deprecated. In fact, any fixed routine of treatment for these cases is undesirable, and it is preferable for each case to be treated individually on its merits according to recognized surgical principles. Thus if haemorrhage is severe it should primarily be arrested by the appropriate surgical measures, while if sepsis is the dominant feature it should first be treated by rest and antibacterial drugs. If this is unsuccessful in the presence of the source of infection after a trial period of 36 hours, the uterine contents should be removed. The convalescence is likely to be more prolonged and severe in these patients, but in the end a satisfactory result will be obtained. It is of no advantage to wait for a longer period than 36 hours of sulphonamide and antibiotic therapy before intervening, for if the infection by then shows no sign of responding to drugs it is unlikely to do so later, unless sensitivity tests are carried out, which are too time-consuming to be done whilst awaiting operation. After evacuation of the uterus, and in Type II and Type III cases, they are invaluable in dealing with resistant organisms.

When the infection has been eliminated, the abortion, if it is inevitable or incomplete, should be treated by evacuation of the uterus. This is best done 24 hours after the temperature and pulse rate have reached a normal level, for although no evidence has been forthcoming that infection may arise in an incomplete abortion when evacuation is delayed, as Stallworthy (1948) suggests, there is definite evidence that improved results are not obtained by delaying operation for longer than this period. If the abortion is complete, as recognized by the character of the lochia and the involution of the uterus, evacuation is unnecessary.

Owing to the efficiency of the modern drugs now available, it is agreed that good results are achieved by both the interventionist and the non-interventionist schools; it is claimed, however, from the present analysis, that the severity and duration of the patient's illness and the mortality rate are reduced to a minimum when a fixed regime of treatment is avoided and operation, if carried out at all, is done at the optimum time for each individual patient. In this series this procedure has involved operation in 93% of cases of intrauterine infection, and the best results have been obtained in those patients in whom the sepsis was controlled before operation.

Modern drugs and blood transfusions are the basis of the successful treatment of patients suffering from septic abortion; most cases, however, still require a planned operation performed by an expert gynaecologist to ensure the best chance of a short illness and the reasonable expectation of future pregnancies to follow.

Summary

An analysis is presented of 267 cases of septic abortion among 2,322 cases of abortion of all types occurring at the West Middlesex Hospital during the five years 1946-50 inclusive.

The septic abortions are classified into three types, dependent upon the anatomical extent of the infection, and into mild or severe clinical cases according to the degree of pyrexia.

The treatment required for an abortion in its different stages and the treatment of sepsis are discussed in so far as they may be complementary or antagonistic.

The results of evacuation of the uterus, which was performed in 215 (93%) cases of uterine infection, are described. Evacuation was performed in 123 (57.2%) cases when the temperature had subsided, in 53 (24.7%) in the presence of continuing sepsis, and in 39 (18.1%) because of severe haemorrhage.

Improved results after evacuation were obtained in the apyrexial cases.

The length of apyrexia before operation did not influence the post-operative convalescence.

The technique of evacuation of the uterus in septic cases is described.

There was no difference in the clinical course of disease in patients who confessed to criminal instrumentation and those who denied it.

Bact. coli infections occurred in 37.1% of cases; staphylococci were present in 23.6%, and haemolytic streptococci in only 5.2%.

A septic abortion mortality rate of 0.75% was obtained, with an overall abortion mortality rate of 0.09%.

Thanks are due to my colleagues of the obstetric and gynaecological department who have collaborated in this survey; special appreciation must be accorded to the sister and nurses of the isolation ward (H2), without whose skill these results would not have been possible.

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POST-MORTEM DIAGNOSIS OF AIR EMBOLISM BY RADIOGRAPHY

BY

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The post-mortem diagnosis of air embolism depends upon the demonstration of bubbles of air within the blood vessels and within one or more of the heart cavities. Bubbles of gas may be found in the blood vessels within a relatively short period after death, through the action of spore-bearing, gas-producing organisms. Bubbles of gas may also pass into the blood vessels through manipulation of the viscera during necropsy (Simpson, 1942). It is therefore necessary to exclude both these possibilities before air embolism can be diagnosed.

Burn (1934a) has shown that spore-bearing gas-producing organisms—for example, *Clostridium welchii*—are capable of invading the tissues of guinea-pigs and rabbits within 5-48 hours after death if the animals are kept at 25° C. In a further study, similar organisms were cultured from human necropsy specimens of the internal organs. The post-mortem interval in these cases was from 1 to 4 hours (Burn, 1934b). Consequently, anaerobic bacteriological examinations are an important part of the post-mortem examination.

In order to prevent air bubbles passing into the blood vessels during dissection it is necessary to ligate all vessels before sectioning. Shennan (1935) has recommended the following procedure in cases of suspected pulmonary air embolism: a small incision is made in the parietal pericardium; the sac is then filled with water and the right ventricle is opened *in situ*. The escaping air can then be detected. However, this procedure has limitations. Unless the main arterial and venous trunks are ligated before incision of the heart, air may, through handling of the organ, enter the blood vessels. Moreover, blood samples for bacteriological culture

should be taken from the heart and the peripheral blood vessels. Shennan's procedure is a distinct disadvantage in the aseptic collection of blood specimens.

It would appear that radiological examinations carried out within a short period of death are a most satisfactory means of diagnosis. The presence of air in the blood vessels and in the heart cavities can be seen with certainty. Moreover, this procedure provides an indication of the most satisfactory dissection technique to be adopted in order to observe the full necropsy findings. This procedure was followed in the two cases of air embolism reported below. Regional radiological examinations were made on the cadavers within an hour of death. It is unlikely that air detected by radiological means within an hour of death could be accounted for by the presence of gas-producing organisms in the two cases studied.

Chase (1934) reported the successful use of post-mortem stereoscopic examinations of the skull, which demonstrated the presence of air in the cranial vessels in a fatal case of arterial air embolism. The stereoscopic pictures of the skull showed shadows resembling air outlining the anterior portion of the circulus arteriosus, and extending along the course of the middle cerebral artery. The air in the smaller meningeal vessels appeared as an irregular network of fine pale lines most marked in the parietal and temporal regions of the skull. In this case the chest was radiographed but no air shadows were detected.

In order to overcome difficulties in the demonstration of air embolism by dissection methods in cases of rapid death following upon criminal abortion, Gordon (1945)

suggested the use of post-mortem radiological examinations of the pelvis prior to necropsy, in order to detect the presence of air emboli in the uterine plexus and pelvic veins.

Case 1

A European woman, aged 52, was admitted to hospital for pneumothorax therapy. The initial manometer reading for a refill was 0 mm. Hg, and some 50–60 ml. of air was introduced. She suddenly collapsed and became dyspnoeic, frothy sputum being seen at the mouth.

Radiological examinations were made within one hour of death. *Chest*: Both domes in the diaphragm were in the cadaveric position. The right upper lobe had collapsed, and the cavity in the left mid-zone persisted. No pneumothorax was visible. The heart, trachea, and mediastinum were deviated to the right and free air appeared to be present in the mediastinum. Dappled translucencies in the left ventricular region might well represent froth. The ascending aorta and its arch were distended with air (Fig. 1). The air column extended to the innominate artery and to the common and internal carotid arteries. The right subclavian artery was outlined by air in its first part. *Skull*: No free air was visible in the cranium. *Abdomen and Pelvis*: Intestinal contents masked any free air which might be present in the vascular system.

Necropsy Findings.—A post-mortem examination was carried out two and a half hours after death. Apart from the tuberculous lesions of the chest, the main pathological findings were confined to the cardiovascular system. Special care was taken during the dissection to ligate the blood vessels before section, and the demonstration of air emboli was carried out *in situ*. Frothy blood was found in the left ventricle and in the ascending aorta, the aorta-arch, abdominal aorta, the common carotid arteries, common iliac arteries, the internal carotid artery, and the circulus arteriosus. In the small vessels, such as the coronary arteries and the cerebral arteries, the air emboli appeared as columns interspersed with blood within the vessel walls. The blood on the venous side of the circulation was fluid in consistence. The right ventricle, jugular veins, inferior vena cava, and the meningeal sinuses were opened *in situ*. No air emboli were seen within the coronary veins or the mesenteric veins. On the antero-lateral aspect of the superior lobe of the lung there was an area of haemorrhage between the pleurae and the lung tissue, where it was deep to the skin-puncture mark. It is possible that the air entered the pulmonary venous system at this site.

Case 2

An Asiatic woman aged 36 was admitted to hospital suffering from bronchogenic tuberculosis of the left lung. Sixteen days before death an artificial pneumoperitoneum was induced. At the first refill the initial manometer reading was 0 mm. Hg. Approximately 300 ml. of air was introduced. The patient suddenly collapsed and convulsive movements of the arms, legs, and the face developed. She died 35 minutes after the onset of these symptoms.

Radiological examinations were made within one hour of death. *Chest*: Gas outlined the right auricle, the right ventricle, the pulmonary artery, its main branches, and their subdivisions. No free gas was visible in the left side of the heart (Fig. 2). *Abdomen*: The stomach and duodenum were excessively dilated (possibly owing to the post-mortem attempts at resuscitation). Free gas was present under the left dome of the diaphragm and on the anterior border of the liver (Fig. 3). The splenic vein was moderately well outlined, through the gas in the stomach, in the antero-posterior view. The main portal vein and its branches were not unequivocally demonstrated. However, the air-filled vessel opposite the level of the disk between the bodies of the first and second lumbar vertebrae might represent the portal vein and its right and left branches (Figs. 3 and 4). The intra-hepatic vessels were well demonstrated, as was the left

FIG. 1.—Radiograph of Case 1.

hepatic vein. This was seen to join the inferior vena cava opposite the body of the 12th thoracic vertebra. *Skull*: No air-filled vessels were visible.

Necropsy Findings.—A post-mortem examination was carried out three and a half hours after death. The main pathological findings, apart from the tuberculous lesions, were present in the cardiovascular system. Frothy blood was present in the right ventricle, pulmonary arteries,

inferior vena cava, common iliac veins, portal vein, splenic vein, and the mesenteric veins. Columns of air were seen in the coronary veins, the tributaries of the mesenteric veins, internal mammary veins, and the tributaries of the external jugular veins. Air emboli were not detected in the arteries (except the pulmonary artery), the left cardiac cavities, internal jugular veins, or the meningeal sinuses. Ligation of the vessels before section was carried out in each instance and the examinations were made *in situ*. A small quantity of blood clot was present in the left hypochondrium, and blood clot was seen at the hilum of the spleen. (The skin-puncture mark was situated at the tip of the ninth left costal cartilage.) It may be that the air entered the portal venous system through one of the tributaries of the splenic vein. Frothy blood was present in the large veins of the liver.

Further morbid anatomical and histological findings in these two necropsies are not relevant to the discussion.

Pathogenesis of Air Embolism

Arterial Air Embolism

Moore and Braselton (1940) injected air into the pulmonary veins of anaesthetized cats, and observed air emboli in the coronary arteries within a few seconds. This was rapidly followed by ventricular fibrillation; the myocardium became pale and the ventricles dilated—that is, a rapid myocardial ischaemia resulted. The signs of cerebral anoxia followed the onset of ventricular fibrillation. The authors concluded that death in these cases was due to ventricular fibrillation resultant upon coronary occlusion, the cerebral anoxia being a secondary manifestation. The work of Durant *et al.* (1949) supports the view of the occurrence of myocardial ischaemia. They injected air into the coronary arteries of dogs and observed electrocardiographic tracings which showed evidence of gross myocardial ischaemia.

In man, however, air emboli have been demonstrated in the terminal branches of the cerebral arteries. Chase (1934) postulated that death may be due to loss of function of the vital centres resultant upon both the mechanical obstructive and the neurovascular paralytic and haemostatic effects of the air emboli. The detailed observations of the mesenteric

FIG. 2.—Radiograph of Case 2.

FIG. 3.—Radiograph of Case 2.

FIG. 4.—Radiograph of Case 2.

blood vessels of rabbits following the injection of air into the aorta have shown that the effects of air emboli are not only mechanical but also neurovascular.

Pulmonary Air Embolism

Forbes (1944) postulated that death in these cases may be due to (a) mechanical interference with the function of the heart through the presence of frothy blood in the right ventricle, to which the signs of cerebral anoxia are secondary; (b) blockage of the pulmonary artery; or (c) the obstructive effects of multiple air emboli in the smaller arterioles of the lungs.

In the case reported above air emboli were not observed in the left side of the heart or in the cerebral arteries, and it was assumed that the air entered the circulation through one of the tributaries of the splenic vein. Air emboli were observed in the portal venous system and parts of the systemic venous circulation. It is therefore of interest to consider whether air emboli are capable of passing through the hepatic sinuses. If air emboli are prevented from passing the hepatic sinuses one of the portal venous systemic anastomoses in the liver may be involved, or one of the collateral portal venous anastomoses. Curtillet and Curtillet (1939c) showed the passage of air emboli from the arterial to the related venous side of the circulation, following the injection of air into the arteries of the limbs of dogs. They concluded that the air passed through the arteriovenous anastomoses in the limbs. These results, however, have not been observed in the internal organs of animals (Curtillet and Curtillet, 1939a, 1939b; Chase, 1934).

Summary

A case of arterial air embolism and one of pulmonary air embolism are reported.

The difficulties in the post-mortem diagnosis are discussed.

In each case necropsy was preceded by regional radiographic examinations of the cadavers. The results of these examinations are reported, with radiographs.

It is shown that radiological examinations are a useful adjunct to the actual diagnosis, and also prove a guide to the most advantageous method of dissection to be followed in each case.

Adequate bacteriological examinations are an essential part of the post-mortem investigations.

The mechanism of death in the two types of air embolism is discussed, with special reference to the circulatory pathways involved in the embolic phenomena.

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Application has been made by the French Government on behalf of Morocco for admission as an Associate Member of the World Health Organization, and will be submitted to the Fifth World Health Assembly which opens in Geneva on May 5. Of the 79 countries which have joined W.H.O., Southern Rhodesia is so far the only Associate Member.

PROLONGED ANTICOAGULANT THERAPY WITH HEPARIN

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The use of the anticoagulant drugs dicoumarol and "tromexan" in the treatment of thrombo-embolic disease is restricted to institutions equipped for performing daily prothrombin estimations. There is, therefore, a need for a safe anticoagulant which can be used where facilities for this test are not available. Heparin would be suitable if the practical difficulties associated with its prolonged intravenous administration could be overcome. The use of an indwelling needle has been recommended by Jorpes (1946) and Forrester (1949), and fine-bore polythene tubing by MacFadyen (1949) to avoid frequent venepuncture. When more than ten days' treatment is required it is usually necessary to resort to intramuscular administration.

In order to determine whether heparin could be satisfactorily administered for long periods, 37 patients with thrombo-embolic diseases were treated for periods of up to five weeks: 20 were suffering from acute myocardial infarction, 2 from acute coronary insufficiency, 7 from acute venous thrombosis, 4 from acute pulmonary embolism, and 4 from embolism of peripheral arteries.

Techniques

Intravenous Administration.—A needle or cannula with an attached Gordh adapter (Forrester, 1949) was inserted into a forearm vein at wrist level and strapped down. Heparin was given four-hourly in doses of 50–75 mg. through the diaphragm of the adapter. A fine-bore polythene tubing was also used, but it was found to be less satisfactory than a needle, except when the only suitable vein was in the antecubital fossa. The flexible tubing then permitted free movement at the elbow.

Intramuscular Administration.—A concentrated aqueous solution containing 250 mg. of heparin per ml. (approximately equal to 25,000 Toronto units*) was used. Two ml. of 1% procaine was mixed with each dose of heparin, which was given through fine short needles (s.w.g. 23, 24, serum gauge VI). The heparin solution used initially was hypertonic, but later an isotonic solution of the same strength† was employed.

Estimation of Coagulation Times.—A modified Lee-White method was used (Quick et al., 1948). The average time taken for blood to clot in three dry tubes at 37° C. in the patients undergoing anticoagulant therapy and in 50 normal controls was six minutes, the range being five to eight minutes. Coagulation times were estimated twice daily: one hour after intravenous, four hours after intramuscular injections, and again just before the next dose with both routes. These represent approximately the maximum and

*The preparation was standardized in units, and the number of units per mg. varied slightly from batch to batch.

†Pularin, supplied by Evans Medical Supplies Ltd., Liverpool.