CONTENTS

A SHORT PRACTICE OF SURGERY

CHAPTER I

NON-SPECIFIC INFECTIONS AND WOUNDS

McNeill Love

INFECTION is the invasion of the body by pathogenic or disease-producing organisms. These organisms show a predilection for different tissues, e.g. staphylococci for skin and bones, streptococci for mucous membranes, and pneumococci for lung and peritoneum.

The more important pyogenic organisms are :

1. **Staphylococci,** which commonly cause infection of the skin and subcutaneous tissues, such as boils and carbuncles. They are also responsible for some varieties of deep-seated suppuration, e.g. osteomyelitis or perinephric abscess. In these cases the organisms are conveyed from the skin or respiratory passages to the deeper tissues by the blood-stream.

Staphylococci occur in characteristic clusters (fig. 1), are Gram-positive,
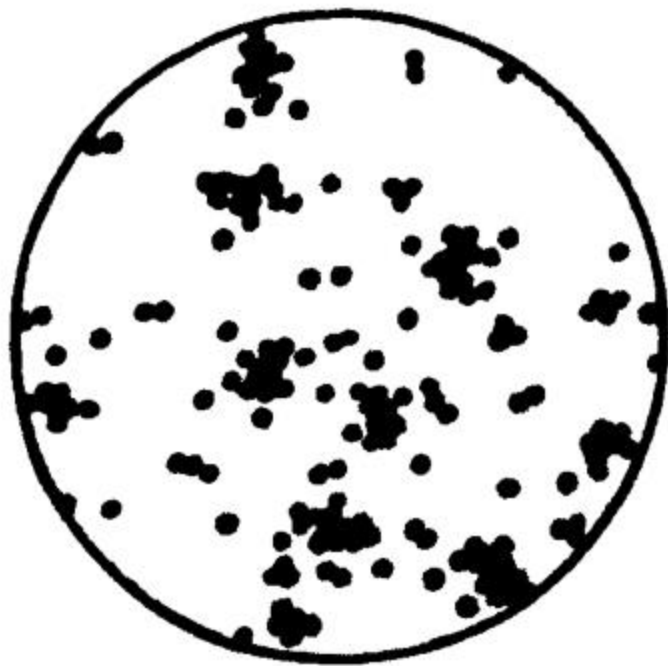
FIG. 1.—Staphylococci.

FIG. 2.—Streptococci.

and grow readily on culture media. Cultures vary in colour, and are named accordingly, e.g. albus, aureus, citreus, but the latter is non-pathogenic.

2. **Streptococci** are Gram-positive organisms, which grow in chains (fig. 2), and comprise many different strains. Members of the same strain often develop varying degrees of virulence. Two main groups of streptococci are the hæmolytic and non-hæmolytic varieties, the former being the more virulent, and producing spreading types of infection, such as

Hans Christian Joachim Gram, 1853–1938. Professor of Medicine, Copenhagen.

S.P.S.—1

erysipelas, cellulitis, lymphangitis, and occasionally gaining access to the blood-stream and causing ulcerative endocarditis or puerperal fever.

Non-hæmolytic streptococci are more commonly concerned with infection of the tonsils, gall-bladder, etc.

3. **Pneumococci** are arranged in pairs, the individual coccus being oval in shape. These organisms are the common cause of pneumonia, and are usually found either alone or in association with other organisms, e.g. in pus from empyemata. Acute arthritis, meningitis, otitis media, and peritonitis, particularly in young girls, are also sometimes caused by pneumococci.

4. **Escherichia coli** are Gram-negative, and normally inhabit the healthy intestine. They are distinguished from the typhoid group of bacilli by their action on various sugars. In intestinal obstruction and other pathological conditions of the intestine the organisms are liable to become extremely virulent. Peritonitis, cholecystitis, and urinary infections are commonly due to *E. coli*.

5. **Salmonellæ** may cause enteritis, acute osteomyelitis, or acute or chronic cholecystitis, sometimes years after the original infection. Some patients after recovery continue to excrete bacilli in the urine, bile, and fæces. These ' carriers ' occasionally cause epidemics, as in the Aberystwyth epidemic of 1946, which was traced to an infected ice-cream vendor.

6. **Pseudomonas pyocyanea** occasionally infect wounds as secondary invaders, and delay healing. The pus is bluish green, with a musty odour. Applications of gauze moistened with perchloride of mercury, 1 : 8,000, usually overcome the infection. Resistant cases respond to a 2·2 per cent. dressing of phenoxetol (the monophenylether of ethylene glycol), applied daily.

7. **Neisseria gonorrhœæ** are Gram-negative organisms arranged in pairs. Each coccus is kidney-shaped, and the two lie with their concave sides adjacent (fig. 32). When gonoccocal pus is examined, some of the polymorphonuclear cells are seen to be crowded with *N. gonorrhœæ*. The most characteristic lesion produced by *N. gonorrhœæ* is urethritis. Direct transmission is responsible for conjunctivitis (p. 34) or proctitis in the female, and organisms in the blood-stream sometimes cause arthritis, fibrositis, or endocarditis.

ACUTE ABSCESS

Organisms which cause pus formation in any part of the body reach the infected area by one of three routes :

(i) Direct infection from without, e.g. penetrating wounds.

(ii) Local extension from some adjacent focus of infection, such as an alveolar abscess from an infected tooth root.

(iii) Blood-stream or lymphatic vessels.

In the case of hæmatogenous infection, some predisposing factor may operate, e.g. a torn muscle causes an extravasation of blood which forms a suitable nidus for pyogenic organisms, or debilitating disease lowers the general resistance and allows infection to arise, e.g. perinephric abscess. The bacteria, having gained access to the tissues, multiply and produce

Antony van Leeuwenhoek of Delft, Holland, invented the microscope, and was the first to see bacteria in 1675. He made over 400 microscopes with his own hands.

toxins, and so cause acute inflammation. The vitality of the tissues is lowered, and the area is surrounded by a peripheral and painful zone of acute inflammation, which is infiltrated with leucocytes and bacteria. The central necrotic mass undergoes liquefaction, and the tension within the cavity is raised by exudation of plasma, the resulting fluid containing leuco-cytes and bacteria. The abscess, if it enlarges, spreads along the paths of least resistance, usually towards the surface of the body or a hollow viscus, and eventually discharges its contents.

Occasionally the resistance of the body is sufficient to destroy the bacteria before pus finds its way to the surface, in which case the fluid is absorbed, and either fibrosis follows or a cavity remains containing inspissated pus. For example, this condition occasionally occurs in the breast, following hæmatogenous infection of a traumatic hæmatoma, and may easily be confused with a scirrhous carcinoma. In some cases, as in staphylococcal abscesses of bone (Brodie's abscess), infection remains latent, but gives rise to exacerbations of inflammation consequent on local injury or impaired general health.

Symptoms.—The patient complains of malaise, the degree depending to some extent upon the size of the abscess, the virulence of the organism, and the tension within the cavity. Throbbing pain is characteristic of suppuration, the pain becoming more acute if the affected part is dependent, e.g. an infected finger.

Signs.—(a) *General.*—The signs of inflammation are present to a varying extent. In severe cases rigors may occur.

(b) *Local.*—The five classical local signs of inflammation are :

1. *Heat*—the inflamed area feels warmer than the surrounding tissues.

2. *Redness* of the skin over the inflamed area. Both this sign and the previous one are due to hyperæmia.

3. *Pain*, owing to the pressure of exudate on the surrounding nerves. If the exudate is under tension, e.g. a furuncle of the external auditory meatus, pain is severe, whereas lax tissues, such as the scrotum, may swell enormously with but little discomfort.

4. *Swelling*, as a result of hyperæmia and inflammatory exudates.

5. *Loss of function*—an inflamed tissue does not perform its physiological function.

The readiness with which these signs present depends on the extent of the inflammation and its proximity to the surface. The swelling is at first brawny

FIG. 3.—Abscess of neck. The arrows indicate fluctuation in two planes.

and œdematous ; later softening and fluctuation are manifest (fig. 3). In some cases increasing œdema is characteristic of deep pus, as in acute mastitis. If untreated, an abscess tends to point, the skin or membrane

Sir Benjamin Brodie, 1783–1861. Surgeon, St. George's Hospital, London.

covering it gives way and the contents are discharged, usually with marked amelioration of symptoms.

Treatment.—When an abscess threatens to form it can sometimes be aborted by rest, and elevation of the affected part will relieve pain. Kaolin poultices promote hyperæmia, and constitutional treatment, including chemotherapy and penicillin, is instituted.

If pus is suspected, steps are usually taken to evacuate the abscess by incision and drainage. In regions where incisions are fraught with danger to important anatomical structures, as in the neck or axilla, a modification of Hilton's method should be used. This consists of incising the skin and superficial fascia, and opening the abscess by thrusting a pair of sinus forceps or a hæmostat into the cavity. By separating the blades, a sufficiently large opening can be made to insert, if necessary, a finger in order to convert loculi into a single cavity, followed by a drainage tube. Pus from an abscess should be examined bacteriologically, and, if considered advisable, the sensitivity of organisms to antibiotics is ascertained (p. 8).

SINUSES AND FISTULÆ

If an abscess is opened inadequately, a sinus or fistula may result. A *sinus* is a narrow track lined with granulations which opens on the surface, whereas a *fistula* is an abnormal communication between two cavities, or between a cavity and the body surface. Thus, a perianal abscess may burst on the surface and lead to a sinus, erroneously termed a blind external 'fistula.' In other cases the abscess opens both into the anal canal and on to the surface, resulting in a true fistula.

Sinuses and fistulæ often heal slowly, for the following reasons :
(i) A foreign body or necrosed tissue may be present.
(ii) The walls become lined with epithelium.
(iii) Dense fibrosis prevents contraction.
(iv) Irritating discharges, such as urine or fæces, maintain continuous inflammation.
(v) Inefficient or non-dependent drainage.
(vi) Absence of rest, such as the normal sphincteric contractions in the case of fistula-in-ano.
(vii) Type of infection, e.g. tuberculosis or actinomycosis.

Treatment consists in removal of any cause, e.g. provision of adequate drainage, if necessary by counter-openings. Packing with gauze moistened with a suitable antiseptic will encourage healing from the bottom of the cavity. Antiseptics should occasionally be changed, as organisms appear to become immune to long-continued use of the same preparation. Rest is provided as efficiently as possible, and scraping or cautery is sometimes necessary to destroy any lining of epithelium.

AMYLOID DISEASE

This results from persistent suppuration and is becoming increasingly rare. It is most commonly seen nowadays as a result of chronic empyema, or sinuses in con-

John Hilton, 1805–1878. Surgeon to Guy's Hospital. One of the original 300 Fellows of the Royal College of Surgeons. Wrote a classic on " Rest and Pain." He used a grooved director in his search for pus.

nection with the hipjoint. The term 'amyloid disease' is a misleading one, as the infiltration of tissues is not due to any starchy substance, but to chondroitin-sulphuric acid in combination with a protein. Infiltration commences in the walls of the smaller arterioles, and later spreads to larger vessels, and even to connective-tissue stroma. The substance is stained a mahogany brown by tincture of iodine, and microscopically, methyl violet stains the infiltrated tissues a rose pink, while normal structures are stained blue.

Affected organs show a regular, smooth enlargement. The first changes in the liver occur in the intermediate zone of the lobule. Polyuria is present owing to infiltration of the kidneys, which first commences in the glomeruli. Diarrhœa ensues owing to infiltration of the capillaries in the villi of the small intestine, and splenic enlargement occurs, the Malpighian bodies being chiefly affected (sago spleen). If the source of infection can be eradicated, early amyloid disease will resolve.

FIG. 4.—Enlargement of the liver and spleen due to amyloid disease. Amputation was performed through the left hip joint for osteomyelitis of the upper end of the femur, but sinuses persisted. He succumbed six months later.

CELLULITIS

Cellulitis is due to spreading inflammation of the subcutaneous and cellular tissue which sometimes progresses to suppuration or gangrene. In the latter case widespread sloughing of tissues occasionally results. The condition was formerly known as 'hospital gangrene,' which often progressed to a fatal issue.

The streptococcus is usually the causative organism, and often gains admission to the tissues through an accidental wound, trivial in nature, such as a graze or scratch, or possibly as the result of an operation. If the general resistance of the patient is undermined as by such conditions as diabetes, alcoholism or renal inefficiency, cellulitis is likely to spread rapidly and extensively.

The clinical condition depends upon the virulence of the organism and the extent of infection. Redness and itching or stiffness commence at the site of inoculation, to be followed by tenderness and swelling (fig. 5).

FIG. 5.—Cellulitis of forearm following infection of a lacerated wound. (Col. E. J. Pulaski U.S. Med. Corps.)

The general features of infection are usually obvious, and septicæmia or pyæmia sometimes develops.

Treatment consists in attending to the general health of the patient, and a course of penicillin or other chemotherapy is prescribed. If pus is suspected, free incisions are made in the axis of the limb, down to the deep fascia. Baths of hypertonic saline (5 per cent.), to encourage lymphatic drainage, alternating with antiseptic dressings, are useful.

CELLULITIS IN SPECIAL SITUATIONS

Scalp.—This is due to infection of the sub-aponeurotic layer of areolar

Marcello Malpighi, 1628–1694. An Italian Physiologist.

tissue. Pus may extend to the attachment of the epicranial aponeurosis, so that the whole scalp is lifted off the calvarium. Necrosis of bone, or thrombosis of emissary veins spreading to intracranial sinuses, may follow. Early incisions, parallel to the arteries, are necessary when pus is suspected.

Orbit.—This follows wounds or spread of infection from air sinuses in the vicinity (p. 134). Proptosis and impairment of ocular movements follow, and infection may spread to the meninges, or thrombosis extend along the ophthalmic veins to the cavernous sinus. The eyeball itself occasionally becomes infected (panophthalmitis).

Owing to risk of cellulitis, all wounds of the orbit demand careful attention. If infection supervenes, drainage is provided by incisions in the eyelids or conjunctival fornix. Panophthalmitis is treated by evisceration of the eye ; this procedure is safer than excision, which is liable to be followed by meningitis from infection extending along the open sheath of the optic nerve.

Neck.—A complication of wounds, tonsillitis, or mastoiditis. Ludwig's angina is a term applied to submaxillary cellulitis (p. 196). The two main dangers of cervical cellulitis are œdema of the glottis with possible asphyxia, and mediastinitis.

Pelvis.—Not infrequently follows lacerations of the cervix uteri, or less commonly results from disease or injury to any of the pelvic organs, such as extraperitoneal rupture of the bladder. Inflammation may extend upwards from the pelvis, in which case an indurated swelling appears above the inguinal (Poupart's) ligament.

In the early stages, hypogastric fomentations and vaginal douches are useful. If the swelling appears above Poupart's ligament and deep œdema or softening is detected, the abscess is incised and drained extraperitoneally. Posterior colpotomy is sometimes indicated.

WOUND INFECTION

Infection of accidental wounds is often unavoidable, although early and thorough treatment frequently prevents the development of the infection. Surgical wounds in ' clean ' cases may become infected owing to some flaw in technique, or faulty sterilisation of instruments or material.

LOCAL changes are those of inflammation, which, if superficial, manifests itself as a cellulitis of varying extent. If infection is deep in a wound, swelling occurs, so that the stitches appear to be under tension ; tenderness and induration follow. If suppuration occurs, the abscess is liable to burst superficially, and perhaps a knot or ligature is discharged.

GENERAL evidence of infection is due to toxæmia, septicæmia, or pyæmia, or a combination of these conditions.

TOXÆMIA is due to absorption of toxins, and a small collection of pus under tension, as in the mastoid antrum, often causes profound toxæmia. The general features of inflammation are present, although in severe cases the temperature may be subnormal, with increased pulse-rate.

Wilhelm von Ludwig, 1790–1865. Professor of Surgery and Midwifery, Tübingen.
François Poupart, 1661–1709. French Anatomist.
Lord Lister, 1827–1912, of Glasgow University, Edinburgh University, and King's College Hospital, London,
introduced antiseptic surgery in 1867.

SEPTICÆMIA and BACTERIÆMIA are due to the presence of organisms in the blood. In the former condition the organisms are not only present in the circulation but actually proliferate therein. Streptococci are the commonest organisms to be found in the blood culture.

The clinical features are those of severe infection, frequently preceded by a rigor. The temperature is commonly intermittent, and rigors may continue. Icterus occasionally occurs from hæmolysis, and the degree of polymorpho-leucocytosis present is an indication of the patient's power of resistance.

Treatment consists in dealing promptly and efficiently with the causative focus of infection. Antibiotic therapy often yields striking results, and organisms should be isolated and tested regarding their sensitivity to suitable antibiotics.

PYÆMIA is due to the circulation in the blood-stream of infective emboli composed of masses of organisms, vegetations or infected clot. Pyæmia may be associated with acute infective osteomyelitis, infection of an intra-cranial sinus, infective phlebitis and ulcerative endocarditis.

When the infected embolus is arrested in a vessel, thrombosis occurs round it, and infection spreads into the adjacent tissues. If the embolus arises in connection with the systemic circulation, it is likely to be arrested in the lung, so that a wedge-shaped hæmorrhagic infarct results, which may later form an abscess. From these abscesses fresh emboli may arise and reach the left side of the heart, and thus be widely disseminated. If the focus of infection is in the portal area, the emboli are carried to the liver, giving rise to pylephlebitis (*syn.* portal pyæmia).

Clinically, pyæmia is characterised by rigors, an intermittent temperature and the formation of abscesses. Abscesses occur in any part of the body, and are commonly painless; thus an abscess in the back may be accidentally discovered as a swelling by a nurse while washing the patient. Joints are occasionally affected, and sometimes become quietly disorganised. Death usually follows abscess formation in vital structures, such as heart or brain.

The treatment of pyæmia consists in endeavouring to prevent further emboli from reaching the blood-stream. Thus, in the case of pyæmia due to suppurative arthritis of the knee joint (nowadays a rare occurrence), amputation is indicated, or if the condition is caused by thrombosis of the lateral sinus, then ligation and division of the internal jugular vein may be successful in interrupting the stream of emboli. In portal pyæmia successful cases have been reported following ligation of the superior mesenteric vein, combined with penicillin. Otherwise, abscesses are dealt with as they occur, and general treatment is instituted as for septicæmia.

ANTIBACTERIAL AND ANTIBIOTIC THERAPY

An antibacterial agent is one which destroys organisms in the body, whereas an antibiotic is a substance produced from living organisms which inhibits the growth of organisms. For many years attempts were made to produce a therapeutically useful antibiotic, but it was not until 1941 that Florey

Sir Howard Florey, Contemporary. Professor of Pathology, Oxford.

produced a reliable and stable preparation suitable for clinical purposes. Following this discovery, innumerable antibiotics have been isolated, and their numbers steadily increase.　The uses of the commoner preparations are depicted in fig. 6.

	Penicillin	Streptomycin	Aureomycin	Chloromycetin	Sulphonamides
Gram-positive bacteria					
Diphtheria					▓
Anthrax					▓
Gas gangrene					▓
Streptococcus	▓		▓		▓
Staphylococcus	▓		▓		▓
Pneumococcus	▓		▓		▓
Gram-negative bacteria					
N. gonorrhoeae	▓	▓	▓	▓	▓
N. meningitidis	▓	▓	▓	▓	▓
Dysentery		▓			
E. coli		▓		▓	
Proteus		▓		▓	
Pyocyaneus		▓			
Typhoid		▓			
Tuberculosis				▓	
Viruses					
Lympho-grunuloma Inguinale			▓	▓	
Psittacosis			▓	▓	
Virus pneumonia			▓	▓	
Typhus (Rickettsia)			▓	▓	
Syphilis, Yaws	▓			▓	
Actinomycosis	▓			▓	

FIG. 6.—Shaded squares indicate sensitivity.

ANTIBACTERIAL AGENTS

SULPHONAMIDES.— Sulphatriad is commonly used, and has a wide application. It is composed of sulphathiazole, sulphadiazine and sulphamerazine. Toxic symptoms and crystalluria are uncommon with this preparation. Sulphasuxadine or sulphathalidine are usually prescribed as an intestinal disinfectant. Vomiting necessitates intravenous or intramuscular injection of a suitable preparation. If injected subcutaneously, sloughing is likely to occur.

Adequate chemotherapy depends on maintaining a suitable concentration of the chemical in the blood, and the usual course of treatment lasts four or five days. During administration fluid intake must be increased, due allowance being made for loss due to increased temperature and perspiration. Potassium citrate is prescribed so as to maintain alkalinity of the urine.

Severe toxic reactions are nearly always due to an excessively long course, even though doses are small. Crystals derived from the drug may form in the renal tubules, causing renal colic, hæmaturia, and even fatal suppression. Hæmolytic anæmia and agranulocytosis are especially apt to occur during a second course of treatment. Agranulocytosis may respond to intramuscular sodium pentose nucleotide ('pentnucleotide'), 20 ml. being administered daily, and hæmatinic agents, such as liver extracts, should also be given. No course of sulpha drugs should last longer than one week, and a second course is only prescribed after a lapse of three days, and provided that the blood picture is satisfactory. Toxic hepatitis, skin rashes, and optic neuritis also occasionally occur.

When suppuration has occurred, care must be taken that subclinical evidence of pus does not cause deferment of a necessary operation ; this is particularly true of mastoid infection, and abscesses in any situation.

Ambulant patients are apt to suffer from lack of mental concentration, and should be warned that this may affect such intricate manœuvres as car driving.

PENICILLIN is a valuable antiobiotic agent, which, in contradistinction to the sulphonamides, retains its activity in the presence of blood, pus, and autolysed tissues. It is particularly valuable in combating streptococcal and staphylococcal infections, and Cl. tetani and the organisms responsible for gas gangrene are sensitive to its action. It is the treatment of choice for gonorrhœa, syphilis, and actinomycosis. If circumstances permit, the organism is tested for sensitivity to penicillin. If the organism is sensitive, no growth occurs on a suitable medium in the vicinity of the pencillin fungus (fig. 7).

Penicillin is usually administered by intramuscular or intravenous injection and adequate blood concentration is necessary, as it is rapidly excreted by the kidneys ; or it can be applied locally provided that the whole of the infected area is accessible. Procaine penicillin provides an effective blood level for twenty-four hours, but more recent preparations are effective for a week. Allergic skin reactions, or rarely anaphylaxis, may prohibit further administration, but mild cases usually respond to antihistamine. Oral administration is less reliable, as penicillin is destroyed by acid,

but some absorption occurs if large amounts are taken on a fasting stomach. The early administration of penicillin is a valuable prophylactic measure against infection of contaminated wounds, e.g. industrial injuries and road accidents, but it is not a substitute for inadequate surgical measures.

STREPTOMYCIN is produced from a mould culture—*Streptomyces griseus.* It possesses a bacteriostatic effect on some Gram-negative organisms which are penicillin resistant. As organisms tend to become resistant a short and intensive course is advisable. Streptomycin is valuable in meningeal and urinary infections due to Gram-negative bacilli and in tuberculosis, but is of little use in intestinal infections caused by typhoid or salmonella organisms. Pulmonary tuberculosis is inhibited as long as administration is continued, and some cases of tuberculous meningitis have been cured, but toxic effects occasionally follow prolonged treatment.

When used in the treatment of tuberculosis streptomycin is combined with either *p*-amino-salicylic acid (P.A.S.), or iso-nicotinic acid hydrazide (I.N.A.H.), in order to maintain the sensitivity of the organism. Disturbance of vestibular function occasionally occurs, but returns to normal if the drug is withdrawn forthwith.

FIG. 7.—Culture of Staphylococcus pyogenes, sensitive to streptomycin (1), less so to sulphonamide (2) and penicillin (3), and resistant to chloromycetin (4).

The TETRACYCLINES include aureomycin, terramycin and achromycin. *Achromycetin* is more static than the two following preparations, and rarely is responsible for side-effects.

AUREOMYCIN is obtained from a mould, *Streptomyces aureofaciens,* and is so-called because it is a golden-coloured crystalline substance. It is potent against a wide range of Gram-negative and Gram-positive organisms. At present its use is restricted to combat organisms which are resistant to other antibiotics. It is comparatively non-toxic, and organisms do not become resistant to it. If administration is required for more than a few days Vitamin B must be prescribed, as otherwise disturbance to the normal intestinal flora results in deficiency of this vitamin. Prolonged use of aureomycin may also give rise to pruritus or even to entero-colitis.

TERRAMYCIN is very similar chemically to aureomycin, and has an almost identical 'spectrum.' It is claimed to cause fewer unpleasant effects, and has the advantage that it can if necessary be administered intravenously, e.g. for speedy control of severe infections. Terramycin is especially effective in infections of the urinary tract.

CHLOROMYCETIN was the first antibiotic to be synthesised, and is specially useful in bowel diseases, such as typhoid and bacillary dysentery, also in psittacosis and virus pneumonia.

POLYMIXIN, NEOMYCIN AND BACITRACIN are useful in the treatment of skin conditions and wounds as a surface application. If administered orally or parenterally, they are apt to cause renal damage.

CATHOMYCETIN is especially useful for staphylococcal infections which are resistant to other antibiotics, and is the preparation of choice in cases of *proteus* infections. Moreover, it has a synergistic bactericidal action with many other antibiotics.
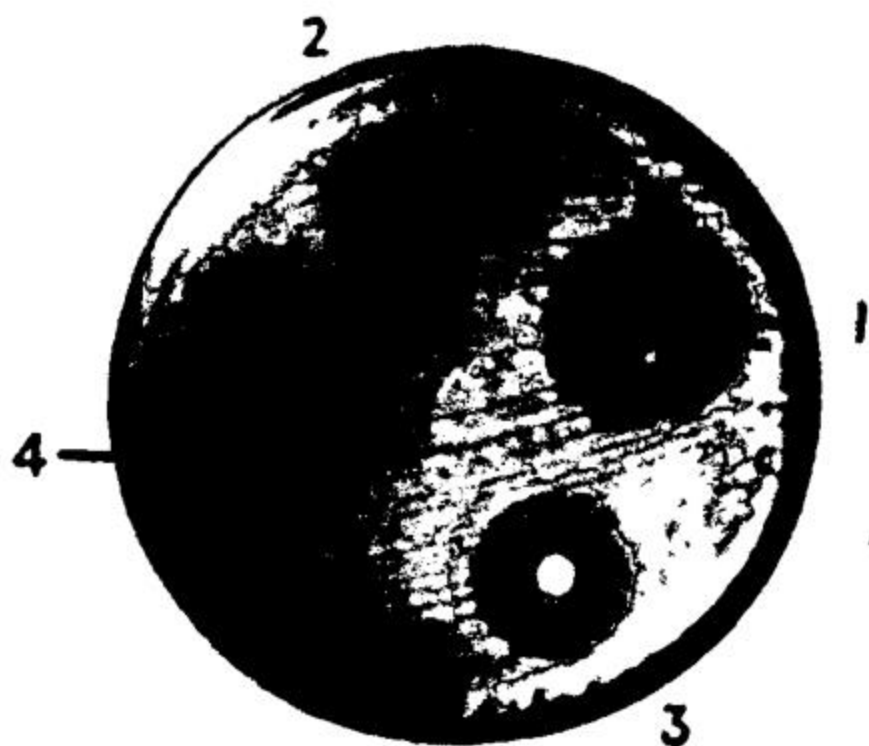
SELECTION OF ANTIBIOTICS

New antibiotics appear monthly, and refractory patients and resistant organisms are increasing steadily. The tendency to ' blunderbuss ' antibiotics is greatly to be deprecated, as many are antagonistic. At the present time two most valuable synergic ones are penicillin and streptomycin. Each clinical case must be judged on its merits, with due regard to the organism, laboratory tests, ease of administration, and possible troublesome or dangerous side-effects.

ANTIBIOTIC ENTERO-COLITIS (*syn.* PSEUDO-MEMBRANOUS ENTERO-COLITIS, STAPHYLOCOCCAL CHOLERA)

This condition occasionally follows the administration of broad-spectrum antibiotics, but may occur when any antibiotic sulpha drug is used. It is due to a resistant strain of *Staphylococcus aureus*, which establishes itself when the usual intestinal flora, especially *Esch. coli*, are reduced in numbers. Occasional vomiting and profuse diarrhœa, with associated dehydration, are the usual features, and in post-operative cases severe shock may cause diagnostic difficulty.

A smear of fæces should be examined microscopically in suspected cases, so that if the diagnosis is confirmed treatment can commence immediately, and at the same time cultures are made on blood agar.

Treatment consists in fluid replacement and the injection of corticotropin for immediate action, also cathomycetin is prescribed, but in severe cases its action alone may be too slow to overcome the infection.

WOUNDS

The treatment of a lacerated wound is primarily concerned with prevention of infection. A secondary consideration is the repair of damaged structures, which is considered in the appropriate chapters. In the case of recent wounds, e.g. due to accidents, an emergency operation is performed in order to cleanse the wound as completely as possible, and every hour's delay adds to the risk of the infection becoming established. An anæsthetic is usually necessary, and the surrounding skin is purified. The edges of the wound are excised, and damaged tissue and foreign bodies removed. Sulphonamide and penicillin powder (5 to 15 G., according to the size of the wound) is insufflated into every recess, and suitable doses of penicillin are administered. If a large nerve is exposed, light dusting is beneficial, but any excess is liable to result in toxic neuritis. Unless loss of skin is excessive, closure can usually be obtained with the help of a relaxation incision (fig. 8). Hæmorrhage from small vessels is controlled by torsion, ligation with catgut
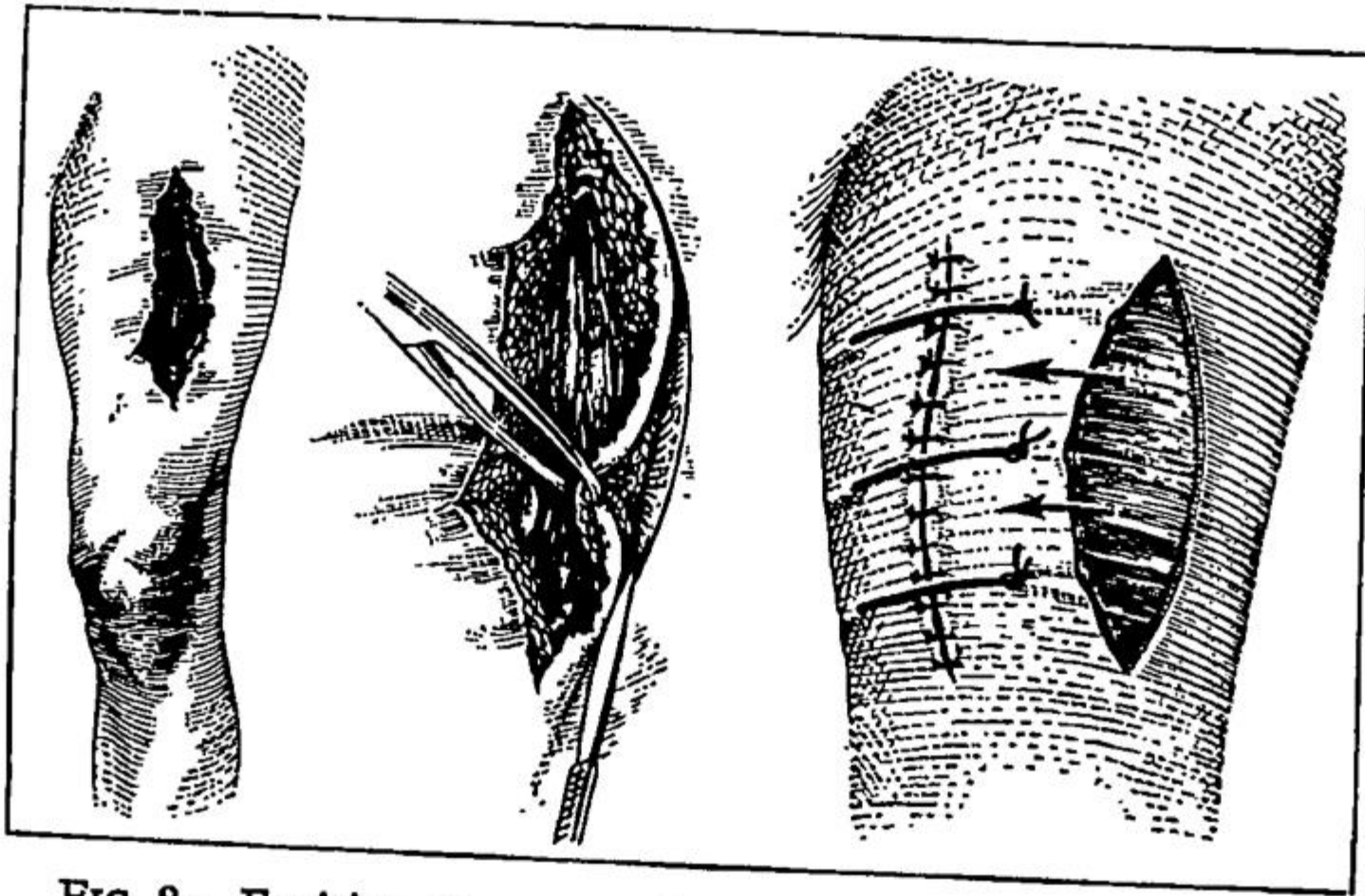

FIG. 8.—Excision of an extensive wound. Closure is facilitated with the help of tension sutures and a relaxation incision. (The bare area is covered with a split-skin graft.)

being reserved for larger vessels. Catgut is dead protein, and as such encourages infection. A plaster cast may be advisable, and in the case of the leg must extend to the toes, otherwise œdema of the foot will tend to cause

ulceration where the edge of the plaster presses on the swollen tissues.   The plaster provides adequate rest to the damaged structures ; it is removed in about three weeks, and is reapplied if necessary.   In some cases secondary suture is required at a later date.   In the case of a dangerous punctured wound, such as might occur during a post-mortem or operation, acriflavine (1 ml. of 1 : 500) should be injected immediately with a hypodermic needle around the track of the wound.

The following points should be borne in mind concerning other antiseptics which are commonly used in the treatment of wounds.   Those which depend on oxygen or chlorine as active principles are inactivated by blood or serum, and chlorine is driven off if the solution is heated.   Iodine also is inactivated by blood, but it is now obsolescent as an antiseptic.   Such substances as lysol, cyllin and carbolic acid devitalise tissues if used in sufficient strength to act as efficient antiseptics.   Mercury compounds are rendered inert by combination with proteins in the serum, and are incompatible with iodine.

In all cases in which tetanus *might* develop, a prophylactic dose of antitetanic serum *must* be given (p. 22).

SERUM REACTIONS

Patients who have had previous serum injections, and especially those who are subject to asthma or allergic diseases, are prone to local or general reaction.   To test for sensitivity a small amount of normal horse serum, or the serum to be used, should be diluted with ten times the amount of saline, and 0·1 ml. is injected intradermally. In sensitised patients a local reaction occurs within fifteen minutes, in which case the serum must be administered in fractional doses, e.g. 0·5 ml. is injected subcutaneously, and the dose doubled at half-hourly intervals, until the full dose is given.   After this desensitisation, further doses can be given safely.

Acute anaphylaxis may develop in sensitised patients if the above precautions are not observed.   The symptoms, notably respiratory distress, usually appear in a few minutes.   A tourniquet should be applied immediately, and adrenalin hydrochloride 1 ml. (1 : 1,000) injected subcutaneously at hourly intervals.

Local anaphylaxis is occasionally seen if further injections are given at the same site after the interval of a week.   An acute inflammatory reaction occurs, which in rare cases progresses to sloughing of tissues.

Serum sickness is the commonest serum reaction and may occur in any patient. Urticaria, œdema, pains or effusion in joints, and elevated temperature are usual features, which frequently occur seven to ten days after the injection.   Anti-histamine compounds, e.g. 'benadryl,' should be administered.   Cold applications applied locally, and injection of adrenalin, minimise the discomfort.

BITES

Insect bites in this country are usually inflicted by wasps or bees, and anthrax has followed the bite of a horsefly.   Anaphylaxis can follow a bee or wasp sting in sensitised people.   Vasomotor collapse, coma and death may occur within twenty minutes.   If anaphylactic symptoms arise, a subcutaneous injection of adrenalin (1 ml. of 1 : 1,000) is urgently required. Bees and wasps (including hornets) are easily distinguished if seen, otherwise most bees, as distinct from wasps, suffer avulsion of their sting, which is left protruding from the wound.   Bee venom is acid, and should be neutralised by the application of ammonia, soda, or methyleneblue.   On the contrary, the venom of the wasp is alkaline, and requires an acid, such as vinegar or lemon juice, for its neutralisation.   Anti-histamine

drugs given orally or applied locally are of value in allaying local irritation.

Bites of animals such as the horse, cat, and dog require the usual treatment of wounds. When there is the slightest suspicion that the animal is suffering from rabies, the bite should be freely excised or cauterised with carbolic acid, solid silver nitrate, or the cautery. If possible the responsible animal should be kept under observation, or if it has been killed Negri bodies should be sought for in the brain. Prophylactic treatment can be obtained only at a special institute.
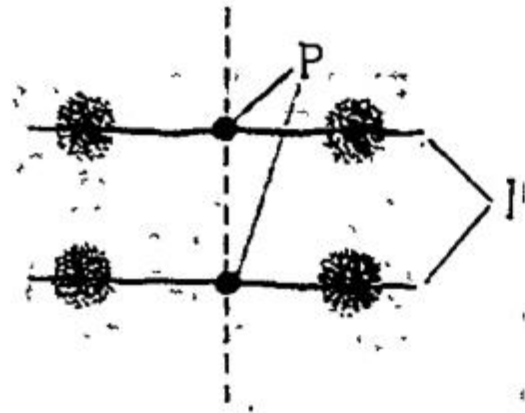

FIG. 9.—P = punctures, I = incisions. The shaded areas indicate possible deposits of venom.

Snake bites should be treated by the immediate application of a tourniquet, and, if the patient is co-operative, two incisions are made through the puncture wounds at right angles to a line connecting them (fig. 9). A snake's fang is curved, so poison may be deposited on either side of the puncture wounds, according to the position of the reptile on biting. If available, permanganate of potassium is then applied. If incision is impracticable, the patient, or a friend, sucks the wound ; any poison which may be swallowed is harmless. Stimulants are given generously, and anti-venom neutralises the poison of some varieties. If possible, the reptile should be killed or captured for identification purposes. In England the only poisonous reptile is the adder, or viper, but a fatal result is unlikely unless the victim is very young or debilitated. During the decade 1943–1953 only three fatal cases occurred in England and Wales, two of whom were debilitated children.

Human bites should be cauterised with fuming nitric acid, and subsequently dressed with a chlorine-containing solution.

FOREIGN BODIES IN THE TISSUES

In every case of suspected foreign body which is opaque to X-rays, a radiograph must be taken in at least two planes. Other aids at X-ray localisation are the insertion of straight needles or Kirschner wires aimed at the foreign body, or Michel's clips applied to the skin over the presumed site. We have found that, in the case of comparatively superficial foreign bodies, personal observation and palpation in the X-ray room is of great assistance. When removal is attempted, a good light, ample time, and exsanguination of the limb are all highly desirable. Exsanguination assists by rendering the field bloodless, and in recent cases a reddish or brown track, due to extravasated blood, indicates the path of the foreign body.

Hypodermic needles not infrequently break at the neck, where corrosion easily occurs. Stainless needles are advisable, and should be tested frequently. The most difficult needle to recover is one situated in the internal pterygoid muscle, which has broken when a dental surgeon has attempted a mandibular block. The glistening tendinous intersections in the muscle continually raise the surgeon's hopes, and he is fortunate if the needle is recovered within an hour, but a good anæsthetic, adequate light, and patience bring their due reward.

Domestic needles commonly become impacted between the small bones of the hand or foot. The patient may be entirely unaware of their entry. Unless a small fragment is lodged deeply, removal is advisable, as infection may otherwise develop, and startling cases are on record in which a needle

has entered the venous circulation and become embedded in the heart muscle, or travelled to some distant part of the body.

Sewing-machine needles occasionally transfix the terminal phalanx and nail, and then break. After injecting a local anæsthetic the finger should be forcibly pressed on to a hard surface, so that the fragment retraces its path. The end then projects through the nail and is removed with forceps.

Indelible-pencil fragments occasionally become lodged in the subcutaneous tissue of the hand, particularly in children (fig. 10). The treatment is immediate excision of the fragment and adjacent tissue. If allowed to remain, a pigmented discharge will persist for months, and the exuberant granulations require constant attention.

Fish hooks, and similar articles which possess barbs, are removed by pushing the hook in such a direction that it emerges through the skin at the nearest point. The barb is then nipped off, and the hook withdrawn along the path of entry. Local anæsthesia is desirable.

FIG. 10.— Chronic discharging wound resulting from a fragment of indelible pencil.

Gravel is not uncommonly driven into the subcutaneous tissues of the face, hands, or knees. Ugly scars are the penalty of incomplete removal—a particularly distressing sequel if occurring on the face—'tattoo marks.' In all but minor cases an anæsthetic and meticulous removal are indicated. Brisk rubbing with a nail-brush is sometimes helpful. Any small remaining fragments are encouraged to extrude themselves by the application of hot compresses of hypertonic saline, or 10 per cent. sodium sulphate.

Glass splinters as a rule contain sufficient lead to render them opaque to X-rays. Every lacerated or punctured wound caused by glass must be

examined radiographically, as it is surprising how often fragments of glass are otherwise missed (fig. 11). In the majority of cases removal is indicated.

Surgical operations in which metallic sutures are used occasionally lead to trouble. Thus, wire sutures in the abdominal wall sometimes break within a few days of their insertion, and the fragments are apt to cause sinuses until they extrude or are removed. It is remarkable that even

FIG. 11.—A piece of glass at the outer side of the wrist joint. Its presence was unsuspected for three weeks.

stout wire may snap spontaneously, and the fragments in some situations cause serious trouble (fig. 12).

Punctured wounds, see p. 11.

Swabs and *packs* are occasionally overlooked, especially during an abdominal operation, an oversight which is a not uncommon cause of litigation. The foreign body causes a local peritoneal irritation, and usually within a few

weeks a tender swelling is palpable. In due course suppuration occurs and some months later the swab escapes with a discharge of pus either on the surface or into the alimentary canal. Radio-opaque threads (such as those in bank notes) should be incorporated in all swabs or packs, so that if one is overlooked during an operation it can be discovered by portable X-rays (fig. 13). Alternatively, a negative X-ray permits the surgeon to close the abdomen with an easy mind.

FIG. 12.—Ten years after suture of a fractured patella. The stout silver wire has snapped, and two loose fragments have eroded into the joint.

FIG. 13.—A 'lost' swab located by portable X-ray on the operating table.

TRAUMATIC SHOCK

Shock has been defined as ' a state of collapse of the circulation.' It is either primary or secondary and is associated with :

(i) Diminished force of the heart beat, which is governed chiefly by the venous inflow. Death usually follows if the systolic pressure falls to 60 mm. Hg., unless speedy measures are taken to counteract the condition.

(ii) Increased permeability of the capillaries, which allows the exudation of plasma into the tissues.

(iii) Diminished blood volume, which is caused by hæmorrhage, vomiting, sweating and exudation of plasma into the tissues (especially in the case of burns).

(iv) Increased viscosity of the blood, owing to loss of fluid from the circulation. Hæmoconcentration follows, and is particularly liable to occur in the case of burns, owing to excessive loss of plasma (p. 63). If hæmoconcentration rises to over 150 per cent. of hæmoglobin, recovery is unlikely.

Primary shock occurs immediately as a result of over-stimulation of the medullary centres by either psychogenic or neurogenic impulses, or a combination of both.

Psychogenic shock is due to apprehension, fear, or terror. Nervous patients are much more prone to post-operative shock than those of a philosophical temperament. Thus patients who suffer an injury while their minds are engrossed, such as soldiers in the heat of battle, are sometimes entirely un-

affected, even though their wounds are serious. One of the authors has seen a soldier, who was shot through the chest, entirely oblivious of the wound until a comrade enquired why his shirt was bloody. Conversely, nervous people are apt to suffer from severe primary shock from the most trivial injury. The expression " I nearly died of fright " is not necessarily hyperbolical.

Neurogenic shock follows over-stimulation of the medullary centres as a result of excessive somatic or autonomic impulses ; thus a blow on the testicle or over the solar plexus may be immediately fatal. Neurogenic shock is often associated with severe burns or multiple injuries, and may complicate abdominal operations, especially if viscera do not receive gentle treatment.

Secondary shock develops within two to a few hours after injury. It is predisposed to by exposure, pain, starvation, loss of fluid, especially blood, absorption of products from damaged tissue, and toxæmia. The psychogenic factor also plays a part, but to a lesser extent than in the case of primary shock.

The obvious clinical features of secondary shock are pallor, sweating or clamminess, an anxious expression, and often vomiting. The patient complains of thirst, but becomes increasingly apathetic if the condition progresses. Respirations are shallow, and the pulse-rate increases, while the blood pressure diminishes. Repeated blood-pressure recordings are some indication of the progress of the case, bearing in mind that individual blood pressures vary within wide limits. A more important guide is variations in the degree of hæmoconcentration, which should be checked at intervals, in order to assess the progress of the case and the effects of treatment.

Treatment.—*First-aid.*—" What first-aid treatment is administered by the ear ? " was a question in an oral examination. The answer required was " Words of comfort ! " Cheerful confidence on the part of first-aid personnel, by counteracting the natural fear of an injured person, is not only humane but also a valuable therapeutic measure. Hæmorrhage is controlled, fractures are immobilised if advisable, a hot drink is given if available, and the patient is transported to hospital, bearing in mind that he must be protected from cold and the head kept low.

Resuscitation.—A *resuscitation room* should be available at every hospital which caters for the treatment of seriously injured patients. The room should be warm, a radiant-heat cage available, scissors, etc., at hand to remove dirty clothes, and infusion and transfusion apparatus ready for immediate use. An anæsthetic trolley, drugs, syringes, etc., are also essential. After cleansing and resuscitation the patient can be transported to the operating theatre if his injuries require any major surgical procedure.

Warmth.—Over-heating is harmful, more so than over-cooling, and care must be exercised in the use of such appliances as electric blankets or cradles. The patient's temperature should be raised to normal, and unless special heat-providing appliances are thermostatically controlled, it is wise to resort to the old-fashioned method of blankets and covered hot-water bottles.

Morphia.—This drug has no specific anti-shock value and may indeed be harmful in increasing respiratory depression, as in the case of head injuries. Therefore, if the patient is comfortable in body and tranquil in mind, it should be withheld unless some definite indication arises which requires its administration. If relief of pain is urgent, an *intravenous* injection of $\frac{1}{6}$ to $\frac{1}{4}$ grain (10 to 15 mg.) in 1 ml. of sterile water is advisable. In the case of patients with low blood pressures, a subcutaneous or intramuscular injection is tardily absorbed, and if repeated doses are injudiciously administered, an excessive amount is liable to be absorbed when the circulation improves.

Maintenance of Body Fluid (Chapter V).—If the patient is conscious and can retain fluid by the mouth, thirst is relieved and the fluid balance more or less restored by the administration of fluid by the mouth. Warm sweet tea is excellent for this purpose. In more severe cases infusion or transfusion is urgently required. In the shock-hæmorrhage syndrome blood transfusion is necessary, but if shock is unassociated with hæmorrhage, plasma or substitutes are administered either intravenously or into the marrow of a suitable bone.

In severe cases frequent hæmoglobin readings are taken, so that dangerous hæmoconcentration can be counteracted by increased infusions.

Posture.—Raising the foot of the bed helps to maintain adequate cerebral circulation, especially in cases of primary shock. Firm bandages applied to the limbs are useful in suitable cases.

Oxygen Therapy.—Routine administration of oxygen is not indicated in cases of uncomplicated shock, but oxygen therapy is useful in patients who are heavily morphinised, suffer from pulmonary complications, or who have been exposed to coal gas.

Toxæmia.—Severe injury to tissues results in the formation of some toxic substance which encourages shock. Whether histamine is the causative agent is doubtful, but that some toxic body is produced is beyond doubt, since the removal of a tourniquet from a crushed limb may be immediately succeeded by an exacerbation of shock. Therefore, in the case of a crushed limb some surgeons amputate above the tourniquet, and include it in the part removed. Should it be decided that removal of the tourniquet is advisable, the appliance should be loosened gradually.

Pressor Substances.—Desoxycortone (D.O.C.A.) may be useful in encouraging peripheral vasoconstriction. It is also alleged to diminish the permeability of the capillaries, but further evidence is necessary before its value can be established.

FIG. 14.—Oxygen
'spectacles.'

OXYGEN THERAPY

The administration of oxygen is of value in many conditions, e.g. coal-gas poisoning, pulmonary complications after operations, injuries to the chest, following operations on the thyroid gland, or in cases of fat embolism.

Oxygen 'spectacles' ensure that the oxygen passes directly into the nose, and if the patient moves the flow of gas is uninterrupted. The apparatus is comfortable and easily adjusted (fig. 14). The gas can be passed through a Woulfe's bottle, which acts as a flowmeter.

The *injector mask* (fig. 15) is a modification of the Boothby mask with an expiratory valve placed in the nose-piece. This relieves the patient from being forced to breathe against pressure of high rates of oxygen flow, and the mouth can be kept partially closed in comfort. Also the flow-meter is incorporated in the oxygen cylinder head. (A similar mask is used by airmen, when high-altitude flying necessitates an additional supply of oxygen.)

Oxygen tents are valuable, and the oxygen content is easily estimated by chemical means. Children should be reassured, as they are likely to be frightened by confinement in an enclosed space, and, if possible, nervous patients should be accustomed to a tent before its necessity arises. Nurses are warned against the risk of explosion, and naked lights and smoking are forbidden in the proximity of the tent.

FIG. 15.—The injector mask.

CRUSH SYNDROME

This syndrome, which was commonly associated with air-raids, sometimes occurs in connection with mining or industrial accidents. As a result of massive crushing of muscles, some substance gains access to the circulation which exerts a depressive effect on the renal tubules. The degree of shock associated with the injury has no relation to the development of the crush syndrome. A similar effect may follow the application of a tourniquet for too long a period, or one that has been forgotten! If a tourniquet is used, it is a wise precaution to attach it to the operating table, so that the tourniquet cannot be overlooked when the patient is lifted on to the trolley.

First-aid treatment may necessitate the application of a tourniquet to the affected limb. The tourniquet is gradually released so that deleterious substances are admitted to the circulation in small quantities. The patient usually appears to be comparatively well for two or three days following the accident, although his excretion of urine is scanty. Apathy, restlessness and possibly mild delirium indicate deficient renal function, and uræmia supervenes. If oliguria develops, the fluid intake must be maintained, if necessary intravenously or intramuscularly. The urine should be rendered alkaline by the administration of sodium citrate and sodium bicarbonate. In severe cases intravenous isotonic sodium sulphate (4·285 per cent.) is urgently required.

It is now recognised that there is an alternative circulation in the kidney. The blood, instead of flowing through the vasa afferentia to the glomeruli in the cortex, may be shunted via the vasa recta to the medulla, and hence little or no urine is secreted. This medullary circulation opens up in such conditions as incompatible blood transfusion, crush syndrome and blackwater fever, and protects the cortex from damage by noxious substances. In established cases sympathetic block abolishes the reflex which initiates secondary renal circulation.

Peter Woulfe, 1727–1803. English Chemist.
Walter Meredith Boothby, Contemporary. Director, Section on Metabolism, Mayo Clinic. The Boothby mask is sometimes referred to as the B.L.B. mask (Boothby, Lovelace, and Bulbulian).

CHAPTER II

SPECIFIC INFECTIOUS DISEASES

McNeill Love

ERYSIPELAS

ERYSIPELAS is a spreading inflammation of the skin and subcutaneous tissues, due to infection by one of the hæmolytic streptococcus group (fig. 2). The general health of the patient is usually below par, and debilitating conditions and the extremes of life are predisposing causes.

Symptoms.—The patient notices that the skin in the vicinity of a scratch or abrasion has become irritable and feels stiff. After a few hours symptoms of toxæmia supervene, which usually increase in severity until the patient is obviously ill, or even delirious.

Signs.—If the infection commences in a wound, this will exhibit an inflamed or sloughing appearance, and from the margins a rose-pink rash extends over the adjacent skin. The edge of the rash is raised, a feature which is often more easily appreciated with the finger than the eye. The colour of the rash and its obvious edge are important points in distinguishing a true erysipelas from cellulitis. As the rash extends, vesicles appear, which burst and discharge serum.

Considerable swelling occurs when lax tissues are involved, particularly the orbit and the scrotum, owing to extensive œdema of the subcutaneous layers. The scrotum is liable to become as large as a melon, and is often of a peculiar waxy colour. The rash gradually fades, and for some weeks a brown discoloration of the skin remains, due to pigment set free as a result of destruction of red corpuscles. Inflammation of regional lymph nodes invariably accompanies the infection, but suppuration is unusual.

In some cases the infection wanders about the body, perhaps for months (*erysipelas migrans*).

An uncommon, but very troublesome, form of the disease is the *recurrent type*, which usually affects the face and head. Periodically, for no apparent reason, the patient suffers from an outbreak of the disease, in spite of every prophylactic measure.

COMPLICATIONS

toxæmia is liable to be fatal in debilitated subjects.

Sloughing of skin and subcutaneous tissues occasionally occurs, of lax tissues in patients of poor resistance. Septicæmia or pyæmia may

on.—A severe attack of erysipelas is sometimes followed vessels and nodes, so that lymphatic drainage is impaired.

The eyelids are not uncommonly affected, greatly to the detriment of the patient's appearance and comfort (fig. 16).

Intercurrent Disease.—It is not uncommon, particularly in the elderly, for some fatal complication to develop during an attack of erysipelas, especially pulmonary or renal complications.

- **Treatment.**—Erysipelas is a contagious disease, and therefore the patient should be isolated or, at least, removed from a surgical ward.

General treatment is directed towards improving the health, and parenteral penicillin usually results in rapid resolution; it is combined with sulphonamide if considered desirable.

Ichthyol ointment is useful for relieving pain and stiffness, and gauze soaked in a saturated aqueous solution of magnesium sulphate is a very satisfactory dressing. Ultra-violet irradiation is useful in arresting the spread of inflammation.

FIG. 16.—Lymphatic œdema of face and eyelids, following erysipelas. The patient was unable to open his eyes.

ERYSIPELOID[1]

Erysipeloid is caused by the Gram-positive bacillus *Erysipelothrix rhusiopathiæ* of Rosenbach which is introduced into the tissues by a punctured wound, usually as a result of a prick or scratch by a fish bone or scale, or, less commonly, a splintered meat bone. Thus the disease is occupational, and it is also seasonal, being most common in late summer and early autumn. The incubation period is from two to seven days, following which a purplish induration appears, usually on a finger. Induration and dusky discoloration gradually extend to the palm or back of the hand and adjacent fingers (fig. 17). Discomfort and stiffness may be sufficiently severe to disable the patient, but general symptoms of infection are slight, and regional lymph nodes are not affected. Temporary improvement is commonly followed by relapses, but after a period of from three to six weeks the condition gradually subsides.

FIG. 17.—Erysipeloid. (Dr. L. Forman, London.)

Sulphonamides are useless. Treatment consists in keeping the affected hand at rest, and intramuscular penicillin. Under this régime the condition subsides in a few days. The disease is more common than is generally supposed.

ANTHRAX

B. anthracis are large, rectangular organisms which tend to arrange themselves in chains (fig. 18). They are Gram-positive, facultative anaerobes, and form spores which are very resistant to antiseptics. The disease causes epidemics in cattle, and is likely to occur in men who handle cattle, carcases, wool, hides, hair or imported bonemeal.

[1] Described by Morrant Baker, of St. Bartholomew's Hospital, in 1873, as Erythema serpens, and now commonly known as fish-handler's disease.

A. J. F. Rosenbach 1842-1923. Professor of Bacteriology, Göttingen, Germany.

FIG. 18.—*B. anthracis*, large rectangular bacilli in chains, with central spores.

The cutaneous type is the commonest human variety; the incubation period is from three to four days. The lesion usually commences on an exposed portion of the body, such as the hands, forearms or face (p. 137). An itching papule occurs, around which a patch of induration soon becomes evident. The papule suppurates and is replaced by a black slough, and a ring of vesicles appears on the surrounding indurated area. This stage comprises the typical 'malignant pustule' (fig. 19). The induration extends subcutaneously, so that a brawny, congested patch develops around the site of infection. The regional lymph nodes are invariably involved. Toxæmia is always in evidence, and an elevated temperature and raised pulse-rate are important evidences in the diagnosis of an early case of anthrax. The diagnosis is confirmed by examining a smear of the fluid from a vesicle, as the organisms are easy to stain and recognise.

Treatment.—Official regulations have done much to reduce the incidence of the disease, and prophylactic measures should be followed rigidly.

Excision was formerly a favourite method of local treatment, but is no guarantee against the onset of septicæmia. Ipecacuanha paste appears to be of decided benefit as a local application.

FIG. 19.—Anthrax pustule.
(*A. E. Hodgson, Liverpool.*)

Neo-salvarsan can be regarded as a specific for anthrax, and has practically replaced serum therapy. It should be given intravenously in doses of 0·6 G. daily, or on alternate days, according to the severity of the infection. Neo-salvarsan is used extensively in South Africa, where anthrax is comparatively common. Successful results have also followed the administration of penicillin.

Pulmonary (*syn.* Woolsorter's Disease).—Caused by the inhalation of spores, and characterised by a virulent bronchitis and bronchopneumonia, with toxæmia, dyspnœa and blood-stained sputum. The organisms are found in the sputum. Immediate and intensive antibiotic therapy may save the patient.

Alimentary.—Follows the ingestion of spores, provided they escape destruction by the acid in the stomach. Severe enteritis follows, which resembles cholera. The patient collapses and suffers from severe abdominal pain and blood-stained watery diarrhœa.

TETANUS

This disease can be associated with any type of wound, but particularly those contaminated with cultivated soil, or of a punctured and infected nature. The popular impression that tetanus is especially liable to follow a

Dr. *Guillotin, 1738–1814, who advocated the use of the guillotine so that executions should be speedy and painless died from an anthrax pustule.*

wound between the thumb and index finger is due to the fact that those who dig much, such as gardeners and gravediggers, are likely to excoriate the skin in that area and contaminate it with soil.

The *Cl. tetani* is Gram-positive, and occurs as straight rods which develop a terminal spore, so that the name ' drumstick ' spore has been aptly applied (fig. 20). The clostridium is anaerobic, hence its partiality to deep or punctured wounds, or if pyogenic organisms are also present. In some cases the wound through which the organisms gained admittance has healed before symptoms are evident. The reopening of an old wound, even years after infliction, occasionally stimulates dormant organisms into activity.

FIG. 20.—*Cl. tetani* (Ziehl-Neelsen's stain).

Other occasional causes are penetration of the sole by a nail in the shoe, wounds caused by wads of toy pistols, felt applied to a pressure sore, and infected catgut.

CLINICAL TYPES

Acute tetanus occurs within fifteen days of inoculation, and the shorter the incubation period the higher the mortality. The first symptoms are psychical. The patient becomes restless and uneasy, he is unable to concentrate or even keep still, and he experiences a dread of some impending evil. The temperature and pulse-rate are above normal. Within twenty-four hours muscular spasm supervenes, usually first affecting the muscles at the back of the neck, and then the jaw muscles. Risus sardonicus appears later, due to contraction of the facial muscles (fig. 21). Spasms follow, which extend to all the skeletal muscles, and during severe exacerbations the patient rests on his head and heels (opisthotonos). The psoas or rectus abdominis muscles are sometimes ruptured (fig. 22). The spasms are tonic as well as clonic, so relaxation is incomplete during the intervals. This feature distinguishes tetanus from strychnine poisoning ; also in the latter case spasms commence in the extremities. Death occurs from cardiac failure following exhaustion, pulmonary œdema, or occasionally from asphyxia during a vice-like spasm of the respiratory muscles. A post-mortem rise of temperature follows.

FIG. 21.—Risus sardonicus. (*Mr. R. Blunden, Christchurch, New Zealand.*)

Chronic Tetanus.—The incubation period is over fifteen days, and may be as long as six weeks. The symptoms are similar to those of acute tetanus, but much less severe. The prognosis is favourable.

Delayed Tetanus.—Organisms are capable of remaining latent in a wound for years, and causing tetanus when the wound is reopened.

The Clostridium tetani was first cultivated by Kitasato in Berlin in 1889.
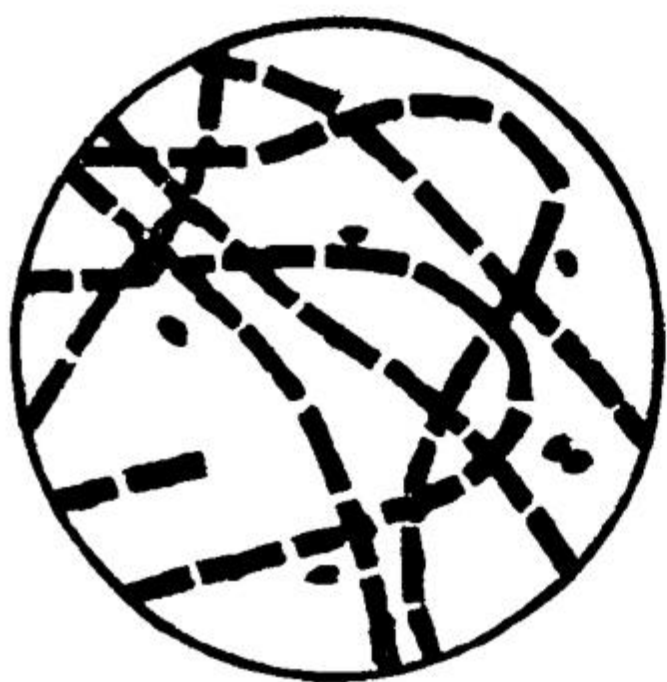
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FIG. 22.—A torn rectus abdominis muscle from a case of tetanus, which followed a small wound of a toe.

A prophylactic dose of serum must always be given if a potentially infected wound (e.g. for the removal of a foreign body) requires reopening.

Local tetanus occurs in the muscles around the initial wound. It is usually seen when the prophylactic dose of serum has counteracted general infection but was insufficient to prevent local nerve involvement.

Head tetanus follows a wound in the distribution of the facial nerve. This is a rare type, not many more than one hundred cases having been reported. The toxin reaches the central nervous system via the lymphatics in the sheath of a nerve, and so swelling of the nerve results. In the case of the facial nerve, which is enclosed in the rigid facial canal, swelling compresses the nerve and causes paresis of the muscles of expression instead of risus sardonicus.

Bulbar tetanus is a rare and fatal form, which follows visceral infection. Involvement of the muscles of deglutition and respiration results in dysphagia and fatal dyspnœa. This type may be confused with hydrophobia.

Tetanus neonatorum is due to infection of the newborn child via the wound left after separation of the umbilical cord. This type is fatal.

TREATMENT

Prophylactic.—Immunity conferred by injections of toxoid is of extreme importance, particularly with regard to the fighting forces. It seems that permanent immunity is obtained if 1 ml. of toxoid is administered and repeated at intervals of eight weeks and nine months, and followed up with a ' recall ' dose every four years.

Unless active immunity has been obtained, it is imperative that every patient with a potentially infected wound should receive an intramuscular injection of 1,500 International Units of anti-tetanic serum. Surgical treatment of the wound should be postponed until at least one hour after the injection. A smaller dose of serum may be repeated, with advantage, at weekly intervals for a month. Also, should old wounds require reopening, as for the removal of a foreign body, serum is given prior to the operation.

Symptomatic.—The patient is isolated in quiet surroundings. Anæsthetics are required to permit of nasal feeding, catheterisation, and the injection of antitoxin, and during the first anæsthetic it is advisable to pass a Ryle's stomach tube intranasally. Chloretone, chloral, and bromides are given by the mouth or rectally, and avertin or paraldehyde by the latter route is strongly recommended. Muscular spasms not only exhaust the patient, but possibly increase the amount of toxin entering the spinal cord by compressing the motor nerves, and also, under avertin anæsthesia, the patient is spared the terror which otherwise heralds the onset of a spasm. Myanesin (which has a less depressing effect on respiration than curare) is valuable in controlling spasms, and can be given in doses of 0·5-1·0 G. at intervals of two to

John Ryle, 1889–1950. Nuffield Professor of Social Medicine, Oxford, formerly Physician, Guy's Hospital.

FIG. 23.—Ray fungus × 500 microphotograph. From material excised from the neck of a girl of eighteen.

direct invasion of adjacent tissues. Lymph nodes are not affected, but if a vein is invaded, pyæmic infection is likely to follow.

The following are the usual sites of infection :

(i) *Facio-cervical.*—The lower jaw is more frequently affected, often adjacent to a carious tooth. The gum becomes so indurated that it simulates a bony swelling. As extension occurs, nodules appear, which soften and burst. The overlying skin of the face and neck is indurated and bluish in colour, softening occurs in patches, and eventually abscesses burst through the skin (see fig. 281). The characteristic features of the condition are chronicity, dense induration and sinuses surrounded by bluish skin (see p. 202).

(ii) *Thorax.*—The lungs and pleura are infected either by aspiration of the fungus or, occasionally, by direct spread downwards from the pharynx or neck, or upwards through the diaphragm.

The disease extends through the lungs to the pleura and chest wall, which, in the late stages, is riddled with sinuses (fig. 24). An empyema is not uncommon, and the infection sometimes spreads through the diaphragm to the liver or subphrenic spaces. Clinically, the condition resembles tuberculosis, and in the early stages is only distinguished by the discovery of mycelial threads in the sputum.

(iii) *Abdomen.*—The ileo-cæcal region is most commonly affected, owing to the considerable stasis which occurs in this part of the bowel. Possibly for the same reason, the sigmoid colon is occasionally involved.

FIG. 24.—Actinomycosis of the lung involving the chest wall.

Ileo-cæcal actinomycosis usually occurs in one of two forms. Either an indurated mass forms in the iliac fossa, or the disease resembles appendicitis. In the latter case the true nature of the infection is usually unsuspected until, following appendicectomy, the wound breaks down a few weeks later. In many cases the appendix shows no naked-eye evidence of inflammation.

The liver is not infrequently affected. The disease may be primary, but nearly always it arises as a pyæmic infection from the ileo-cæcal angle. The liver becomes adherent to adjacent structures, and on section the abscesses

present a 'honeycomb' appearance due to interlacing strands of fibrous tissue.

Treatment.—An intensive and prolonged course of penicillin is prescribed (Zachary Cope). Iodised milk may be beneficial, and is administered as described on p. 203. Streptomycin is sometimes more effective than penicillin. Deep X-ray therapy is worthy of trial in obstinate cases. Excision of infected tissues, formerly advocated, is now abandoned in favour of antibiotics.

CAT-BITE, OR CAT-SCRATCH FEVER

This is a distinct clinical entity, and is probably due to a virus of the lympho-granuloma-psittacosis group. Localised inflammation occurs at the site of the lesion, associated with fever, malaise and anorexia. This subsides in a few days, but from two to several weeks later the regional lymph nodes become inflamed. Suppuration usually occurs, and the pus is sterile.

Penicillin is valueless, but the constitutional symptoms are relieved by chloramphenicol, although this has no obvious effect on the adenitis.

A positive intradermal test with antigen clinches the diagnosis of active or previous infection, and distinguishes the condition from chronic pyogenic or tuberculous adenitis.

LEPROSY

This disease was formerly world wide in its distribution. Nowadays, owing to the ease and rapidity of modern travel, cases are apt to present themselves when least expected.

Prodromal features include irregular temperature, loss of eyelashes and eyebrows, skin eruptions, pruritus and sweating. The disease then develops into one of two forms, although some features are often common to both.

Nerve Leprosy.—Nerves become thickened, and those near the surface are easily palpable or even visible. Early sensory changes include pain, formication, and later anæsthesia, and subsequently atrophy occurs of the corresponding soft tissues and bones, so that toes and fingers are destroyed. Perforating ulcers of the feet, and stenosis of the larynx (leper's cough), are later manifestations. Death commonly results from some intercurrent infection.

Nodular Leprosy.—Infiltration of the skin occurs, which begins as small nodules and eventually extends until large plaques are evident. These often coalesce so that on the face natural folds are obliterated, and the appearance becomes leonine (fig. 25). The nasal septum and the conjunctivæ are affected in the later stages. Some of the nodules gradually absorb and leave an anæsthetic area, others ulcerate and become secondarily infected.

Treatment.—Where the disease is common, lepers should be segregated in organised colonies. Chaulmoogra oil, which was formerly widely employed, has now been replaced by D.D.S. (diaminophenylsulphone). Co-existing syphilis is not uncommon and demands recognition. Burdensome and useless limbs should be amputated, and a tracheostomy is sometimes required for stenosis of the larynx.

FIG. 25.—Nodular leprosy.

FIG. 23.—Ray fungus × 500 micro-photograph. From material excised from the neck of a girl of eighteen.

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Sir Zachary Cope, Contemporary. Consultant Surgeon, St. Mary's Hospital, London.

YAWS (syn.) FRAMBŒSIA

A non-venereal disease which occurs endemically in tropical countries. It affects children and young adults, especially in crowded and insanitary districts. The disease is caused by the *Treponema pertenuis*. The W.R. is strongly positive.

As in the case of syphilis, three stages are recognised. The primary sore is followed by the secondary stage, in which cutaneous nodules appear, especially on the face and ano-genital region. These break down to form granulomatous nodules, somewhat resembling a raspberry. The third stage is characterised by ulceration, which, when healed, leaves tissue-paper scars resembling those of healed gummata.

Unlike syphilis, the cardiovascular and nervous systems are unaffected. The disease responds to penicillin, but terramycin appears to be even more effective.

MADURA FOOT

A fungus infection which occurs in tropical countries, and affects bare-footed natives. Granulomata occur on the feet, and eventually multiple sinuses develop, which involve bones and joints. There is, as yet, no effective remedy, and when the foot is disorganised amputation is required.

ORIENTAL SORE (syn. DELHI BOIL, BAGHDAD SORE, ETC.)

This disease is due to infection of a protozoal parasite, *Leishmania tropica*, and is a common condition in Eastern countries. An indurated papule appears on an exposed surface, usually the face. If untreated this breaks down to form an indolent ulcer, which eventually leaves an ugly, pigmented scar. The condition readily responds to intravenous injections of antimony tartrate, but very small lesions can be treated by carbon dioxide snow.

SYPHILIS[1]

A detailed description of syphilis and gonorrhœa is outside the scope of this work, and those requiring such should refer to one of the many text-books on venereal diseases. We include here a general summary of these diseases, and affections of the various individual organs and structures are considered in their appropriate chapters.

The incubation period of acquired syphilis is from ten to ninety days. Diagnosis was revolutionised by the discovery in 1905, by Schaudinn, of the causative organism, the *Treponema pallidum* (syn. Spirochæta pallida). The treponema can be discovered in serum or scrapings from most surface lesions. If enlarged lymph nodes are present, lymph can be aspirated with a fine needle, and examination will often reveal spirochætes.

By means of dark-ground illumination the treponema is seen as a spiral organism resembling a corkscrew in appearance. On the average eight spirals are present, and the organism is about 8 microns in length (fig. 26).

FIG. 26.—Treponema pallidum (corkscrew) and Spirochæta refringens (spiral). Smear preparation from hard chancre.

The complement-fixation test, or Wassermann reaction, is usually positive in untreated cases, about two weeks after the appearance of the primary sore. Treatment should not be delayed until the test is positive, but commenced immediately the treponema is demonstrated. Treatment instituted while the serum is negative yields excellent prospects of permanent cure. In untreated late primary and secondary syphilis the W.R. is almost always positive. In the

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[1] Syphilis derives its name from a poem by a physician, Girolamo Fracastor, published in Venice in 1530. The poem tells of the shepherd Syphilus, who was struck down by the disease as a punishment for neglecting the worship of Apollo.

Fritz Schaudinn, 1871–1906. A Prussian Zoologist.
Sir William Leishman, 1865–1926. Professor of Pathology, Royal Army Medical College.

tertiary stage a positive result is obtained in about 90 per cent. of cases. If the central nervous system is affected, the cerebrospinal fluid may give a positive reaction, even though the blood serum is negative. In addition to its diagnostic value, the W.R. is also a valuable control in estimating the efficacy and result of treatment.

- Other conditions which render the serum positive to the W.R. are yaws, glandular fever, and leprosy. Weak reactions are sometimes obtained in miliary tuberculosis, malaria, typhus, vaccinia, relapsing fever, and advanced malignant disease.

Precipitation tests are useful when elaborate technique is impossible or curtailment of time is necessary. These tests depend upon the development of a flocculent precipitate when antigen and syphilitic serum are mixed and incubated. These tests are of great practical value as a rapid confirmation before commencing treatment, and also as a check on the W.R.

Clinical Features.—Acquired syphilitic manifestations are roughly divisible into three stages.

Primary Stage.—In 96 per cent. of cases the primary sore or chancre is situated on the genital organs.

In the male the chancre is usually obvious, but in the female a primary sore on the inner aspect of the vulva or on the cervix is often unnoticed

FIG. 27.—Primary chancre of the tongue. On palpation its edges felt hard. The submaxillary lymphatic nodes are enlarged. A scraping revealed *Treponema pallidum.*

by the patient, and the infection is likely to progress well into the second stage before its real nature is recognised. Extragenital chancres occur on the lips, usually the upper (fig. 117), the tongue (fig. 27), the tonsil, the anal margin, the nipple, the fingers and, rarely, in other situations.

Primary sores on the lips usually result from kissing, and one case is recorded in which a gentleman with secondary ulceration of the mouth infected five young ladies at a dance, each of whom developed a chancre on the lip. Dental surgeons and accoucheurs are particularly prone to inoculation on the fingers, but ' syphilitic onychiæ ' are less common than formerly owing to the routine use of rubber gloves and more rigorous surgical cleanliness.
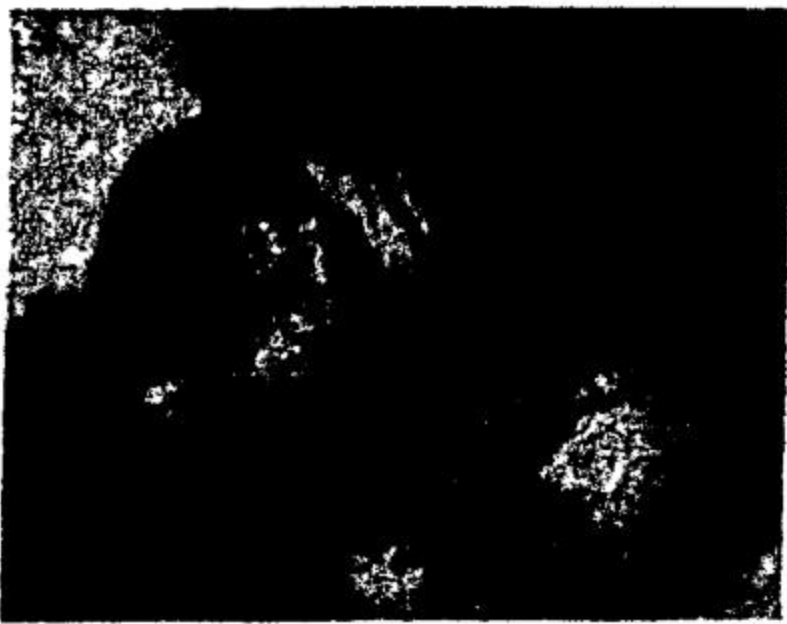

FIG. 28.—Two chancres on the glans. *(Dr. Schneider-Green, Royal Northern Hospital.)*

A primary sore is due to inoculation of an abrasion, and is first noticed as an indurated papule. Associated endarteritis leads to ulceration, and a typical Hunterian chancre develops (fig. 28). The ulcer presents a definite margin, with characteristic induration due to lymphocytic infiltration. In the case of vascular structures, such as the lip, considerable œdema of the underlying tissues is

John Hunter, 1728-1793. Surgeon to St. George's Hospital. To further his knowledge of venereal disease he inoculated himself with syphilis in 1767.

present. In about 20 per cent. of cases chancres are multiple, either as a result of infection of two or more abrasions, or owing to auto-inoculation of an apposing surface by the primary sore. The regional lymph nodes become enlarged and firm, the skin is not reddened and there is no tendency to suppuration. In the case of a penile chancre, the dorsal lymphatics can often be felt to be 'wiry' when the subcutaneous tissue is rolled between · the finger and thumb.

In some cases the initial papule disappears without ulceration, and the patient is genuinely unaware of its presence. If phimosis is present, secondary infection sometimes supervenes and the ulcer becomes acutely inflamed, with secondary acute lymphangitis and enlarged and tender lymph nodes. In virulent cases phagedena may develop.

A primary chancre must be distinguished from a traumatic ulcer (which follows irritation of an abrasion), a soft sore (p. 35), an early epithelioma, herpes, and, indeed, from any other lesion on the genitalia.

Secondary Stage.—Lesions occur from two to twelve months after infection, and are typically generalised and symmetrical. The W.R. is strongly positive in 98 per cent. of cases.

The general manifestations of the secondary stage include malaise, anæmia, a varying degree of pyrexia, and generalised enlargement of the lymph nodes. The epitrochlear, suboccipital and posterior cervical nodes are especially liable to be affected. Alopecia is not uncommon (the ' rat-bitten ' type).

Cutaneous eruptions, although varying widely in their natures, are usually characteristic. A syphilitic rash appears, as a rule, about eight weeks after infection, and is commonly widely distributed in a symmetrical manner. The earliest manifestation is a roseolar rash due to hyperæmia of the cutaneous capillaries. Cellular infiltration and fibrosis may follow, with the formation of papules. If the infection is virulent or the patient debilitated, pustules and ulceration are likely to develop. In some cases the rash exhibits a scaly appearance, somewhat resembling psoriasis, but differing from that condition in that the flexor surfaces are chiefly, if not entirely, affected.

The main characteristics of a syphilitic eruption are the dull red or coppery colour, the absence of irritation, the symmetrical distribution, and the polymorphic nature, i.e. two or three types of rash are often present simultaneously.

Mucocutaneous junctions and mucous membranes are commonly affected during the secondary stage. Papules appear at such mucocutaneous junctions as the anal margin, vulva, or angle of the mouth, or where cutaneous surfaces are constantly in apposition. As a result of their situation these papules become sodden, and frequently form large, foul, greyish masses, which are termed condylomata. Condylomata are intensely infectious, but disappear rapidly with general treatment and local cleanliness.

Moist papules or mucous patches occasionally occur in the mouth as circular raised areas, greyish in colour, and surrounded by hyperæmic mucosa. Ulceration occasionally occurs. Mucous patches are sometimes so large that they resemble condylomata, and those on the dorsum of the tongue were formerly described as ' Hutchinson's warts.'

Sir Jonathan Hutchinson, 1828-1913   Surgeon to the London Hospital.

' Snail-track ' ulcers particularly affect the mucosa covering the soft palate and tonsils. These characteristic ulcers are shallow, greyish in colour, and exhibit well-defined edges. The mucous membrane of the nose is occasionally affected in a similar manner.

Warning.—The saliva in these cases is teeming with spirochætes. Gloves should always be worn, and tongue depressors either burnt or rigorously sterilised.

At a later period of the secondary stage, fleeting bone pains (osteocopic) or periosteal nodes are often in evidence. Transitory and usually symmetrical effusions may occur in the larger joints. Epididymitis occasionally develops and is sometimes associated with albuminuria. Iritis sometimes occurs, and gives rise to pain, lachrymation, circumcorneal congestion, and a sluggish and irregular pupil. The colour of the iris may alter owing to œdema. At a later date such conditions as choroido-retinitis may develop. Perivascular infiltration and endarteritis are likely to manifest themselves, especially in connection with the brain or cord, and neurological phenomena may result.

Rupia occasionally occurs as a late secondary manifestation, particularly in virulent or neglected cases. The discharge from cutaneous ulcers dries in successive layers, so that an excrescence of dried pus and débris gradually accumulates, and somewhat resembles a limpet.

Tertiary Stage.—This commences some three years after infection, and may last throughout the patient's lifetime. The characteristic pathological changes are either diffuse gummatous infiltration, or local gumma formation, and almost any structure in the body is liable to be affected. In some organs both changes occur; thus a gummatous orchitis is sometimes associated with a local gumma, and a cirrhotic liver may harbour gummata.

A gumma is a mass of necrotic tissue surrounded by granulation tissue beyond which is a zone of fibrosis. Necrosis of tissue is partly due to toxins, and also to deficient blood supply resulting from endarteritis and surrounding fibrosis. If untreated, a gumma tends to enlarge and soften as the necrosis extends. If near the skin, hyperæmia and induration are evident. The centre of the indurated area then softens and eventually breaks down. The gumma discharges, and typically a wash-leather slough is seen at the bottom of the cavity, or on the floor of the ulcer, which is painless. The edges are characteristically sharply cut and circular·in outline (fig. 29).

Under appropriate treatment a gumma usually absorbs with surprising rapidity, but occasionally it becomes walled-off by fibrous tissue. In certain situations, notably the testes and bones, long-standing

Fig. 29.—A punched-out, gummatous ulcer.

gummata are resistant to medical treatment owing to the density of the surrounding fibrosis or sclerosis, which prevents remedial agents in the blood from reaching the diseased tissues. In these circumstances, orchidectomy is advisable in the case of the testes, while guttering or trephining of bone is necessary for the relief of pain caused by an endosteal gumma (see fig. 30).

Gummatous ulcers, following subcutaneous gummata, are especially common on the leg, the backs of the thighs and forearms, and the face. A healed gumma leaves a 'tissue-paper' scar, which is silvery, supple and serpiginous, and sometimes surrounded by a pigmented area.

A gummatous ulcer of the leg has sometimes been mistaken for a varicose ulcer (see fig. 93). The following are the main points of distinction.

Varicose Ulcer	*Gummatous Ulcer*
Usually lower third of leg.	Region of the knee joint.
Irregular shape, rounded edges, and granular base.	Circular or serpiginous in shape, sharply cut edge, and sloughing base
Single and painful.	Often multiple and painless.
History of years.	History of weeks or months.
Varicose veins present.	Other signs of syphilis.

The surgical manifestations of parasyphilis are considered in their appropriate chapters.

Treatment.—Public Health Regulations of recent years have greatly reduced the incidence of syphilis. Clinics are available in all large towns for treatment and tracing contacts, and notices to this effect are posted in suitable public places. In addition, lectures, diminished inebriety, propaganda work and increased self-respect which is engendered by better education, all encourage sufferers to seek treatment.

The TREATMENT of syphilis falls into three groups—general, local and specific.

(i) *General.*—As with any infection, the general resistance of the patient is an important consideration. Hygienic surroundings, adequate food and suitable tonics are necessary ; iron is useful in order to combat anæmia during the secondary stage.

(ii) *Local.*—No antiseptic of any description should be applied to a suspected chancre until the serum has been examined bacteriologically. Pending the examination a saline compress is applied. After the diagnosis is made, the chancre is bathed twice daily with a weak antiseptic, and calomel ointment, 15 to 30 per cent., is applied.

Condylomata are treated by ordinary cleanliness and suitable dusting powders, such as one containing calomel, starch and boracic acid. Gummatous ulcers are kept surgically clean and dressed with mercurial lotion.

(iii) *Specific.*—In 1909, Ehrlich, at his 606th attempt, produced an arsenical preparation—*Salvarsan*—suitable for intravenous injection. Subsequently, Neosalvarsan (N.A.B. or '914') appeared. However, arsenical preparations are now abandoned in favour of penicillin, which is non-toxic and equally effective.

Penicillin is now used as a routine in addition to other measures. The usual course is 600,000 units of procaine penicillin daily until 6 mega units have been administered.

Bismuth preparations are used in conjunction with or following a course of penicillin, 0·2 G. being injected intramuscularly weekly for ten weeks. Bismuth remains locally in the tissues for years, and unless this point is remembered, confusion may result in

Paul Ehrlich, 1854–1915. *Director of Experimental Therapy, Frankfurt-on-Main.* ('606' indicated the number of attempts to produce a suitable substance.)

the interpretation of radiographs (fig. 30). Dental hygiene is important before a course of bismuth is commenced, and the gums should be inspected at intervals. Blue lines occasionally occur on the gum margins following absorption of bismuth.

Mercury preparations, formerly the recognised treatment, have been largely supplanted by bismuth medication. Dover's powder (pulv. ipec. co.) is prescribed if diarrhœa results.

Various ' courses ' of treatment are advocated, but no hard-and-fast rules are permissible—each patient should be treated individually, as degrees of tolerance vary widely.

CONGENITAL (*syn.* INHERITED) SYPHILIS

This disease is arbitrarily divided into four grades of severity :

(i) Abortion after the fourth month.

(ii) Birth of a still-born and often macerated fœtus.

(iii) The infant presents obvious syphilitic features, such as wasting, snuffles, skin eruptions.

(iv) The child is apparently healthy, but subsequently develops syphilitic stigmata.

The following are the more important lesions in connection with inherited syphilis :

Mucous Membranes.—Inflammation of the muco-periosteum of the nose causes a purulent discharge—known as ' snuffles.' Mucous patches, condylomata and eventually gummatous ulceration of mucous membranes and adjacent skin can occur. Radiating scars or rhagades are sometimes left at the angles of the mouth.

FIG. 30.—Bismuth injections in the gluteal muscles, in a patient with an endosteal gumma of the femoral shaft.

Skin.—The commonest lesion is a bullous rash, known as 'syphilitic pemphigus,' but a roseolar rash is not uncommon in the early months, especially on the buttocks. Nodular infiltration of the skin, especially that of the face, sometimes occurs in older children, and resembles lupus vulgaris, but extends with greater rapidity and is much more destructive.

Teeth.—The milk teeth erupt late and are ill-formed. The permanent incisors are peg-shaped, so that the base is wider than the edge (' screwdriver ' teeth) and, in addition, they often present a well-marked notch—Hutchinson's teeth. The central part of the crown of the first permanent molar is maldeveloped, a feature more obvious in the lower jaw, and known as ' Moon's turreted molar.'

Eye.—Iritis, sometimes accompanied by cyclitis, occurs in young children. The most characteristic lesion is interstitial keratitis, which usually appears between the ages of eight and sixteen years. The first indication is a ' ground-glass ' appearance of the cornea, associated with photophobia and lachrymation. ' Salmon patches ' occur later, due to leashes of newly formed vessels. One eye only is affected at first, but the second eye is subsequently involved. Prognosis should be guarded, as although most cases gradually subside, opacities may remain in the cornea, or deeper-

Thomas Dover, 1660-1742. Physician and buccaneer. Rescued Alexander Selkirk (Robinson Crusoe) from Juan Fernandez in 1709, and practised medicine in Bristol.
Henry Moon, 1845-1892. Dental Surgeon to Guy's Hospital.

seated mischief, which owing to corneal opacity cannot be seen with the ophthalmoscope, may have occurred.

Ear.—Acute otitis media may result from nasal infection. Nerve deafness sometimes develops about puberty, and is often associated with interstitial keratitis.

Bones.—Osteochondritis occasionally appears up to about the sixth month and gives rise to pain and swelling of a large epiphysis, the ' pseudo-paralysis ' of infants. A radiograph confirms the diagnosis. The epiphysis is broad and irregular, yellow in colour, and the adjacent periosteum is thickened. Separation of the epiphysis sometimes occurs.

From the sixth year onwards periostitis and sclerosis occur. The tibia is characteristically affected and, as the anterior aspect is mainly involved, a ' sabre-shaped ' tibia results.

Parrot's nodes, caused by localised areas of pericranitis, sometimes appear on the skull, especially in the frontal region.

Gummatous involvement of the nasal septum leads to destruction and interferes with development. In severe cases the typical depression of the bridge results in a ' saddle ' nose (fig. 31).

FIG. 31.—Frontal bosses and depressed nose of congenital syphilis.

Joints.—The characteristic affection is Clutton's joint, which typically presents itself as a painless effusion into a large joint, most commonly the knee. It is frequently bilateral, although involvement of one joint may precede the other. It may be clinically the only congenital stigma in evidence.

Other Organs.—A diffuse interstitial fibrosis occasionally involves the lungs. Syphilitic cirrhosis of the liver and splenic enlargement are not uncommon. Orchitis may be bilateral, and if occurring before puberty results in impotence.

Four typical lesions which shortly precede or occur at puberty are Clutton's joints, interstitial keratitis, otitis interna and orchitis epitomised as ' the halt, the blind, the deaf and the impotent.'

Treatment.—Prophylactic treatment is essential, and as a rule the mother is very tolerant to treatment during pregnancy. A healthy child is usually the reward of efficient ante-natal treatment. Treatment of an infected child should be instituted immediately after birth. A course of penicillin is prescribed in conjunction with cortisone should interstitial keratitis develop.

GONORRHŒA

In 1879 Neisser discovered the specific kidney-shaped coccus which occurs in pairs, and which is Gram-negative. On examination of suspected

FIG. 32.—*N. gonorrhœa* (Gram's stain).

Jules Marie Parrot, 1829–1883. Professor of Diseases of Children, Paris.
Henry Clutton, 1850–1909. Surgeon, St. Thomas's Hospital.
Albert Neisser, 1855–1916, of Breslau, recognised the gonococcus in 1879.

pus only a few polymorphonuclear cells are found to be affected (fig. 32). The probable explanation of this characteristic feature is that the cell has been killed by toxins and so the organisms have multiplied without hindrance. As a rule organisms are readily identified by the usual methods of staining, but in doubtful cases, or for medico-legal reasons, culture is necessary. The complement-fixation test may be the only means of confirming the diagnosis in chronic and systemic infections, e.g. arthritis.

IN THE MALE

Acute Stage.—The incubation period is from two to ten days. The early symptoms are itching and redness of the meatus, the lips of which are sticky. A viscid discharge appears, which soon becomes thick and yellowish. Anterior urethritis develops within a day or two, with the characteristic symptom of scalding pain on micturition. Acute retention is a very rare complication. Malaise and slight elevation of temperature are present during the acute stage, and the inguinal lymph nodes are sometimes tender. After ten to fourteen days acute symptoms abate, but the discharge persists.

Posterior urethritis is liable to occur at any time, either from extension of the infection or ill-advised treatment, such as irrigation or the passage of instruments.

Posterior urethritis is recognised by the frequency or urgency of micturition, with slight hæmaturia at the end of the act, aching in the perineum, painful erections and turbidity of a second specimen of urine after the first flow has washed out the anterior urethra. When the posterior urethra is first infected, symptoms of toxæmia are usually evident.

LOCAL COMPLICATIONS.—*Anterior Urethritis.*—Folliculitis following infection of glands of Littré is a common complication. Balanitis is sometimes troublesome, and chordee may result from inflammation of the corpus spongiosum or corpora cavernosa. Cowperitis occasionally occurs on one or both sides.

Posterior Urethritis.—Acute prostatitis causes rectal and perineal pain which is worse on defæcation. Retention of urine is likely to occur if suppuration ensues. The inflamed prostate is easily palpable per rectum. Acute vesiculitis causes frequent and painful emissions of purulent or blood-stained semen. Epididymitis usually occurs from the third to the fifth week, and is preceded by pain in the groin or lower abdomen due to inflammation of the vas deferens. Basal cystitis is common and causes frequency and pain at the end of micturition.

Chronic or Latent Stage.—The discharge is often very inconsistent and may occur only after such events as undue exercise or alcoholic excess. Typically, a ' morning dewdrop ' appears, which is thick and whitish in colour. Massage of the prostate and vesicles and examination of any expressed fluid will probably reveal latent infection. Partial emptying of the bladder followed by prostatic massage and completion of the act is a valuable test for posterior urethritis and prostatitis. Any threads which appear should be examined bacteriologically.

Urethroscopic examination requires considerable experience, but readily exposes folliculitis, erosions, abscesses and other abnormalities, and also allows the application of local treatment.

Alexis Littré, 1668–1726. A Teacher of Anatomy in Paris.
William Cowper, 1666–1709. London Surgeon.

LOCAL COMPLICATIONS.—Chronic prostatitis, with which is associated chronic vesiculitis, is a common cause of persistence of infection. Inflammation of the glands of Littré or lacunæ is also a frequent cause of relapse. Epididymitis is encouraged by the passage of bougies and rectal examinations before the disappearance of symptoms of acute urethritis. Strictures, formerly common, are becoming increasingly rare. They are due to such conditions as subepithelial inflammation of the wall of the urethra, or chronic folliculitis, and are encouraged by undue zeal in treatment, such as irrigation with excessively strong antiseptics. 'Gonorrhœal' warts occasionally occur on the glans or prepuce, and are due to an associated virus infection.

Metastatic Complications.—Infection of joints and fibrositis are common in neglected cases. Endocarditis occurs as a rare complication, and is associated with pyæmic abscesses. Iridocyclitis sometimes occurs, especially in chronic cases, and necessitates repeated instillation of atropine. Most cases respond favourably to cortisone.

IN THE FEMALE

The early symptoms are much less acute than in the male. Infection usually commences in the urethra or cervix, and Bartholin's glands are infected in 2 per cent. of cases.

The symptoms of acute infection include a sensation of heat and discomfort of the vulva and pain on micturition, but in about 30 per cent. of cases symptoms are negligible. Should the cervix become infected, a blood-stained discharge is noticed and backache follows.

Complications.—Vaginitis is common in children who are accidentally infected, but adults usually escape. Cervicitis sometimes occurs spontaneously, or is encouraged by unwise instrumentation. Salpingitis, which is sometimes accompanied by oöphoritis or peritonitis, is a dreaded complication which is apt to cause sterility. Proctitis often occurs, and is commoner than in males owing to the greater ease of infection.

Chronic or Latent Stage.—Chronic gonorrhœa is due to urethritis, cervicitis or infection of Bartholin's glands, and any discharge from these organs must be meticulously examined in suspected cases. The symptoms accruing from chronic infection are very slight and the patient may merely notice an occasional yellowish discharge.

Local Complications.—Chronic endometritis occasionally occurs, and results in menorrhagia, metrorrhagia and mild dysmenorrhœa, associated with backache. Salpingitis is often quiescent, but exacerbations are liable to follow sexual excess, debility or labour. Warts are not uncommon and are sometimes large and numerous.

Treatment.—Acute gonorrhœa and its complications formerly responded very satisfactorily to adequate doses of sulphonamide, but apparently the organism is now becoming resistant. It is necessary to maintain a high blood concentration for five days. Therefore procaine penicillin is commonly used immediately the diagnosis is assured, and 300,000 units is usually curative. The patient is warned of the risks of conjunctivitis and transmission of

Thomas Bartholin, 1616–1680. A Danish Anatomist.

infection, and he is kept under observation for three months, the blood being tested monthly for syphilis, as penicillin may mask a syphilitic infection or prolong the incubation period.

Chronic gonorrhœa (*syn.* gleet) often improves following a course of sulphonamide, but relapses are apt to occur, in which case penicillin should be administered. Persistent posterior urethritis can sometimes be combated by weekly instillations of silver nitrate (2 per cent.) into the prostatic urethra. Periodic dilatation by metal sounds, once or twice weekly, squeezes out infected material from the glands and crypts. With the assistance of an operating urethroscope such local conditions as follicular abscesses and ulcers receive appropriate treatment. Rectal diathermy of the prostate is useful in skilled hands, but is rarely necessary.

OPHTHALMIA NEONATORUM

Infection at birth is a common cause of blindness. The incubation period is twenty-four to forty-eight hours, and is followed by chemosis, lachrymation and purulent discharge. Corneal ulceration and sloughing are liable to follow in neglected cases. Should infection occur, the eye must be irrigated with penicillin (10,000 units in 1 ml.) at frequent intervals, and 200,000 units are injected intramuscularly four-hourly during twenty-four hours. In unilateral cases the child lies on the affected side, the sound eye being protected by a Buller's shield.

SOFT CHANCRE (*syn.* SOFT SORE, CHANCROID)

This type of venereal disease is caused by the specific bacillus of Ducrey (*Hæmophilus ducreyi*). The incubation period is short, and in two or three days a vesicle appears, which becomes infected and breaks down to form an ulcer about a week after infection. The sores are commonly multiple and painful, and are associated with enlargement of the inguinal lymph nodes. Suppuration usually follows (bubo), and if the nodes are infected with *H. ducreyi*, considerable periadenitis results, and months may elapse before the lesions heal. Venereal sores are sometimes due to both *H. ducreyi* and spirochætes, so in all cases a search must be made for the latter organisms.

An uncomplicated soft sore persists and enlarges unless adequate treatment is prescribed. As the organism is penicillin resistant, a course of sulphonamide and streptomycin is prescribed, and a five-days' course usually suffices. Mild antiseptics are applied locally, and balanitis receives appropriate treatment.

Frank Buller, 1844–1905. Canadian Ophthalmic Surgeon.
Augusto Ducrey, 1860–1931, Professor of Dermatology, Pisa, isolated the bacillus in 1889.

CHAPTER III

TUMOURS

McNeill Love

A TUMOUR is a new formation of cells of independent growth usually arranged atypically, which fulfils no useful function and has no typical termination. The term 'tumour' should be reserved for new-growths, and its loose application to inflammatory swellings, such as Pott's puffy 'tumour,' or enlargement of an organ due to hypertrophy, should be abandoned.

CAUSATION

Over 300 years ago it was stated that " any kind of external irritation, whether from motion, heat, or acrimony, may cause cancer," and in spite of an enormous amount of research work and expenditure of money little has been added to our knowledge.

FIG. 33.—Kangri carcinoma of the abdominal wall. (*R.C.S. Museum.*)

Natives of Kashmir are prone to develop carcinoma of the skin on the inner sides of the thighs and lower abdomen (fig. 33). This is due to their habit of endeavouring to keep warm by squatting and hugging eathernware pots which contain glowing charcoal (the pot being termed a kangri), with the result that the adjacent skin is irritated by heat and fumes.

It is also common knowledge that women can swallow in comfort fluids at a considerably higher temperature than men can tolerate, which fact may explain the greater incidence of post-cricoid carcinoma in females.

' Chimney-sweeps' ' cancer of the scrotum is due to the chronic irritation produced by soot, which collected in the rugæ of the scrotum. Owing to increasing personal cleanliness and fewer coal-fires, this variety of cancer is nearly obsolete, but chronic irritation from chemicals, tar, etc., occasionally produces squamous-celled carcinoma of the exposed skin in those who work among these irritants. Again, carcinoma of the lower lip was prevalent when clay pipes were popular, and carcinoma is occasionally seen at the site where tobacco smoke continually impinges on the tongue.

Regeneration of tissue appears to encourage malignant changes in the newly formed cells, which are presumably in a state of instability. Primary carcinoma of the liver is sometimes seen in cases of cirrhosis, and apparently arises from the liver cells which are endeavouring to regenerate. Similarly, squamous-celled carcinoma occasionally occurs in a chronic ulcer (fig. 34) and a fibrosarcoma arising in a scar is not uncommon. In some situations the site of fusion of embryonic elements constitutes a favourite position for the development of carcinoma. On the tongue, for example, carcinoma is prone to occur at the junction of the anterior two-thirds and the posterior third, also carcinoma is not uncommon at the junction of the anal canal and the rectum.

Percival Pott, 1714-1788. Surgeon, St. Bartholomew's Hospital, London.

Is carcinoma hereditary? In many cases it is difficult to exclude coincidence, but in our experience the disease appears to 'run in families.'

Tumours reproduce cells which are similar to those from which they arise, although if the tumour grows rapidly the resemblance becomes less obvious (anaplasia). It sometimes happens that the epithelium from which the tumour grows has already changed its characteristics. The gall-bladder is normally lined by columnar epithe-

FIG. 34.—Squamous-celled carcinoma in a varicose ulcer (note everted edge).

lium, but the advent of cholecystitis eventually results in the epithelium undergoing cuboidal or even squamous-celled metaplasia.
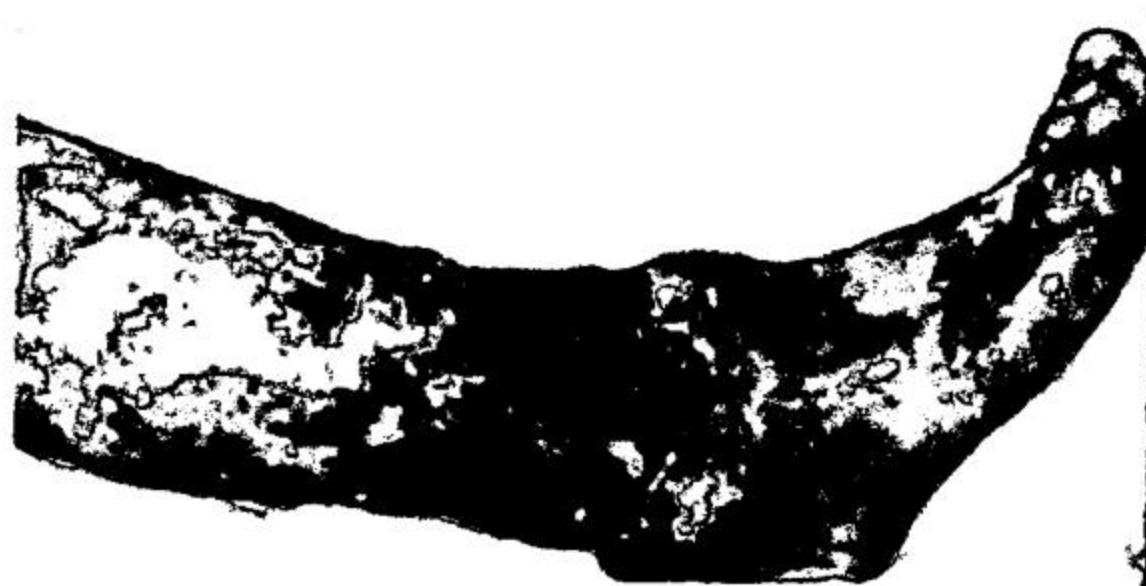
CLASSIFICATION

The classification of tumours is fraught with difficulty owing to their varied and sometimes atypical appearances. Following the suggestion of Adami, tumours can be subdivided into two groups, teratomata and blastomata.

Teratomata are composed of cells of one individual within the tissues of a second individual (fig. 35). These tumours may arise from ' totipotent ' cells, or contain representative cells from all three embryonic layers ; for example, a dermoid sometimes contains hair, teeth, muscle, gland tissue, etc. Included in this group is the chorion-epithelioma, which, very occasionally, occurs in the testicle.
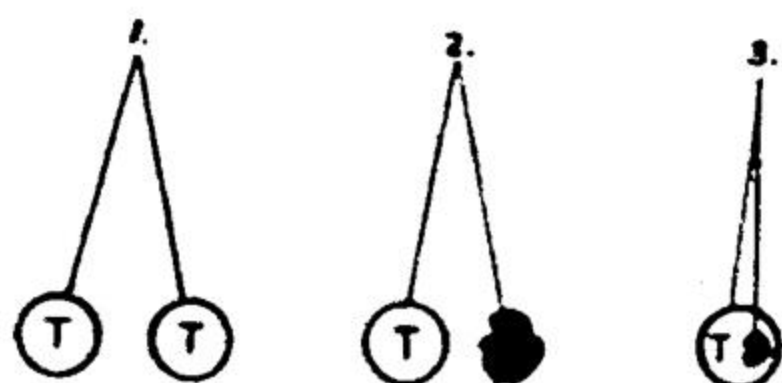

FIG. 35.—Twins and teratoma.

1. Normal twins. 2. One normal twin, the other an acardiac, anencephalic monster. 3. A teratoma—the twin brother's remnants are included in his normal brother.

Teratoid tumours are a subdivision of teratomata. They are composed of cells of the same individual, and these apparently become displaced during development (Cohnheim's theory). A mixed parotid tumour was formerly considered to be a teratoid tumour, but it is now regarded as a new-growth of a parotid duct and therefore epithelial in origin. Refinements of staining indicate that the substance formerly considered to be cartilage is in reality altered mucin secreted by the gland. Sequestration dermoids are a variety of teratoid tumour.

Blastomata develop from unipotent cells, and arise from any one of the three embryonic layers. From the clinical standpoint tumours thus formed are either innocent or malignant.

An *innocent* or *benign* tumour is usually encapsulated, and does not disseminate. Symptoms are entirely due to its size and position. Frequently they are multiple.

HAMARTOMA

The term hamartoma is roughly translated from the Greek as a 'fault' or 'misfire' tumour, and its original meaning was 'missing the mark in spear throwing.' It is a developmental malformation consisting of a tumour-like overgrowth of tissue or

tissues proper to the part. The possible range therefore is very wide, and the lesions are often multiple. If tissue foreign to the part is present the growth is a teratoma.

Common lesions that are hamartomata are benign pigmented moles, and the majority of angiomata and neurofibromata.

On rare occasions malignant change occurs in a hamartoma, but for practical purposes the lesion is benign, although it may become large enough to cause trouble, according to its size and location (P. M. Peters).

Malignant tumours are usually single, and are liable to infiltrate surrounding tissue. They nearly always continue to grow, and prove fatal in the absence of adequate treatment. The tumour is assumed to have disappeared in patients who succumb to malignant lymph nodes of the neck, when no primary growth is discovered at necropsy. Possibly a very small growth in some obscure position, such as the naso-pharynx, had been overlooked. Very malignant tumours, such as secondary deposits of chorion-epithelioma, are apt to destroy adjacent blood-vessels with such avidity that they become surrounded by clot. They are thus isolated from their source of nutriment, and consequently perish.

The commonest forms of malignant tumours are carcinoma, sarcoma and melanoma malignum.

BRODERS' GRADING OF MALIGNANT TUMOURS

Tumours are arbitrarily divided into four categories, according to the degree of differentiation shown by component cells. Squamous-celled carcinoma best illustrates these points, which include the degree of anaplasia, the absence or presence of prickle cells, and the number of mitotic figures.

Grade I. This is the least malignant, and not more than 25 per cent. of cells are lacking in well-marked differentiation. The remainder show keratinisation and obvious differentiation.

Grade II. From 25 per cent. to 50 per cent. are undifferentiated.

Grade III. From 50 per cent. to 75 per cent. are undifferentiated.

Grade IV. Over 75 per cent. of cells are undifferentiated, marked with anaplasia and mitotic figures.

This grading must not be taken too literally in estimating treatment or prognosis, e.g. different parts of the same tumour may show varying grades, and Grade I neoplasms may have disseminated widely, whereas a Grade IV tumour may still be localised. Anaplastic tumours are usually radio-sensitive, but commonly recur, whereas highly differentiated tumours tend to be radio-resistant.

METHODS OF SPREAD OF MALIGNANT TUMOURS

(i) *Local Extension.*—Malignant tumours infiltrate adjacent tissues and spread by direct invasion. This feature is the most reliable evidence of malignancy when the tumour is examined microscopically. Tissues are not always invaded in a uniform manner. Invasion takes place most readily along connective-tissue planes, whereas fascia or aponeurosis forms a temporary barrier. An avascular structure, such as articular cartilage, resists invasion to a remarkable extent. Other factors influence local extension; thus it is alleged that the spread of a rodent ulcer is checked when the growing edge reaches an area of skin supplied by a different sensory nerve. Also a carcinoma of the pyloric end of the stomach rarely extends into the duodenum.

(ii) *Blood-stream.*—This is the most common method of dissemination of a sarcoma, as the venous clefts, so typical of a sarcoma, readily permit malignant cells to enter the blood-stream. These malignant emboli are

liable to be arrested in the lungs, where they form secondary deposits, some-
times accompanied by a blood-stained pleural effusion.   It is probable that
in some cases malignant cells grow along the pulmonary capillaries into the
veins, and so reach the systemic circulation.   Large veins are sometimes
extensively invaded by sarcoma (fig. 36).

FIG. 36.—Intravenous spread of sarcoma.   (*British Journal of Surgery.*)

Dissemination by the blood-stream is usually a late feature of carcinoma.
However, for example, a carcinoma of the kidney not infrequently invades
the renal vein, with the result that secondary deposits are found in the lungs.

(iii) *Lymphatics.*—The spread of carcinoma along lymphatics occurs both
by permeation and by embolism.   In the former case the malignant cells
grow along the lymphatic vessels from the primary growth, sometimes in a
retrograde direction.   The presence of the cells in the lymphatics stimulates
a perilymphatic fibrosis, which compresses and destroys the malignant cells,
but this destruction does not keep pace with the rate of malignant cell growth.
A few cells are always ahead of the fibrosis, and so reach the shelter of a lymph
node, where they multiply in safety.   Other struc-
tures, such as bones, are sometimes affected by
lymphatic permeation.

In some instances, notably melanoma malignum,
occasional groups of cells overcome the surrounding
fibrosis, and give rise to intermediate deposits between
the primary growth and the lymph nodes (fig. 37).

In the case of embolism, cancer cells invade a
lymphatic vessel and are carried by the lymph cir-
culation to the regional node, so that nodes com-
paratively distant from the tumour are liable to be
involved in the early stages.

(iv) *Inoculation.*—Inoculation of carcinoma has
been observed in situations where skin or mucous
membrane is closely in contact with a primary
growth.   Examples of this 'kiss cancer' are car-
cinoma of the lower lip affecting the upper, and
carcinoma of the labium majus, giving rise to a
similar growth on the opposite side of the vulva.

Recurrence after operation is, in some cases, due
to implantation in the wound of malignant cells.
Examples of this mischance are the appearance of a
malignant deposit in the bladder scar after supra-
pubic removal of a primary growth, and nodules of
carcinoma in the scar of the incision after mastectomy.

(v) *Gravity.*—Cells from a carcinoma in the

FIG.   37. — Melano-
matous deposits in sub-
cutaneous lymphatics
of the abdominal wall.

upper abdomen sometimes become detached and gravitate to the pelvis or ovaries. This transcœlomic method of spread occasionally gives rise to malignant ovarian tumours (Krukenberg's tumour), which may mask the presence of the primary growth. Krukenberg's tumour is unlikely to arise after the menopause, as the ovary is then avascular and fibrotic.

(vi) *Physiological Propulsion.*—A papilloma of the kidney pelvis is sometimes associated with similar tumours in the ureter or bladder. Also it is alleged that carcinoma cells from the colon can pass along the alimentary canal and give rise to a further growth at a lower level.

BENIGN TUMOURS

PAPILLOMA

A papilloma consists of a central axis of connective tissue, blood-vessels, and lymphatics ; the surface is covered by epithelium, either squamous, transitional, cuboidal or columnar, according to the site of the tumour.

The surface of a papilloma may be merely roughened, or composed of innumerable delicate villous processes, as in the case of the kidney, bladder and rectum. In these situations papillomata resemble malignant tumours as secondary growths arise by implantation, but, sooner or later, the tumour itself becomes frankly malignant.

Other common sites for papillomata are the skin, the colon, the tongue and cheek, the vocal cords and the walls of cysts, particularly those in connection with the breast and ovary (fig. 38).

Fig. 38.—Papilloma of the lip.

Papillomata affecting the vocal cords often disappear spontaneously. Therefore, rather than attempt removal in a child, a tracheostomy should be performed, if necessary, in the expectation that papillomata will disappear about puberty, when the opening in the trachea can be closed.

FIBROMA

Fibromata occur in connection with fascia, aponeurosis, muscle and nerve sheaths, or connective tissue of organs. They are therefore widely distributed throughout the body.

In some situations, notably the breast, glandular tissue is incorporated amongst the fibrous stroma, so that the tumour is in reality a fibro-adenoma.

Fibromata are occasionally multiple, as in the case of von Recklinghausen's disease (*vide* p. 44).

The following types of fibromata occur :

Hard.—These tumours grow slowly and do not attain a large size. All grades of hardness exist, according to the relative proportion of fibrous and cellular tissue. They not infrequently occur on nerve sheaths.

Soft.—These may be so cellular that macroscopically they closely resemble a sarcoma. Occasionally they do become sarcomatous, the innocent tumour imperceptibly undergoing malignant changes. Soft fibromata are common in

Friedrich Krukenberg, 1872–1946. Ophthalmologist of Halle. Wrote a classical thesis in 1896 (at the age of twenty-four) on malignant ovarian tumours.
Friedrich von Recklinghausen, 1833–1910. Professor of Pathology, Strasbourg.

the subcutaneous tissue of the face, and appear as soft brownish swellings. Oliver Cromwell was disfigured by one of these tumours, which he referred to as a ' wart.'

Desmoid.—This is an unusual type of fibroma occurring in the abdominal wall of middle-aged females, particularly in those who have borne children. The tumour is a typical fibroma, with the exception that it has no capsule and invades the abdominal muscles, so much so that islands of muscular tissue become incorporated in the tumour. X-rays usually cause regression of the desmoid, but if this is ineffectual, and if disability ensues, excision may be considered.

Keloid.—These tumours occur in scars, particularly those following burns. The tendency to develop a keloid is inherited, and is particularly in evidence in tuberculous and negroid families (fig. 39). In appearance a keloid is smooth, sometimes lobulated or even claw-like, and many invade the subcutaneous or subfascial tissues. Micro-scopically, the structure is similar to that of a soft fibroma. A keloid never becomes malignant, and though it may persist for years, the ultimate tendency is to disappear gradually.

Mere excision of a keloid should never be performed, as recurrence is the rule. Good results have followed excision and exposure to deep X-ray therapy before suture of the wound. If unsightly, the application of radium or low-voltage X-ray therapy causes retrogression.

FIG. 39. — Extensive keloid in a West African.
(C. Bowerman, Kumasi, Ghana.)

LIPOMA

Diffuse lipoma occasionally occurs in the subcutaneous tissue of the neck, from which it spreads on to the preauricular region of the face. It is associated with excessive beer drinking, and therefore is less common than formerly, owing to the price and inferior quality of this commodity. The tumour is not obviously encapsulated, and gives rise to no trouble beyond being unsightly. The tumour should be excised if the patient wishes to improve his appearance.

Multiple lipomata are not uncommon. The tumours remain small or moderate in size, and are sometimes painful, in which case the condition is probably one of *neurolipomatosis*. Dercum's disease is an associated condition.

Circumscribed lipomata are among the commonest of tumours. The characteristic features are painlessness, the presence of a definite edge and lobulation. If the proportion of fibrous tissue is not excessive, a sense of fluctuation may be obtained. These tumours have a widespread distribution, as they can occur in any part of the body where fat is found, and are therefore referred to as the 'universal' tumour. As would be expected, a lipoma deeply situated is liable to be mistaken for other swellings, as difficulty arises in recognising the typical signs.

Oliver Cromwell, 'Protector' of England from 1649 until his death in 1658.
Francis X. Dercum, 1856–1931. Neurologist, Jefferson Medical College, Philadelphia.

Should the lipoma contain an excessive amount of fibrous tissue it is termed a *fibrolipoma*. In other cases considerable vascularity is present, often with telangiectasis of the overlying skin, in which case the tumour is a *nævolipoma*. A retroperitoneal lipoma, or one in the thigh (fig. 40), occasionally under-goes sarcomatous changes. Myxomatous degeneration and calcification (fig. 41) sometimes occur in lipomata of long duration.

FIG. 40.— Liposarcoma of thigh which had been present for over twenty years. The scar indicates a previous attempt at removal.
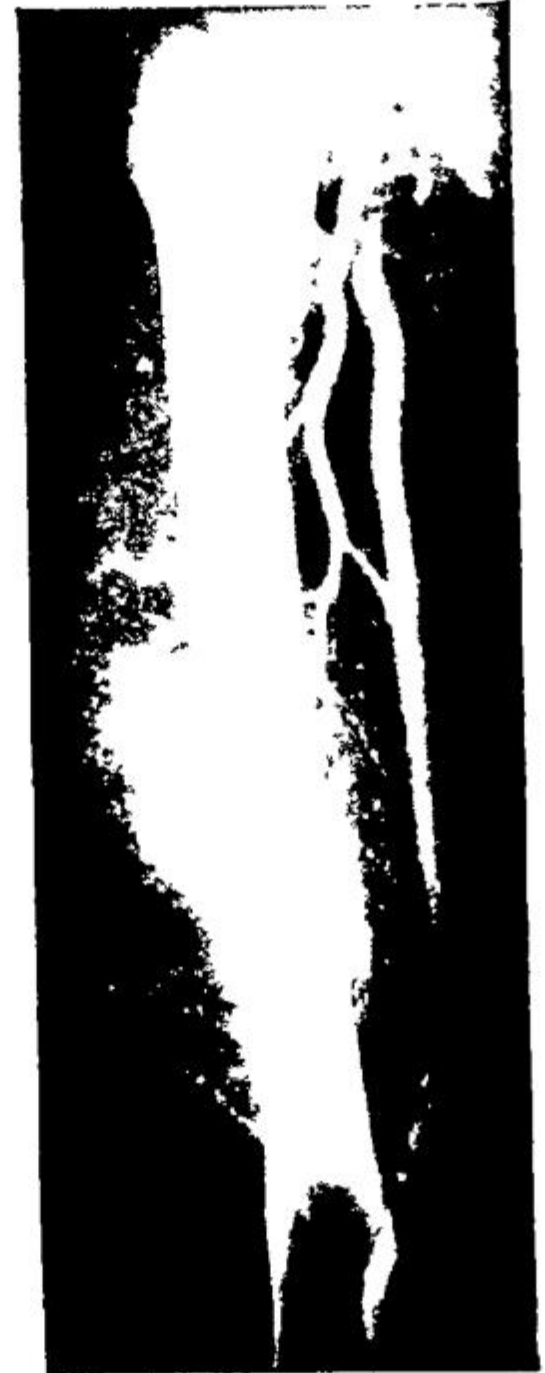
Clinically, circumscribed lipo-mata are conveniently classified according to their situation:

(i) *Subcutaneous* are most com-monly found in the shoulders or back (fig. 42), although no part of the body is immune. Usually the characteristic features are readily ascertained. It must be remembered that a lipoma is occasionally present over the site of a spina bifida. A careful ex-amination should distinguish such conditions as a tuber-culous abscess or a sebaceous cyst, which may superficially resemble a lipoma. Subcutaneous lipomata occasionally be-come pedunculated, or the influence of gravity may cause the tumour gradually to change its position (fig. 43).

FIG. 41.— An arteriogram of case shown in fig. 40 reveals increased vascularity of the tumour, also an area of calcification.

(ii) *Subfascial.*—Lipomata occurring under the palmar or plantar fascia are liable to be mistaken for tuberculous tenosynovitis, as the dense, overlying fascia masks the definite edge and lobulation of the tumour. However, the swelling is circumscribed, and wasting of muscles is negli-gible. Difficulty is encoun-tered in complete removal as pressure encourages the tum-our to ramify. Subfascial lipo-mata also occur in the arcolar layer under the epicranial aponeurosis, and if of long duration they erode the under-lying bone, so that a depress-ion is palpable on pushing the tumour to one side (fig. 44).

(iii) *Subsynovial* arise from the fatty padding around joints, especially the knee. They are apt to be mistaken for Baker's cysts, but are easily distinguished as, in distinction to a cyst or bursa, their consistency is con-stant whether the joint is in extension or flexion.

FIG. 42. — A lobulated, sub-cutaneous lipoma.

FIG. 43.—Peduncu-lated lipoma.

William Morrant Baker, 1839–1896. Surgeon, St. Bartholomew's Hospital, London.

(iv) *Intra-articular.*—The term 'lipoma arborescens' is somewhat misleading, as the condition is, strictly speaking, not neoplastic, but rather a fatty and fibrous infiltration of synovial tags.

(v) *Intermuscular.*—These occur particularly in the thigh or around the shoulder. Owing to transmitted pressure the tumour becomes firmer when the adjacent muscles are contracted. Weakness or aching results, owing to mechanical interference with muscular action. The condition is often difficult to distinguish from a fibrosarcoma, and exploration is usually necessary in order to determine the true nature of the swelling.

FIG. 44.—Erosion of the skull due to a subaponeurotic lipoma.

(vi) *Parosteal* occasionally occur under the periosteum of a bone, and are difficult to diagnose with confidence if deeply situated.

(vii) *Subserous* are not common, but are sometimes found beneath the pleura, where they constitute one variety of innocent thoracic tumour. A retroperitoneal lipoma may grow to enormous dimensions, and simulate a hydronephrosis or pancreatic cyst. A lipomatous mass is frequently found at the fundus of the sac of a femoral hernia, but this is a condensation of extra-peritoneal fat rather than a neoplasm.

(viii) *Submucous* occur under the mucous membrane of the respiratory or alimentary tracts. Very rarely a submucous lipoma in the larynx causes respiratory obstruction. A submucous lipoma occasionally occurs in the tongue. One situated in the intestine is likely to cause an intussusception, which is the first indication of its presence (fig. 45).

(ix) *Extradural.*—A lipoma is a rare variety of spinal tumour. Owing to the absence of fat within the skull intracranial lipomata do not occur.

(x) *Intraglandular.*—Lipomata occasionally arise from the fat within the lobules of the breast, and they have been found in the pancreas, under the renal capsule, and in connection with other organs.

As will be noted, lipomata are very widely distributed. The 'universal tumour' is an appropriate term, which should be remembered when a swelling causes diagnostic difficulty.

FIG. 45.—Intussusception caused by a submucous lipoma of the cæcum.

Treatment.—If a lipoma is causing trouble on account of its site, size or appearance, removal is indicated. Owing to its definite capsule and comparative avascularity, excision is usually easy.

ADENOMA

Adenomata arise in connection with secretory glands, and resemble to a greater or lesser extent the structure from which they arise. They are encapsulated tumours, and sometimes profoundly influence the metabolism, as in the case of the thyroid, parathyroid and pancreas. Occasionally an adenoma contains a large proportion of fibrous tissue, e.g. the hard fibro-

adenoma in the breast, while in other situations, notably the pancreas and thyroid gland, cystic degeneration is common. Adenomata arising from secretory glands of mucous membrane are liable to pedunculation, as in the case of a rectal ' polyp.' Simple enlargement of the prostate is due to a diffuse hyperplasia of glandular tissue, usually associated with multiple adenomata. Adenomata in certain situations tend to undergo malignant changes, e.g. those occurring in the prostate and thyroid gland.

NEUROMA

True neuromata are rare tumours, and occur in connection with the sympathetic system. They comprise the following types :

(a) *Ganglioneuroma*, which consists of ganglion cells and nerve fibres. It arises in connection with the sympathetic cord, and therefore is found in the retroperitoneal tissue, or in the neck or thorax. It usually occurs after the first decade, and is entirely innocent, causing symptoms merely by its size and position.

(b) *Neuroblastoma*, which is less differentiated than the ganglioneuroma, the cells being of an embryonic type. The tumour somewhat resembles a round-celled sarcoma, and disseminates by the blood-stream. It occurs in infants and young children.

(c) *Myelinic neuroma*, composed only of nerve fibres, ganglion cells being absent. The very few tumours which have been reported have arisen in connection with the spinal cord or pia mater.

FIG. 46.—A false neuroma of the median nerve. The patient complained of tingling in the middle fingers.

False neuromata arise from the connective tissue of the nerve sheath. The following varieties are described :

Local.—A single neuroma is usually found in the subcutaneous tissue, although occasionally a 'trunk neuroma' grows from a peripheral nerve (fig. 46) or cranial nerve, the acoustic tumour being an example. The ' painful subcutaneous nodule ' forms a smooth firm swelling, which may be moved in a lateral direction, but is otherwise fixed by the nerve from which it arises. Paræsthesia or pain is likely to occur from pressure of the tumour on the nerve fibres which are spread over its surface. Cystic degeneration or sarcomatous changes occasionally occur.

Generalised Neurofibromatosis (*syn.* von Recklinghausen's Disease of Nerves).— Cranial, spinal and peripheral nerves may all be diffusely or nodularly thickened (fig. 47). The overgrowth occurs in connection with the endoneurium. Associated pigmentation of the skin is common,

FIG. 47.—Neurofibromatosis.

and sarcomatous changes occasionally occur.

Plexiform Neurofibromatosis.—This rare condition usually occurs in connection with branches of the fifth cranial nerve, although examples met with in the extremities occur (fig. 48). The affected nerves become enormously thickened as a result of myxo-fibromatous degeneration of the endoneurium. If occurring in the scalp, the underlying skull may be eroded, and in other situations the involved skin sometimes hangs down in pendulous folds. Plexiform neurofibromatosis is sometimes associated with the generalised type of neurofibromatosis. Sarcoma rarely develops.

Elephantiasis Neuromatosa.—This rare condition is congenital in origin, and usually affects one leg. The skin and subcutaneous tissues become greatly thickened, so that the patient finds walking increasingly difficult. The skin is coarse, dry and thickened, resembling an elephant's hide. Other types of neurofibromatosis are sometimes associated. Amputation is usually necessary.

AMPUTATION 'NEUROMATA.'—Fusiform swellings occur at the ends of divided nerves after amputation of a limb. These swellings consist of fibrous tissue and coiled nerve fibres, and are a physiological rather than a pathological phenomenon.

FIG. 48.—Plexiform neurofibromatosis affecting the right arm. The subcutaneous tissues are thickened, and the patient was unable to use the right eye.

HÆMANGIOMA

Hæmangiomata are tumours composed of blood-vessels, and are congenital in origin. They sometimes remain insignificant for a prolonged period, but are apt to enlarge in size at any time.

Capillary nævi are composed of dilated capillaries, and are most common on the face and scalp. Occasionally they are submucous, in which case bleeding often occurs. The term 'spider' nævus is applied when portions of the tumour radiate into surrounding tissues. Applications of carbonic-acid snow are efficacious in destroying small capillary nævi, but larger ones sometimes require radium or excision.

Cavernous angiomata consist of masses of dilated veins into which arteries open more or less directly. They occasionally occur in viscera, but are more commonly submucous or subcutaneous (fig. 49). Frequently capillary nævi are

FIG. 49.—Cavernous angioma. The patient also suffered from a dental cyst.

found in the overlying skin. Submucous nævi are prone to hæmorrhage, which is sometimes alarming (fig. 208). A characteristic feature of a cavernous angioma is its compressibility. If possible the tumour should be excised by means of an electric cautery. Otherwise diathermy, or injections of sclerotics, causes thrombosis of vessels and consequent shrinkage.

Plexiform angiomata consist mainly of arteries, and consequently pulsate. The usual form is a cirsoid aneurism (Chapter xxxviii). Very rarely similar tumours are found in bones, in which case a pulsating tumour appears when the compact bone is eroded.

GLOMANGIOMA (syn. GLOMUS TUMOUR)

These tumours arise from a cutaneous glomus. The glomera are composed of a tortuous arteriole which communicates directly with a venule, the vessels being surrounded with a network of small nerves. These specialised organs regulate the temperature of the skin, and are found in the limbs, especially the nail-beds. The tumour resembles a nævus, and is compressible. The associated pain is out of all proportion to the size of the tumour, which may be only a few millimetres in diameter. The pain is burning in nature and radiates peripherally, and is often more noticeable when the limb is exposed to sudden changes of temperature.

On section the tumour consists of a mixture of blood spaces, nerve tissue and muscle fibres derived from the wall of the arteriole (angioneuroma). Large cuboidal cells are frequently seen (glomal cells). Glomal tumours grow very slowly, and do not undergo malignant changes. They should be destroyed with an electric cautery, or excised.

MALIGNANT TUMOURS

CARCINOMA

Carcinoma, which arises from tissues of ectodermal and endodermal origin, is the commonest form of malignant new-growth, and is alleged to be increasing in frequency. This increase is probably apparent rather than real, and is explained by more accurate methods of diagnosis and the greater number of people who now survive to riper years. In some situations, such as the alimentary canal and bronchi, an actual increase has occurred during recent years. Greater petrol consumption, with consequent contamination of air by irritating fumes, and increased cigarette smoking are alleged explanations of the frequency of bronchial carcinoma, which has increased tenfold in the past twenty years. Fortunately, owing to increasing avoidance of predisposing causes, other types of carcinoma are less frequent than formerly, notably that of the skin, lip and tongue.

Carcinomata are conveniently classified according to the type of cell from which they arise, as, for example, glandular squamous or basal-celled.

(i) GLANDULAR is widely distributed, and commonly occurs in the alimentary tract, breast and uterus, and less frequently in the kidney, prostate, gallbladder, thyroid and other organs. Glandular carcinomata not only arise from secreting columnar epithelium, but also from ducts when the cells are cubical. The three pathological types of glandular carcinoma are as follows :

Carcinoma simplex, in which the cells are arranged in circumscribed groups or masses, no glandular structure being recognisable. This type commonly occurs in the breast, and the majority of cells are spheroidal in shape.

Adenocarcinoma, so called from the tendency of the cells to form acini, which resemble those of the gland from which they are derived. The alveoli are ductless, and the walls are composed of layers of cells which invade the surrounding tissues. This type is common in the stomach and colon. The cells of the primary growth, and even of the metastases, sometimes retain secretory powers.

Colloid, which develops in tumours arising from cells which secrete mucin, and is a degenerative process. The mucin permeates the stroma of the growth, which appears as a gelatinous or semi-translucent mass. This type is typically seen in growths of the colon and stomach.

Glandular carcinoma is also subdivided into various types, e.g. encephaloid, scirrhus and atrophic scirrhus. These distinctions depend clinically on their rate of growth, and pathologically on the relative proportions of fibrous tissue and gland elements. Examples occur in connection with the breast, and are described in Chapter xlii.

(ii) SQUAMOUS—which arise either from surfaces covered by squamous epithelium, or as a result of metaplasia. Thus, prolonged irritation of the gall-bladder by stones causes the normal columnar epithelium to revert to a less differentiated type, so that cuboidal or even squamous-celled carcinoma develops.

Squamous-celled carcinoma is particularly liable to occur as a result of chronic irritation (p. 36). The regional lymph nodes are likely to be invaded, but blood-borne metastases are rare. The lymph nodes occasionally undergo mucoid degeneration, to which secondary infection from the primary growth may be superadded, so that, if the skin gives way over the softened node, a glairy, semi-purulent fluid is discharged.

Macroscopically, squamous-celled carcinomata are either papilliferous or ulcerative. On section solid masses of polyhedral cells are seen, which invade the deeper structures.

' Cell-nests ' are usually apparent in slowly growing cases, and are due to deeper cells becoming flattened and undergoing keratinisation. ' Prickle ' cells are characteristic, and resemble the prickle cells present in the epidermis.

Squamous-celled carcinomata of different tissues are discussed in their appropriate chapters.

(iii) BASAL-CELLED (*syn.* Rodent Ulcer, p. 138).

SARCOMA

Sarcomata occur in connection with structures of mesoblastic origin. They differ from carcinomata, not only in their derivation, but also in their age incidence, as sarcomata are most common during the first and second decades. Moreover, sarcomata often grow with greater rapidity, and dissemination occurs mainly by the blood-stream. Microscopically, the cells of a carcinoma are arranged in masses or columns, whereas sarcoma cells are always separated from each other. In some cases a sarcoma develops in pre-existing benign tumours, such as a fibroma or a uterine fibroid, and in bones which are affected by osteitis deformans. A few instances are on

record in which a sarcoma, usually of bone, apparently resulted from an injury. If the tumour grows slowly, the sarcomatous cells reproduce tissue from which the tumour originated, e.g. osteosarcoma or chondrosarcoma.

Fibrosarcoma.—This tumour occurs in scars, muscle sheaths (fig. 50) (described by Paget as a 'recurrent fibroid') and as a fibrous epulis (p. 149).

FIG. 50.—Fibrosarcoma arising from the sheath of the right pectoralis major. Infra-red photography reveals dilated veins over the tumour.

A fibrosarcoma of a muscle sheath presents as an elastic or firm and slowly growing swelling. It either commences as a true fibroma, and gradually becomes sarcomatous, or is actually of low-grade malignancy from the beginning. In any case malignant changes are hastened by incomplete efforts at removal. The moral is that wide excision should be practised in all cases, so that the tumour will not be 'recurrent.' Even so, prognosis is poor, and recurrences are apt to occur in other muscles and eventually in the lungs. Dilated veins over the tumour indicate malignancy, and these may be demonstrated by infra-red photography.
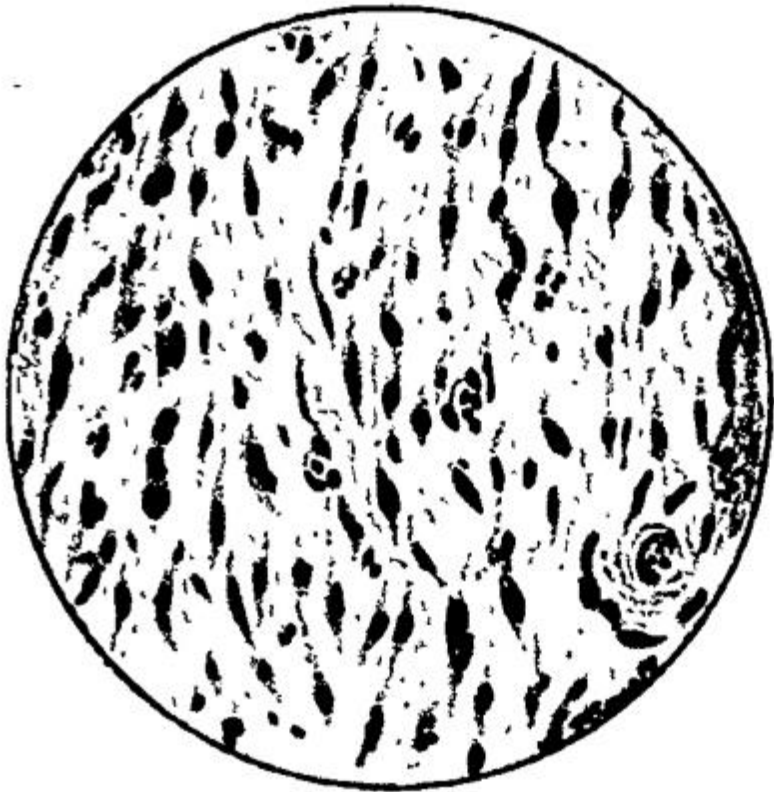

FIG. 51.—Spindle-celled sarcoma arising from a muscle sheath (Paget's ' recurrent fibroid ').

These tumours are composed of spindle cells of varying lengths (fig. 51). In many cases it is difficult to distinguish with certainty, even microscopically, between a simple fibroma and a fibrosarcoma of low-grade malignancy.

Fibrosarcomata not uncommonly arise in scar tissue, sometimes many years after the scar developed. Owing to the relative avascularity of scar tissue, an associated sarcoma grows slowly, but eventually causes extensive destruction of adjacent structures.

If untreated, or if local excision is unsuccessful, a fibrosarcoma eventually fungates through the skin (fig. 52). Metastases are widely scattered, and, unfortunately, radiotherapy has no permanent effect on either the primary growth or on the secondary deposits.

Sir James Paget, 1814–1899. Surgeon. St. Bartholomew's Hospital, London.

Reticulosarcoma (*syn.* lymphosarcoma) arises in lymph nodes, tonsils, Peyer's patches or lymph nodules in the intestines. Lymph nodes of the neck or mediastinum are most commonly affected. This variety of sarcoma grows rapidly, and gives rise to metastases in adjacent lymphoid tissue, and later in distant organs via the blood-stream. The tumour is composed of small round cells which stain deeply and which are highly radio-sensitive, but owing to early dissemination the chance of cure is negligible.

FIG. 52.—Fungating fibrosarcoma of the scalp.
(*T. A. Bouchier-Hayes.*)

The terms round-celled, spindle-celled, etc., are applied to tumours which contain no differentiated cells.

The macroscopic appearance of a sarcoma varies considerably. As the word implies, most tumours appear as a fleshy mass, but their consistency depends on the relative proportion of fibrous and vascular tissue. An avascular fibrosarcoma appears as a hard, almost white tumour, whereas a sarcoma of the breast is frequently soft, hæmorrhagic and often cystic, owing to mucoid degeneration. Hæmorrhage commonly occurs in a sarcoma, owing to the very thin walls of the veins, which in some places are represented merely by venous spaces. The absorption of fibrin ferment from extravasated blood (comparable to aseptic traumatic fever) accounts for the irregularities of temperature which are so characteristic of a rapidly growing sarcoma.

FIG. 53.—Chloroma.
(*A. A. McConnell, Dublin*).

Sarcomata of separate organs are considered in their appropriate chapters.

Chloroma (*syn.* myeloblastic reticulosarcoma) is a rare condition in which the bones of the face, and especially those of the orbits, are involved by a growth resembling sarcoma (fig. 53). It is a leukæmic condition, and at post-mortem the tumours present a bright green colour. Blood examination shows a lymphocytosis, and no treatment is of avail.

MELANOMA

Melanotic tumours usually arise in the skin, the pigmented layers of the eye, or the lower colon.

Benign melanomata occur as congenital pigmented nævi or moles, or as pigmented warts. These tumours usually remain unaltered, but occasionally malignant changes supervene, especially if they are subjected to repeated trauma, e.g. friction from shoes on the sole of the foot. There is some evidence to suggest that pregnancy initiates malignant changes in an innocent tumour.

A *melanoma malignum* most commonly is secondary to a benign pigmented tumour. To answer the question " When is a mole not a mole ? " is often difficult, but ulceration, a tendency to bleed or induration should give rise to the gravest suspicions. In case of any doubt the mole must be excised
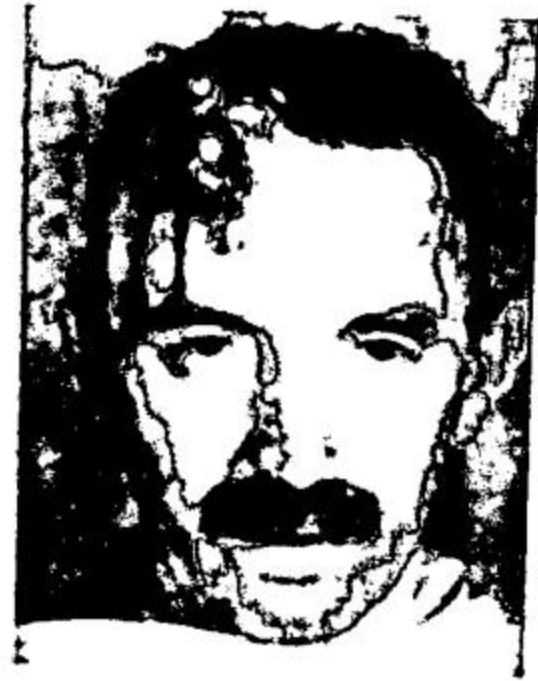
Johann Peyer, 1653–1712. Anatomist of Schaffhausen, Switzerland.

FIG. 54.—Melano-
ma of the nail-bed

widely and scrutinised by a pathologist. The primary growth may remain quite small, and yet give rise to large secondary deposits. Occasionally a melanoma malignum arises spontaneously in the nail-bed (fig. 54), in the uveal tract or on the sole of the foot (fig. 55).

Even if radically treated, a melanoma malignum carries a high mortality, as these growths give rise to early and widespread dissemination, but exceptional cases have been reported in which spontaneous regression has occurred. Tumours arising in the skin permeate lymphatics, and intermediate deposits commonly occur between the primary growth and regional nodes (fig. 37). At a later stage bones and viscera are likely to be involved. Mela-nomata occurring in the uveal tract cause blurring of vision, and frequently give rise to visceral deposits, which may be enormous in size, particularly in the liver (fig. 146). After removal of an eye on account of a melanoma a latent period of many years may elapse, but secondary deposits almost inevitably appear.

Histologically, melanomata arising in the skin usually show an alveolar arrangement. The pigment granules vary in colour from black to yellow, and are situated both in the cells and in the stroma. Secondary deposits are typically black (fig. 102), but sometimes contain very little pigment or even none at all (amelanotic melanoma)[1]. In advanced cases melanuria occurs. It is now generally agreed that melanomata should be regarded as carcino-


FIG. 55.—The growth, the scar and the specimen, which measured 28 inches.
(The late G. Grey Turner.)

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[1] Cells which contain no obvious pigment usually contain precursor substances, which can be demonstrated by the ' dopa ' reaction (di-hydroxyl-phenyl alanine).

mata—an epithelial melanocarcinoma of the skin, or a neuro-ectodermal carcinoma in the case of the eye.

The *treatment* of a melanoma malignum, if the site permits, consists in wide local excision, followed by an incision over the course of the lymphatic drainage. Skin flaps are turned back and a wide strip of deep fascia, containing the lymphatics, is excised until the regional lymph nodes are reached, when they are also removed. If possible the tumour, fascia and nodes are removed in one continuous strip (fig. 55) (Hogarth Pringle). However, as widespread lymphatic permeation occurs between the primary growth and the regional lymph nodes (fig. 56), this procedure is only advisable in early cases,

FIG. 56.—Melanoma malignum of the foot, with secondary deposits in the lymphatics of the thigh.
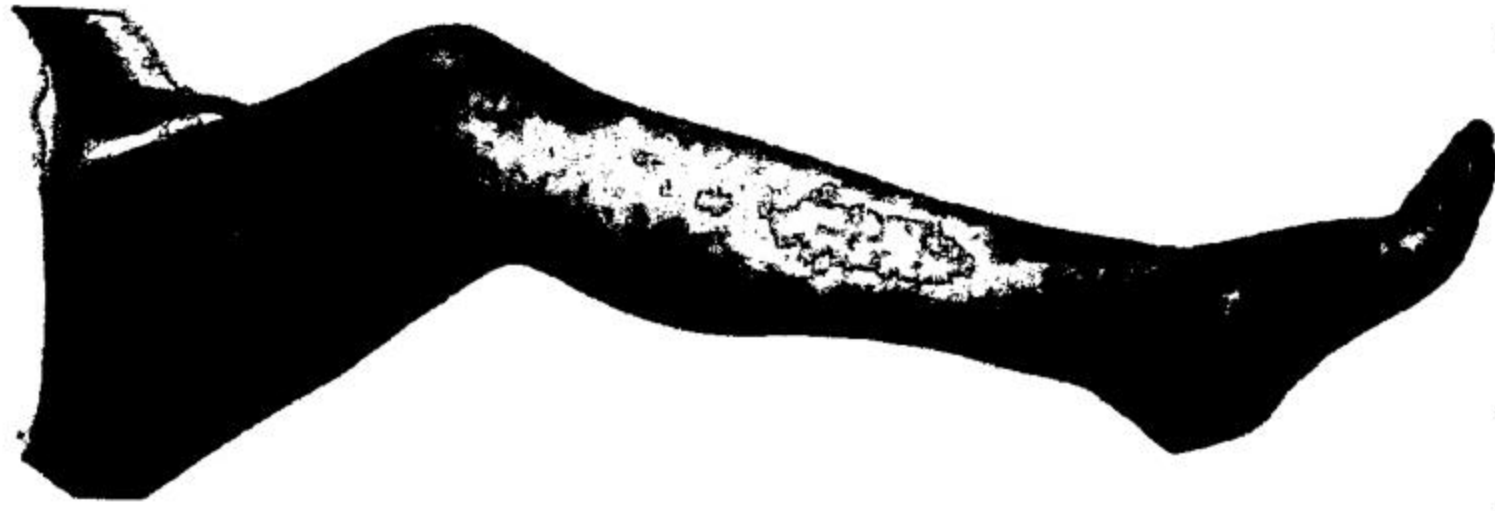
or if the primary growth is not far distant from the regional nodes. Otherwise wide and early excision of the melanoma, with, if necessary, skin grafting of the resultant wound, combined with block dissection of the regional nodes, is recommended. Block dissection must be performed even if clinical examination reveals no enlargement of the lymph nodes, as early involvement is undetectable. It is a curious fact that the prognosis in children, even when microscopy indicates malignancy, is much better than in adults.

An unusual variety of *melanosis* is occasionally seen, in which the pigment from a congenital mole slowly spreads in the surrounding skin, with no immediate evidence of malignancy. After a period of months or even years malignant changes supervene, therefore the pigmented patch should be excised freely.

ENDOTHELIOMA

The endothelial linings of blood-vessels, lymphatic spaces and serous membranes occasionally give rise to neoplasms. Endotheliomata, therefore, enjoy a wide range of distribution. Although the original cells are flattened, they become spheroidal or cuboidal when neoplastic changes occur. Endotheliomata are not usually highly malignant and dissemination occurs in a minority of tumours.

Endotheliomata occasionally arise from the pleura and rarely from the pericardium or peritoneum. The ' endothelioma ' (meningioma) of the dura mater is thought by some to arise from the arachnoid membrane, which is not an endothelial structure. Calcification occasionally occurs in these tumours, in which case it is termed a ' psammoma.'

Peritheliomata are tumours arising in connection with the endothelial lining of small blood-vessels or lymphatics. Carotid body tumours are probably of this nature (p. 204).

J. Hogarth Pringle, 1863–1941. Surgeon, Glasgow Royal Infirmary.

Cylindroma (*syn.* 'turban' tumour) is so called from the arrangement of the stroma in peculiar transparent cylinders. It is considered by some to be a basal-celled carcinoma, although other authorities classify the tumour as an endothelioma. The tumour gradually forms an extensive turban-like swelling extending over the scalp. Ulceration is uncommon, and the tumour is relatively benign.

Tumours arising in connection with special structures or organs are considered in their appropriate chapters.

BENIGN——→MALIGNANT

Certain innocent neoplasms are prone to undergo malignant changes, and it is important, both for treatment and prognosis, to realise when the malignant characters supervene. Some or all of the following changes may be recognised :

(i) *Increase in size*—comparatively rapid enlargement is always suspicious, as in the case of a soft fibro-adenoma of the breast which is becoming sarcomatous.

(ii) *Increased vascularity*—as evinced by dilated cutaneous veins, expansile pulsation of the tumour, or ulceration and bleeding in the case of a superficial growth.

(iii) *Fixity*—due to invasion of surrounding structures, e.g. carcinomatous changes in a prostatic adenoma may cause ' tethering ' of the rectal mucosa.

(iv) *Involvement of adjacent structures*—carcinomatous changes in an adenoma of the thyroid should be suspected if the recurrent laryngeal nerve is implicated, and facial palsy associated with a parotid tumour indicates malignancy.

(v) *Dissemination*—discovery of secondary deposits is occasionally the clue to malignancy. Thus the true nature of a doubtful lump in the breast is rendered evident if involved lymph nodes or osseous metastases are detected, or the discovery of a secondary deposit in a bone may lead to recognition of a hypernephroma.

ULCERATION AND GANGRENE

McNEILL LOVE

ULCERATION

AN ulcer is caused by progressive destruction of surface tissue, i.e. cell by cell, as distinct from death of macroscopic portions.

Ulcers are classified as non-specific, specific, and malignant: the two latter groups are discussed in appropriate chapters.

Non-specific ulcers are due to infection of wounds or physical and chemical irritants. Local irritation, as in the case of a dental ulcer, or interference with the circulation, e.g. varicose veins, are predisposing causes. Trophic ulcers are associated with derangement of vasomotor control, and any debilitating condition predisposes to and hinders the healing of an ulcer. Perforating ulcers commonly occur on the sole of the foot, and are associated with neurological diseases.

The life-history of an ulcer consists of three phases; these are extension, transition, and repair. During the stage of extension the floor is covered with exudate and sloughs, while the base is indurated. The edge is sharply defined, and discharge is then purulent and perhaps sanious. The transition stage is occupied in preparation for healing. The floor becomes cleaner and sloughs separate. Induration of the base diminishes, and the discharge becomes more serous. Small reddish areas of granulation tissue appear on the floor, and these link up until the whole surface is covered (fig. 57). The stage of healing consists in the transformation of granulation to fibrous tissue, which gradually contracts to form a scar. The edge of the ulcer becomes more shelving, and epithelium gradually extends from it to cover the floor. This healing edge consists of three zones—the outer of epithelium, which appears white, the middle one bluish in colour, where granulation tissue is covered by a few layers of epithelium, and the inner reddish zone of granulation tissue covered by a single layer of epithelial cells. Excessive granulations, commonly known as 'proud flesh,' need to be discouraged by scraping, or by the application of a caustic, such as silver nitrate. Chronic or indolent ulcers often respond to infra-red radiation or short-wave therapy.

FIG. 57.—A healing varicose ulcer involving the lower third of the leg. (*Dr. R. H. Gorrill, London.*)

CLINICAL EXAMINATION OF AN ULCER

This should be conducted in a systematic manner. The following are, with brief examples, the points which should be noted:

Site, e.g. 95 per cent. of rodent ulcers occur on the upper part of the face. Carcinoma typically affects the lower lip, while a primary chancre is usually on the upper.

Size, particularly in relation to the length of history, e.g. a carcinoma extends more rapidly than a rodent ulcer, but more slowly than an inflammatory ulcer.

Shape, e.g. a rodent ulcer remains circular until of a larger size than a carcinoma. A gummatous ulcer is typically circular, or serpiginous, due to the fusion of multiple circles.

A square or angular ulcer is the result of 'dermatitis artefacta.' This condition is due to self-mutilation, e.g. by the application of irritants, such as corrosives. The patient usually has a neurotic or neuropathic temperament, or litigation may be involved. The ulcer readily heals if protected by a dressing which cannot be disturbed by the patient.

Edge, a rodent ulcer is rolled or rampart, an epithelioma everted, while a tuberculous ulcer has an undermined edge (fig. 58).
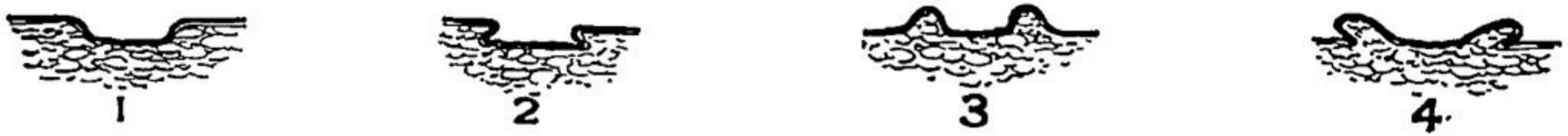

FIG. 58.—1. Healing ulcer, edges shelving.   2. Tuberculous ulcer.   3. Rodent ulcer.
4 Epithelioma.

Floor, a 'wash-leather' slough may cover the floor of a gummatous ulcer, while a tuberculous ulcer often exhibits watery or greyish granulations.

Base, whether indurated, e.g. infiltration of carcinoma, or attached to deep structures, e.g. a varicose ulcer to the tibia.

Discharge, e.g. a purulent discharge indicates active infection, a watery discharge is typical of tuberculosis, while a sanious discharge is associated with oozing from granulation tissue in a healing ulcer. Organisms may be detected, e.g. spirochætes, tubercle bacilli, actinomyces.

Lymph nodes, not enlarged in the case of a rodent ulcer, unless due to secondary infection. May be enlarged and hard in the case of carcinoma, or firm in consistency if associated with a primary chancre.

General examination of the patient may confirm suspicion concerning the type of ulcer. Thus a gummatous ulcer may be associated with chronic superficial glossitis. Lupus verrucosis (Chapter 37), causes enlarged regional lymph nodes.

Pathological examinations, e.g. biopsy may confirm carcinoma, or the W.R. or Mantoux test may be of value.

SKIN GRAFTING

This procedure is useful in hastening the healing of an extensive wound or ulcer, and provides a more or less supple scar. The method recommended by Thiersch is most commonly used. The operation consists of scraping away the granulations on the floor of the ulcer, and securing hæmostasis by pressure with hot saline pads. Areas of cuticle are removed from healthy

Charles Mantoux, Contemporary. Physician, Le Cannet, France.
Karl Thiersch, 1822–1895. Professor of Surgery, Leipzig.

skin, usually from the thigh, with a non-bevelled razor, or a Padgett's or similar dermatome. The line of section just reaches the papillæ, which appear as tiny oozing spots on removal of the graft. The grafts are transferred by a spatula to the prepared ulcer, so that they are in contact with each other, and a protective dressing is all that is necessary. Tulle gras is excellent for this purpose, and is composed of sterilised mesh gauze saturated with soft paraffin and impregnated with balsam of Peru.

Reverdin's method is simple but less reliable than that of Thiersch. The skin is elevated by means of a needle or mosquito forceps, and a tiny area is snipped off and transferred to the raw area. This procedure is repeated as often as necessary.

Wolfe's method of using whole skin is useful when normal suppleness is desired, as in the palm. Tessellated grafts are a refinement of this method. The skin to be used is denuded of fat, cut into small squares, and arranged as desired.

Pedicle grafts are used to cover large raw surfaces, and scope for ingenuity exists in planning the precise method for individual cases. Thus a flap may be raised from the pectoral region and turned upwards on to the face, the base of the pedicle being divided when the graft has taken (fig. 59). Allowance must be made for shrinkage of the graft.

FIG. 59.—A pedicle graft.
(*Sir Archibald McIndoe, London.*)

GANGRENE

Gangrene implies death of macroscopic portions of tissue combined with putrefaction.

The features of gangrene are as follows :

(i) Cessation of circulation, i.e. loss of pulsation, and pressure on the skin causes no alteration of colour, indicating absence of capillary circulation.

(ii) Loss of heat.

(iii) Loss of sensation in the affected part.

(iv) Loss of function.

(v) Change of colour, depending on the type of gangrene.

Gangrene manifests itself clinically in one of two types :

Dry gangrene occurs when the tissues are desiccated by gradual slowing of the blood-stream, and typically occurs as a result of arterial degeneration, e.g. senile gangrene, or Mönckeberg's medial degeneration in diabetes. The affected part becomes dry and wrinkled, discoloured from disintegration of hæmoglobin, and greasy to the touch.

Moist gangrene occurs when venous as well as arterial obstruction occurs, or when the artery is suddenly occluded, as by a ligature or embolus. Infection and putrefaction usually follow, and the affected part becomes swollen, discoloured, and the epidermis may be raised in blebs. Crepitus can sometimes be detected on palpation, due to infection by saprophytic gas-forming organisms.

When gangrene occurs, the local changes depend on the size of the affected tissue and the degree of infection present. Small amounts of gangrenous tissue are absorbed ; larger amounts, if aseptic, are cast off as a slough. This separation of the slough is accomplished by a layer of granulation tissue which forms between the dead and living tissue. These granulations extend into the dead tissue, until those which have penetrated farthest are unable to derive adequate nourishment owing to fibrosis occurring behind them. This defective nutrition results in ulceration, and thus a ' line of demarcation ' forms which separates the gangrenous mass from healthy tissue.

If the gangrenous tissue is infected, separation occurs as a result of inflammatory changes in the adjacent healthy structures. In addition to the toxins produced by infection, irritating chemical substances are formed by disintegration of the dead tissue, and the consequent inflammatory reaction in neighbouring living tissue results in suppuration. A layer of granulation tissue then forms on the surface of the healthy tissue, forming a line of separation. Infection may extend beyond the line of separation along lymphatic vessels or cellular tissue into healthy parts, and extensive inflammation then results.

The general treatment of gangrene consists of dealing with any predisposing causes, e.g. diabetes, and in relieving pain, ordering nutritious diet and stimulants if necessary. Locally, when gangrene threatens, the part should be kept dry, dusted with sulphanilamide powder and wrapped in cottonwool. In the case of a limb, elevation will encourage venous return and discourage pressure sores. Treatment of different varieties is discussed later.

VARIETIES OF GANGRENE

The varieties of gangrene may be classified as follows :

i. SYMPTOMATIC :

(*a*) Raynaud's disease.

(*b*) Ergot poisoning.

(*c*) Senile.

(*d*) Thrombosis and thrombo-angiitis obliterans.

(*e*) Embolism.

(*f*) Diabetes.

ii. INFECTIVE :

(*a*) Gas gangrene.

(*b*) Phagedena, and cancrum oris et noma.

(*c*) Carbuncles and boils.

iii. TRAUMATIC :

(*a*) *Direct*, which includes crushes, pressure sores, and the constriction groove of strangulated bowel.

(*b*) *Indirect*, due to injury of vessels at some

FIG. 60.—A post-mortem photograph of an electric burn, second degree. The deceased touched a live terminal.

Maurice Raynaud, 1834–1881. *Physician, Hôpital Laribosière, Paris.*

distance from the site of gangrene, e.g. pressure on the popliteal artery by the lower end of a fractured femur, or the gangrenous contents of a hernial sac.

iv. PHYSICAL, e.g. burns, scalds, frostbite, trench feet, chemicals, radium, X-rays, and electricity (fig. 60).

SYMPTOMATIC GANGRENE

Raynaud's disease is discussed in Chapter 41

Ergot is a common cause of gangrene among dwellers on the shores of the Mediterranean Sea and in the Russian steppes who eat rye bread infected with *Claviceps purpurea*. The extremities, and sometimes the nose and ears, are affected (fig. 61).

Senile gangrene is predisposed to by arterial degeneration, the vessels becoming calcified, narrowed and often thrombotic. Myocardial weakness causes slowing of the circulation, and slight injury causing local thrombosis may determine the onset of gangrene. Constitutional conditions, such as nephritis or diabetes, lower the vitality of the tissues, and encourage the development of gangrene.

Treatment first consists in the prevention of minor injuries in patients who suffer from painful cramps and tingling in the legs,

Fig. 61.—Ergot poisoning following treatment for post-partum hæmorrhage.
(*Mr. R. Kennon, Liverpool.*)

or other evidence of impaired circulation. Warm clothing, careful chiropody, and attention to the general health receive due consideration. If gangrene threatens, lumbar ganglionectomy, which must include the first lumbar ganglion, is considered, but is unlikely to improve many cases, as actual degeneration rather than spasm of the arteries is the causative factor. The body must be kept warm to encourage reflex vasodilatation, and the affected limb is cooled to reduce metabolism. Anticoagulants are of value, and in suitable cases alcohol promotes vasodilatation, relieves pain and acts as a soporific. In selected cases arterial grafting should be considered (page 95).

If gangrene develops (fig. 62), amputation is usually necessary and should be performed at a level where the blood supply is adequate. If there is no pulsation in the tibial arteries, it is sometimes necessary to amputate through

Fig. 62. — Arterio - sclerotic gangrene.

the lower third of the thigh, but in many cases a transmetatarsal or Syme's amputation of the foot is adequate. An arteriogram is often of value in assessing the level at which amputation may be performed in safety. Owing to the calcareous state of the vessels, hæmorrhage is controlled by digital pressure rather than by a tourniquet, and surprisingly little bleeding occurs. Flaps should be planned so as to be no longer than necessary and equal in length, as sloughing is otherwise encouraged. If calcification renders ligation of a large artery difficult on account of brittleness, some of the adjacent muscle is included in the ligature.

Venous thrombosis is an uncommon cause of gangrene, but occasionally occurs as a complication of specific fevers, notably enteric, or following thrombosis of deep veins, e.g. as a result of injection of varicose veins. Thrombo-angiitis obliterans (Chapter 41) may also cause gangrene of the leg.

Embolic gangrene either arises in connection with cardiac lesions, e.g. endocarditis or mitral stenosis, or follows separation of an atheromatous plaque. Emboli are arrested at the site of bifurcation of an artery (fig. 63), or where sudden narrowing occurs owing to a large branch leaving the parent vessel. Sudden, severe pain is experienced, both at the site of impaction and along the distal course of the vessel. Circulatory changes speedily follow, and the limb becomes ' painful, pallid and pulseless.'

FIG. 63.—Moist gangrene due to an embolus at the bifurcation of the popliteal artery.

Gangrene commences peripherally, and extends upwards until it reaches a level of adequate circulation.

Treatment is discussed on p. 97.

Diabetic gangrene is due to three factors. These are trophic changes resulting from peripheral neuritis, mesial calcification of the arteries resulting in ischæmia, and excess of sugar in the tissues, which lowers their power of resistance to infection. As in the senile type, gangrene is usually preceded by some slight trauma, and is either of the moist or dry variety.

The neuropathic factor impairs sensation, and thus favours the neglect of minor injuries and infections, so that inflammation and destruction of tissues are ignored. Diffuse pain and vasomotor disturbances are early features, and depression of vasomotor responses renders tissues physiologically ischæmic to infection or injury, so that the reaction of hyperæmia is absent. Muscular involvement is frequently accompanied by loss of reflexes and deformities, such as claw toes, on which callosities form with consequent risk of infection.

James Syme, 1799–1870. Professor of Clinical Surgery, University of Edinburgh.

Ischæmia is associated with burning pain, usually worse at night, and diminution of peripheral pulsation. Oscillometry may be useful in gauging the level of adequate circulation. The foot is waxy or pinkish in colour, and is cold to the touch.

TREATMENT.—It is important to decide whether gangrene is due to neuropathic or ischæmic causes. In the former case the blood supply is adequate and amputation is often successful at a low level, e.g. a single toe, or Syme's amputation if the dorsum of the foot is involved.

Ischæmic gangrene usually requires a more radical amputation, but if a single toe is affected disarticulation at the metacarpophalangeal joint may be satisfactory. To await separation of a gangrenous toe immobilises the patient and invites infection, which rapidly spreads to the dorsum of the foot. Should this occur, or if gangrene and infection have involved the heel, a below-knee amputation is indicated. Sympathectomy may relieve pain, but has little effect on the circulation.

Should a patient with diabetic gangrene require confinement in bed, the limbs should be supported on canvas slings or Thomas's splints and suspended from a frame in order to prevent pressure on the heels (W. Oakley). Otherwise, the dreaded black patches on the heels may develop overnight in a bedridden patient.

INFECTIVE GANGRENE

Gas gangrene, although uncommon, is a regular contributory cause of death in the case of accidents. It is now considered that the anaerobes are introduced into the wound from infected clothing rather than carried in with soil, hence wounds of the thighs and buttocks are especially liable to infection owing to fæcal contamination. Excessive hæmorrhage and the use of a tourniquet are predisposing causes, and, as in all cases of gangrene, the leg is more prone to be affected than the arm.

The causative organisms fall into two groups—those which break down starch and those which break down protein. *Cl. welchii* (*aerogenes capsulatus* or *perfringens*) is the most important member of the saccharolytic group; it is a Gram-positive anaerobe with a definite capsule. The proteolytic group include *Cl. sporogenes,* which splits protein into ammonia and sulphuretted hydrogen.

The diagnosis of true gas gangrene or clostridial myositis, i.e. gas in the tissues combined with gangrene, is essentially clinical. Gas-forming organisms are often cultivated from wounds in which they produce little or no evil results, and energetic surgical intervention is not indicated in these cases. Clostridial myositis is associated with pain, swelling, œdema, and toxæmia, which usually develop within forty-eight hours. The patient is often mentally alert and apprehensive, and complains of severe pain in the region of the wound. Later signs include rapid increase in the pulse-rate, a slight rise, or, in severe cases, a fall of temperature, and vomiting. It has been suggested that the toxins produced by the infection exert a selective and depressing action on the suprarenals, causing marked lowering of the blood-pressure and hence vomiting. The mental condition usually remains clear, and death occurs suddenly. We have seen a patient die while engaged

Hugh Owen Thomas, 1834–1891. Orthopædic Surgeon, Liverpool. Often referred to as the Father of Orthopædic Surgery.
Wilfred Oakley, Contemporary. Physician, King's College Hospital, London.
William Henry Welch, 1850–1934. Professor of Pathology, Johns Hopkins University, Baltimore
Hans Christian Joachim Gram, 1853–1938. Professor of Medicine, Copenhagen.

in completing a football forecast.   On examination of the wound, stitches
are seen to be under tension, and, through the pouting edges, thin brownish
fluid exudes, which possesses a mouldy or 'mousy' odour.   The limb is
tense and swollen, and palpation often reveals crepitus.   A radiograph will
demonstrate the presence of gas in intermuscular planes, and is very useful
in the diagnosis of early cases (fig. 64).

Ampoules are obtainable which contain 22,500 I.U. of polyvalent anti-
toxin (9,000 units *Cl. welchii*, 9,000 units *Cl. œdematiens*, 4,500 units *Cl.*

FIG. 64.—Comminuted fracture of humerus due to fragment of high-
explosive.   Bubbles of gas are present under the triceps muscle.

septicum).   One such dose should be given intravenously, or into healthy
muscle, in all cases where the onset of gas infection is likely.   Prophylactic
penicillin should also be administered.

The next essential prophylactic measure is adequate surgical intervention.
Meticulous excision of dead and dying tissue within six hours, and encasing
the limb in plaster of Paris, practically abolishes gas-gangrene infections.
Partial suturing is sufficient, and secondary suture can be undertaken at a
later date.   If infection is already established, free incisions, local excision
of a muscle, groups of muscles, or amputation may be necessary, according
to the extent and virulence of infection.   Gas and foul fluid are found in
the cellular spaces ; contractility of the muscle is soon lost, and its colour
changes successively from the dull red of boiled ham to green and then
black.   For therapeutic measures three ampoules (see above) of polyvalent
serum should be given without delay, and repeated at six-hourly intervals as
necessary (or combined in an intravenous drip).   Neutralisation of toxin is
a quantitative reaction, and early delay cannot be compensated for by
the subsequent administration of an excess of serum.   Sulphonamide and
penicillin should be administered at the earliest opportunity, but they are
only adjuvants to serum.   If septicæmia occurs, gas is produced in many
organs, notably the liver, which, at necropsy, drips with frothy blood, and is
well named a ' foaming liver.'

Less severe forms of gas infection occasionally occur :

(i) *Local type.*—Invasion is sometimes limited to a single muscle, which becomes necrotic while adjacent muscles escape.

(ii) A *gas abscess* frequently occurs if a contaminated foreign body is present in a wound, and infection subsides when the wound is opened and the foreign body removed.

(iii) *Subcutaneous infection* is sometimes seen spreading for a considerable distance around a wound. Crepitus is easily palpable, and the skin becomes khaki-coloured as a result of hæmolysis. *Unless this condition is recognised, a needless amputation may be performed.* The only surgical treatment required is excision of the wound, combined with multiple incisions into the affected subcutaneous tissues, down to, but not including, the deep fascia, otherwise infection may be carried into the underlying fascial planes or muscles.

Cancrum oris et noma is a virulent type of infective gangrene which sometimes occurs in children who are debilitated and possibly recovering from some infectious disease (p. 153).

Carbuncles and boils are considered in connection with diseases of the skin.

TRAUMATIC GANGRENE

This variety of gangrene follows either local injury or occlusion of blood-vessels, and thus is either direct or indirect.

(i) **Direct traumatic gangrene** is due to local injury of the affected tissue, and may arise as a result of crushes, or pressure, as in the case of splints, plasters, or bedsores.

Gangrene following a direct and severe injury, e.g. a street accident in which a heavy vehicle passes over a limb, is of the moist variety, and if the affected part is devitalised, removal without delay is indicated. As the tissues are presumably healthy, amputation is performed as close to the affected part as will leave the most useful limb.

BEDSORES (*syn.* decubitus ulcers) are either acute or chronic. The acute or *trophic* variety is associated with disease or injury of the spinal cord, and often progresses with alarming rapidity in spite of every care and attention.

The chronic or *postural bedsore* is predisposed to by four factors —pressure, injury, malnutrition and moisture (fig. 65). Prophylactic treatment is of the utmost importance. Thus pressure over bony prominences is counter-acted by change of posture and

FIG. 65.—Postural bedsores over the sacrum.

protection by cottonwool 'nests' or sorbo-rubber rings. A water-bed is sometimes desirable. Injury due to wrinkled drawsheets, biscuit crumbs, or grit in the dusting powder is obviated by careful nursing. The nutrition of the skin is maintained by the application of astringent and stimulating

preparations such as eau-de-Cologne or surgical spirit. Maceration of the skin by sweat, urine or pus is combated by skilled nursing.

A bedsore is to be expected if erythema appears which is unaffected by pressure. The application of tannic acid, or protection by strips of flexible adhesive plaster, will reduce ulceration to a minimum. Actual bedsores during the stage of extension are best treated by the application of gauze moistened with antiseptics, such as dettol or flavine. If response is unsatisfactory local application of insulin may be effective. When healing has commenced, 10 per cent. ichthyol in glycerine usually gives good results, and further stimulation is obtained by the use of red lotion. If the patient is young and otherwise healthy, free excision and sliding skin grafts are often successful.

(ii) **Indirect traumatic gangrene** is due to interference with blood-vessels, and some of the moreimportant causes of this condition are as follows:

(*a*) Obstruction to artery and vein, as occurs in the loop of bowel contained in a strangulated hernia, or following pressure by a fractured bone on the main vessels of a limb.

(*b*) Thrombosis of a large artery, following injury or embolus.

(*c*) Ligation of the main artery of a limb, as after division by injury. The likelihood of gangrene then depends upon the efficiency of the collateral circulation, the elasticity of the arteries, and whether the arm or leg is affected. It is now generally agreed that in the case of a limb the accompanying vein should also be ligated, as thereby the risk of gangrene is diminished, although this procedure applied to the leg may be followed by prolonged œdema.

Treatment is first directed to the cause, thus embolectomy, or closed or open reduction of a fracture, will sometimes prevent the onset of gangrene. A divided artery may be sutured, possibly with the aid of a vein graft, and heparin administered. In other cases, where gangrene is slow in its development, delay is sometimes advantageous in that a line of demarcation will indicate the level of vitality, but if moist gangrene rapidly spreads then amputation must be performed in order to safeguard healthy tissue. In cases of threatened gangrene the limb must be kept cool, so as to reduce metabolism to the minimum.

PHYSICAL AND CHEMICAL CAUSES

Frostbite is due to exposure to cold, especially if associated with wind or high altitudes (e.g. explorers and airmen). Oxygen deficiency results in tachycardia and weak cardiac contraction, also the low oxygen content of the blood diminishes the vitality of the tissues. The sufferer notices severe burning pain in the affected part, after which it assumes a waxy appearance and is painless. Pathologically, the condition is due to damage to the vessel walls, which is followed by transudation and œdema, hence the waxy appearance of the frostbitten part. In severe cases, or if unwise treatment is adopted, vessels rupture and extravasation of blood-stained serum follows.

Treatment demands adequate clothing, and oxygen for altitudes. Frostbitten parts must be warmed *very gradually*. The circulation is temporarily in abeyance, and it is therefore obvious that any temperature higher than that of the body will be detrimental, as the affected part will merely rise in temperature equal to that of its surroundings. Many frostbitten limbs have been either stewed or roasted

in ignorance, and gangrene thereby rendered inevitable. The affected part should be wrapped in cottonwool and kept at rest. Friction, e.g. rubbing with snow, is contraindicated, as it damages the already devitalised tissues. Warm drinks and clothing are provided, and powerful analgesics are required to relieve the pain which heralds the return of circulation. Alcohol, although comforting, is contraindicated, as it causes peripheral dilatation and thus embarrasses the slowly returning circulation. If gangrene develops, the deeper structures are affected to a less extent than the skin, which naturally bears the brunt of the exposure.

Trench foot is due to cold, damp, and muscular inactivity, and is predisposed to by unsuitable clothing, such as garters, puttees, or ill-fitting boots. Other factors which encourage the condition are exhaustion, inadequate food, and cardiac or vascular disease. Prophylaxis is therefore of paramount importance. Numbness is followed by pain, which is often excruciating when boots are removed. The skin is mottled like marble, and in severe cases blisters containing blood-stained serum develop, and moist gangrene follows. The pathology is similar to that of frostbite, and treatment is the same.

BURNS AND SCALDS

Burns are due to dry heat and scalds to moist heat.

Complicated classifications of burns are unnecessary, and all that is required is to decide whether the burn is superficial or deep. A superficial burn is one in which the skin is involved but not destroyed, whereas a deep burn implies destruction of the skin over some or all of the area involved.

The extent of the burn is estimated by the ' Rules of Nine,' i.e. the head and upper limbs each comprise 9 per cent. of the body surface, while the front and back of the trunk and each lower limb represent 18 per cent. of the surface. The external genitalia account for the remaining 1 per cent.

General Treatment.—Severe burns should be treated in special Burns Clinics, which are now available in many of the larger hospitals. A severe burn requires specialised treatment concerning the combat of shock, especially fluid replacement, nutritional supervision, immediate attention to the burnt area, and subsequently operative procedures such as skin grafting or possibly amputation. If, owing to the condition of the patient, or environment, speedy transfer to a special clinic is not practicable, immediate treatment is instituted, and the patient is transferred as soon as circumstances permit. On admission, the burnt area is covered with a sterile towel or dressing, and intravenous morphia is given as required. Oxygen therapy may be necessary in order to combat anoxia.

Fluid replacement is a vital problem in all cases of serious burns. If more than 10 per cent. of the body surface is affected, intravenous dextran is given until the renal excretion is adequate, but after forty-eight hours the fluid should be limited in quantity lest pulmonary œdema develops. Various formulæ have been advocated regarding the actual amount of fluid required for burns of varying extent. However, the clinical condition of the patient is the best guide, and the hourly amount of urine excreted should be maintained at a minimum of 50 ml. Plasma loss is greatest in superficial burns, and amounts to nearly three-quarters of the total blood volume when one-sixth of the surface of the body is burnt. Several pints of dextran may be necessary before hæmoconcentration returns to normal.

In the case of deep burns toxins from the damaged tissues inhibit the

activity of the bone marrow with the result that secondary anæmia occurs, which should be counteracted by repeated small blood transfusions.

Those responsible for treatment should take precautions against infecting the burn, and they should wear a mask if the area is exposed. Increased katabolism of protein is reflected in excessive amounts of nitrogen excreted in the urine. In addition, outpouring of exudate results in further loss of protein, therefore a high protein intake is essential, and, if necessary, the diet should be supplemented by the administration of complan. Prophylactic penicillin is useful in order to control subsequent infection.

Local Treatment.—MINOR BURNS.—These are commonly treated by the application of antiseptic ointments or picric acid. Tannafax, which is a non-greasy, water-soluble jelly, is a useful first-aid dressing. A satisfactory method is to clean the area with cetavlon (1 per cent.), and to apply penicillin cream. The dressing of gauze and wool is retained in place with strapping or a firm crêpe bandage.

EXTENSIVE BURNS.—The essentials in the treatment of extensive burns (fig. 66) are to prevent infection and, as with all wounds and injuries, to repair damaged tissues as expeditiously as possible by operative measures.
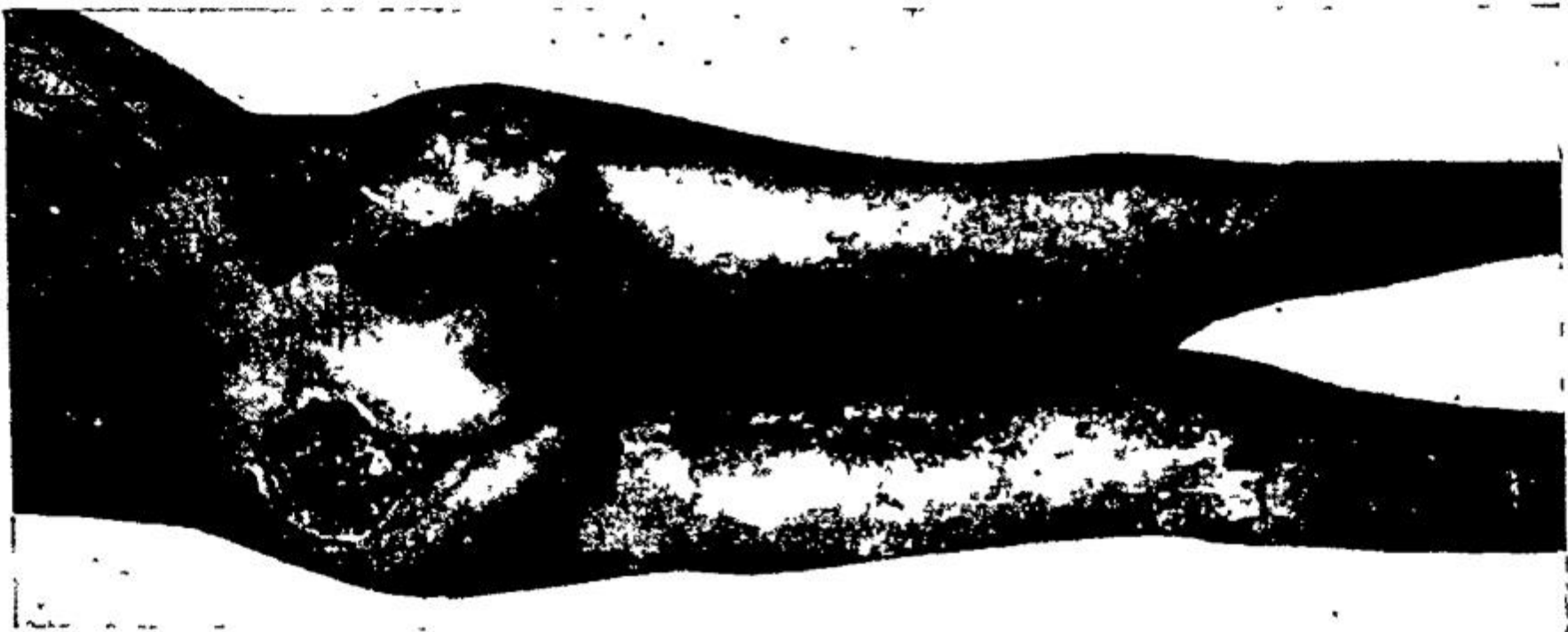

FIG. 66.—Multiple burns of the back and legs.

Extensive burns fall into two groups—early or clean cases, i.e. those seen within two or possibly three days, and later or infected cases where delay in instigating adequate treatment was unavoidable or unappreciated.

Clean Cases.—As soon as resuscitative measures have sufficiently improved the general condition, the patient is removed to the theatre. Under anæsthesia adherent clothing is removed, blisters are punctured and detached necrotic tissue is gently swabbed away with gauze moistened in saline.

If circumstances permit, the burn is treated by exposure, so as to encourage a state of dry necrosis, the drying process being assisted by currents of warm air or the proximity of hot-water bottles. Limbs are suspended in order to discourage œdema, and in Burns Clinics special frames are available for exposure of burns of the trunk. In about a fortnight necrotic tissue separates, and superficial burns will have healed. In the case of deep burns skin grafting is necessary, and for large areas a mechanical dermatome is invaluable, and homografts are sometimes useful, especially in children, as small bodies

have a proportionately small surface area. Subsequent skin grafting is often required to supplement the first operation, or to replenish areas where grafting was unsuccessful.

If circumstances preclude the exposure method of treatment, the affected area should be smeared with penicillin cream, covered with gauze and a thick layer of cottonwool, and encased in a tight pressure bandage. Subsequent dressings are required every two or three days, under strict aseptic technique. Slow healing may be stimulated by the local application of hydrocortisone.

Infected cases are treated on principles accorded to any infected wound. Saline baths are useful in removing sloughs, and tulle gras dressing is applied, which is renewed as necessary. Ichthyol (10 per cent.) in glycerine, is valuable in overcoming infection after sloughs have separated. When the condition of the wound is satisfactory, skin grafting is performed as in ' clean ' cases.

During convalescence care must be taken to obviate disabilities which may arise from contractures (fig. 67), and if scars are likely to diminish movement of joints it is important to obtain the optimum position, e.g. in the case of the hand the position of function must be observed (Chapter 45).

FATAL RESULTS are due to one of three causes :

1. *Primary shock* (p. 14), which occurs simultaneously with the injury. Reassurance, warmth, and, if necessary, morphia nearly always tide the patient over the condition.

2. *Secondary shock* (p. 15) is responsible for 80 per cent. of deaths from burns ; children are particularly susceptible, especially if the face or abdomen is involved. Plasma is lost from the circulation, some of which escapes on to the burnt surface, but probably a large amount exudes from the capillaries into surrounding tissues.

3. *Toxæmia* occurs after forty-eight hours, and is augmented if secondary infection occurs. Severe cases are only likely to occur if prompt and efficient treatment of the burn is neglected, or if circumstances render such treatment impossible.

FIG. 67.—Scarring of neck and left elbow following severe burns.

CHEMICAL BURNS

Chemicals sometimes cause gangrene, the most dangerous being carbolic acid, as anæsthesia masks the pain which occurs before the onset of gangrene. *Carbolic compresses should never be used*, and fingers have been lost by the application of compresses even as dilute as 1 : 80. Gangrene is due to local arterial spasm.

The accidental injection of pentothal into a branch of the brachial artery

may cause gangrene of the fingers.   Scalding pain accompanies the injection, and should act as a warning, but the anæsthetist should have observed that the blood in the syringe was bright red in colour.   The needle should be left *in situ* and procaine injected into the artery in order to relieve spasm.

Phosphorus burns require special treatment.   Particles continue to burn until neutralised, the best preparation for this purpose being 2 per cent. aqueous solution of copper sulphate.   Oil dissolves phosphorus and extends the scope of the burn. After the phosphorus has been rendered inert and any macroscopic particles removed, triple dye should be applied.

Electrical burns are usually deep and localised, and are best treated by early excision.

CHAPTER V

FLUID AND ELECTROLYTIC BALANCE

HAMILTON BAILEY

NORMAL INTAKE AND OUTPUT OF WATER

The intake is derived from two sources (a) exogenous, and (b) endogenous. *Exogenous* water is either drunk or ingested in solid food. The quantities vary within wide limits, but average 2 to 3 litres per twenty-four hours, of which about one-third is contained in solid food ingested.

Endogenous water is released during the oxidation of ingested food and the amount is less than 500 ml. per twenty-four hours. During starvation this amount is supplemented by water released from the breakdown of body tissues.

The Output.—Water is lost from the body by four routes :

1. *By the Lungs.*—About 400 ml. of water is lost in expired air each twenty-four hours. In a dry atmosphere, and when the respiratory rate is increased, the loss is correspondingly greater.

2. *By the Skin.*—When the body becomes overheated there is visible perspiration, but throughout life invisible perspiration is always proceeding. The cutaneous fluid loss varies within wide limits in accordance with the atmospheric temperature and humidity, muscular activity, and body temperature. In a temperate climate the average loss is between 600 and 1,000 ml. per twenty-four hours.

3. *Fæces.*—Between 60 and 150 ml. of water are lost by this route daily. In diarrhœa this amount must be multiplied not only by the number of stools, but with allowance for their fluidity and size.

4. *Urine.*—The volume of the daily output of urine is under the control of the body's water-regulating mechanism,[1] and the excess of water in the body after the requirements of the first three routes have been met is excreted by the kidneys. The optimum urinary output is 1,500 ml. per twenty-four hours, and provided the kidneys are healthy, the specific gravity of the urine bears a direct relationship to the volume of the urine excreted (fig. 68).

When compiling an intake and output chart, which

FIG. 68.—The required minimum volume to the maximum specific gravity (*After H. L. Marriott.*)

is absolutely essential in every case where fluid balance is restored and main-

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[1] The secretion of the posterior lobe of the pituitary gland is the guardian of the osmotic pressure of the body fluids, a function that it performs by stimulating the reabsorption of water by the renal tubules, thus varying the amount excreted.

tained by artificial means, the endogenous production and (unless the patient has diarrhœa) the output of water in the fæces can, for clinical purposes, be disregarded without transgressing accuracy.

NORMAL DAILY WATER BALANCE[1]

Intake		Output	
By mouth . . . 3,000 ml.		Insensible loss . . 1,500 ml.	
		Urine . . . 1,500 ml.	
Total . . . 3,000 ml.		Total . . 3,000 ml.	

(L. P. Le Quesne)

In the case of a person at rest in bed at room temperature in a temperate climate the insensible loss is considerably less (about 700 ml.); consequently either a smaller quantity of fluid is imbibed, or the urinary output is increased.

Taking into consideration their body-weight, the water requirements of infants and children are relatively greater than those of an adult because of (a) the larger surface area per unit of body-weight ; (b) the greater metabolic activity due to growth ; (c) the comparatively poor concentrating ability of the immature kidneys.

NORMAL INTAKE AND OUTPUT OF ELECTROLYTES

Unfortunately, the daily requirements of electrolytes cannot be calculated with the same facility as those of water.

Sodium.—In temperate climates the average daily intake of an adult is probably 3 to 6 G. (130 to 260 mEq.) in the form of sodium chloride. About 2·5 to 5·5 G. is lost in the urine, and less than 60 mg. (2·6 mEq.) in formed fæces. The loss in perspiration is normally negligible; however, prolonged profuse sweating results in a considerable loss of sodium—as much as 2 G. per hour (J. Nash). If water alone is given to counterbalance the fluid loss, serious sodium depletion can occur from excessive sweating. There is no electrolytic loss whatsoever in expired air.

Potassium.—A healthy adult consumes daily 3 to 4 G. (77 to 102 mEq.) of potassium in food, and nearly a like amount is excreted in the urine, with very small quantities in fæces and sweat.

Flame Photometry.—In hospitals with full laboratory facilities, flame photometry has made possible the rapid estimation of plasma sodium and potassium, so that day-to-day, or even more frequent, determinations can be made. For electrolytic determinations blood should be collected in the following ways :

(a) Venous blood collected under liquid paraffin in a tube containing 2 drops of heparin, 1,000 units per ml., for Na, K. Cl. and bicarbonate estimation.

(b) *Arterial* blood collected as in (a), mixed and put on ice for pH and HCO_3 estimations.

DEHYDRATION

Clinical manifestations of dehydration appear when there is water depletion corresponding to 6 per cent. of the body-weight. In most cases encountered

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[1] More specifically, the 24-hourly water balance of a normal adult taking average exercise. Leslie Philip Le Quesne, Contemporary. Assistant Director, Department of Surgical Studies, The Middlesex Hospital, London. Joseph Nash (1902–1945). Associate Surgeon, Bellevue Hospital, New York. Died on Active Service.

NORMAL VALUES FOR PLASMA

Na :	137–147 mEq. L.	=	315–338 mg./100 ml.
K :	4–5·5 mEq. L.	=	16–22 mg. 100 ml.
Cl :	95–105 mEq. L.	=	570–650 mg./100 ml. (NaCl).
HCO_3 :	25–30 mEq. L.	=	55–70 vol. CO_2/100 vol.

in surgical practice dehydration involves a depletion of electrolytes, mainly, if not entirely, sodium chloride, as well as water, and most of the symptoms of dehydration are due to the loss of sodium ions.

In established cases the eyes are sunken and the face is drawn. In infants the anterior fontanelle is depressed. The tongue is coated and dry; in advanced cases it is brown in colour. Unlike the dehydration produced by loss of water only, in water + salt depletion thirst is not particularly in evidence. The skin is dry and often wrinkled, making the patient look older than his years. The subcutaneous tissue feels lax. Peripheral veins are contracted and contain dark blood. The arterial blood pressure is likely to be below normal. The urine is scanty, dark in colour, of a high specific gravity, and except in cases of salt-losing nephritis contains little or no chloride.

Presuming that the erythrocyte count before the dehydration commenced was normal, the hæmatocrit reading provides an index of the degree of hæmoconcentration. On the other hand, hæmoconcentration can be masked by pre-existing anæmia.

The hæmatocrit (fig. 69) is a specially graduated tube which is filled with a small quantity of freshly drawn blood, to which has been added a little anti-coagulant such as powdered potassium oxalate. The tube is centrifuged for 30 minutes at 3000 revolutions per minute and the volume occupied by the packed blood cells is thus obtained. Any increase of the volume of packed cells over 45 per cent. in a male adult indicates a corresponding degree of dehydration. The normal reading varies with age, sex, weight and height.

FIG. 69.—
A hæmatocrit.

ELECTROLYTIC SOLUTIONS FOR INTRAVENOUS ADMINISTRATION

The sterility of a solution for parenteral, and particularly for intravenous use must of course be assured. Furthermore, the solution must be free from dead bacteria and other particulate matter, as also must the delivery tube. For these reasons proprietary solutions manufactured on a large scale, with facilities for the prevention of contamination that cannot be emulated by a hospital pharmacy, are now used extensively.

Normal saline solution is not now recommended for routine use in the *maintenance* of fluid balance, for the following reason : One litre of normal saline solution contains 9·0 G. of NaCl (154 mEq.) Na. A normal adult requires 8 to 15 G. of NaCl daily. In health an excessive intake of sodium

A milli-equivalent (mEq.) is the equivalent weight of an element expressed in milligrams.

chloride is excreted readily, but an ill patient should never be assumed to possess this power of elimination.

1. **Dextrose 4·3 per cent. with Saline 0·18 per cent.** (one-fifth normal saline).—This solution, which is isotonic, may be regarded as the standard solution to employ. It is referred to throughout this book as dextrose-saline solution. When the solution is continued for more than twenty-four hours it is essential to be absolutely certain that the patient is receiving sufficient sodium chloride; consequently, the urine must be tested each day for the presence of chlorides. Fantus's test is performed easily, and is accurate enough for most clinical purposes.

The Fantus Test.—Using a glass dropper, place 10 drops of urine in a test-tube. Add 1 drop of 20 per cent. solution of potassium chromate. Rinse the glass dropper with distilled water, and fill it with 2·9 per cent. solution of silver nitrate. Add the silver nitrate solution to the urine drop by drop, and shake the test-tube after the addition of each drop. The end point is a colour change from yellow to brown. If the end-point colour change occurs with the first drop, chlorides should be regarded as ' absent.' The number of drops used=concentration of chlorides in G. per litre.
Note.—Preferably the test should be carried out on a twenty-four-hour specimen of urine.

As long as chlorides are present in the urine, there is no serious deficiency of that substance in the body; but the reverse is not true. Patients with renal failure fail to excrete chlorides [1] (Sir Lionel Whitby).

2. **Normal (0·9 per cent.) saline solution** is needed in the following conditions only: when there has been considerable vomiting or a large quantity of chloride has been removed by gastric aspiration. Excessive sweating is also liable to result in a state of hypochloræmia. Perhaps the most potent cause of preventable hypochloræmia in surgical practice is produced by allowing a patient who is undergoing gastric aspiration to drink freely, the ingested fluid being aspirated promptly; this certainly washes out the stomach, but it also stimulates the secretion of HCl, large quantities (5 G. in each litre) of which are removed in the aspirate. (In cases where it is necessary to rest the alimentary canal, *all* fluids should be given parenterally; washing out the mouth with ice-cold water is effective in slaking thirst.)

When the Fantus test shows a depletion of sodium chloride in the urine, usually 2 pints (1·14 litres) of normal saline solution is sufficient to replenish the lack for twenty-four hours.

Dextrose-saline and normal saline solutions meet all requirements in about 97 per cent. of cases.

3. **Dextrose 5 per cent. solution** is seldom required, and it should not be given unless there is a special indication, for when administered intravenously it is liable to cause thrombosis of the vein employed and there is the danger of water intoxication (see p. 75). However, should the salt requirements of a patient needing much fluid be satisfied on any particular day by dextrose-saline, rather than risk hydræmia, 5 per cent. dextrose solution can be substituted for the remainder of the twenty-four hours.

4. **Darrow's solution** contains sufficient potassium to combat hypopotassæmia (hypokalæmia) and in surgical practice it is a safe and convenient method of supplying

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[1] The exception to this rule is salt-losing nephritis.

this salt. After four days of parenteral fluid therapy, half a litre can be given as a prophylactic measure against hypopotassæmia. In cases of established hypopotassæmia, 1 litre can be given during twenty-four hours until the deficiency is remedied. The composition of the solution is as follows :

Darrow's Solution

Potassium chloride	2·7 G. (36 mEq.K).
Sodium chloride	4·0 G. (68 mEq.Na).
Molar sodium lactate	50 ml. (50 mEq.Na).
Water for injection to	1,000 ml.

PARENTERAL FLUID THERAPY

To overload the circulation is a grievous fault, and grievously does the patient pay for it.

The administration of fluid by any route other than the alimentary canal, i.e. intravenous, intramuscular, subcutaneous, or into the bone marrow, is known as parenteral administration.

Continuous Intravenous Infusion (Venoclysis).—Because of the certainty with which the fluid enters the circulation without the necessity of being absorbed, this is by far the most usual method of parenteral administration. If by the application of a light tourniquet a suitable vein can be rendered reasonably prominent, usually it can be entered by a hollow needle (venepuncture) (fig. 70). The limb is then immobilised by placing it on a light splint or, if a vein of the forearm can be entered, with a few turns of plaster-of-Paris bandage in the manner shown in fig. 71.

FIG. 70.—Vein below the fold of the elbow has been cannulised; the tourniquet has just been released and the solution is running into the vein. The needle is immobilised, and the drip set to the desired rate of flow by turning the screw clamp.

When a vein suitable for percutaneous puncture is not available, it is necessary to expose the vein through a small incision and insert a cannula
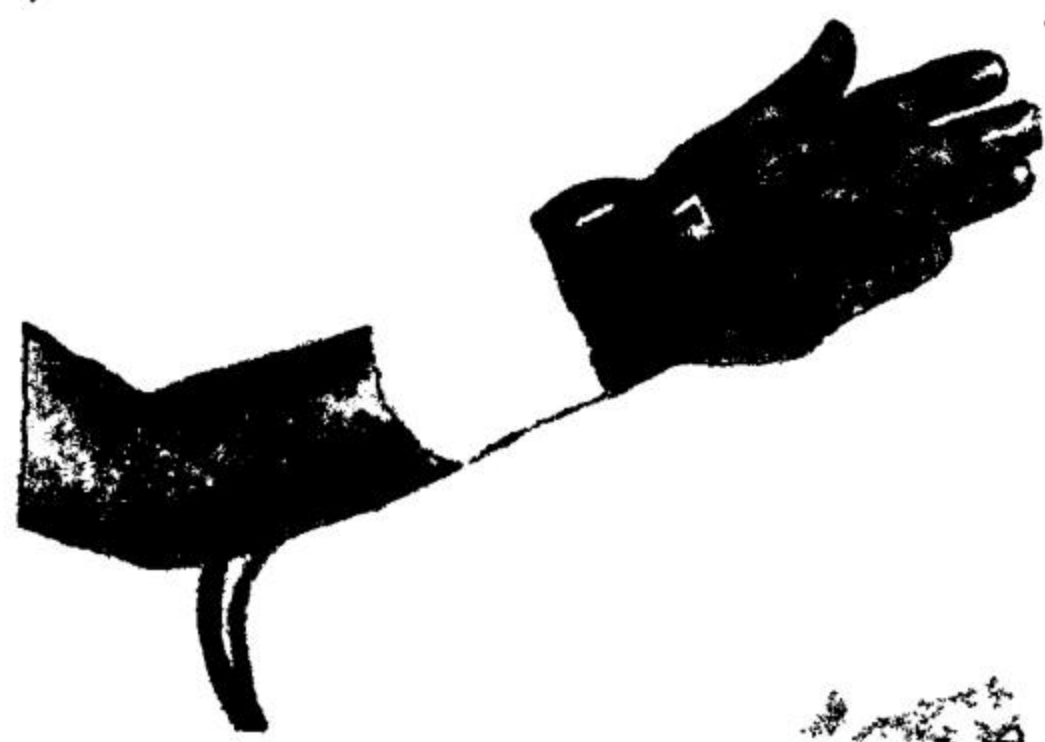

FIG. 71.—A method of immobilising a hollow needle in a vein during continuous fluid therapy. The screw clamp in the position shown will obviate the danger of air embolus from punctured or cracked tubing.

or a length of polythene tubing connected to the infusion apparatus.

Site.—As a routine measure, a vein in the upper third of the forearm, or one on the back of the hand is chosen. In women, young children, and even some men, especially when the venous pressure is low, a visible or palpable vein cannot be found in the arm ; consequently another site must be selected. When this is the case, if a transverse incision is made over the commencement of the internal saphenous vein ¾ inch (2 cm.) above and in front of the medial malleolus, the commencement of the internal saphenous vein can always be found. Nevertheless, because of the risk of thrombophlebitis and pulmonary embolism,

a vein of the leg should not be selected if it can reasonably be avoided. This injunction does not hold good for infants and small children, who are singularly immune to the latter grave complication. If, in cases where the forearm veins are not visible, the cephalic vein in the delto-pectoral groove (fig. 72) is selected, almost every requirement will be satisfied.

Continuous intravenous fluid therapy is of inestimable value in the treatment of many surgical conditions. The contraindications to its use are few ; notwithstanding, they are most definite.

Contraindications :

1. *The Failing Heart.*—A history of dyspnœa on exertion, uncompensated valvular disease, or any possibility of cardiac weakness should call for hesitation in increasing the bulk of circulating fluid.

2. *Pulmonary Congestion.*—In all conditions where there are signs of œdema or consolidation of the bases of the lungs the method should be absolutely forbidden.

FIG. 72.—The cephalic vein in the delto-pectoral groove has been cannulised. Note the range of movement possible without interference with the flow. (*Mr. N. H. Antia, Poona.*)

3. *Hypertension.*—If the blood pressure is high, it is obviously courting danger to burden the circulation still further.

4. *Nephritis.*—In all its stages nephritis is a grave contraindication (salt-losing nephritis excepted).

Replacement and Maintenance Dose.—When a patient is admitted in a dehydrated condition it is of course impossible to measure the loss of fluid and electrolytes he has sustained, but a detailed history of the nature and quantity of the fluid lost (usually, in surgical practice, by vomiting), and particularly the appearance of the patient, are the means by which the amount of electrolytic solution he should receive is estimated. The hæmatocrit reading may be a help in this direction. In most instances the necessary fluid *replacement* should be undertaken by giving normal saline solution intravenously. When the bulk of the loss has been made up in this way, the *maintenance* of fluid balance is effected with dextrose-saline. In cases of extreme dehydration, where peripheral circulatory impairment is in evidence, it is advisable to commence by supplementing the volume of circulating fluid by dextran or plasma infusion, and to follow this by substituting normal saline solution. When the fluid loss is considered to be rectified and fluid by mouth is contraindicated, it is again advisable to supply the maintenance fluid requirements in the form of dextrose-saline solution.

In small infants the loss of weight that has occurred can usually be calculated, and on a basis of 1 pint (568 ml.) of water weighing $1\frac{1}{4}$ lb. (570 G.) the loss can be used to estimate the amount of *replacement* fluid that can be administered comparatively quickly.

Rate of Flow.—The average rate of flow for an adult in need of fluid should be 50 drops a minute, i.e. $\frac{1}{4}$ pint (140 ml.) per hour, or 6 pints [1]

———————————

[1] Pints × 0·5682 = litres.

(3·4 litres) in the twenty-four hours. In severely dehydrated patients, for the first hour the rate can be accelerated to 100 drops a minute, after which the rate should be decreased by half. If in doubt as to how much fluid the patient should receive, the flow should be cut down to 30 drops a minute, a dose that, at any rate, is unlikely to do harm. Once the initial deficit has been replaced, the maintenance dose for the succeeding twenty-four hours is calculated as described below, and in no circumstances whatsoever must this amount, stated in writing, be exceeded.

Charting Fluid Intake and Output.—When fluid is administered intravenously, or for that matter by any alternative route, it is absolutely essential that the amount of fluid the patient receives should be recorded. It is equally important that all urine passed during each twenty-four hours should be measured, recorded, and saved. To this figure is added fluid recovered by gastro-intestinal aspiration, plus that lost from a fæcal, urinary, biliary, or pancreatic fistula. To this total is added 1,500 ml. for insensible loss from the lungs and skin. If the patient has been sweating, the last figure is increased.

Vitamin Requirements.—Unless total intravenous alimentation is required for more than a week, there is no need to supply fat-soluble vitamins, of which there will be an adequate supply stored in the body. The requirements of the vitamin B complex vary considerably, but more is required if there is any disturbance of dextrose metabolism. Antibiotics produce vitamin deficiency, notably of the B complex. Therefore it is best to err on the side of safety and assume that a liberal amount of B vitamins will be required. Vitamin C should be given in large doses, to ensure saturation.

Twin ampoules of parenterovite [1] intravenous (high potency) are recommended daily. They should be mixed before being injected into the tubing of the intravenous apparatus.

ALTERNATIVE ROUTES FOR FLUID THERAPY

Following the introduction of hyaluronidase some of the former popularity of continuous subcutaneous and intramuscular infusion has been regained.

Hyaluronidase[2], which causes diffusion, and therefore acceleration of absorption of fluids injected or gravitated subcutaneously or intramuscularly, is a mucolytic enzyme manufactured from bulls' testes, and is issued as a sterile powder in ampoules of 1,000 units. The powder is readily soluble in sterile water, and the solution must be prepared freshly immediately before use. Hyaluronidase must be injected before the fluids to be infused, and the most convenient method is to inject the enzyme through the rubber tubing of the infusion apparatus about 1 inch (2·5 cm.) above the needle as soon as the fluid has commenced to gravitate into the chosen site. Usually 1,000 units of hyaluronidase is sufficient to accelerate the absorption of 1,000 ml. of fluid.

Contraindications to the use of Hyaluronidase.—It is necessary to realise

[1] Contains massive doses of vitamin B complex and ascorbic acid (Vitamins Ltd.).
[2] Hyalase (Benger Laboratories Ltd.).

that hyaluronidase is completely ineffective if the patient is in a state of severe shock or is suffering from hypoproteinæmia or venostasis. It is also important to remember that with this enzyme it is dangerous to give dextrose solution without sodium chloride to patients with electrolytic deficiency. In this circumstance diffusion of the already depleted sodium and potassium salts from the blood-stream into the infusion area may be sufficient to induce a shock-like state.

Continuous subcutaneous infusion (Hypodermoclysis), administered correctly, does not cause much discomfort, but even so the discomfort it occasions is one of its chief drawbacks. Should the infusion be given into an unsuitable site, or too rapidly, discomfort becomes pain.

Because of its loose subcutaneous tissue and rich lymphatic network, the site of election for subcutaneous infusion is an axilla. With a Y-shaped connection, both axillæ can be utilised simultaneously. For an infant, the region of the scapula is suitable.

Continuous Intramuscular Infusion.—The advantage of this route is that in a hospital without a resident doctor an experienced Sister, following telephone instructions, can insert a hollow needle (fig. 73) connected to a
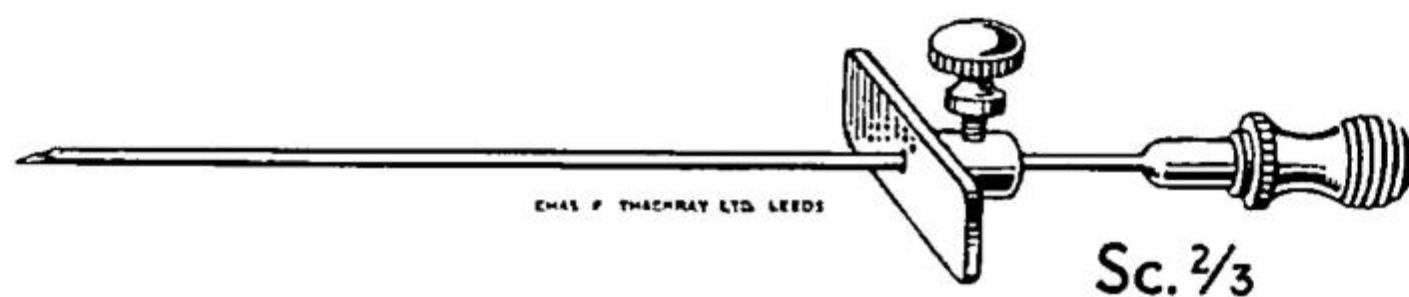

Sc. ⅔

FIG. 73.—Needle for intramuscular administration of fluid. The shield prevents the needle being inserted too far, and permits fixation by strapping (Billimoria and Dunlop's pattern).

flask of parenteral fluid[1] into the muscles of the outer side of the middle third of the thigh and administer the stated quantity of fluid herself.

Continuous Marrow Infusions.—In collapsed patients there is often considerable difficulty in cannulising a vein, and even when the cannula is within the vein the flow is sometimes unsatisfactory because of venospasm. Also, all suitable veins may have been utilised on previous occasions. In cases such as these infusion via the bone marrow is effective, for the flow of crystalloid solutions into bone marrow is always unhampered; moreover, as bone puncture is effected mostly by touch, it can be carried out in a comparatively poor light. The manubrium sterni is chosen for the puncture in adults, and the subcutaneous surface of the tibia in infants (fig. 74). A special trocar and cannula is available for each of these sites, and the correct instrument permits the bone cannula being retained without leakage for many hours. In the case of an infant penicillin should be administered to avoid the possibility of osteomyelitis which, however, occurs but seldom as a complication of marrow infusion.

FIG. 74.—Marrow infusion into the tibia of an infant.

[1] Only dextrose-saline or saline solution should be given by this route.

Continuous Rectal Infusion (Proctoclysis).—The administration of fluid via the rectum has the advantage of simplicity. It requires but little apparatus, and neither asepsis nor isotonicity. Its great disadvantage, if not danger, is the uncertainty of the method : not infrequently the fluid is expelled—too often by patients who need it most.

Avery Jones advises *dilute* saline solution for proctoclysis, viz. to 1 pint (568 ml.) of normal saline solution is added 4 pints (2·3 litres) of tap water. Dilute saline given per rectum avoids the absorption of an excessive quantity of sodium chloride that results in hydræmia. Via a catheter in the rectum, the fluid is given by the drip method according to the needs of the patient. The rate of administration should not be greater than 60 drops a minute. It should be noted that there is no point in administering dextrose per rectum for little, if any, is absorbed.

Transnasal Intragastric Drip.—When it is unnecessary to keep the alimentary tract at rest and the patient cannot or will not drink a sufficient quantity of fluid, a simple and effective method of ensuring an adequate fluid intake is to gravitate the fluid by the drip method into the stomach through a transnasal intragastric polythene or Ryle's tube.

THE DANGERS OF FLUID THERAPY

1. **Pyrogenic Reactions.**—When reliable proprietary solutions are employed, rigors from this cause are most unusual. If a rigor occurs, the infusion must be discontinued immediately. When rigors do not cease after a few minutes, an intravenous injection of $\frac{1}{6}$ grain (11 mg.) of morphine is almost always effective.

2. **Water intoxication** is relatively uncommon. Most cases have occurred as a result of administering intravenous 5 per cent. dextrose solution, or the rectal administration of tap water. This complication occurs more often when renal function is impaired ; it has also been encountered in the neonatal period. The rate at which the fluid is administered seems to be a critical factor ; in most cases it had been given at a fast rate.

Clinical Features.—Nearly all reported cases have arisen within thirty-six hours of the commencement of the infusion. The first symptoms are rapid and stertorous respirations. Twitching of the limbs and mental confusion follow. However, *the characteristic feature of water intoxication is convulsions*, followed by unconsciousness or coma which lasts for hours or days. Œdema of the limbs is uncommon, but puffiness of the eyelids is often present. At first there is diuresis and a large volume of dilute urine, low or deficient in chlorides, is passed. This is followed by oliguria or anuria.

Treatment.—The infusion of salt-free fluid must cease forthwith. In severe cases the intravenous administration of hypertonic (2 per cent.) saline solution, if started early enough, often brings about a resumption of renal activity. Not more than 200 ml. should be given, and it must be administered slowly and stopped as soon as the symptoms are relieved or a satisfactory amount of urine containing chlorides is recovered, otherwise cardiac arrest or circulatory overloading is liable to supervene.

3. **Sodium Depletion.**—Unlike the foregoing, the symptoms seldom arise until an infusion, lacking in the necessary amount of sodium, has been in progress for more than forty-eight hours. Provided the urinary excretion is excellent, the register of a fall in urinary chlorides is indicative that the patient is in need of NaCl. However, the best evidence of sodium deficiency is a plasma-sodium estimation.

Clinical Features.—The early symptoms are headache and giddiness.

The salt deficiency causes pylorospasm, and the resulting vomiting adds to the salt deficiency (H. L. Marriott). Peripheral circulatory impairment follows.

Treatment.—Sodium should be replaced by giving 1 to 3 pints (say 0·5 to 1·5 litres) of normal saline solution intravenously, but the best immediate treatment in severe cases is blood transfusion.

4. Sodium Excess.—The danger of sodium chloride retention is considerably increased if there is coincident hypoproteinæmia. Sodium excess and hydræmia go hand in hand, and in response to the law of osmosis, permeation of fluid occurs from the capillaries into the extracellular tissue spaces. Even a subclinical degree of sodium excess is harmful, for it results in œdema of intestinal and other suture lines and is, for instance, a cause of failure of an end-to-end intestinal anastomosis to function. A plasma-sodium level of above 147 mEq. per litre (338 mg. per 100 ml.) is proof that the patient has received too much sodium.

Clinical Features.—The first visible sign is often puffiness of the face. If the ankles and sacral region are examined, pitting œdema may be found ; if pitting œdema is present, at least 1 gallon (4·5 litres) has accumulated in the tissue spaces (H. L. Marriott). Signs of over-hydration in infancy (infants are very susceptible) are increased tension in the anterior fontanelle, increase in weight, increase in the number of urinations, and œdema.

Treatment.—The infusion should be discontinued at once. In extreme instances the ever-present danger is pulmonary œdema, which often comes on suddenly. If this occurs, having stopped the infusion, the patient is placed in Trendelenburg's position, and postural drainage of the lungs carried out. Oxygen, and a cardiac stimulant, are administered also.

5. Hypopotassæmia (*syn.* Hypokalæmia).—Potassium is chiefly an intra-cellular ion. As the kidneys are unable to conserve this element, excretion continues in all circumstances save in anuria or severe oliguria. When, over a period of days, the intake of potassium is zero or negligible, and particularly when this is accompanied by increased potassium loss from vomiting or gastro-intestinal aspiration, some degree of potassium deficiency should be strongly suspected. A plasma-potassium estimation is valuable, but it must be realised that in severe dehydration intracellular potassium deficiency can occur with a normal plasma level.

Clinical Features.—At first the patient lies listlessly in bed : this is soon followed by intense drowsiness, and all the patient desires is to be left in tranquillity to sleep. Muscular hypotonia is the outstanding physical sign. Reflexes are lost and incontinence of urine is common. Abdominal distension amounting to paralytic ileus is a constant accompaniment, and in all cases of paralytic ileus the plasma-potassium level should be investigated. Weakness of the respiratory muscles frequently occurs and results in rapid, shallow, gasping respirations ; these are conducive to post-operative pul-monary complications. The diastolic blood pressure is low, but there is usually a bounding pulse and a presystolic murmur. Often the diagnosis can be confirmed by electrocardiography, which shows a prolonged QT

interval and a lowering or inversion of the T wave, but these changes are not always present, even in severe deficiency. Alkalosis (see below) accompanies potassium depletion.

Treatment.—It is dangerous to give potassium intravenously unless it is certain that renal function is adequate. When practicable, potassium chloride (30 grains (2 G.) six-hourly) is given by mouth in fruit drinks. Should the patient be comatose, or has difficulty in swallowing, the potassium is given by a transnasal intragastric drip. If ingestion is inadvisable, the intravenous administration of potassium, which is not without danger, is the only alternative. Because of the risk of raising the extracellular potassium concentration to a dangerous level, and thus causing cardiac arrest, it is essential to ensure, whenever possible, that there is an adequate excretion of urine. To this end it is advisable to gravitate 500 ml. of 5 per cent. dextrose solution into a vein before administering potassium (preferably in the form of Darrow's solution, see p. 70) intravenously, and to verify, by catheterisation, if necessary, that the kidneys are functioning adequately. It is also essential to have an hourly pulse-rate recorded during the administration of potassium, and if the pulse becomes slow to substitute 5 per cent. dextrose solution for the potassium infusion. Not more than 3 G. (80 mEq.) of potassium should be given in twenty-four hours, and it should only be repeated after consultation with a physician.

6. Hypoproteinæmia.—Except in the presence of a profuse discharge from a duodenal or jejunal fistula, or extensive burns, hypoproteinæmia is most unlikely to develop within five days of total parenteral sustenance with crystalloid solutions. As a rule the patient has a lean and hungry look. Œdema is likely to develop, especially in the area of the wound, leading to delayed healing. Œdema of the pyloric mucous membrane, causing delay in gastric emptying, is frequently present in this condition. Œdema does not develop until the plasma albumin [1] is grossly depleted and the body reserves of mobile proteins are exhausted. Once present, hypoproteinæmia takes a long time to remedy, even when the patient can take nourishment by mouth. Milk fortified with powdered skimmed milk is an excellent source of protein. In other circumstances protein hydrolysates [2] must be given intravenously or, if permissible and possible, by duodenal intubation. As an emergency measure the administration of 1 pint (568 ml.) of plasma will supply the patient with his immediate protein needs.

ACIDOSIS AND ALKALOSIS

The *p*H (acidity) of the blood is regulated by various buffering systems basically consisting of weak acids (and bases) of which the most important is H_2CO_3. The fraction $\dfrac{H_2CO_3}{BHCO_3}$ is a variable factor in determining the *p*H. An increase of the fraction leads to increased acidity, and *vice versa*.

The term acidosis should be confined to states in which the plasma bicarbonate (alkali reserve) is diminished, while the term alkalosis is applied when the plasma bicarbonate is increased. Of the two, the latter is more commonly encountered in surgical practice.

[1] Normal level 3·6–4·5 G. per 100 ml.   [2] Travamin (Baxter Laboratories Inc.).

Alkalosis (cation excess) can be brought about in the following ways :

1. *Repeated vomiting or prolonged gastric aspiration* is the most frequent cause of alkalosis and it is engendered by loss of HCl in the vomit or the aspirate. At first the recovered gastric content is rich in chlorides and sodium, but as the loss continues the concentration of these ions falls. Not so with potassium, the concentration of which in the ejected or aspirated fluid remains constant. Continued loss of potassium in this way combined with the potassium loss in the urine brings about a deficiency of potassium in the blood, which for a time is partially rectified by a shift of intracellular potassium and its replacement by sodium. The loss of K and Na from the blood causes the plasma bicarbonate (alkali reserve) to rise. Nevertheless, the view now held widely is that it is the potassium deficiency rather than the alkalosis that is the more important therapeutic problem (A. W. Wilkinson). An interesting and important practical point is that K deficiency due to loss of gastric contents is brought about much more readily in patients with achlorhydria than those with normal gastric acidity.

The reason is this : the gastric juice of a patient with achlorhydria consists almost entirely of mucus, and mucus is particularly rich in potassium. Finally, it has been suggested that the reason why patients with pyloric stenosis so frequently have hypochlorhydria or achlorhydria is that on account of oft-repeated, though not necessarily recent, vomiting they have lost chlorides.

2. Excessive oral intake of absorbable alkali, as is not uncommon, e.g. in patients who take proprietary indigestion powders and tablets without medical supervision.

3. *Cortisone Excess.*—Usually the result of over-administration of cortisone, e.g. for rheumatoid arthritis, but occasionally due to Cushing's syndrome (see p. 260), cortisone excess sometimes leads to alkalosis with potassium deficiency, the reason being that the excess of circulating hormone lowers the kidney's threshold for potassium.

Clinical Features.—The dual phenomena of severe alkalosis and potassium deficiency are so interwoven that their clinical separation is well-nigh impossible. Subclinical degrees of alkalosis are recognisable only by a raised plasma bicarbonate concentration. The most striking feature of severe alkalosis is Cheyne-Stokes' respiration with periods of apnœa lasting from 5 to 30 seconds. Tetany sometimes occurs, and is due to alkalæmia. For Tetany, see p. 20.

Treatment.—The replacement of potassium is the primary consideration, and it is administered first in the same manner as has been described under hypopotassæmia. This accomplished, either sodium chloride is added to the mixture, given by mouth if practicable, or not more than a litre of normal saline solution is given intravenously.

Acidosis can be due to increase in fixed acid, or a decrease in the available base, either of which results in a reduction of the plasma-bicarbonate concentration (lower normal limit 25 mEq. per L = 55 volumes CO_2 per cent.).

Increase in acid (anion excess) is due to (*a*) retention of phosphate, sulphate and organic anions in renal excretory insufficiency ; (*b*) resorption of acid excreted by the kidneys in cases of implantation of the ureters into the colon ; (*c*) most notably from the production of keto-acids in uncontrolled diabetes and, infrequently, in starvation.

Reduction of available base (cation deficiency) follows loss of sodium in severe or sustained diarrhœa, ulcerative colitis, and loss of alkali in intestinal secretions (as in a high intestinal fistula or prolonged *intestinal* aspiration). In each of these conditions there is a concomitant loss of water, chlorides and potassium, and the symptoms of sodium loss do not necessarily prevail.

Clinical Features.—In severe acidosis the leading sign is rapid, deep, noisy respirations which are unremittent save, perhaps, momentarily while the patient endeavours unsuccessfully to moisten his dry lips with his parched tongue. This hyperpnœa is due to over-stimulation of the respiratory centre by the reduction of pH of the blood, and the physiological purpose of over-breathing is to eliminate as much as possible of the acid substance CO_2. Except in renal acidosis, the pulse-rate and the blood-pressure are raised. The urine is strongly acid.

Laboratory Findings.—The plasma-bicarbonate level is lowered. In cases of loss of intestinal juice sodium and potassium values are also lowered.

Treatment.—When there is an easily reversible metabolic abnormality like ketosis, or when there is a deficit of cation which can be replaced, the treatment of acidosis is

comparatively straightforward. Diabetic acidosis (ketosis) usually responds well to adequate treatment of the diabetic state, for details of which the reader is referred to works on medicine. When acidosis is due to diarrhœa, especially in infants, the intravenous administration of Darrow's solution is eminently satisfactory. In other circumstances, provided renal output is adequate, 500–1,000 ml. of 1·86 per cent. ($\frac{1}{6}$ M.) solution of sodium lactate, given as an intravenous infusion over a period of six hours, followed by 500–1,000 ml. of normal saline solution (also given slowly) is of signal value. What is of great importance is that at the earliest possible moment the patient should take a mixture containing potassium citrate 30 grains (2 G.), and sodium lactate 15 grains (1 G.), to the ounce, by mouth, and as soon as it is assured that oral administration is tolerated, the intravenous route is abandoned. In patients in a parlous condition, in order to avoid the risks of intravenous administration of these anions, they should be given by the drip method through a transnasal intragastric tube. In uræmic cases potassium should not be given, and the main hope lies in endeavouring to remedy the uræmia (see Chapter 31).

It should be especially noted that in cases of hyperpnœa due to acidosis there is no anoxia, consequently it is futile to administer oxygen.

Acidosis due to transplantation of the ureters into the colon is due to reabsorption of chlorides from the urine in the colon. The first consideration is the prevention of urine being retained in the colon for hours at a stretch. To this end a flatus tube is inserted into the rectum, so that the urine runs into a receptacle as soon as it reaches the bowel. If the tube is left in place for four to five days, and the patient is given potassium citrate, 30 grains (2 G.) to the ounce (30 G.), t.d.s., recovery usually follows. It should be known that urine stimulates the colon to secrete mucus. Mucus is rich in potassium, and therefore these patients readily develop hypopotassæmia. Consequently, directly a patient who has had the ureters transplanted into the colon feels unwell and/or runs even a slight temperature, he or she should resort to the above mixture for three or four days as a preventive measure.

Daily Fluid Chart for Housemen.

Name.		Date		Ward.		Diagnosis		
LOST				**REPLACED**				
Type of Fluid	Volume	Electrolyte Content	Other	Route	Type of Fluid	Volume	Electrolyte Content	
Vomit or Aspirate				Oral				
Diarrhoea				IV				
Urine				Other				
Total				Total				
Serum Electrolytes Time					Water	Sodium	Potassium	
		Day's Balance						
		Cumulative "						
		Requirement						
Blood Urea		To be given in the next 24 hours		IV				
P. C. V.								
B. P.				Oral				
Weight								
Comment								

A fluid balance chart in use at the Cardiff Royal Infirmary.

M = Molarity. $\frac{1}{6}$ molar is chosen because the resultant solution is isotonic.