had encouraging results from penicillin therapy, even when a definite focus of infection cannot be found : but the penicillin must be given within 2 weeks of the onset of clinical symptoms. (iii.) To prevent further renal damage, chill and exposure must be avoided, the

bowels regulated, and all alcohol forbidden. (iv.) Although concentrated plasma transfusions are usually disappointing in that the transfused protein is rapidly eliminated, when anæmia is severe a blood transfusion is often helpful.

Nephrosis is a term used to describe a special type of parenchymatous nephritis. The essential lesion is a lipoid degeneration of the kidney tubules, without any signs of inflammation. Thus, in addition to marked œdema and albuminuria, there is hypercholesteræmia and slight myxœdema; but there are no cardio-vascular changes nor is there any nitrogen retention. At autopsy, the masses of lipoid in the tubules form the so-called "myelin" deposits.

C. *The* ALBUMEN *is* ASSOCIATED WITH CASTS. BLOOD *is usually* ABSENT *and the condition is* CHRONIC. *The disease is* CHRONIC NEPHRITIS.

§ **399.** There are three anatomical varieties of **chronic renal disease** attended with more or less albuminuria, which, when occurring in their typical forms, present well-marked clinical distinctions, as shown in tabular form on p. 490. In the condition of SECONDARY CONTRACTED KIDNEY, we are dealing with the end result of progressive acute and subacute nephritis with gradual destruction of the kidneys and replacement by fibrous tissue. In CHRONIC INTERSTITIAL NEPHRITIS there is no such history of previous acute or subacute nephritis; the onset is usually insidious, hypertension and arterial disease are often marked, and pathologically there is found considerable increase in the interstitial tissue of the kidneys and hyperplasia of the middle coats of the arteries. In the AMYLOID (Waxy) Kidney the vessels are primarily involved, the lardaceous degeneration beginning in the middle coat. Pathologists make many sub-divisions, but these represent the three clinically recognisable groups of chronic renal changes attended by albuminuria.

Following an attack of ACUTE *or* SUBACUTE NEPHRITIS *the patient complains of the symptoms of* INCIPIENT URÆMIA. *There is a small quantity of* ALBUMEN, POLYURIA *is present,* DROPSY *is slight or absent. The condition is one of* SECONDARY CONTRACTED KIDNEY.

§ **400. Secondary Contracted Kidney** (Synonym: Chronic Diffuse Nephritis). *Symptoms:* (1) Urinary changes: (i.) diminution of the large amount of albumen which was present in the early stage; (ii.) the volume of the urine rises; (iii.) the specific gravity falls, and the urea content is considerably reduced. (2) The dropsy disappears as the diurnal quantity of the urine increases. (3) The blood urea and the blood pressure rise progressively, and the left ventricle hypertrophies. (4) In the terminal stage of renal failure the urinary volume falls and uræmic symptoms ensue. In children a condition of renal rickets may accompany this form of nephritis. The treatment is as for chronic interstitial nephritis.

§ **401. Chronic Interstitial Nephritis** used to be regarded as a single clinical entity, but now different varieties are becoming recognised. It is convenient to reserve this term for a composite group of cases distinguished by *persistent albuminuria* and *cylindruria*, often with hypertension,

in which the progressive renal destruction is not due to a previous attack of acute or subacute nephritis. In one variety the primary cause is arterial disease associated with hypertension, benign or malignant, and recent experimental and clinical evidence regards the chronic renal destruction as being due to the diminution of blood supply to the kidneys. In another variety the kidneys are primarily at fault, due to congenital or acquired lesions: here the renal destruction often causes the liberation of a pressor substance which produces hypertension, the resultant arterial disease causing a "vicious circle." The clinical symptoms produced in these different types are influenced in part by the age of the patient, as when chronic nephritis causes renal rickets and renal dwarfism. A classification which includes most of these forms of chronic interstitial nephritis is:—

Type 1. Chronic Nephritis develops in a *middle-aged* or *elderly patient* suffering from *hypertension* (hypertensive nephritis).

(*a*) Benign hypertension.

(*b*) Malignant hypertension (Nephrosclerosis).

Type 2. Chronic Nephritis occurs in a *young person*, previously in good health, and *may* or *may not* be associated with *hypertension*. It is probably due to some congenital abnormality in the kidneys (renal dysbiotrophy).

(*a*) Chronic type.

(*b*) Rose Bradford type with acute symptoms.

or Chronic Nephritis occurs in a *young or middle-aged person* as a result of a *congenital cystic defect* (Congenital Cystic Kidneys). § 424. V.

Type 3. Chronic Nephritis occurs as a result of renal destruction by other causes, *e.g.*, renal calculus, hydronephrosis, chronic pyelonephritis.

1 (*a*). *The patient is* MIDDLE-AGED OR ELDERLY *and has suffered from* BENIGN HYPERTENSION *for years. The* DIURNAL QUANTITY OF URINE *increases, and* ALBUMINURIA *and* CASTS *appear: later signs of* INCIPIENT URÆMIA *develop. The disease is* CHRONIC NEPHRITIS *with* BENIGN HYPERTENSION.

Benign hypertension is a condition of hypertension which for long periods is non-progressive, or very slowly progressive, and associated in the majority of cases with no renal changes and no albuminuria (§ 94). In a small number of cases, albuminuria and casts appear later, due probably to renal arterio-sclerosis.

Symptoms.—(1) The symptoms of benign hypertension are fully described in § 94. When impairment of kidney function follows (i.) the albuminuria is small in amount, and many samples of urine may be examined without finding any. In cold weather, however, when there is deficient skin action, there is generally a trace, especially after a chill or any cause which produces renal congestion. The other characters

of the urine are: (ii.) The diurnal quantity is increased (perhaps to 100 ounces). The patient has to get up at night several times to pass large quantities of water. (iii.) The specific gravity is low (1002 to 1010), owing chiefly to the increased quantity of urine. (iv.) The urine is clear, pale, and contains but few casts, and these are chiefly hyaline or granular (Fig. 92). (2) Dropsy is usually absent. If dropsy occurs it is due to secondary cardiac failure. (3) The patient may look robust, but sometimes he has a greyish pallor. (4) The pulse indicates persistent high blood pressure, associated with hypertrophy of the left ventricle, and with a thickened condition of all the arteries. (5) There develops a condition of chronic or incipient uræmia (§ 371), due to the deficient elimination of nitrogenous and other substances.

Diagnosis.—Often the patient has been known to have hypertension for many years. Although degenerative retinal changes associated with retinal arterio-sclerosis are present, *papillœdema never occurs.*

Prognosis.—The disease is very slowly progressive, even when renal damage is present. The older the patient the better the outlook, and he is more likely to die of heart failure or apoplexy than of uræmia, even when renal disease is well established. With proper care and treatment, the patient may live for five or ten years. The amount of albumen is no criterion as regards prognosis in chronic interstitial, as it is in parenchymatous, nephritis.

1 (*b*). *The patient has suffered from* HEADACHE *and other symptoms of* HYPERTENSION *for months or years.* VOMITING, PRECORDIAL PAIN *and* ALBUMINURIA *develop, with* PAPILLŒDEMA. *The disease is* CHRONIC NEPHRITIS *with* MALIGNANT HYPERTENSION (MALIGNANT NEPHRO-SCLEROSIS).

§ **402. Malignant Nephrosclerosis** (Synonym: Chronic Focal Glomerular Nephritis) is accompanied by widespread cardio-vascular changes. There is no history of antecedent acute or subacute nephritis; often the patient has been in normal health and not known to have hypertension before symptoms arise. In other cases there has been benign hypertension for years, the condition developing into malignant hypertension in the course of a few months (see § 94).

Symptoms.—(i.) Headache, especially on waking, with vomiting, is associated with attacks of precordial pain, breathlessness, and nocturnal paroxysmal dyspnœa. An epileptiform convulsion may be the first symptom. (ii.) The blood pressure is very high, with figures of 240 mms. (systolic) and 130 mms. (diastolic) or more. A figure of 290/180 is not unusual in association with hypertensive cerebral attacks (§ 94). (iii.) The left ventricle is hypertrophied, the brachial and radial arteries contracted and hardened, and in the late stages stress and failure of the left ventricle are shown by attacks of œdema of the lungs, by tachycardia, premature beats, pulsus alternans and gallop rhythm. (iv.) Failing vision is due to changes in the fundus oculi: the fundi show papillœdema, contracted silver-wired arteries and patches of retinal degeneration, especially at the

maculæ. Whereas in the early stages of malignant hypertension there is little evidence of renal damage, later this becomes a prominent feature; when this occurs, (v.) the specific gravity of the urine becomes more and more fixed around 1012, albuminuria is marked, and the urinary deposit contains some red and white blood cells, and a number of hyaline and granular casts; (vi.) the blood urea may be normal when the patient is first seen, but later rises to 300 mgms. per cent. or more in spite of treatment; (vii.) symptoms of incipient uræmia become more marked, with loss of appetite and considerable loss of weight, thirst, impairment of mental and physical vigour, and tremor and twitchings of the muscles; hiccup is often very troublesome. The *Diagnosis* depends on the very high blood pressure, the retinal changes (and especially the papillœdema), the moderate or considerable albuminuria and the absence of a previous history of nephritis.

Etiology.—(i.) The disease may occur at any age, but most often between 30 and 50 years of age. (ii.) A family history of hypertension is very common.

Structural Pathology. (See § 94.) The kidneys are a little smaller than normal. There is fibrinoid necrosis especially of the afferent glomerular arteries, with acute focal degeneration of the glomeruli, and severe degenerative changes in the tubules.

Prognosis.—The course of the disease is relatively rapid once the kidneys are involved; patients rarely live more than two years after diagnosis. The greater the degree of hypertension, of albuminuria and especially of papillœdema when first seen, the worse is the prognosis.

2 (*a*). *The patient, who is* UNDER 30 YEARS OF AGE, *is found to have* ALBUMINURIA. *There is no previous history of acute or subacute nephritis.* HYPERTENSION *may or may not be present. The course of the disease is slow, but* URÆMIA *supervenes after a course of years. The disease is* CHRONIC NEPHRITIS *probably due to a* CONGENITAL DEFECT *in the kidneys.*

This little understood group has recently been separated from the heterogeneous group of chronic interstitial nephritis, and merits a separate description.

Symptoms.—(i.) The patient, who is usually 15–20 years of age, is found on routine examination to have chronic albuminuria. The amount of albumen is never large. The urine contains some red cells, and occasional granular and hyaline casts. (ii.) For months or years the patient may otherwise appear to be in perfect health, but sooner or later lassitude, attacks of pallor, and occasional headaches make their appearance. (iii.) From the time the patient is first seen there is often polyuria, the renal function tests give a poor result, with deficient urea concentration and urea clearance, and often a blood urea raised above the normal. (iv.) In some the blood pressure is raised, but it may be normal throughout. (v.) In cases before puberty, signs of renal infantilism or of renal rickets (§ 596) may be present.

Diagnosis.—In the earlier stages it may be difficult to distinguish

postural or orthostatic albuminuria, especially as the amount of albumen in both cases is reduced by rest in bed. Impaired renal function tests prove the kidneys to be diseased.

Etiology.—These cases are believed to be due to an inborn tendency to renal degeneration (dysbiotrophy); rarely they are familial, and at autopsy it is not unusual to find such congenital abnormalities as double ureters.

Prognosis.—The course is very slowly progressive, and it is common to find the patient living 5 to 10 years after the disease is discovered. It is often surprising how long a young person will live with a blood urea persistently raised at a level of 100 mgms. per cent. or more. The rapidity of the renal failure is best judged by periodic renal function tests.

2 (*b*). *The patient is commonly* 15–26 YEARS OF AGE, *and has not previously suffered from acute or subacute nephritis. He may be* SUDDENLY TAKEN ILL *with* URÆMIA, *and is found to have a* VERY HIGH BLOOD PRESSURE. *The disease is probably* CHRONIC NEPHRITIS (*Rose Bradford type*) *with* SMALL WHITE KIDNEYS.

The cause is unknown, but it does not follow acute or subacute nephritis. Often the first symptom is an attack of uræmia in an apparently healthy person. There is no œdema, the blood pressure is very high, the respiration assumes a hissing quality, and the urine is normal in quantity, of low specific gravity, with a few casts and more albumen than is met in the cases with red granular kidney.

§ **403.** 3. *A patient with* HYPERTENSION *and* ALBUMINURIA *also has symptoms of chronic* PYELONEPHRITIS, *a* RENAL CALCULUS *or* OTHER DISEASE OF THE KIDNEYS. *The disease may be* CHRONIC NEPHRITIS *associated with a* SURGICAL KIDNEY LESION.

As already discussed in §§ 87, 94, any lesion of a kidney which produces chronic renal destruction may cause the liberation of a pressor substance which produces hypertension and subsequent chronic nephritis in the sound kidney. Such lesions are chronic atrophic pyelonephritis, renal tuberculosis, renal calculus, hydronephrosis, or a renal tumour. When unilateral lesions are present, the progressive hypertension and the chronic nephritic lesions in the sound kidney may be controlled by surgical removal of the diseased kidney, and in certain cases the blood pressure may return to normal. In future it will therefore be necessary to investigate for these several conditions (*q.v.*) as part of the routine investigation of cases of hypertension and chronic nephritis. The best results are obtained by removing a unilaterally diseased kidney affected by chronic atrophic pyelonephritis.

Treatment of Chronic Nephritis.—The first aim is to discover the cause whenever possible. Septic foci should be eliminated, and drugs which damage the kidneys (such as phenol, cantharides, mercurial salts) avoided. When unilateral renal disease is present, such as chronic pyelonephritis or a calculus, considerations of nephrectomy arise. General measures include the avoidance of chill or of excessive mental or physical exertion, the administration of a suitable dietary (§ 297. VIII C.) when the blood urea is raised, and exercising extreme moderation with alcohol. Pregnancy is not permissible, as it increases the renal damage, and abortions

or a macerated fœtus usually result. Otherwise the treatment is that of the main complications: (i.) Heart failure will need rest in bed, the relief of hypertension, and of insomnia (§ 62). (ii.) Hypertension may be relieved by mannitol nitrate, gr. ½ or sodium nitrite, gr. 1, together with small regular doses of calomel; (and see § 94): malignant hypertension may require surgical treatment. (iii.) Anæmia does not necessarily respond to iron salts, and these may be injurious by leading to constipation: in certain cases transfusion of concentrated red cells may stimulate a hypoplasic bone marrow. (iv.) Treatment often resolves itself into the treatment of uræmia. In *chronic* uræmia keep the diet low, give enemas or high colon douches, and encourage the action of the skin. The treatment of *acute* uræmia—muttering delirium, convulsions, coma—is fully described in § 372.

There is **abundant albumen** *with the passage of* LARGE QUANTITIES *of urine, but little tendency to dropsy and uræmia; the patient is anæmic; there is a history of prolonged* SUPPURATION, *or of* SYPHILIS; *and there may be evidences of lardaceous disease elsewhere.* The disease is AMYLOID KIDNEY.

§ 404. Amyloid Kidney (Waxy or Lardaceous Kidney) is generally part of a widespread lardaceous disease. With more efficient modern surgical methods, amyloid degeneration is becoming a very rare condition.

Symptoms.—(1) The albumen, though it may be small in quantity in the early stage, is marked when the condition is established. (i.) The diurnal quantity is greatly increased, even to 150 ounces; (ii.) the specific gravity is very low, but the urea is not diminished till the later stages; (iii.) the colour is pale and clear; (iv.) all varieties of casts may be found, including amyloid and fatty casts. (2) There is great pallor of the surface and anæmia, but there may be no dropsy, till near the end. In cases with great cachexia dropsy *may* occur early (§ 29). (3) Other evidence of lardaceous disease is present—enlargement of the liver and spleen; consequently hæmorrhages may occur from different parts. Amyloid disease of the bowel causes intractable diarrhœa, and when it attacks the suprarenals the blood pressure is low.

It is important for the *diagnosis* to ascertain the history of a *cause*—namely, (*a*) prolonged suppuration, either from a chronic abscess, chronic phthisis, or caries. (*b*) Syphilis is an important cause.

Prognosis.—The patient may live long, dying from exhaustion from diarrhœa,

TABLE XXII.—CHRONIC ALBUMINURIA OF RENAL ORIGIN.

	Quantity of Albumen.	*Tendency to Uræmia.*	*Quantity of Urine.*	*Tendency to Dropsy.*
Subacute Parenchymatous Nephritis.	Large.	Moderate.	Diminished or normal.	Great.
Secondary Contracted Kidney.	Moderate.	Great.	Increased.	Slight.
Chronic Interstitial Nephritis.	Varies with the cause.	Great.	Increased.	Very slight.
Amyloid Kidney.	Very great.	Slight.	Greatly increased.	Slight.

or other complications; rarely from uræmia due to supervention of acute nephritis. With careful treatment patients may live for many years, or even recover if the disease is seen early; but the prognosis is bad in proportion to (1) the amount of albuminuria, and (2) the extent of the involvement of other organs. The prognosis is good if the cause is removed.

Treatment.—Alkalies have been reputed not only to prevent, but also to improve, the lardaceous process—*e.g.*, the tartrates and citrates of the alkalies. Iodide of potassium or of iron should be given, particularly in syphilitic cases. The most troublesome complication is diarrhœa. The only remedies of any use are liquor ferri pernitratis, ℥ 15; or pil. plumbi cum opio, gr. 5, continued every four hours until the diarrhœa ceases. The *preventive treatment* consists in the adequate treatment of syphilis in its early stages, and in curing prolonged suppuration.

D. *The* ALBUMEN *is* NOT *usually* ASSOCIATED *with* CASTS *or* BLOOD; *the condition is often* INTERMITTENT *and tends to be chronic.*

§ 405. The chief causes to be reviewed are:

I. PHYSIOLOGICAL.—Albumen occurs regularly in the urine of new-born infants in the first week of life, apparently due to the kidney not having gained its normal semi-permeability. Albumen is also present for some hours after any severe exercise, such as running or rowing. Probably the albuminuria is due to a temporary vaso-constriction of the renal vessels during exercise.

II. ORTHOSTATIC or FUNCTIONAL albuminuria occurs in the adolescent, as a result of the upright position. It therefore disappears at night, when asleep and in the horizontal position; occasionally it continues to be excreted for the first hour after lying down. It is commonest (i.) in young people; (ii.) it shows a familial tendency; (iii.) it occurs in tall people, during the periods of most active growth; it is associated (iv.) with a tendency to attacks of pallor, faintness and fatigue states; and (v.) with a low systolic blood pressure and often a low pulse pressure. *Diagnosis:* casts and other evidences of renal failure are absent, renal efficiency tests give normal findings and, if the patient voids urine an hour after going to bed, the morning specimen is free of albumen. The albuminuria often disappears with full doses of calcium salts. Mild cases of nephritis also may show albuminuria when the patient stands upright for long, but other evidences of renal disease are present.

III. KYPHOTIC albuminuria is due to a kyphotic stance causing pressure on the left renal vein. It disappears on correcting the cause.

IV. Any form of TOXÆMIA may produce albuminuria. The milder cases probably recover completely, with no permanent renal damage; more severe cases tend to progress to acute or chronic nephritis. In hyperpyrexia albuminuria is invariably present. A small quantity of albumen is common in febrile conditions, *e.g.*, in pneumonia, typhoid, diphtheria, diarrhœa and vomiting of infants, the reaction stage of cholera, secondary syphilis, tuberculosis, streptococcal infections and in any septicæmia. The albumen may be accompanied by some casts in the severe forms, but it disappears completely within 2 or 3 weeks of the subsidence of the fever.

V. Pregnancy.—The cause of the albuminuria is almost certainly a toxæmia, although mechanical pressure may play a part. The condition is more common in primiparæ. *Mild cases* occur after the sixth month; there is albuminuria (up to 0·2 per cent.), and an excess of renal epithelium and occasionally of casts. The blood pressure is slightly raised (systolic up to 150 mm.), but there are no signs of renal failure, such as œdema, retinitis, or urea retention. The condition rapidly disappears in the puerperium, but may recur in subsequent pregnancies. *Severe cases* may begin as mild cases, or they may start suddenly, often with eclampsia. The blood pressure is considerable (up to 230–240 mm.), and there is usually evidence of renal failure with œdema, oliguria, retinitis, headaches, drowsiness, muscular twitchings, etc. The condition may respond to medical treatment or may need artificial termination of pregnancy. It often passes into chronic nephritis, and recurs in subsequent pregnancies.

VI. Drugs and poisons are closely allied to the previous group. Common causes are mercury, arsenic, phosphorus, phenol, cubebs, copaiba, salicylic acid, quinine, lead, cantharides, turpentine, alcoholism, and vegetable or animal poisons such as mushroom or fish poisoning. Excessive protein intake may act in a similar manner. This cause is recognised by: (i.) the presence of the drug in the urine; (ii.) there may be a history of the administration of the drug; and (iii.) the albuminuria usually disappears when the drug is stopped.

VII. Endogenous poisons such as jaundice, diabetes, and acute gout may all cause temporary albuminuria.

VIII. Chill to the Surface.—This is recognised by: (i.) The amount of albuminuria is never great, and it does not last for more than a few days; (ii.) the urine is otherwise normal, or may deposit urates; (iii.) the patient is healthy, or complains only of slight bronchial catarrh or coryza.

IX. Mild renal congestion causes albuminuria in: (i.) right-sided heart failure; (ii.) rapid catheterisation of a distended bladder (and see Hæmaturia, § 406); (iii.) after epileptic fits.

X. Chronic gout and arterio-sclerosis lead to an ischæmia of focal areas in the kidneys. The urine is copious, of low specific gravity and contains at times a trace of albumen. The blood pressure is raised, but there is no tendency to uræmia (see § 93).

XI. Urinary calculi and crystals, especially oxalates, may give rise to albuminuria, but other signs are usually present (§ 408).

XII. "Leaky Kidney" or "Residual Albuminuria" is a name given to a condition of albuminuria which follows a past attack of nephritis, and is due to albumin leaking through the healed scars. It is known by: (i.) the absence of signs of renal failure, and the renal function tests are normal; (ii.) absence of casts; (iii.) normal blood pressure; (iv.) the condition is not associated with progressive renal disease.

XIII. Anæmia.—Severe anæmia may be accompanied by a trace of albumen.

XIV. Obscure Causes, *e.g.*, when albumen appears for unknown reasons, as (1) after burns and other causes of severe shock. (2) In exophthalmic goitre the albuminuria is usually temporary, though it may last for months. It may vary in amount at different times on the same day, which tends to show that it is of vaso-motor origin. The urine in other respects is healthy. (3) Excessive study or other cause of nerve strain has been reported to have occasioned albuminuria. (4) Certain cases of cerebral tumour, and other conditions in which there is increased intracranial pressure, have been attended by albuminuria.

The *Prognosis* of albuminuria in the above groups is that of its cause. Before

giving a prognosis it is important to examine thoroughly and repeatedly the urine, for casts in particular, so as to be satisfied that the kidneys are structurally healthy. Young subjects with functional albuminuria are not necessarily predisposed to kidney troubles, but they are often under par; the albuminuria will disappear as the general condition improves. The prognosis as to life is excellent.

Treatment.—The treatment must be directed to the cause. Rest in bed will do a good deal for the renal complication of cardiac disease. In the *albuminuria of pregnancy* careful investigations should be made, and the amount of urea watched. If (1) there is a clear history of renal disease prior to pregnancy, or (2) puerperal eclampsia has occurred in previous pregnancies, or (3) the renal disease, no matter of what kind it may be, is distinctly *progressive in its nature*, then termination of pregnancy or induction of premature labour should be advised. For the treatment of functional albuminuria general hygienic and dietetic rules must be followed. The administration of calcium lactate and alkalies temporarily stops the albuminuria.

E. *The* ALBUMEN *is* ASSOCIATED WITH BLOOD, *and* CASTS *are scanty or absent*—HÆMATURIA. When the condition is associated with severe abdominal pain, see renal colic, § 408.

§ 406. Hæmaturia.—When the patient is "passing blood" in the urine, an endeavour should be made to ascertain if the blood comes chiefly at the beginning of micturition, chiefly at the end, or whether it is intimately mixed with the urine and gives to it a "smoky" tint. For the test for blood in the urine and the methods of distinguishing it from hæmoglobinuria, see § 382. The fallacy of menstrual blood must be avoided by using a catheter.

1. *If the blood is bright crimson and comes chiefly* AT THE COMMENCEMENT *of micturition, it is probably of* URETHRAL *or* PROSTATIC *origin.*

In these circumstances, which are mainly of surgical interest, there will probably be a history of injury or gonorrhœa. In congestion or abscess of the prostate there are local pains or tenderness and rectal irritation. Urethral angioma and excessive sexual indulgence in the male and urethral caruncle in the female may lead to hæmaturia.

2. *If the blood comes most freely* AT THE END *of micturition, and especially if in clots, it is probably of* VESICAL *origin.*

The COMMONEST CAUSES of vesical hæmorrhage are:

I. ACUTE CYSTITIS, chiefly at its onset (see § 411). The bleeding is usually slight.

II. CALCULUS, or stone, in the bladder. Here the hæmorrhage is worse after exercise, moderate in amount, and there is pain, which, like the bleeding, is worse at the end of micturition and after exercise or jolting, and is frequently referred to the point of the penis. The ensuing cystitis may complicate the symptoms and render the diagnosis of stone difficult, but its detection by X-ray, the sound or cystoscope is conclusive.

III. TUMOURS of the bladder.—The hæmorrhage here, especially in *papillomata*, is usually great in amount. Shreds of the growth may be passed, and cystitis may develop. In *cancerous* tumours the hæmorrhage is more or less intermittent and resists treatment; there are pain and cachexia, and sometimes the growth may be palpable above the pubes or per rectum. Extension of tumours of neighbouring organs, or even spread of inflammation or congestion, as in appendicitis or dysenteric ulcers, may cause hæmaturia. The cystoscope is the best means we have of recognising the condition of the bladder.

IV. An enlarged PROSTATE may produce hæmaturia either from congestion or from the rupture of enlarged veins near the neck of the bladder.

V. Some of the LESS COMMON CAUSES of vesical hæmaturia are TUBERCULOUS DISEASE of the bladder, VESICAL VARIX, certain constitutional diseases such as SCURVY and PURPURA, and SCHISTOSOMA HÆMATOBIUM.

VI. § **407. Schistosomiasis** (Syn. : *Bilharziasis*).—The endemic hæmaturia of Egypt and South Africa results from the depositions of schistosomal eggs in the bladder by the adult female worm—*Schistosoma hæmatobium*—which lives in the portal system (§ 308, (3)) and pelvic plexuses of veins. Ova occur chiefly in the liver, bladder, lungs, prostate, lower third of the ureter, and in the pelvic viscera of the female ; occasionally they are deposited in the pancreas, spleen and colon. Carcinoma of the bladder or penis may occur.

FIG. 107. — EGG of *Schistosoma hæmatobium*, magnified about 120.

Symptoms : Urticarial eruptions, terminal hæmaturia, frequency, perineal, penile and suprapubic pain and aching in the lumbar region. The blood is bright red, occurs at the end of micturition, and is increased by exercise. Cystoscopic examination in the early stages shows round, yellowish-white, pseudo-tubercles and ulcers ; later, papillomata and sandy patches may develop. Schistosomal complement fixation reactions and intradermal tests are generally positive, and eosinophilia may be present, especially in the early stages. In the majority of cases terminal spined eggs are readily demonstrable in the urine. As the disease progresses the clinical picture may be modified by complications. Ureteric involvement may lead to back pressure on the kidney with hydronephrosis and chronic nephritis. Secondary bacterial infection of the genito-urinary tract is common, leading to septic cystitis, pyelonephritis and pyonephrosis ; urethral fistulæ and vesical calculi may occur.

Etiology.—After the eggs in the excreta come in contact with water, motile miracidia are set free, enter certain fresh-water snails of the *Bulinus* species and develop in the liver into sporocysts and later cercariæ ; these in turn escape into water, penetrate the skin of man during bathing, or invade the mucous membrane of the mouth and the œsophagus during drinking.

Treatment.—Antimony is specific, and the treatment of uncomplicated cases is highly satisfactory. The details of treatment are the same as in schistosomal dysentery (see § 308, (3) (*a*)). The presence of hepatic cirrhosis, splenomegaly, septic cystitis and renal involvement render effective treatment difficult ; surgery may be required for complications.

3. *If the blood is* INTIMATELY MIXED *with the urine, causing it to assume a "smoky" tint, it is probably of* RENAL *origin. In these cases also the tests for blood should be carefully applied, and fallacies avoided* (§ 382).

Symptoms and signs pointing to the kidney will usually be detected on examination.

The CAUSES of RENAL HÆMORRHAGE may for convenience be grouped under these headings : (I) Inflammation ; (II) Severe congestion ; (III) Nephroptosis ; (IV) Blood conditions ; (V) Renal calculus and crystals ; (VI) Drugs ; (VII) New growths ; (VIII) Essential hæmaturia ; (IX) Paroxysmal hæmoglobinuria ; (X) Injury.

I. INFLAMMATION : (i.) In acute nephritis the urine also contains casts (§ 397) ; (ii.) in subacute and chronic nephritis bleeding may occur during an acute exacerbation, or as a consequence of high blood pressure, in the same way that bleeding may occur from the nose (epistaxis) or into the brain ; (iii.) Infarction, due to subacute bacterial endocarditis (§ 50) ;

(iv.) Tuberculous disease of the kidney (§ 412); (v.) Acute pyelitis (§ 412); (vi.) Parasites, *e.g.*, *Schistosoma hæmatobia* (see above). The *Microfilaria sanguinis hominis* usually causes chyluria, but hæmaturia may also occur.

II. Severe congestion.—Mild congestion causes albuminuria, but marked congestion causes hæmaturia also. (i.) The commonest cause is right-sided heart failure (§ 55). The scanty, highly-coloured urine contains at first albumen only, but later a large quantity of albumen, accompanied by blood. Particularly in long-standing cases, there is an excess of hyaline casts. (ii.) Sudden congestion occurs after rapid catheterisation of a distended bladder, probably as a result of sudden relief of a bilateral hydronephrosis. Suppression of the urine may also ensue. It can be avoided by emptying the bladder gradually. (iii.) Thrombosis of the renal vein causes acute congestion. It occurs chiefly with streptococcal infections, and rarely in cachectic states—sudden hæmaturia with rapid enlargement of a tender kidney is very suggestive. (iv.) Sudden congestion may occur with a patient who has been bedridden for many months, as with a fractured femur (Wilson), usually on the second day of walking. There is colic, hæmaturia, and pain in the loin, which disappear when the patient returns to bed for a few days.

III. Nephroptosis, with or without aberrant renal vessels, may produce intermittent attacks of hæmaturia, probably congestive in origin.

IV. Blood conditions, especially scurvy, purpura and malaria.

V. Renal calculi and crystals, particularly oxalates, produce renal colic and hæmaturia (§ 408).

VI. Drugs, particularly salicylates, phenol and its derivatives, sulphapyridine and sulphathiazole, hexamine, cantharides and turpentine can cause hæmaturia.

VII. New growths of the kidney (carcinoma, sarcoma, hypernephroma and polycystic disease), or of the renal pelvis (papilloma, carcinoma) (§ 424). The hæmaturia is often painless, and either intermittent or continuous.

VIII. Essential Hæmaturia (nephritis dolorosa hæmorrhagica) is a name given to a group of cases in young adults in which either slight or severe unilateral hæmorrhage is accompanied by paroxysmal colic or dull renal pain. The cause is probably a patchy nephritis; bleeding usually ceases dramatically after nephrotomy; nephrectomy should not be performed.

IX. Paroxysmal Hæmoglobinuria is not, strictly speaking, hæmaturia. Free hæmoglobin is plentiful in the urine (§ 409), but blood discs are absent.

X. **Injury of the Kidney,** laceration or rupture, is usually caused by a fall on the back of the loin, or in "buffer accidents" on the railway, or in street accidents. There may be no bruising or external signs, but a laceration of the kidney may be inferred from (1) the history of such an accident; (2) a tense swelling (due to extravasated blood) with increased area of dulness in the region of the kidney; and (3) copious hæmaturia. In a few cases there is no hæmaturia, and the other two evidences have to be relied on. Immediate operation is sometimes necessary, the collapse being treated by blood transfusion or saline injections.

§ **408. Renal Calculus and Renal Colic.**—Calculi may form either in the pelvis of the kidney (Fig. 103) or, more rarely, in its substance. Perhaps the commonest form, dark brown in colour, consists of *calcium oxalate*,

and gives rise to more acute symptoms, for each bristles with sharp-pointed crystals which cause bleeding and colour the calculus. Another form consists of *uric acid* and urates mixed in varying proportions (§§ 388, 393). These form light brown stones, round or branching, and are the commonest stones in gouty subjects, and those whose highly acid urine habitually deposits urates. These two stones occur in acid urine. Calculi are often multiple. Compound stones consist of an oxalate or organic nucleus, or alternate layers. Phosphate stones are rare and usually occur where infection is present, in an alkaline urine. Cystine and xanthin are rarely met with renal calculi. Various *events* may happen. (1) A large calculus may remain in the renal pelvis, giving rise to chronic pyelitis (§ 412) for years (Fig. 103); or (2) by its movement produce acute symptoms, RENAL COLIC. (3) It may obstruct the ureter and lead to hydro- or pyo-nephrosis (§ 424). (4) If the other kidney is not healthy sudden blocking may lead to obstructive suppression (§ 421). (5) It may pass into the bladder and result in cystitis. (6) Small stones may be voided through the urethra as "gravel." (7) In rare cases small calculi become encysted and quiescent. (8) Hypertension may develop (§§ 87, 403). The clinical history of renal calculus consists of (*a*) *attacks of renal colic*, separated by (*b*) *intervals* in which the symptoms are those of calculous pyelitis.

The *Symptoms of Renal Colic* consist of severe paroxysms of lancinating pain, starting in one loin, shooting down to the front of the thigh or testicle or vulva on that side. This is associated with retraction of the testicle and with frequency of micturition, and is attended by vomiting, shivering, sweating, pallor, and a certain amount of collapse. These symptoms are in most cases followed by hæmaturia, the urine containing blood and pus cells, but usually no casts. Crystals may be present, and reveal the nature of the stone. Most blood and pain occur with an oxalate calculus.

The *diagnosis* of renal from other forms of colic is given in Table XIV, § 246. Cystoscopic examination may reveal blood issuing from one ureteral orifice or even an impacted calculus. X-ray examination is of assistance except in the case of uric acid and cystine stones. All the symptoms of renal colic may arise simply from the irritation of *fine crystals*. They may also be produced without alteration in the urine by *movable kidney*; or by the passage of *clots* of blood or *caseous material* down the ureter. *Malignant* disease of the kidney may be mistaken for calculus, but in that case the blood is more copious and more constant, and the pain is less severe, but more continuous.

Treatment.—(1) Of the colic and (2) during the intervals. 1. The treatment of an attack of *renal colic* consists mainly in the relief of the symptoms—pain, vomiting, and collapse. Usually nothing avails except injections of morphia, papaverine, ephedrine, trasentin or atropin. Locally, hot applications relieve. Effervescing citrate of potassium with spiritus ammoniæ aromatici may be administered with advantage. After the painful attacks the patient must rest to allow the inflammation to sub-

side. 2. The treatment in the intervals resolves itself into the removal of the stone, and treatment directed to the pyelitis. The urine in all cases should be kept diluted by drinking plenty of fluid. Dietetic treatment is of great use in some cases. If oxalates are being passed, any dyspepsia should be carefully treated; for diet, see § 297. XV; if the urine is kept strongly acid with sodium acid phosphate or with ammonium chloride, the crystals are kept in solution. In uric acid cases a purin free diet is given. The alkaline waters are very useful here, such as those of Vichy, Ems, and Contrexéville. In uric acid calculus large doses of alkaline salts are certainly useful, especially the citrate and the acid tartrate of potassium. Begin with potassium citrate gr. 50 in 4 fl. oz. of water every four hours until the urine is alkaline, and then give an effervescing drink, consisting of sodium bicarbonate gr. 60, and citric acid gr. 40 in 4 ounces of water, t.i.d. This treatment should not be continued if the urine is or has become ammoniacal. For pyelitis, see § 412. Operative treatment is often called for, although small stones are often passed spontaneously. Before operation the function of the other kidney must be investigated.

Hyperparathyroidism due to an adenoma can occur with minimal bone changes: any patient with a renal calculus (especially if multiple) and a serum calcium over 12 mgm. per cent. should be suspect.

§ **409.** In **Paroxysmal hæmoglobinuria** porter-coloured urine is passed at intervals. An attack commences abruptly with (1) a rigor and temperature to 104°, nausea, headache and malaise. (2) Abdominal cramp, aching pains in the back and legs: severe shock may follow. (3) An hour or so later the patient passes dark, highly albuminous urine, showing the spectroscopic bands of methæmoglobin, oxyhæmoglobin and hæmatin, containing no red cells, but albumen, red cell casts and amorphous hæmosiderin may be present. Anuria is a dangerous sequela. (4) In severe cases, a hæmolytic anæmia is present which may endanger life. Thrombosis and infarcts are common. Free hæmoglobin can often be detected in the plasma as well as in the urine. Each attack lasts a few hours, passes off suddenly only to recur later.

The types are—(1) In 90 per cent. of the cases (Roberts) the attacks are connected with chill to the surface. In this type attacks are induced by immersing a hand in ice-cold water for 10–20 minutes. A hæmolysin is present in the serum which unites with the red cells when the temperature is lowered and lyses them when the temperature rises again (Donath-Landsteiner reaction). The cause is usually syphilitic as in most cases stigmata of acquired or congenital syphilis are present, the Wassermann reaction is positive, and the disease is cured by antisyphilitic measures.

(2) In the second decade hæmoglobinuria may follow severe exertion, and especially running on a metalled road. Hæmoglobinæmia is usually absent, and it has been suggested the hæmolysis occurs locally in the renal vessels (Witts). It is often accompanied by lordosis, and treatment to overcome this helps. Patients are spontaneously cured in a year or so.

(3) Recurrent hæmoglobinuria, usually occurring at night with a hæmolytic anæmia (Marchiafava-Micheli syndrome), is often associated with splenomegaly, some bronzing of the skin and a constant reticulocytosis. Sooner or later the severe anæmia and hæmolysis endanger life, but splenectomy and transfusions are unavailing. The cause is associated with an altered pH in the blood at night. Death usually occurs in three to five years.

(4) Massive toxæmia with Cl. Welchii or with the Bartonella of Oroya fever, and the hyperacute form of Lederer's anæmia, are occasional causes.

(5) Favism following ingestion of the sensitised portion of the bean Vicia fave.

(6) In paralytic hæmoglobinuria the pigment is myohæmoglobin and is associated with weakness and paralysis of skeletal muscles.

The *Diagnosis* depends on the precipitating cause. Only in the form due to exposure to cold is syphilis a factor.

The *Treatment* consists of rest in bed during the attacks, with warmth.

HÆMOGLOBINURIA AND METHÆMOGLOBINURIA occasionally accompany severe burns and acute infective diseases, especially malaria. It may be produced by toxic doses of chlorate of potassium, nitrites, pyrogallic acid, arseniuretted hydrogen, and quinine in those who have had malaria. Blackwater fever, see § 511. Hæmoglobinuria also occurs after incompatible blood transfusions (§ 537).

EPIDEMIC HÆMOGLOBINURIA is seen in the new-born, with jaundice and nervous symptoms.

F. *The patient complains of* LASSITUDE *and ill-health, which may be associated with fever; the urine is found to contain* PUS (§ 385)—*i.e., there is* PYURIA. *With few exceptions, when the pus comes from the* BLADDER *the urine is* ALKALINE, *and the pus remains diffused through the urine; but when it comes from the* KIDNEYS *or any other part of the urinary passages, the urine is* ACID, *and the pus settles at the bottom. Pus cells are often accompanied by a trace of albumen in the urine.*

§ 410. Pyuria.—If we except the rupture of an abscess into the urinary passages, there are three sources of pus in the urine:

1. From the **Urethra** (*e.g.*, gonorrhœal or B. coli infection).
2. From the **Bladder** (cystitis).
3. From the **Kidney** (pyelitis).—The chief forms are due to B. COLI INFECTION, or to ASCENDING, CALCULOUS or TUBERCULOUS PYELITIS.

Abscesses bursting into the Urinary Tract.—The abscesses most liable to burst into the urinary tract are: abscess due to diverticulitis; prostatic abscess (below); perineal abscess; pelvic cellulitis; psoas abscess; perinephric abscess; and abscess of the liver; and there are also many other sources. (i.) The urine is usually acid; (ii.) the pus is in large quantity and settles at the bottom; (iii.) there is a clinical history of abscess prior to the appearance of pus in the urine; and (iv.) localising signs of the abscess may be present.

It is believed by some observers that persons in health may pass a few leucocytes, but it is extremely probable that these are always derived from the generative organs (male or female), and that the occurrence of *any* pus cells in a properly collected catheter specimen is always pathological: a number of leucocytes are present in acute and subacute nephritis. Special precautions may have to be taken to exclude pus mixing with the urine as it is passed (false pyuria). When the presence of pus is suspected, the reaction should be tested immediately after it is passed, before decomposition makes the urine ammoniacal.

1. *The* **pus** *comes chiefly at the* BEGINNING OF MICTURITION, *and the urine is* ACID; there is PAIN IN THE URETHRA during micturition. The pus comes from the URETHRA, and is usually caused by one of three conditions:

I. URETHRITIS.—There is pain, swelling, and redness of the meatus, scalding during micturition, and discharge of pus cells (often with gonococci) apart from micturition.

II. PROSTATIC ABSCESS is known by: (1) pain in the perineum, which is worse at the end of micturition; (2) the finger in the rectum detects a tender, fluctuating swelling; (3) the symptoms closely resemble those of vesical calculus with concurrent cystitis. It may be distinguished from this, however, by: (i.) a history of gonorrhœa, which is the chief cause of prostatic abscess; (ii.) the signs on examination per rectum; and (iii.) a discharge occurring in the intervals between micturition.

III. PERINEAL ABSCESS is detected by the local signs.

2. *The* **pus** *comes chiefly at the* END OF MICTURITION, *or is intimately mixed with the urine. There is* SUPRAPUBIC PAIN *or* DISCOMFORT *and frequency of micturition.*[1] The pus comes from the BLADDER, and is indicative of CYSTITIS.

§ **411. Cystitis,** or inflammation of the bladder, occurs in two well-recognised forms—acute and chronic.

(*a*) ACUTE CYSTITIS.—(1) In this condition the pus is in small amount, and in severe cases there may be considerable hæmaturia at the onset. At first the urine is acid, but it soon becomes alkaline, and ropy with pus and mucus. (2) There are pain and tenderness in the hypogastrium. (3) Micturition is frequent and painful ("scalding"). There is a constant desire to pass water immediately after micturition (strangury); this relieves the pain for a short time, unless the cystitis is due to stone in the bladder, when the pain is severe *after* micturition, because the inflamed walls of the emptied bladder come into contact with the stone. (4) There is generally marked constitutional disturbance, with pyrexia.

(*b*) In CHRONIC CYSTITIS (which may supervene upon the acute form, or may be chronic from the onset), there is (1) a larger amount of pus. (2) The urine is alkaline directly it is passed and contains a large amount of ropy mucus.[1] (3) The pain and other symptoms are less severe than in acute cystitis.

Etiology.—Infection of the bladder is rarely primary in origin. Predisposing causes are: (i.) the presence of residual urine, the bladder never being completely emptied. This occurs with prostatic enlargement, urethral stricture, atony of the bladder in old age, and various nervous disorders producing paralysis and retention (§ 420). (ii.) Stone or foreign body; (iii.) papilloma, carcinoma and other tumours; (iv.) diverticulum of the bladder; (v.) following surgical operations on the bladder or other pelvic organs. Infection spreads to the bladder: (i) in the stream of urine from the renal pelvis, as in B. coli and tuberculous pyelo-nephritis; (ii.) from adjacent organs, especially cervicitis, diverticulitis or growths of the colon and rectum (forming a fistula), pelvic cellulitis or pelvic peritonitis; (iii.) via the urethra, as after the passage of infected instruments or foreign bodies introduced by the patient, by extension of urethritis, and possibly via the wide urethra of women, especially when there is leucorrhœa or infection of Bartholin's glands or Skene's ducts.

[1] The urine may be acid—(i.) at the onset of acute cystitis; (ii.) in the stage of recovery from chronic cystitis; (iii.) in the early stage of tubercle and new growths of the bladder; (iv.) in cystitis due to Bacillus *coli communis*. In all other conditions in which the urine contains pus derived from the bladder the reaction is alkaline.

Almost any variety of organism may be found, but the most common are (*a*) in acid urine B. coli, tubercle bacilli and gonococci, (*b*) in neutral urine B. coli and streptococci, (*c*) in alkaline urine staphylococci and B. proteus. For schistosomiasis, see § 407.

Differentiations.—(1) Cystitis due to VESICAL CALCULUS.—In addition to the symptoms of simple cystitis, there are (i.) very severe pain at the end of micturition lasting for some time after, shooting down the urethra; pain is often much worse after jolting, as on a bus ride. (ii.) Hæmaturia is common, though in some cases it may be so slight that it is detected only by the microscope; (iii.) sometimes a preceding history of renal colic (§ 408); (iv.) the stone may be detected by the sound, the cystoscope or by radiography.

(2) Cystitis due to NEW GROWTH IN THE BLADDER, or ULCERATION, is characterised by (i.) continuous suprapubic pain, with paroxysms of lancinating pain, quite independent of micturition and movement; (ii.) copious hæmorrhage at intervals; (iii.) the urine may contain cancer cells or tubercle bacilli; a tumour may be felt per rectum or through the abdominal wall. (iv.) Cystoscopic examination or radiography may settle the diagnosis. The cancerous ulcer is often covered by a fine deposit of calcium phosphate which gives a characteristic X-ray appearance.

(3) ABACTERIAL PYURIA causes the symptoms and signs of cystitis and urethritis, but organisms cannot be cultured from the urine and tubercle bacilli cannot be found. The amount of pus from the bladder and urethra may be considerable and cystoscopy reveals generalised cystitis. *Treatment:* the disease fails to respond to the usual urinary antiseptics but disappears rapidly after 1 or 2 small doses of neoarsphenamine. Relapse may occur unless septic foci are treated.

Prognosis.—Cystitis is not dangerous to life unless the inflammation spreads upwards from the bladder to the kidneys and produces pyelonephritis; but, on the other hand, it is a very troublesome, painful complaint, and has a special liability to recur. When the cause is not removable—*e.g.*, in cystitis due to tumours of the bladder—the prognosis is very grave. When it is due to retention of urine, and when it is due to gonorrhœa, it tends to cause ascending pyelitis and pyelo-nephritis. When there is pre-existing hydronephrosis (§ 424), and acute cystitis develops, the inflammation is almost certain to extend upwards to the kidney, and so lead to pyonephrosis.

Treatment.—The cause must be sought for, and, if possible, removed. (*a*) Otherwise, in the *acute* form absolute rest in bed with milk diet is necessary. Copious libations of water, barley-water, and other bland fluids are called for. The drug chosen will depend on the infecting micro-organism: with coli infections, a sulphonamide drug with alkalies, streptomycin or mandelic acid preparations should be used as for pyelitis (§ 412); but in coccal infections penicillin or hexamine and sodium acid phosphate should be used—otherwise boric acid (gr. 10) and salol (gr. 5). The sulphonamide group of drugs has been found to have a lethal effect on gonococci, and on many strains of B. coli, B. proteus vulgaris, and occasionally staphylococci. B. proteus and Ps. pyocyaneus infections are most obstinate and often respond to chloromycetin or to lavage with acriflavine (1 in 8,000). Hyoscyamus, hot sitz-baths and morphia suppositories relieve pain. (*b*) For the *chronic* and *subacute* forms, apart from the drugs just

mentioned, it may be necessary to wash out the bladder with warm water and boric acid (gr. 10–20 to 1 fl. oz.), or with mercury oxycyanide ($\frac{1}{4000}$–$\frac{1}{8000}$), followed by normal saline to prevent mercurialism. Cystopurin, hexyl-resorcinol and pyridium are also good. *Prophylactically*, penicillin injections are very valuable in those with a paralysed bladder, *e.g.*, in paraplegia.

3. *The* **pus** *is associated with a urine which is* ACID *when freshly passed* (**acid pyuria**), *the pus cells are at first disseminated through the urine, but in a short time they settle down as a* SEDIMENT, *and there is* PAIN, *perhaps* SWELLING *of the kidney, and* PYREXIA ; the pus comes from the kidney—the disease is PYELITIS.[1]

§ **412. Pyelitis,** or inflammation of the pelvis of the kidney, is indicated by the symptoms just mentioned. The urine, which is acid unless there be concurrent cystitis, contains, in addition to pus cells (Fig. 95), epithelial cells from the renal mucosa and often red blood cells ; but, unless the renal parenchyma is involved, no casts and no albumen in excess of the quantity which would be accounted for by the pus are found, nor is there any dropsy. There is increased frequency of micturition. Renal pain and tenderness are nearly always present, but they vary widely in degree and character in the three varieties about to be mentioned. *The kidney should always be carefully examined* (§ 394), because, in addition to the renal congestion, all forms of pyelitis are liable to result in partial or complete obstruction of the infundibula, and the gradual supervention of pyo-nephrosis. A few pus cells in the urine may be found in acute nephritis, with typhoid and other fevers, and toxic doses of cantharides or turpentine. Apart from these there are four well-marked varieties of acid pyuria.

(I) PRIMARY INFECTIVE PYELITIS.—This is the commonest group, and in the majority of cases the kidney is primarily infected from the blood stream by the bacillus coli. The disease occurs chiefly in females, either children or adults, and especially during pregnancy. The right kidney is most commonly involved, but both kidneys or only the left may be affected. The disease may be acute or chronic. (*a*) ACUTE PYELITIS. *Symptoms :* (i.) *Constitutional :* sudden onset, with headache, languor, anorexia, shivering, sweating, dry furred tongue and pyrexia of swinging type, up to 103 or 104° F. In adults, one or more rigors, and in children convulsions may occur. (ii.) *Urinary :* The first symptoms are often due to bladder irritation—frequency of micturition, perhaps every 15 to 20 minutes, sometimes associated with strangury. Later, a dull ache in the loin is felt, and local tenderness and rigidity develop. Sometimes acute abdominal pain may simulate appendicitis. The urine is concentrated, and contains a trace of albumen, pus cells, bacilli, occasionally

[1] In obscure or resistant cases it may be necessary to collect a specimen of urine from each kidney by ureteric catheterisation. This will confirm that pus cells and organisms are derived from the *kidney*, and will decide whether from one or both sides. This procedure should never be undertaken if the bladder is extensively septic, lest ascending pyelo-nephritis be induced.

a considerable amount of blood. In the earlier stages the amount of pus and bacilli may be microscopic, but later the urine is uniformly turbid, gives a shimmering appearance when rotated in a glass, and has an unmistakable fishy odour, due to the presence of sulphides. (*b*) CHRONIC PYELITIS or BACILLURIA. *Symptoms:* (i.) *Constitutional:* general ill-health, headache, periodic low-grade pyrexia. (ii.) *Urinary:* frequency of micturition, enuresis in children, pain in the loins or hypogastrium. The urine shows a trace of albumen, pus, bacilli and occasional hæmaturia, as in the acute form.

Etiology.—(i.) The *Bacillus coli* is the common infecting agent and may arrive (*a*) from the blood stream, (*b*) from the colon, and (*c*) from the pelvic organs by the lymphatics. (ii.) When other organisms are present, such as staphylococci, streptococci, *B. pyocyaneus*, *B. proteus* or *B. subtilis*, the infection is often secondary to some other disease of (*a*) the kidneys, such as hydronephrosis, tuberculosis, or to some congenital abnormality, such as double ureters: or (*b*) disease of the bladder, prostate, cervix uteri, Bartholin's glands or Skene's crypts.

II. ASCENDING PYELITIS OR PYELO-NEPHRITIS arises from: (*a*) *obstruction of the urinary passages* below the kidney. The resulting retention and decomposition of the urine causes infection to arise, which may go on to pyo-nephrosis. (*b*) *Extension of cystitis* without obstruction, and thus the numerous causes of the latter disease (§ 411) are brought into operation. *Symptoms:* (i.) A high swinging temperature, often with repeated rigors. (ii.) Pain, tenderness, rigidity, and often a considerable enlargement of the kidney may be felt in the loin. (iii.) There may be a history of the cause, *e.g.*, enlarged prostate, renal calculus. (iv.) Often both kidneys are involved, with gradual diminution of the urinary output and symptoms of uræmia. *Treatment:* Surgical aid should be sought early. If time permits, special investigations as to the cause and the functional condition of the kidneys should be undertaken.

III. CALCULOUS PYELITIS is due to the irritation and obstruction set up by the presence of a stone. The *Differential Symptoms* are: (i.) A history of renal colic (§ 408) is often obtainable. (ii.) Pain on the diseased side, which varies with exercise; and (iii.) hæmaturia, also varying with exercise. (iv.) The quantity of pus often varies from day to day, and the patient may feel easier after its discharge, as the retained pus causes pain, and sometimes swelling. (v.) Attacks of intermittent pyrexia and sometimes rigors. (vi.) Crystals in the urine aid the diagnosis considerably.

IV. TUBERCULOUS PYELO-NEPHRITIS.—Tuberculous disease of the kidney may be primary or secondary to tubercle elsewhere, and is often associated with tuberculous infection of the genital system. Sometimes both kidneys are diseased. This condition may be difficult to diagnose from Calculous Pyelitis. *Differential Symptoms:* (i.) Increased frequency of micturition, and perhaps strangury, is the commonest early symptom; (ii.) hæmaturia occurs in 75 per cent. of cases (Fullerton); (iii.) dull pain in the loins, liable to colicy exacerbations from the passage of caseous masses; (iv.) *pyrexia of a regularly intermitting type;* (v.) the urine is acid, contains some albumen, pus and often red blood cells. Tubercle bacilli may be demonstrated in the deposit of a 24-hours' specimen, by culture, or by guinea-pig inoculations; other organisms are absent unless secondary infection has occurred. A sterile pyuria

is often tuberculous or due to abacterial pyuria; (vi.) the cystoscope may show the presence of swelling or ulceration at the mouth of one ureter. The tuberculous focus in the kidney may or may not be constantly in connection with the ureter (the "open" and the "closed" types). In the latter, many specimens of urine may have to be searched before tubercle bacilli are found.

Prognosis.—With modern methods of treatment, uncomplicated coli pyelitis usually clears up within 3–4 weeks, and provided the urine has been rendered sterile, as shown by examination of catheter specimens, relapse is unlikely. The course of ascending pyelitis depends very much upon the cause, the possibility of its removal, the age of the patient and the general condition: it used to be the common mode of death after fracture of the spine or transverse myelitis. Calculous pyelitis may last for years, but after surgical removal it may be possible to sterilise the urine with modern drugs. In the tuberculous form the prognosis depends on whether one or both kidneys are involved, the possibility of successful surgical removal, and the presence of lesions elsewhere. Pyelo-nephritis and pyo-nephrosis (§ 424) may follow all the chronic forms of pyelitis.

Treatment.—In all forms of pyelitis fluid diet and warm drinks, rest in bed and warmth, are essential; cupping of the loins is sometimes useful. (1.) The most common form is that due to bacillus coli infection. When there is fever, the best drugs are equal parts of potassium citrate and sodium bicarbonate (grs. 30 of each). This dose must be given four, three or two hourly (even at night) until every specimen of urine is alkaline to litmus paper. Sulphanilamide or one of the other sulphonamides (G. 1 six-hourly) can be combined with these doses of alkali, and acts best in a strongly alkaline urine.[1] At the same time copious drinks of fluid must be given (4 to 6 pints daily); with this the temperature should settle in 3 to 4 days and the urine be sterile in 7 to 10 days. If alkalies alone are used once the fever and vomiting have been controlled, it is preferable to make the urine strongly acid. For this purpose hexamine (gr. 20) before meals, and sodium acid phosphate (gr. 30) after meals, were formerly used and are still most effective with those forms of B. coli which are "late lactose fermenters." Apart from these older methods, streptomycin is giving excellent results. The ketogenic diet has been replaced by mandelic acid preparations. To obtain the maximum bactericidal effect fluid intake must be limited to 2 pints daily and the urinary acidity maintained below pH 5·5 (*i.e.*, a red colour when tested with methyl red). Sodium mandelate (G. 3 t.i.d.) is combined with sodium acid phosphate or ammonium chloride (G. 1–3 t.i.d.); these are better given as ammonium mandelate (G. 3 t.i.d. or q.i.d.). Calcium mandelate in similar doses is equally efficacious and less nauseating. With these preparations the urine should be sterile in 2–3 weeks. Whichever method is used, it must be continued until two successive specimens of urine at

[1] In view of the very variable susceptibility of different strains to the various sulphonamides, in a resistant case it is wise to perform laboratory tests to determine which sulphonamide is best.

an interval of 1–2 days are sterile. *General measures.*—Diet is important. Food of high protein content should be avoided; skimmed or ordinary milk, raw salads and fruits and wholemeal bread taken freely. The bowels must be regulated by mild aperients, such as paraffin, petroleum agar, senna, etc., so that the stools are neither constipated nor loose. Colon irrigation is sometimes advisable. *B. acidophilus* and intestinal antiseptics aid. (2.) When the infecting pyogenic organism is other than *B. coli* the urine must be kept acid with sodium acid phosphate, and antiseptics used, such as hexamine, hexyl-resorcinol or pyridium. Preparations of mandelic acid sometimes succeed in cases other than those due to *B. coli*. In staphylococcal infections penicillin injected is valuable: boracic acid (gr. 10) and salol (gr. 10) are sometimes effective. (3.) Many cases call for nephrectomy or other surgical measures. Before operation it is necessary to determine which kidney is diseased and the state of activity of the healthy kidney. This is seen by the cystoscope, the ureteral catheter and sometimes by X-ray. In cases of *calculous pyelitis*, large doses of potassium citrate and bicarbonate may be employed for uric acid calculi; for oxalates, see Oxaluria (§ 423); and nephrolithotomy is needed in nearly all cases. (4.) In cases of *tuberculous pyelitis*, build up the general health. Excision of the kidney is to be advised if (i.) the other kidney is shown to be healthy; and (ii.) there is no tuberculous disease elsewhere in the urinary tract, lungs or intestines. Heliotherapy, properly carried out, is advisable in some cases, and a course of tuberculin has given good results.

A **diminution in the specific gravity,** *when marked and continuous, even in the absence of albumen, is suggestive of* CHRONIC INTERSTITIAL NEPHRITIS, *or more rarely* DIABETES INSIPIDUS. **A marked increase** *in the specific gravity is suggestive of* DIABETES MELLITUS.

§ **413.** The other **causes of altered specific gravity** are relatively less important, because they are identified mainly by other means. Nevertheless, the specific gravity of the urine is an extremely important feature, because, in the absence of sugar, it is a MEASURE OF THE UREA and SODIUM CHLORIDE EXCRETION, the specific gravity being higher in direct proportion to the amounts contained in a given sample of urine. Therefore, it is a very fair measure of the power of concentration of the two kidneys taken together (and see §. 376). For this purpose an early morning specimen is essential, to avoid the effect of food and drink consumed during the day.

The specific gravity is DIMINISHED in—

1. Increased intake of fluid.
2. When the kidney reserve is called upon (see introduction to this section), as in Chronic Interstitial Nephritis, Secondary Contracted Kidney, etc.
3. Polyuria, and all the diseases mentioned below under that heading, excepting Diabetes Mellitus.
4. Myxœdema and other conditions with lowered nitrogenous metabolism.

The specific gravity is INCREASED in—

1. Diabetes Mellitus (owing to the sugar).
2. Some renal diseases where the quantity of water is considerably diminished, such as Acute Nephritis, Subacute Parenchymatous Nephritis, or the Cardiac Kidney.
3. Febrile and other conditions where the nitrogenous disintegration is excessive.
4. Whenever the urine becomes concentrated by profuse sweating, vomiting, diarrhœa, or diminished intake of fluid.

An **increase** (POLYURIA), *or* **diminution** (OLIGURIA), *in the* **quantity of urine** *is complained of by the patient in several important diseases.*

§ **414.** In **Polyuria** it is necessary to measure the total diurnal quantity, since patients are very apt to mistake increased frequency for increased quantity, and *vice versa*. It must be remembered that *in old age*, there is normally some increase in the diurnal excretion due to loss of concentrating power in the renal tubules.

Otherwise there is INCREASED QUANTITY of urine secreted in—

1. *Diabetes mellitus*, which is known by the high specific gravity of the urine and persistent glycosuria.
2. *Diabetes insipidus*—low specific gravity and malaise, but no sugar.
3. *Chronic interstitial nephritis*, which is known by the persistent low specific gravity of the urine, slight albuminuria, etc. (§ 401).
4. *Amyloid kidney*, which is known by the low specific gravity of the urine and great albuminuria (§ 404).
5. *Dietl's crisis* is known by a dull pain in the loin which becomes more severe, associated with an enlarged tender, and often mobile, kidney. As the pain subsides, polyuria occurs for a few hours, with decreasing tenderness and swelling of the affected kidney: recurrences are common. The condition is not due to hydronephrosis but to temporary engorgement of a mobile kidney which becomes twisted on its pedicle: the polyuria is a reaction to the establishment of a normal blood flow as the attack subsides.
6. *Convalescence* after fevers.
7. *Temporary polyuria* occurs in hysteria, nervous excitement, Dietl's crises, alcoholism, following an attack of paroxysmal tachycardia or of asthma, and any condition giving rise to a reactionary or paralytic condition of the abdominal sympathetic. Cerebral tumours may be accompanied by polyuria.
8. During the administration of *diuretics*.
9. During the *absorption of exudations*, such as general anasarca.

There is DIMINISHED QUANTITY of urine in—

1. Acute Nephritis.
2. Subacute Nephritis.
3. The final stage of Chronic Interstitial Nephritis and of Secondary Contracted Kidney.
4. The Cardiac Kidney and some other Renal Congestions.
5. Febrile states.
6. Whenever there is profuse vomiting, diarrhœa, or perspiration, or when little fluid is taken.

The patient complains of **polyuria ;** *the urine is of* HIGH SPECIFIC GRAVITY, *and* CONSTANTLY *contains* GLUCOSE (**glycosuria**) **;** *there are also fatigue, thirst, and, in spite of a voracious appetite, gradual loss of flesh.* The disease is DIABETES MELLITUS. (See § 381 for Fallacies.)

§ **415. Temporary Glycosuria** may arise in many conditions in which the carbohydrate metabolism is deranged; often it is of little or no consequence. (1) There may be a temporary diminution of sugar tolerance, particularly with septic infections (boils, etc.) in the elderly. (2) Chronic alcoholism. (3) Graves' disease. (4) Pregnancy and suckling (lactosuria). (5) Conditions, such as meningitis or tumour affecting the brain, especially the pituitary or the fourth ventricle. (6) Dietetic errors, as after a heavy meal, especially in the obese. (7) During the paroxysms of ague and collapse of cholera. (8) Chronic nephritis and high blood pressure. (9) After acute fevers, such as influenza or diphtheria. (10) At times of sudden emotion or physical stress (*e.g.*, asphyxial conditions), due to excess of adrenalin in the blood. (11) After epileptic fits.

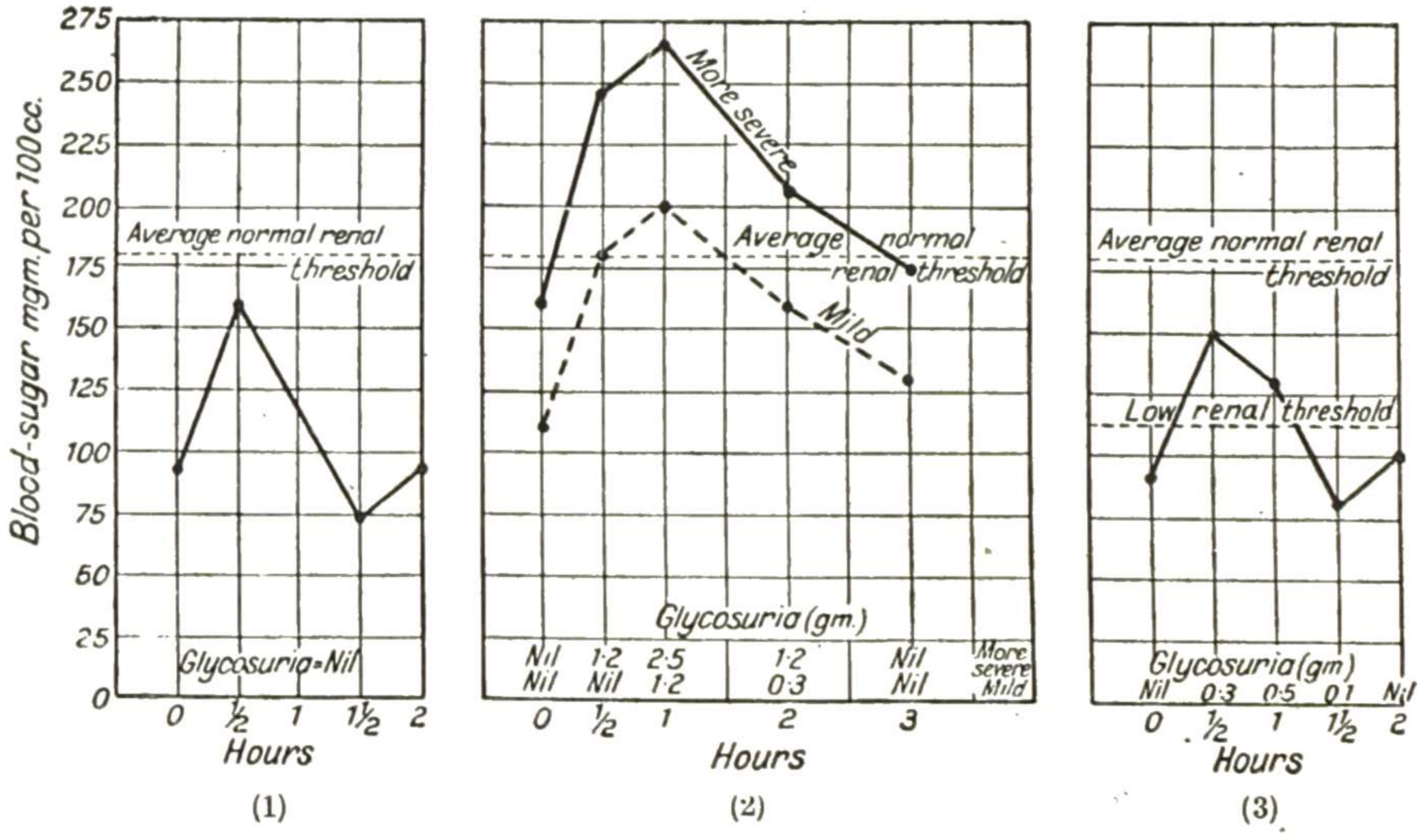

FIG. 108.—SUGAR TOLERANCE CURVES after 50 grammes glucose, with corresponding urinary sugars. (1) Normal. (2) Curves of mild and more severe diabetics. (3) Renal glycosuria showing lowered renal threshold.

(12) **Lag glycosuria** is a condition where the blood sugar rises rapidly after a meal to a value above the renal threshold; the fasting value is normal and the blood sugar returns to normal at the usual rate. It is believed to be due to a delay in the action of insulin. Its presence can only be satisfactorily determined by a sugar tolerance curve, and it has no clinical significance.

(13) **Renal glycosuria** (Diabetes innocens, renal diabetes). When a small quantity of sugar is excreted in the urine, and yet the blood sugar is not above normal (§ 416), the condition is one of renal glycosuria. The threshold, or point at which sugar is excreted by the kidney, is lowered. Renal glycosuria may be found accidentally whilst the urine is being examined. The sugar excretion in this condition is not much affected by increasing the carbohydrate in the diet; in the true diabetic the contrary is true. A sugar tolerance test and a study of the blood sugar curve is required before diagnosing the glycosuria as renal (Fig. 108 (3)). No treatment is required for this condition.

§ **416. Diabetes Mellitus** is a constitutional disease, characterised by the passage of large quantities of urine containing glucose.

Symptoms.—The patient may first complain of the symptoms of the disease itself, or of one of its complications (*e.g.*, cataract, gangrene). The primary symptoms are: (i.) The urine is abundant (polyuria), and may amount to 6–20 pints a day; clear, pale, but of high specific gravity,

1030–1050. The specific gravity is always higher than would be expected from the concentration as judged by the amount of pigment present. Sugar may be in amounts varying from 1 to 9 per cent., is often accompanied by ketone bodies, and a trace of albumen may be present. If the urine drops on the boot, a crystalline deposit may be noticed by the patient. (ii.) Excessive thirst (polydipsia) and a dry tongue, which may become raw and beefy. (iii.) Loss of weight may be extreme, and is a gauge of the severity of the condition. (iv.) The appetite is normal or excessive (especially in relation to the weight), unless ketosis or other complications are present, when it usually fails. (v.) General symptoms such as lassitude, progressive weakness and ready fatigue. (vi.) The skin may lose its elasticity and become dry: it often acquires a yellow tint, especially on the hands and face, by which the disease may be suspected. This is due to an excess of a yellow pigment (carotin) circulating in the blood and staining the tissues. (vii.) The blood sugar is above the normal. This may be determined by estimating the fasting value (normally ·07–·10 per cent.) or by a sugar tolerance estimation. In this test, after determining the fasting value, 50 grammes of glucose are administered and the blood sugar value determined each ½ hour for 1½–2 hours. Typical curves are shown (Fig. 108).

Varieties. There are two well-marked varieties: (*a*) A mild form met with in corpulent middle-aged people, where the symptoms are moderate, and dietetic restriction removes the sugar from the urine. (*b*) The severe variety assumes *acute* and *chronic* forms. The acute form usually occurs in children or young adults, and occasionally after head injuries. The chronic form is met with in older people, and is attributed sometimes to mental worry. It also occurs with other causes of temporary glycosuria (§ 415) which become chronic.

Etiology. (1) The usual cause is insufficient insulin production by the β cells of the islets of Langerhans. This may be due to (*a*) an inherited tendency. The disease often runs in families; in successive generations it tends to occur at an earlier age, with corresponding increase in severity of the disease. (*b*) Infections: A *generalised infection* (i.) calls for a greater output of insulin, which may not be forthcoming, and (ii.) may damage the pancreatic cells. With *acute infections* (boils, carbuncles, pneumonia) the disease may first manifest itself, the condition being temporary or permanent. (*c*) Progressive fibrosis of the pancreas occurs in hæmochromatosis and sometimes in tertiary syphilis. (*d*) A gradual obliteration of blood supply is met in arterio-sclerosis of the cœliac axis and pancreatic arteries. (2) Overaction of the thyroid gland, especially primary thyrotoxicosis, causes a rise in blood sugar level which the pancreas tries to correct. When thyrotoxicosis and diabetes occur together, wasting is rapid and often extreme. In some cases of thyrotoxicosis the blood sugar level is not raised, but glycosuria occurs due to a lowering of the renal threshold (renal diabetes). (3) Oversecretion of the pituitary, as in tumour, basophilism, acromegaly, etc., may produce glycosuria either

temporarily or permanently. (4) Temporary glycosuria from overaction of the suprarenals occurs in times of sudden stress and emotion, as at a medical examination or with athletic sports.

Complications are numerous: (1) *Ketosis* and *coma* are due to defective fat metabolism. The excessive fat utilisation is shown by the excess of fat in the blood (lipæmia): in the absence of sufficient glucose utilisation, the end products of fat metabolism cannot be converted to CO_2 and water, and accumulate in the blood as β oxybutyric and aceto-acetic acids. The former is comparatively harmless but the latter stimulates respiration and depresses the brain, producing drowsiness and finally coma. In the more usual form of diabetic coma these ketone acids are secreted by the lungs and kidneys, and by losing CO_2 are partly converted to acetone, giving a sweet-smelling breath and the ferric chloride and Rothera's tests in the urine (§ 384). A rarer and more fatal variety is that in which the kidneys are unable to secrete these ketone bodies (anuric form), the urine being scanty or absent, containing albumen and abundant casts, and with a corresponding rise in blood urea. The symptoms of ketosis are (i.) in the *earlier stages*, loss of appetite, abdominal pain, nausea and vomiting: drowsiness is usually present but occasionally may be replaced by undue restlessness, irritability and giddiness. In the *later stages* coma develops. This is accompanied by slow deep breathing ("air hunger"), a sweet-smelling breath, diminution in the urinary volume which may be extreme in the anuric form, and usually the presence of acetone and aceto-acetic acid in the urine, with a lowered intraocular tension of the eyeballs. (2) *Infections*, especially staphylococcal and tuberculous, are liable to arise. The former may give rise to skin infections—pruritus vulvæ, boils, carbuncles and deep-seated abscesses; the latter commonly causes pulmonary tuberculosis. It is essential to examine the urine in all cases of pruritus vulvæ, boils and carbuncles, and of acute infections, especially in elderly subjects with pneumonia, who are not responding satisfactorily to treatment. (3) Ocular changes: cataract, retinitis, optic neuritis and atrophy, and blurred vision due to rapidly developing short or long sight. (4) Cardio-vascular changes, especially arterio-sclerosis of the larger and medium sized vessels, often associated with hyperpiesia. Gangrene readily supervenes in the toes and feet, usually of the dry variety; secondary infections may produce a moist gangrene. (5) Polyneuritis (§ 794. X) is common, and cerebral changes (depression or restlessness, mania and melancholia) make satisfactory treatment difficult. (6) Pregnancy markedly increases the need for insulin: the fœtus often dies in utero in the last month of pregnancy. The size of the fœtus and of the newly born is markedly above normal.

Diagnosis.—In any of the conditions mentioned under *Complications* the urine should be examined. This is the key to the diagnosis. In *diabetes insipidus*, *granular kidney*, *amyloid kidney*, and sometimes in *hysteria* the quantity of urine is excessive, but in none of these conditions is sugar present. Two golden rules will enable us to identify a case of

diabetes which otherwise might be overlooked: Always examine the urine of a patient suffering from (1) boils or eczema of the genitals and (2) apparently causeless wasting. Other causes of glycosuria are discussed in § 415.

Prognosis.—1. The glycosuria which is met with chiefly in corpulent persons and others over thirty-five—the so-called "alimentary" glycosuria—has no thirst or other symptoms, but may be true diabetes. Generally with suitable diet and weight reduction the sugar disappears, and the condition warrants an excellent prognosis. 2. In the severer forms the prognosis chiefly turns upon the age of the patient. Before the discovery of insulin if the disease were established in a young adult, life rarely lasted more than two years. Since the discovery of insulin the outlook has much improved. The prognosis is now largely dependent on the patient's careful fulfilment of directions with regard to diet and insulin. The presence of *complications* does not materially add to the gravity of the situation except when phthisis, severe septic infections and gangrene are present. Operative risks, especially under general anæsthesia, are markedly increased when diabetes is present. Death may ensue in three ways: (i.) By complications—a third of the cases die of phthisis; (ii.) asthenia; and (iii.) with coma, a contributory cause of which is often a septic focus such as tonsillitis or otitis media.

The *Treatment* of diabetes has been revolutionised by the introduction of insulin, and the previous methods of starvation have been completely superseded. Insulin is injected to supplement the patient's own insulin. The principles of treatment are: (i.) sufficient calories must be given to maintain normal nutrition; (ii.) the diet taken must prevent ketosis; (iii.) as much variety as possible should be allowed; (iv.) the blood sugar should be maintained within normal limits.

To calculate the calories necessary for a patient, we must remember that elderly obese diabetics should be given the number of calories equivalent to their weight before obesity set in: many of these become sugar free by simple restriction of bread, sugar and other carbohydrates, and their sugar tolerance may return to normal as they lose weight (Embleton). In children, extra calories have to be allowed for growth. In adults, the values are: (*a*) For sedentary workers, 25 calories, (*b*) for those doing moderate muscular work, 35–40 calories, and (*c*) for heavy manual workers, 50–60 calories per kilo body weight. In pyrexial conditions, and especially in phthisis, the diet must be more liberal, but subjects with uncomplicated diabetes must not be allowed to become overweight. Having fixed the daily allowance of calories, the amount to be given as protein is usually next determined at about $\frac{2}{3}$ gram per kilo body weight. The remaining calories have to be distributed between fat and carbohydrate.[1] The present tendency is to give more carbohydrate than formerly; 100–150 grams a day are commonly given. Some physicians are giving amounts as high as 200–250 grams daily. The remaining calories are given as fat. The advantages of a high carbohydrate low fat diet, as in Rabinowitch's scheme (fat not above 50–55 gms., carbohydrate 200–250 gms.) are (i.) it is more palatable and more closely

[1] Many of the advertised starch-free breads are by no means what they claim to be; the careful physician should examine them for starch with the iodine test, and for sugar by boiling them with dilute sulphuric acid, neutralising with caustic potash and adding Fehling's solution. Soluble saccharin B.P. is taken in place of sugar.

resembles the normal diet, (ii.) it is cheaper, (iii.) the sugar tolerance increases in proportion to the carbohydrate value of the diet, (iv.) insulin requirements are not greater than on a high fat low carbohydrate diet, (v.) the patient feels better, (vi.) ketosis and complications such as arterio-sclerosis and infective disorders are less common, (vii.) the heart muscle keeps in better condition. There are several convenient methods of giving as much variety as possible. Lawrence's "Line ration" scheme is easy to follow and is arranged to save trouble in calculating. A "black line" contains 10 G. of carbohydrate (41 calories) and a "red line" contains 7½ G. of protein and 15 G. of fat (114 calories). The carbohydrate of one line may be replaced by the corresponding number in another line. A slight modification of this scheme will allow a higher carbohydrate diet. A convenient list of diets is given in § 297. IX.

INSULIN B.P., better known as soluble insulin (S.I.), must be given when the patient cannot be maintained sugar free on the correct diet. It should be started immediately the patient is seen if the amount of ketosis in the urine is sufficient to give a positive ferric chloride test. During stabilisation the urine must be tested four-hourly, and the insulin administered once, twice or three times daily according to the severity of the case, 15–20 minutes before the principal meals. The dose should be increased by 5 units daily until the urine is sugar free, and then it is wise to perform blood sugar estimations to make sure the values are within normal limits. For severe cases, double and quadruple strengths of insulin are available.

Later preparations of insulin are: (*a*) protamine insulin with zinc (P.Z.I.) in which insulin is combined in an insoluble form, and is slowly liberated in the body. Its action starts some 10 hours after injection and is maintained up to 24 hours or more, depending on the dose. P.Z. insulin is much weaker in its actions than is soluble insulin, and cannot be used in diabetic coma. It is useful in mild diabetics, when it is given in a single morning dose: more commonly it is used with soluble insulin and given as a single injection before breakfast: the soluble insulin is withdrawn into the syringe first, and the P.Z. insulin added, this order being necessary to prevent P.Z. insulin being introduced into the soluble insulin bottle. The combination enables the soluble insulin to act soon after it is given, and the P.Z. insulin continues the action for the remainder of the 24 hours. In any case, with P.Z. insulin 10–20 G. of carbohydrate must be given at bedtime. to prevent hypoglycæmic reactions during sleep, for these are insidious in onset. (*b*) More recently globin insulin with zinc has been introduced: the action commences 2 hours after injection and continues for 16 hours or more, so that a pre-breakfast dose is liable to give hypoglycæmia in the late afternoon. After stabilisation with any of these preparations the dose of insulin may have to be varied from time to time as the disease gets more or less severe; and the patient should not only be instructed how to ward off hypoglycæmic reactions but also how to give his own insulin and test the urine regularly for sugar and acetone.

Ketosis is usually effectively controlled by the combination of insulin with increased carbohydrate and diminished fat in the diet. In pyrexial disorders, there is an increased need of insulin, whereas in pregnancy the dose must be immediately reduced by one half directly after childbirth.

§ 417. Treatment of Diabetic Coma. The main indications are to combat the ketosis and the dehydration which so often accompanies it. Immediately, 50 units of insulin followed by 1–2 pints of normal saline, or saline with added sodium bicarbonate, must be administered (intravenously, if possible). If *consciousness returns*, 500 G. of glucose should be dissolved in 2,500 c.c. of half-normal saline, and 100 c.c. administered by mouth each hour, with 10 units of insulin hourly, until the blood sugar level falls to 0·30 per cent. If the *patient is still unconscious*, 50 G. of glucose in

1–2 pints of normal saline are given (preferably) into a vein or by a duodenal tube, with 30–50 units of insulin subcutaneously each 4 hours until consciousness returns. Then the intravenous medication may be replaced by rectal glucose or the half normal saline and glucose by mouth, until with the control of the ketosis, milk, Benger's food, etc., may be commenced. In the "*anuric*" *variety* still larger doses of intravenous saline (3–4 pints in the first hour) with 50–100 units of insulin must be used : subsequently further intravenous dextrose saline (1–2 pints) with saline per rectum must be combined with 4-hourly insulin until the urine is passed in adequate quantities. When an infection has precipitated coma, often there is no pyrexia, but leucocytosis gives valuable confirmation and penicillin is often necessary. The doses of insulin may then have to be very large, even 500–600 units in 24 hours, but regular blood sugar analyses are essential when using such doses. The circulatory collapse must be met with warmth, the infusion of blood plasma and stimulants such as niketha mide (coramine) or adrenalin.

Estimation of the Blood Sugar. Folin-Wu Method.—Blood is obtained from a finger prick, and 0·2 c.c. is measured accurately into 1·6 c.c. of sodium tungstate solution [1] in a centrifuge tube. Then 0·2 c.c. of 2/3N sulphuric acid is added, and the whole is shaken. By this means the blood is diluted ten times, and the protein coagulated. The protein precipitate is centrifuged off, or allowed to settle, and 0·75 c.c. of the supernatant fluid is pipetted into the special hard glass boiling-tube. From two standard solutions containing respectively 0·01 per cent. and 0·02 per cent. glucose, 0·75 c.c. of each are placed in similar hard glass tubes. To each of these three, 0·75 c.c. of the copper solution is added, and the solutions shaken together. The tubes are boiled for exactly six minutes in a boiling water-bath, and after cooling in a cold water-bath for three to five minutes, 0·75 c.c. of the sodium molybdate solution is added, and each tube has distilled water added to the 9 c.c. mark. The relative depths of the colour of the blue solutions are compared in a colorimeter or in Nessler tubes, the amount of sugar present in each being proportional to the depth of the colour. Suppose a depth of 50 mms. of the unknown sugar solution matches a depth of 40 mms. of the 0·02 per cent. standard sugar solution, the unknown solution contains $\frac{40}{50} \times \cdot 02$ per cent. sugar. Allowing for the dilution of the blood $\times$ 10, the blood sugar value is $\frac{40}{50} \times 0{\cdot}02 \times 10$ per cent. = 0·16 per cent.

The normal fasting blood sugar is 0·08 to 0·10 per cent. After a meal it may rise to 0·17 per cent. Values above 0·20 per cent. are abnormally high. The blood sugar becomes too low after an overdose of insulin, and may fall to 0·03 to 0·05 per cent.

§ **418. Hypoglycæmia** and **Hypoglycæmic Coma.** Since overdosage by insulin causes too great a fall in the blood sugar (hypoglycæmia), the symptoms of this condition must be carefully watched for. There may be sweating, weakness, tremors, palpitation, inco-ordination of movements or of speech, "sinking feelings," numbness of lips and occasionally diplopia (§ 845. VIII). Such results may be warded off by a hot drink of milk or a tomato ; if these fail a little sugar in water is rapidly effective. In severe cases, these early symptoms are followed by unconsciousness and epileptiform convulsions, which may be fatal. The diagnosis is made by the symptoms and by blood sugar estimation ; symptoms occur when this is below 0·07 per cent. If mild symptoms of hypoglycæmia occur at the

[1] The solutions are bought from British Drug Houses, London.

same time on succeeding days, reduce the dose of insulin. Coma is usually due to carelessness on the part of the patient, as when the usual dose of insulin is taken without being followed by a meal. In the severe cases, the blood sugar must be raised by injection of adrenalin (♏ 10–15) or pituitrin (c.c. ½–1); or administration of glucose by a stomach tube or intravenously. Cases are recorded in whom symptoms of hypoglycæmia occurred spontaneously, just before a meal; adenoma of the pancreas was found and removed, with abatement of the symptoms.

The patient complains of **polyuria** *and many of the other symptoms of Diabetes Mellitus, but the* SPECIFIC GRAVITY OF THE URINE IS LOW, *and there is* NO SUGAR. The disease is DIABETES INSIPIDUS.

§ **419. Diabetes Insipidus** is characterised by great and persistent increase in the quantity of the urine, without glycosuria and albuminuria, attended by great thirst and emaciation. It is due to deficiency of the anti-diuretic principles of the posterior lobe of the pituitary, and may come on spontaneously or after head injuries.

Symptoms.—(1) The amount of urine may be very great, from 10 to 20 pints per day. It is pale in colour, so that it may resemble clear water. The specific gravity averages 1002 to 1005. The diurnal amount of solid constituents is as a rule not very much increased, and no other abnormality may be present. Occasionally traces of albumen and sugar appear towards the end. (2) In the mild form of the disease polyuria and thirst are the only symptoms; but in the severer variety nearly all the symptoms mentioned under Diabetes Mellitus are also present—dry skin, emaciation, large appetite, and alternating constipation and diarrhœa. Indeed, it is distinguished from that condition only by the absence of glycosuria. Intercurrent attacks of pyrexia have been observed. (3) Obscure nervous symptoms are common in this disease—irritability of temper, disturbed sleep, occipital headache, neuralgic pains in the lumbar region, diminished reflexes, and muscular twitchings.

Diagnosis.—The disease is apt in its early stages to be mistaken for *chronic interstitial nephritis*, but the greater age of the patient, the presence of traces of albumen, and of cardio-vascular symptoms, and the absence of thirst and voracious appetite distinguish the latter condition. With *amyloid kidney* there is albumen, and with both *hydronephrosis* and *polycystic kidney* a tumour is generally palpable in the region of the kidney. In *Diabetes Mellitus* there is glycosuria.

Causes.—More men than women are affected. Childhood and early middle age are the favourite ages. Causal factors are: injury to the posterior pituitary body, as by a primary tumour or secondary metastases, syphilis, meningitis, trauma, or xanthoma in Hand-Schüller-Christian disease.

Prognosis.—The milder varieties may last for many years, and exist rather as an inconvenience than as a malady. In the severer forms, especially those due to intracranial tumours, the course may be rapid. When setting in acutely after head injury (which may be attended by some glycosuria at first) recovery may ensue after a year or so. In general terms, acute cases are more hopeful than those which start insidiously. Death takes place from exhaustion, drowsiness passing into coma, with or without convulsions, or from complications such as phthisis or pneumonia.

Treatment.—Substances which increase diuresis, such as tea, coffee, alcohol and salt, should be avoided, but the amount of fluid taken should not be reduced below that which the patient can comfortably manage. The active principle in the pituitary is supplied by giving injections of posterior pituitary extract, or better still pitressin tannate in oil, both of which contain the antidiuretic factor. In some cases the missing factor can be given by painting pituitary extract on the nasal mucosa or by inhaling piton snuff. However these are given, the extracts lose their efficacy after a time. Thyroid administration sometimes helps. Anti-syphilitic treatment is given when there is a positive Wassermann. Lumbar puncture has been helpful in some cases.

The patient complains that he **cannot pass water,** *and a* DISTENDED BLADDER *can be made out by palpation and percussion above the pubes, or by the passage of a catheter.* The condition is RETENTION OF URINE.

§ **420.** The Causes of **Retention of Urine** come mainly within the province of the surgeon. Those of *sudden* onset are often due to urethral spasm or congestion; those of *gradual* onset are more numerous. The age and sex of the patient may aid us. Thus, in *childhood* we may suspect impacted calculus or foreign body, a congenital valve of the urethra, phimosis, or a ligature round the penis; in *women*, tumours pressing on the neck of the bladder (*e.g.*, fibroid or retroverted enlarged uterus), hysteria, or reflex irritation after parturition; in young or middle-aged *adults*, urethral stricture, gonorrhœa, with congested mucous membrane, spasm after exposure to cold or a drinking bout, or tabes dorsalis; in *old men*, prostatic enlargement, or atony of the bladder. At all ages there may be a calculus or tumour blocking the neck of the bladder, paralysis of the bladder from diseased or injured spinal cord or brain, or reflex spasm after operations about the perineum. Hydronephrosis commonly results.

The *Treatment* is mainly surgical. Before undertaking any operation the blood urea (§ 389) should be estimated. If this is high, over 75 mgm. to 100 c.c. of blood, there is interference with the kidney function and operation is dangerous to life; drainage of the bladder improves the condition and operation may be safe later on. In cases of spasm a hot bath or hot fomentations to the abdomen give relief. Hysterical and other nervous affections are referred to elsewhere. Atony and simple vesical paralysis may be treated by an injection of carbacholum B.P. (doryl) or a mixture containing nux vomica and belladonna, or by the constant current, one pole being placed on the perineum and the other just above the pubis.

The patient complains that he has **not passed any water** *for some time, but there are* NO EVIDENCES *of a* DISTENDED BLADDER, *and on passing a catheter it is found to be empty, or nearly so.* The condition is SUPPRESSION OF URINE.

§ **421. Suppression of Urine** (Syn., Anuria) is a very grave condition. A catheter should always be passed before the diagnosis of suppression is made. There are two kinds: I. OBSTRUCTIVE suppression, which is due to some obstruction to the flow of urine through the ureters; and II. NON-OBSTRUCTIVE suppression, which is due to the non-secretion of urine by the kidneys. The latter form is sometimes spoken of as true suppression.

I. OBSTRUCTIVE SUPPRESSION is due to blocking of both ureters (the kidneys being healthy) by (i.) renal calculi; (ii.) a renal calculus blocking one ureter may cause reflex suppression in the other kidney; (iii.) blocking of both ureters by sulphonamide crystals (especially after sulphathiazole and sulphadiazine); (iv.) tumour at the base of the bladder; (v.) congenital malformation of the ureters. When only one ureter is completely blocked, the urine that passes is clear, of low specific gravity, and non-albuminous; but, provided the other kidney is healthy, there is no renal inadequacy, the healthy kidney undergoing compensatory hypertrophy (see also Hydronephrosis, § 424). When both ureters are blocked, a condition known as "*latent uræmia*" arises. The *Symptoms* are: the patient passes no urine for about a week, and may complain of nothing except slight drowsiness, but after eight or ten days he becomes restless, with contracted pupils, subnormal temperature, dry brown tongue, and muscular twitchings. In other cases vomiting may be so severe as to suggest the presence of intestinal obstruction. Death is usually sudden, after ten to fourteen days, the mind remaining clear to the end.

II. The causes of NON-OBSTRUCTIVE SUPPRESSION are: (i.) Acute nephritis, or the terminal stage of chronic nephritis (ten to twenty hours before death); (ii.) the anuric form of diabetic coma (§ 416); (iii.) collapse and shock (of which suppression is

one of the symptoms)—*e.g.*, after abdominal operations or injuries, severe burns, severe diarrhœa and vomiting, fevers, local inflammations or any cause of sudden fall of blood pressure ;. (iv.) acute poisoning with phenol, lead, phosphorus, turpentine, or with certain sulphonamide drugs ; (v.) embolism or thrombosis of both renal arteries (very rare) ; (vi.) incompatible blood transfusions (§ 537) ; (vii.) after passage of a catheter, cystoscopy, pyelography or other instrumentation ; (viii.) crush injuries. Whichever of these causes is in operation, the *Symptoms* are : (1) any urine passed is highly-coloured and concentrated (high specific gravity), and may contain albumen and casts (indicating that the suppression is due to renal disease) ; (2) there may be urgent vomiting, diarrhœa, and sweating. The other symptoms are those of acute uræmia (§ 372) and those of the cause.

Crush Injuries follow severe crushing of a limb under débris. The urinary output due to the initial shock falls further, with marked albuminuria and dark brown granular casts. Complete suppression often follows, with incessant vomiting and thirst ; death frequently occurs on the 7th–8th days. *The cause* may be due to a reflex from the injured limb causing the blood flow in the kidneys to by-pass the glomeruli (" renal shunt ").

Prognosis of Suppression.—Suppression is a very serious condition, though the gravity depends somewhat upon the cause. Of the *obstructive* forms, calculus blocking one ureter, the kidney of the opposite side being healthy, is perhaps the most favourable. If the obstruction affects both ureters and is not removed, death will occur in about eleven days after the obstruction began. In the *non-obstructive* forms death or partial recovery takes place in a few days.

Treatment.—Hot air baths, hot packs, and other diaphoretics promote the action of the skin, and so relieve toxæmia. In acute *non-obstructive suppression*, fluids must be given freely by mouth : or as 5 per cent. dextrose into a vein. To the dextrose may be added ½–1 pint of sodium sulphate (4 per cent.) or a 50 per cent. solution of sucrose (1 c.c. per lb. body weight). Alkalies are of value when the blood alkali reserve is low and especially for cases following sulphonamides or blood transfusion. Free purgation promotes the excretion by another channel ; cupping, wet or dry, over the loins relieves the local congestion. Good results have been obtained from blocking the sympathetic vaso-constrictor fibres to the kidneys with either a spinal anæsthetic, or a bilateral paravertebral block with procaine. Decapsulation of the kidneys may relieve, for the kidneys are often in a state of " cloudy swelling," and when given space to expand recover their function. When a sulphonamide drug is causal, lavage through a ureteric catheter by 2·5 per cent. sodium bicarbonate will remove crystals from the ureters : otherwise bilateral nephrostomy may be required.

For the treatment of *obstructive suppression* a surgeon should be called at once.

The patient complains that his urine **dribbles away constantly,** *and on percussing over the pubes or passing a catheter, his bladder is found to be empty. He has* True Incontinence. *If there is* Increased Frequency *he has a frequent call to urination, and cannot always hold his water.*

§ **422. Incontinence of Urine** may be either True Incontinence or Increased Frequency.

(*a*) True Incontinence, when the urine dribbles away involuntarily as fast as it is formed, must not be confused with *overflow* or *false incontinence*, which is due to the overflow of a distended bladder in *retention*. The latter is recognised by the signs of a full bladder and by the relief afforded by the passage of a catheter. In true incontinence, which is relatively a rarer condition, the *Cause* is generally quite apparent, such as vesico-vaginal fistula, paralysis and dilatation of the sphincter after

the operation of lithotrity, or the paralysis of the sphincter associated with various cerebro-spinal affections (§ 690).

(*b*) INCREASED FREQUENCY OF MICTURITION is a very common complaint. The patient can hold his water, but the calls to urinate are too frequent, and sometimes so urgent that a few drops dribble away before arrangements can be made. "Stress incontinence" indicates that any sudden strain, *e.g.*, emotion, laughing, crying, coughing, will cause dribbling. The normal time during which the urine can be retained varies in different individuals, and also according to the amount of fluid taken; but four or five hours is a fair average. It is longer in the female than the male; some women can retain the urine for ten or twelve hours. The habit is injurious, and is said to lead to abnormal flexions of the uterus.

Increased frequency is due to many *Causes*. The first point to determine is whether there is any marked increase in the diurnal quantity, as in diabetes mellitus, diabetes insipidus or chronic nephritis, because any of the causes of polyuria (§ 414) may be a cause of increased frequency of micturition. In young adults diabetes is the commonest, but in advancing years chronic nephritis and enlarged prostate are by far the most common causes. Our attention is often first drawn to the latter condition because the patient develops a habit of rising at night to pass water. It is not always easy to decide whether the quantity is increased or not, as the patient is apt to think that, because he passes water too often, he passes too much: it may be necessary to measure the diurnal volume of urine. There remains three groups of causes of increased frequency to consider: 1. Some cause of *local irritation* is undoubtedly the most frequent. The *urine* may be too acid. *Bacilluria* may for long cause no symptom except increased frequency of micturition; this is a common symptom in coli bacilluria. The *bladder* may be irritable, owing to an enlarged prostate (the usual cause of abnormal frequency in old age), chronic cystitis, ulceration, tumour, stone, oxaluria, or pressure upon the viscus by a displaced or enlarged uterus. Or the irritation may be in the *kidneys* from the presence of stone, tubercle, or other cause of pyelitis (§ 412). Or the irritation may be *reflex*, from disease in the vicinity of the bladder, worms, phimosis, fissure, piles, prolapse or polypus of the rectum, vascular urethral caruncle (a cause frequently overlooked in women), pelvic inflammation, or varicocele. 2. *Constitutional* causes are occasionally associated with this condition, such as hysteria, sexual excesses and possibly adenoid vegetations in the pharynx. 3. The *sphincter* may be incompetent, especially with cystocele. And see § 456. *A congenital* want of development of the sphincter is sometimes present. True congenital cases are rare, and defective action of the sphincter is more frequently due, especially in women and children, to some of the reflex causes above mentioned, the habit persisting after the cause has been removed.

NOCTURNAL INCONTINENCE (enuresis) in children is a troublesome and frequent condition; if untreated it may persist into adult life.

Usually the child has gained proper control of the urine by the age of 2–2½ years, and nocturnal incontinence shows itself later. When complete continence has never been attained, lesions such as spina bifida, a congenital valve in or imperfect development of the urethra must be looked for. In all cases it is important to exclude lesions such as stone in the bladder, cystitis or pyelitis, renal tuberculosis or polyuria with chronic nephritis. Reflex causes such as threadworms, a local vulvitis, and, according to some, phimosis or nasopharyngeal adenoids may be contributory. Having excluded organic diseases, the children having nocturnal incontinence come usually under three types: (i.) In the largest group the condition is the result of an anxiety neurosis: such children are intensely worried about their trouble, are made worse by punishment or the jibes of their brothers and sisters, and so long as their parents continue to regard the condition as a fault, it remains incurable. (ii.) In a small proportion, carelessness and laziness of habit is causal. These children are usually obese and mentally sluggish. (iii.) In a few, mental deficiency is present, making training in their earlier years impossible. In such, diurnal incontinence of urine, and often of fæces, results.

Both *Prognosis* and *Treatment* turn almost entirely upon the cause, and are hopeful in proportion as this is removable. The power of retention of the urine is a habit which can be cultivated in early life, and the relative frequency in different individuals varies with habits engendered in infancy and childhood. Local lesions and reflex causes must be removed when possible. Where there is an anxiety state, it is well to explain the condition to the child, in kindly fashion; stop punishments and scoldings, and adopt a confident attitude that the condition will ultimately be curable. Fluids towards the end of the day should be strictly limited, and the bladder emptied at bedtime. A simple expedient is to let the child keep a calendar which he marks himself, crossing out the nights on which enuresis has occurred; a suitable reward for gradual improvement often works wonders. Most drugs probably act by suggestion, but bromides, belladonna and ephedrine are helpful. Operative measures are not necessary or justified unless organic disease is present. In the sluggish, lazy child, thyroid is useful.

§ **423.** *The urine presents a* **cloudiness,** *due to some* CRYSTALLINE *or* OTHER DEPOSIT; it may be URATES, URIC ACID, PHOSPHATES, OXALATES, or FAT, unless it be pus (§ 410), blood (§ 406), or bacteria (§ 392).

With excess of URATES *the urine,* CLEAR *when first passed, becomes cloudy, with a pinkish* AMORPHOUS DEPOSIT *when it gets cold; the deposit dissolving again when heated in a tube.* This condition is still believed by many to be due to functional derangement of the liver. Various other conditions with which excess of urates and uric acid in the urine may be associated, as a more or less subordinate symptom, have already been referred to in § 393.

The clinical significance of uric acid and urates is still a subject of debate. The deposit may be physiological when occurring after a heavy meal or undue exercise.

In *Multiple Myeloma* the urine may be cloudy on standing or even passing, due to the presence of the Bence-Jones protein (§§ 386, 598. X).

Phosphaturia *is usually indicated by cloudiness in a neutral or alkaline urine* (§§ 388 and 393). It signifies decreased acidity of the urine rather than increased excretion of phosphates. (1) Phosphates frequently occur in the urine in such quantity as to cause a turbidity even when *first passed*. They appear especially towards the end of micturition and may alarm the patient unnecessarily. Phosphates may be especially abundant in the "alkaline tide" of the early morning or after dinner, and may cause an iridescent "scum" on the surface of the water. There may be no symptoms, even when phosphates are passed in large quantities; but more frequently phosphaturia is accompanied by chronic dyspepsia. Phosphaturia may occur with any cause of (1) wasting or with (2) depression and anxiety, when it is probably due to defective acid formation and lowered metabolism. Phosphates in *excess* occur with (3) hyperchlorhydria, (4) wasting disease and (5) after a diet rich in fruit and vegetable. Phosphates are *diminished* in pregnancy and in convalescence after fevers. A deposit of triple phosphates in freshly passed urine indicates decomposition in the bladder.

The *treatment* is based on the cause. Usually the condition responds to measures designed to keep the urine acid, as with ammonium chloride or with sodium acid phosphate, combined with rest or wise regulation of work and worry. As there is evidence that disorder of the calcium metabolism affects the phosphates, success often follows a diet poor in calcium. Therefore milk, eggs, fish and fruit are cut out and potato and other foods poor in calcium content are given freely.

Oxaluria *is generally indicated by a "powdered wig" deposit on the top of the mucus which settles at the bottom* (§ 393). Transient oxaluria has no clinical significance except as indicating the *nature* of a stone, which has revealed its *presence* by other symptoms. It is also found after a diet of rhubarb, sorrel, spinach, tea and coffee, or cocoa. But oxaluria is also connected with other clinical conditions. (1) Cases have been recorded where rapid emaciation and pains in the loins and back were attended by an excess of oxalates in the urine. (2) Pancreatic disease: they are said to be abundant in the early stages of chronic pancreatitis. (3) Other observers have connected certain nervous symptoms, such as mental depression; it is probable that these symptoms are connected with the concurrent dyspepsia and pains. (4) Oxaluria is associated with abnormal fermentation of sugar in the intestine. Urates are generally precipitated in the urine at the same time as the oxalates. (5) Oxalates are found in large excess in paroxysmal hæmoglobinuria (§ 409) and their presence may cause hæmaturia and albuminuria.

Treatment consists in avoiding foods which contain oxalates and those which allow excessive carbohydrate fermentation in the intestine. See Diet (§ 297. XV). The formation of crystals is prevented by the ingestion of magnesia. Calculi of oxalates are reduced by rendering the urine strongly acid with acid sodium phosphate or ammonium chloride.

Fat may occur in the urine in subacute parenchymatous nephritis attended by much fatty degeneration of the epithelium, and after fractures of the bones. It is found in great abundance in **Chyluria.** The presence of chyle in the urine gives a milky white appearance and the power of coagulating. In the tropics chyluria is due to the filaria sanguinis hominis producing obstruction of the thoracic duct; in this country enlarged glands or new growths are the principal causes. The back pressure on the lymphatic vessels of the kidneys and bladder causes some of them to rupture into the urinary tract. The urine passed at night is the more completely white; that passed by day may be mixed with blood. Embryos are to be found in the urine with a few red and white blood-cells, albumen, fat, and shreds of fibrin. Chyluria may follow trauma, and may accompany leukæmia in rare cases.

Prognosis.—The patient may live twenty years with but little impairment of health. In other cases, however, great debility and mental depression may be present.

Treatment.—Prevent the disease by boiling the drinking-water. To meet the loss of weight give plenty of nourishing food.

In *Pseudo-Chyluria* the milky appearance of the urine is due to the presence of the same material that occurs in pseudo-chylous ascites.

§ **424. Renal Tumours** may be of six kinds: (I.) HYDRONEPHROSIS; (II.) PYONEPHROSIS; (III.) PERINEPHRIC ABSCESS; (IV.) MALIGNANT DISEASE; (V.) POLYCYSTIC DISEASE; and (VI.) MOVABLE KIDNEY. The last-named is described under Abdominal Pain (§ 253), which is the symptom for which advice is sought. Extravasation of blood after injury to the kidney may simulate a tumour.

The *Physical Signs* common to all tumours of the kidney, and their diagnosis from other ABDOMINAL TUMOURS are given in §§ 263 and 394.

I. **Hydronephrosis** is a term indicating a cystic tumour of the kidney, caused by the gradual or intermittent obstruction of the urinary passages, and the consequent dilatation of the pelvis of the kidney. It is always present with normal pregnancy.

The *Symptoms* by which this tumour is recognised are: (i.) Intermittent attacks of renal pain, often with vomiting. (2) If large, a renal tumour develops. (3) Local pressure symptoms may arise, causing pain or disturbance of function of the neighbouring organs. (4) Constitutional and general symptoms are absent, unless the stagnant urine becomes infected. (5) It may be discovered on investigating for the cause of pyelitis, the condition having been unrecognised previously.

Etiology.—The causes of obstruction to the outflow of the urine may be (i) *congenital* (narrowed ureters, aberrant renal vessels, a valve in the urethra); (ii.) *acquired* causes, which may occur (*a*) in the *urethra*, such as stricture or enlarged prostate; (*b*) in the *ureter*, such as occur from stone or blood-clot; pressure by pelvic or other tumours; contraction after operation, injury, or disease of the ureter; kinking, as in movable kidney (often associated with aberrant renal vessels). These acquired causes give rise to a *gradual obstruction* (Fig. 105), and when the obstruction is intermittent the tumour may become very large, when it is liable to be mistaken for an ovarian cyst, or even for ascites. In such cases a trocar introduced at operation will reveal fluid free of the albumen which is always present in an ascitic fluid (Table LX). *Complete obstruction* of a ureter causes atrophy of the kidney, not hydronephrosis.

Prognosis.—If the condition is unilateral and intermittent it may cause little trouble, and may disappear after a duration of years. On the other hand, a double hydronephrosis is very serious, as it leads to uræmia. A surgeon should be consulted early. The complications are rupture into the peritoneum or pleura; suppuration in the pelvis of the kidney (pyonephrosis); or uræmia, due to atrophy of the substance of both kidneys.

Treatment.—In all cases the cause must be ascertained and, if possible, treated. Osler recommended the use of a pad to retain the organ in place. Surgical treatment is usually advisable.

II. Pyonephrosis is a cystic tumour of the kidney due to distension of the pelvis and calyces by fluid containing pus. It is consequent on obstruction to the free outlet of the urine in septic cases of pyelitis, or sepsis supervening on hydronephrosis.

The *Symptoms* are: (1) The tumour is tender to palpation; (2) symptoms of pyelitis are present—pyuria, intermittent pyrexia, sometimes rigors, a toxic appearance, and dull pain in the loin; (3) at intervals, when the obstruction is removed or diminished, the tumour may subside, coincident with the passage of a large quantity of pus in the urine.

The *Causes* are: (1) *pyelitis* (§ 412), with blocking, partial or complete, of the ureter; or (2) *hydronephrosis* (*vide* Causes of this above) becoming septic—*e.g.*, from extension upwards of cystitis.

Diagnosis.—(1) From *hydronephrosis*, which has no tenderness or fever; (2) from *perinephric abscess*, which has greater tenderness in the loin and a more superficial swelling, with local signs of abscess sooner or later.

Prognosis.—The condition is serious. A tuberculous pyonephrosis may undergo cure by fibrosis. The structure of the kidney is largely destroyed, and in bilateral cases, uræmia will result. A fatal issue is rapidly brought about by the tumour bursting into the abdomen or chest.

Treatment is surgical, and nephrectomy is usually indicated. Lavage through a ureteric catheter may temporarily relieve.

III. Perinephric Abscess is fairly common. It may arise by (i.) a blood-stream infection often associated with boils; (ii.) extension from kidney disease (pyelitis, pyonephrosis or tuberculosis); (iii.) extension from a perityphlitic abscess; (iv.) extension from other organs—*e.g.*, abscess of the liver, empyema or spinal caries; (v.) after an injury. The *Symptoms* are: (1) dull, aching pain in the loin, sometimes radiating down the leg; (2) deep-seated resistance of the erector spinæ, tenderness on pressure in the post-renal angle, or in the hypochondrium in front; (3) the temperature is continuous, or pyæmic in acute cases with sudden onset, or intermittent in insidious cases; (4) the leg on the same side is kept flexed and the patient stoops when walking; (5) swelling, with œdema of the skin, which appears late in the disorder, is felt between the iliac crest and the last rib, and it may be fluctuant; (6) the urine may or may not be altered according to the cause, but traces of albumen are common; (7) marked leucocytosis; (8) collapse of the base of the lung and sometimes a small pleural effusion. The *Diagnosis* is difficult in the early stage when pain alone is present, when it may readily be mistaken for *lumbago*, *appendicitis* or *spinal disease*, but there is no fever in the first of these. Later it may be mistaken for a *renal tumour*, but in a simple tumour fever is absent, and the leg would not be held constantly flexed; the aspirating needle may be used. In *pyonephrosis* there is not such acute pain or tenderness. *Prognosis.*—The abscess tends to open or to burrow its way in various directions, into the alimentary or urinary canals, peritoneum, or pleura. It may point in the lumbar region or various other directions, and burrow for a considerable distance. *Treatment.*—In the early stages, before the diagnosis can be certain, give penicillin, hot fomentations and opium for the pain; as soon as pus is recognised operative procedure is necessary.

IV. Malignant Disease starting in the Kidney is a rare condition. It affects children under nine (in whom *sarcoma* chiefly occurs), and adults over forty (in whom usually it is *carcinoma*), there being a remarkable immunity between these age periods.[1] Renal sarcoma is the commonest abdominal growth in children (Wilms' tumour). It is met in the first five years of life and is believed often to start before birth. After a period of immunity, malignant disease is found again in people between fifty and sixty. *Hypernephroma* is the commonest form of carcinoma in adults. It may lie latent for years and then assume great malignancy: metastases occur in the opposite kidney, grow along the renal veins and produce early deposits in bones.

The *Symptoms* are: (1) The tumour is rapidly growing, usually of firm consistence, but if of very rapid growth it may appear fluctuating; (2) hæmaturia, frequent, inter-

[1] The solid tumours affecting the kidney consist of (*A*) *Connective tissue type*:—I. Simple or benign growths (fibroma, lipoma, angioma); II. Sarcoma, which is by far the commonest. (*B*) Growths of an *epithelialt ype*:—I. Adenomatous growths (simple adenoma, trabecular, and papilliform cystomata). II. True Carcinoma:—(1) glandular type; (2) malignant papilloma. (*C*) Hypernephroma.

mittent, and of moderate amount; (3) progressive emaciation; (4) the pain is variable, sometimes it is very severe, owing to pressure upon or infiltration of the neighbouring organs. Sometimes pain is entirely absent, and the tumour may have attained a very large size before any symptoms occur; (4) in left-sided hypernephroma left varicocele occurs, and is a valuable early diagnostic sign. (5) In hypernephroma, a spontaneous fracture of bone or an unexplained pyrexia may be the first symptom.

Diagnosis.—When a tumour occurs in a movable kidney it is apt to be mistaken for *ovarian tumour* or *fibroid*, and vaginal examination is necessary (see § 263 for diagnostic points). *Tuberculous* kidney in a child may present difficulty, but the pain is less, and pyuria is present rather than hæmaturia. *Pyonephrosis* is accompanied by fever, the swelling is fluctuant, and there is a history of pyuria. *Retroperitoneal* and *renal sarcoma* are the chief causes of enormous abdominal tumours in children. The diagnosis of malignant tumours is not usually difficult.

The *Prognosis* is very grave. If untreated, death occurs in six to twelve months after detection of the growth, the cancer of adults being of somewhat slower growth.

Treatment is usually too late; early excision gives the only chance of life.

V. Polycystic Disease of the Kidneys is a rare condition, usually of congenital origin and often familial, in which both kidneys contain cysts of varying size and number.

Symptoms.—(1) There is complaint of a dull dragging pain in one or both loins. (2) With this there is a tumour in one or both loins, but usually larger on one side; the surface is irregular and feels cystic, although the kidneys feel very firm otherwise. (3) The other symptoms are those of chronic interstitial nephritis (§ 399), the urine is abundant, pale, of low specific gravity, containing traces of albumen, and occasionally blood and casts. The heart becomes hypertrophied, and the pulse indicates high blood pressure. (4) Polycystic disease may co-exist in the liver, spleen, ovaries and pancreas. The patient may have excellent health for many years, or may develop symptoms of chronic uræmia. It may give rise to an enormous tumour in the fœtus and obstruct delivery. In children, symptoms may be associated with renal rickets.

The *Diagnosis* may be difficult. When symptoms of granular kidney occur, together with a tumour in both renal regions, the condition may be diagnosed as polycystic kidney. The tumours have to be diagnosed from other abdominal tumours (§ 263). Pyelography reveals a large kidney with elongated calyces (Fig. 104).

Etiology.—The disease is usually familial. In the majority, the patients are middle-aged.

Prognosis.—The younger the patient the worse the prognosis. In those diagnosed in middle age, it is common for them to survive 20–30 years.

Treatment is similar to that of nephritis. Death may occur from uræmia or the same complications as those of interstitial nephritis. Operation must not be performed as the condition is bilateral. A surgical support may be of value when the weight of the tumour is producing symptoms.

Hydatid cyst may occur in the kidney, and may be difficult to differentiate from other cysts unless it opens into the pelvis of the organ, when the characteristic hooklets (Fig. 85) are found in the urine. The passage of vesicles may cause renal colic. The condition may be suspected if (i.) the tumour has the "hydatid thrill" on palpation; (ii.) there is evidence of cysts elsewhere; and (iii.) there is a history of residence in infected countries. (iv.) Eosinophilia may be present. The complement fixation test and the Casoni reaction aid diagnosis (§ 347).

The *Prognosis* is generally not grave. The cyst may last for years with no symptoms, or it may burst into the pelvis of the kidney. It may open into the stomach or bowel, with temporary recovery; or into the chest, which is a serious complication. It may become very large and give rise to pressure signs.

Treatment is surgical.