diet the loss was considerable. Similar findings had been noted in man. So far, however, there was no evidence to show whether moderate protein depletion affected convalescence. The clinical impression was that the wounds of patients with severe weight loss healed in the normal time. Probably of more importance to the surgical patient was the effect of a low caloric intake on body composition, particularly fluid and electrolytes.

Studying volunteers and patients undergoing operations ranging in severity up to partial gastrectomy and without complications, workers had found that there was little difference in nitrogen losses between two groups that had similar intakes of protein. An adequate intake of protein and calories given intravenously was found to abolish or greatly minimize the loss of nitrogen. When a complication such as infection occurred, adding to the stimulus for catabolism, it was no longer possible to obtain equilibrium at this level of intake and appreciable negative nitrogen balance developed. As the severity of trauma increased the stimulus to break down protein became greater. No increase in urinary nitrogen occurred with starvation alone in volunteers and in patients, whereas large increases occurred after operation.

Studies on patients with severe burns had shown that three to four times the normal protein requirements were needed to restore the nitrogen balance to normal. But whether it was necessary to achieve nitrogen equilibrium with excessively high protein intakes was undecided. Certainly children with severe burns did just as well clinically when they had a normal intake of protein for their age as other children with burns who had a high protein intake. In man the basal metabolic expenditure increased 10 to 15% after operation, but the total energy expenditure remained unchanged because the energy required for muscular activity was minimal. Extensive third degree burns were an exception to this. Energy expenditure of over 200% of normal figures had been observed in patients with burns, the increase being due mainly to the loss of water by evaporation from the burned surface.

Surgical Intensive Care

Dr. G. VOURC'H (Paris) spoke on the intensive care unit that had been established in the Hôpital Foch in Paris. It enabled expensive equipment, such as respirators, pacemakers, electrocardiographs, monitoring systems, electro-encephalographs, defibrillators, renal dialysis machines, and hyperbaric oxygen chambers to be localized in one hospital area. It was more economical and efficient to have expensive equipment in one place than to have it scattered throughout one or more wards of a hospital. Trained staff could also deal with several patients at once instead of singly in ordinary hospital wards. Dealing with complicated conditions required a staff of experienced doctors, nurses, and paramedical experts. Their location in one unit was in the interests of efficiency and economy. It was unlikely on the grounds of expense that the staffing and technical requirements needed could be met in a general ward. Moreover an intensive care unit enabled students, doctors, and nurses to acquire—through clinical investigation—an intimate knowledge of postoperative complications and physiological disorders. One objection to such units was the danger of cross-infection and the difficulty of sterilizing equipment. Many of the patients suffered from severe infections. Only the strictest application of asepsis and antisepsis could prevent contamination. Two risks had to be balanced—firstly, the treatment of life-threatening conditions (which could best be dealt with in an intensive care unit), and, secondly, the increased danger of infection. Dr. Vourc'h suggested that intensive care units should represent about 2% of the beds in a hospital and that each unit should care for about 20 to 25 patients, who should be drawn from the hospital and not admitted as emergencies from outside.

At the Hôpital Foch with 900 beds there was an anaesthetic recovery room with 14 beds and 18 beds in the intensive care unit. Beds were grouped in specialized sets of four. The medical staff consisted of two full-time and two part-time consultants with the necessary registrars and residents. The nursing staff numbered 50, with two nurses to four patients. So far 900 patients had been admitted to the unit in 18 months

Circulatory and Respiratory Problems

The third session of the conference, which was chaired by Professor E. HUSFELDT (Copenhagen), dealt with problems of the circulation and respiration in surgery. The first paper, on the pathogenesis of venous thrombosis, was given by Dr. J. C. F. POOLE (Oxford), who pointed out that as far back as 1851 Wharton Janes, one of Lister's teachers, had studied the effect of injury on small blood vessels. It was Schimmelbach in 1880 who had first demonstrated the nature of blood thrombi, which he showed were aggregations of platelets, fibrin, and red cells. Dr. Poole explained how electron microscopy had shed new light on the structure of thrombi. It was formerly assumed that in a thrombus platelets lost their identity and coalesced with fibrin and blood cells to form a solid mass. Electron microscopy had shown that platelets preserved their identity in a thrombus, although their shape altered. They were not fused but about 200 Å units apart. In quite a short time resolution of the thrombus occurred by disintegration of the platelets, which were engulfed and digested by monocytes.

Pulmonary Embolism and Thrombophlebitis

Professor P. R. ALLISON (Oxford) said that it was probable that pulmonary emboli occurred in nearly all surgical patients postoperatively and that in many of them it went unsuspected. There was evidence that venous thrombosis and pulmonary embolism were increasing in frequency in both medical and surgical wards. In most necropsy series the incidence of pulmonary embolism was about 10%, but when the lung was closely examined, both macroscopically and microscopically, the incidence was found to be much higher. At Oxford workers had recently found an incidence of 52%, which was close to the figure of 64% found by Freiman at the Beth Israel Hospital. Detailed necropsy studies revealed that pulmonary embolism was a continuing process and not just a single isolated dramatic episode. Moreover the lungs had a remarkable ability for disposing of emboli, so that section of the lungs presented a picture representing an equilibrium between emboli reaching them and those that had been lysed. A study of serial radiographs and histology of radio-opaque pulmonary emboli in dogs revealed that these emboli retracted rapidly within a few hours of impaction, and that within four days they were covered by a smooth layer of cells. By twenty-one days

Inkstand given to Lister by King Edward VII.

the thrombi were reduced to areas of subintimal fibrosis and by twenty-eight days the pulmonary artery was normal in appearance. After non-fatal pulmonary embolism 80% of lung function returned in two weeks.

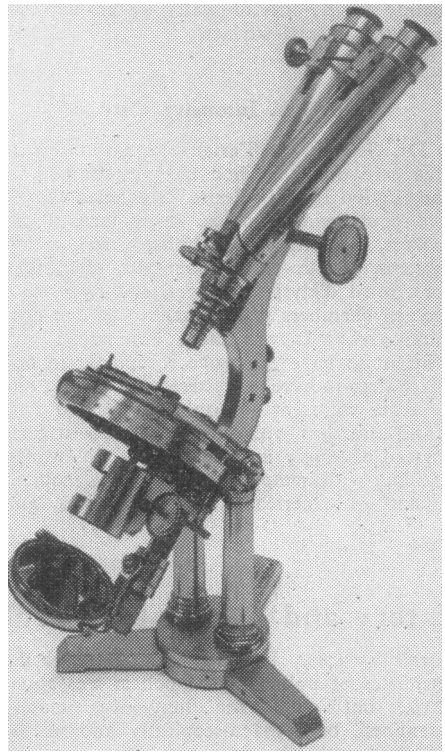
Professor Allison described the prophylactic methods that he used to prevent thrombophlebitis and embolism in surgical patients over 40 who were in hospital for more than three days. Weight was reduced if necessary; physical activity was encouraged; patients were operated on with pads under the ankles and the operating table tilted 15°; postoperatively the patient was tilted 15° until exercise could be taken; and active leg exercises and ambulation were encouraged as soon as possible. Anticoagulants were not given prophylactically but only if there were signs of postoperative thrombosis. Thrombectomy was being increasingly performed.

Treatment of Pulmonary Embolism

Mr. M. PANETH (London) said that major pulmonary embolism could be diagnosed clinically with accuracy in 90% of cases. Of the fatal cases 41% died within 10 to 15 minutes, 22% within 2 hours, and the remainder within 2 weeks. The introduction of external cardiac massage should reduce these figures, though the incidence of pulmonary embolism was said to be rising. Discussing the indications for pulmonary embolectomy, Mr. Paneth said these comprised one or more episodes of cardiac arrest; a systolic blood pressure below 100 mm.; tachypnoea associated with arterial desaturation; and repeated major embolism. The Trendelenburg technique of occluding the outflow of both ventricles by a clamp across them in the transverse sinus before opening the pulmonary trunk was now made possible by total cardiopulmonary bypass and by the development of readily available bubble oxygenator perfusion systems with a low priming volume. Irreversible right ventricular failure, cerebral damage, and renal damage were the causes of death after clearance of the pulmonary circulation. Total bypass could be achieved by a well-drilled team in 10–15 minutes by a vertical median sternotomy, direct cannulation of the ascending aorta for arterial return, and single right atrial cannulation, through its appendage, for venous drainage by gravity.

Acute Circulatory Arrest

Acute circulatory arrest was discussed by Mr. B. B. MILSTEIN (Cambridge), who said that this was first recognized in 1848 in the case of a child who died under chloroform anaesthesia. The condition occurred after cardiac asystole, ventricular fibrillation, rapid tachycardia, bradycardia, cardiovascular collapse, diminished myocardial contractility, and hypovolaemia—as well as under anaesthesia and after potassium depletion from diuresis, diarrhoea, or vomiting. The condition was largely preventable. Sometimes it occurred after a certain combination of drugs or combination of anaesthetic with drugs. Thus halothane and adrenaline together could adversely affect the myocardium. A monitoring electrocardiograph was essential for patients at risk undergoing anaesthesia, which was greater in patients undergoing emergency surgery. Mr. Milstein pointed out that external cardiac massage was first successfully used to treat acute circulatory arrest as far back as 1883. The survival rates after internal cardiac and external cardiac massage were essentially the same—namely, between 24 and 28%. An electrically operated external cardiac massager was now obtainable and could be worked by untrained personnel. External massage should be attempted first and if the patient did not quickly respond the chest should be opened and the heart



Beck microscope made for Lister to his own design by his cousins, Richard and John Beck (1872). Lister's father was a noted microscopist, who was responsible for the development of the achromatic lens and the modern microscope.

massaged directly. The indications for immediate heart massage were cardiac tamponade, massive bleeding, intracardiac obstruction, air embolism, and dilated pupils after cardiac arrest. The only drugs of value in treatment were adrenaline, isoprenaline sulphate, calcium salts, and intravenous lignocaine.

Supportive Perfusion

Dr. E. PROCTOR (London) and Mr. A. YATES (London) described the technique of closed chest circulatory support by emergency pump-oxygenation through the cannulated femoral artery and vein. This technique was used when other methods failed for the treatment of such conditions as massive pulmonary embolism, cardiogenic shock due to acute myocardial ischaemia or severe haemorrhage, and intractable cardiac failure before performing cardiac surgery. The aim was to reduce cardiac work by partially or wholly replacing the heart's function, while at the same time improving myocardial perfusion.

The method of supportive perfusion used by Dr. Proctor and Mr. Yates was to divert venous blood to a pump oxygenator by means of a wide-bore catheter passed via the femoral vein to the level of the right atrium. The venous blood was oxygenated and the P_{CO_2} corrected before being returned to the arterial system. The use of an oxygenator rendered the method more traumatic to the blood than other systems, but with the development of a suitable membrane oxygenator this traumatic effect was being minimized. The method was able to support either the right or the left heart, or to provide total circulatory and respiratory support if the heart failed completely. Total circulatory and respiratory support could be maintained for up to eight hours, during externally induced ventricular fibrilation, without apparent cardiac or pulmonary drainage and with survival. They considered that this method should be tried in younger patients with a coronary occlusion who passed into progressive cardiac shock or who suffered from repetitive ventricular fibrillation.

Postoperative Pulmonary Complications

Dr. K. N. V. PALMER (Aberdeen) discussed the factors influencing postoperative pulmonary complications and their prevention and treatment. He said that 60% of patients operated on for duodenal ulcer developed chest complications, which were a cause of about one-quarter of all deaths occurring after upper abdominal surgery. By far the most important factor determining the development of postoperative chest infection was pre-existing chronic bronchopulmonary disease—particularly chronic bronchitis—which was present in 65% of those developing postoperative chest complications. The diagnosis of even minimal bronchitis preoperatively was therefore important. Symptoms of this were unreliable for diagnosis, the best index of minimal airway obstruction being the determination of the forced vital capacity (F.V.C.) and the forced expiratory volume at one second ($F.E.V._1$). The $F.E.V._1$ fell by the third postoperative day and gradually returned to normal by the sixth day. In a study of 236 patients about to undergo upper abdominal surgery Dr. Palmer found evidence of appreciably increased airway resistance in 35%. After laparotomy the mechanical function of the lung was much impaired, the total lung capacity was reduced, and breathing was shallow and rapid—leading to hypoxaemia. During convalescence arterial oxygen saturation increased and deep breaths were taken, thus preventing the development of alveolar collapse, which was a major factor in the development of postoperative hypoxaemia.

Dr. Palmer explained that the patient with normal lungs gradually expanded the areas of collapse after abdominal surgery, but the bronchitic with pulmonary infection, depressed ciliary activity, increased bronchial secretion, and retained sputum was likely to develop segmental collapse, leading to bronchopneumonia. Collapse usually occurred on the first or second postoperative day, when diagnosis was difficult. All patients should be examined and assessed by a physician before operation. Chest radiography, E.C.G., haemoglobin, and F.E.V. measurements should be done routinely and postural drainage and assisted coughing encouraged in bronchitics, who should not be allowed to smoke. Patients

at risk should be given isoprenaline aerosol inhalations, while in more severe cases the blood gas tensions of arterial blood and acid–base balance were measured. Postoperatively all patients' chests were examined daily or even twice daily. Assisted postural coughing should start as soon as possible and patients encouraged to take periodic deep breaths for four days. If sputum retention persisted, or if hypercapnia or hypoxaemia with respiratory or metabolic acidosis was present, tracheostomy and bronchial aspiration should be carried out combined with oxygen therapy and assisted respiration. Routine antibiotics were not advised by Dr. Palmer, but if bronchopneumonia supervened, and if sputum culture grew *Haemophilus influenzae*, he recommended the use of penicillin with streptomycin, or ampicillin, or a tetracycline.

Respiratory Support

Professor J. S. ROBINSON (Birmingham) discussed the use of mechanical ventilators for the prevention of cardiorespiratory embarrassment during and after surgery, in the treatment of the severe crush injuries of the chest, and in the management of tetanus. The treatment of severe tetanus had been revolutionized by the use of paralysing doses of muscle relaxants, followed by assisted respiration to replace the action of the paralysed diaphragm and accessory muscles of respiration. Artificial ventilation was now used postoperatively for patients with myasthenia gravis who had undergone thymectomy. This was preferable to giving them large doses of anticholinesterase drugs, such as neostigmine. Professor Robinson advocated the routine use of assisted respiration for 24 to 48 hours, or even longer after open-heart bypass surgery. Though patients with an adequate myocardial reserve and little pulmonary insufficiency might well survive without it, those with little reserve were at risk. Patients who were overweight were more likely to develop respiratory failure postoperatively, and had a higher than normal respiratory quotient, so that to maintain gaseous homoeostasis the obese require a greater than normal alveolar ventilation. After major abdominal surgery such patients were likely to slip insiduously into respiratory failure, as were those with chronic bronchitis, emphysema, and cor pulmonale. Their postoperative management was made easier and safer by the use of mechanical ventilation in a special intensive-care ward.

Organ Dysfunction

The final session of the symposium was devoted to organ dysfunction. With Professor FRITZ LINDER (University of Heidelberg) in the chair, Dr. F. M. PARSONS (Leeds) discussed the management of acute renal dysfunction. The commonest cause of this was low cardiac output either due to the loss of blood, plasma, water, or electrolytes, or to cardiac insufficiency. A phase of acute renal insufficiency intervened between the episode of low renal flow and acute tubular necrosis, when renal function could be restored by proper treatment. Unfortunately the reversible phase was not easily recognized. The urinary sodium levels were perhaps the best guide, being less than 10 mEq/l. in the early stages and rising to more than 50 mEq/l. later. Though mannitol infusions could be useful in this phase, they were no substitute for better diagnostic tests. Recognition that a circulatory disturbance had occurred was very important, and central venous pressure monitoring was valuable during such disturbances and during resuscitation, as a minority of patients had subclinical cardiac failure. When acute tubular necrosis had occurred it was necessary to measure the metabolic response, patients in whom the blood urea was rising by more than 60 mg./100 ml. per day being regarded as in a hypercatabolic state. In these patients the indication for haemodialysis was at present a blood-urea concentration rising to 220 mg./100 ml., and repeated dialysis might be necessary to ensure that this level was never exceeded. In normocatabolic patients 90% recovered even if the blood urea rose further, unless they were over 60 years of age, had cardiovascular disease, or developed infection. Peritoneal dialysis was usually adequate.

Mr. E. C. EDWARDS (Liverpool) continued by describing how modern management allowed more extensive surgery in uraemic patients. Uraemia due to obstructive uropathy was more easily investigated with the addition of isotope renography, and treated by nephrostomy and ureterostomy after preoperative preparation. Uraemic anaemia should not be overcorrected. If preoperative haemodialysis was performed 24 hours should be allowed for the heparin to be eliminated and for the circulatory disturbance to settle. If there were real danger of haemorrhage peritoneal dialysis was safer.

Adrenal and Hepatic Dysfunction

Professor B. N. BROOKE (London) said that acute adrenal insufficiency might present either as an Addisonian crisis with gross disturbance of fluids and electrolyte levels, or by a state of shock with a falling blood pressure. These were now seen following corticosteroid therapy. It had been realized that in some cases only intravenous hydrocortisone would maintain the blood pressure postoperatively. Corticotrophin tests of adrenal response and plasma-cortisol levels had been used to monitor surgical patients and had shown that corticosteroid therapy (even hydrocortisone enemas) depressed the adrenal response and that if the blood pressure did fall hydrocortisone would maintain it. Professor Brooke advised that patients who had been having corticosteroids up to the time of operation should be given hydrocortisone but that 200 mg. in 24 hours covered all forms of stress, and overdosage merely invited complications.

Professor N. F. MACLAGAN (London) thought that the reason that liver failure was less common than renal failure in surgical conditions was due to the double blood supply and the great regenerative powers of the liver. It had been known in Lister's time that chloroform affected the liver, though Lister had not accepted the idea. One major problem was that of differentiating between biliary obstruction and hepatitis, and a battery of tests had been developed to make the diagnosis, which nevertheless remained difficult in some cases.

Neurological Dysfunction

Dr. J. B. BRIERLEY (Carshalton) said that damage to the central nervous system found after operation was more likely to be an anaesthetic complication than a purely surgical one related to impaired blood flow and anoxaemia. In young children metabolic disturbances could cause fits and these themselves could cause irreversible cerebral damage and had to be controlled. In adults circulatory arrest for more than three minutes caused cerebral damage. The majority died within a few days, while those who recovered might show dementia, Korsakov's psychosis, or choreoathetosis. Neuropathological studies of the brains of those dying showed a loss of neurones in the third layer of the cortex, particularly in the parietal and occipital lobes with relative preservation of the frontal cortex. The sensory tracts of the medulla were particularly vulnerable in children. Damage was found to occur when the systolic blood pressure had fallen below 50 mm. of mercury, but was rare with hypotensive anaesthesia except when the head of the operating table had been raised. Rapid and extreme falls in systolic blood pressure caused cortical damage at the boundary zones of the areas of the major cerebral arteries. Less severe but sustained falls caused loss of neurones throughout the brain, particularly in the cerebellum. Focal and geographical lesions of both cortex and white matter were seen in patients surviving up to 12 days after cardiac bypass operations and were related to inadequate perfusion pressure or severe blood loss.

Mr. A. B. WALLACE (Edinburgh), recalling Lister's dictum that "the best antiseptic is the living tissue cell," discussed its application to the management of skin loss. In burns there was a lag period while granulation tissue, which was receptive for skin transplantation, was formed. This lag period was shortened if attention was given to fluid replacement, for which Mr. Wallace allowed 3 ml. of fresh plasma per kilogram of body weight per 1% area burnt. Infection was controlled with 0.5% silver nitrate dressings, which were now returning to favour. In degloving and avulsion injuries the temptation to replace the torn skin had to take second place to débridement. For both the final dressing was autograft skin, but intermediate dressings could be absorptive dry dressings—such as Lister used—or homologous or heterologous sheets of biological material, such as split skin, which consists of living tissue cells.

Anaesthesia

Professor G. S. W. ORGANE (London) reviewed the development of anaesthesia since the first use of ether shortly before Lister entered University College. Successively instruments had been developed for