were prepared from these subjects, duly stained and examined. The results showed that, although elementary bodies were present in considerable numbers, they are difficult to detect after pustulation and secondary infection has occurred. Prolonged immersion in distilled water is required to rid the film of excess serofibrinous pus, and the film tends to over-stain. Nevertheless even in late cases, by scraping the base of the pock, it is possible to obtain excellent stained preparations showing elementary bodies.

Discussion

To perform either the complement-fixation test or the variola-vaccinia flocculation test vesicular fluid or dried scabs are required, or the serum of patients 7 to 10 days after infection. In consequence their use is restricted to cases in the stage of pustulation or desquamation. Moreover, both tests demand a high standard of serological technique with proper controls, and about 24 hours must elapse before results can be read. Paul's test likewise suffers from the disadvantage of the time taken to obtain an answer. Moreover, our experiences with Paul's test in true smallpox have been disappointing, and it is not as easy to do as the literature indicates it to be. The slide method provides a quick and easy test for recognition of smallpox from the first day of the rash, when it is in the papular stage before vesiculation. A smear preparation can be made from a suspected case of smallpox, stained, examined, and a reply handed to the physician in half an hour. To assess the relative merits and percentage of experimental error in different laboratory tests would be unfair without comparative trials over a large series of cases. However, we believe that if all the laboratory diagnostic methods for variola were put to a rigid trial and judged according to their merits the slide technique would surpass the remainder in speed and accuracy.

Summary

We have confirmed Paschen's (1933) observation that the elementary bodies of variola are larger than those of varicella, and have utilized this finding to form the basis of a laboratory test for the identification of smallpox.

In Egypt, skin scrapings from 80 cases of smallpox ranging in severity from mild to fatal haemorrhagic variola were subjected to the film test for elementary bodies.

The laboratory and clinical findings corresponded in 77 cases (i.e., 96%). A negative result was returned in three cases of smallpox.

Variola elementary bodies were demonstrated with ease in the papular and vesicular stages of the illness, but after the onset of pustulation they tended to disappear.

In 32 cases of early smallpox the laboratory answer was positive on the first day of the rash, when it was very sparse and the clinical diagnosis was difficult or impossible to establish.

In no instance did a positive laboratory verdict disagree with the final clinical diagnosis of the case.

Control skin scrapings from 64 clinical cases of varicella occurring in Egypt, together with a further 16 cases of chicken-pox contracted in England, have been studied under identical conditions and compared with similar material from 80 cases of variola in Egypt.

The film test is not applicable to the diagnosis of chicken-pox, because the elementary bodies of varicella are too small, are too scanty, and show feeble affinity for Paschen's stain.

The principal conclusion reached is that the film method, when used with caution and discretion, can be of great value in the early recognition of variola, especially on the first day of the rash, when the clinical picture may so closely simulate chicken-pox.

We have to thank Col. H. T. Findlay, D.D.P., G.H.Q., M.E.F., for his interest in our efforts and for the supply of material from cases of varicella from England. Also for the technical assistance given by Sgt. D. Danskin, R.A.M.C., and Pte. G. R. Pollak, A.T.S., who examined and reported on many specimens submitted from units at all hours of the day and night. For permission to publish

this article our thanks are due to Major-Gen. J. A. Dowse, Director of Medical Services, Middle East Forces, Col. W. B. Stevenson, and Col. L. S. C. Roche.

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AIR EMBOLISM AS A COMPLICATION OF VAGINAL DOUCHING IN PREGNANCY

BY

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The potential dangers of air embolism during surgical procedures are well known, and are being constantly emphasized by all those responsible for surgical teaching. Within recent years the importance of this subject has increased proportionately to the frequency with which intravenous resuscitation therapy is employed. According to Hamilton and Rothstein (1935) the first case was reported by Beauchesne in 1818, and since then many other accounts of fatal accidents due to air embolism have been placed on record.

The Causes of Air Embolism

When any large vessel containing blood under less than atmospheric pressure is opened and cannot collapse owing to rigidity of its walls; partial severance, or external fixation, the entry of air is possible and the mechanism easily understood. This may happen during operations in the region of the great vessels of the neck, as a sequel to their traumatic severance, and through opening the dural sinuses during operations on or within the skull. A somewhat similar situation exists when air enters the uterine venous sinuses during or after delivery. This may happen in normal healthy women during labour when the sinuses are open after detachment of the placenta (Osborn and Dawson, 1938), or up to 11 days post partum where retained membranes, clot, or placental fragments have kept the sinuses open and the entry of air into the uterine cavity has been facilitated by the adoption of the knee-chest position (Gough, 1924; Quigley and Gáspár, 1936; Stroh and Olinger, 1938; Redfield and Bodine, 1939). In these circumstances the air is sucked into the open vessel. Criminal abortions are often attempted by the injection of fluid into the uterus. If the fluid passes the cervix its force detaches the membranes or placenta and air may be driven into the open uterine sinuses, as precautions are seldom taken to ensure that the syringe is completely filled with fluid before use (Gonzales, Vance, and Compelyn, 1937; Gough, 1924; Hamilton, 1936).

The fact that even quite small veins may, if damaged, serve as a point of entry for air is perhaps not so widely known.

This is particularly liable to happen if the air is under pressure. This mechanism operates when air embolism occurs during antral lavage (Gording, 1920; McGovern, 1941); during the distension of the bladder or urethra with air (Mathé, 1929; Rettig, 1930; Jeck, 1933; Dible *et al.*, 1938), while testing the patency of the Fallopian tubes by insufflation (Moench, 1927; Mansfield and Dudits, 1934), during therapeutic vaginal insufflation (Latham Brown, 1943; Peirce, 1936; Partridge, 1943), and as a result of perirenal insufflation for diagnostic purposes (Weyrauch, 1940). In these circumstances the vessels may be either diseased from inflammation or tumour growth, or damaged before or during the operation. Finally, the injection of air into the peritoneal cavity or the administration of fluids intravenously may result in air embolism.

When air embolism arises under the conditions outlined above the gas accumulates in the right side of the heart and the emboli lodge in the lungs, except in those exceptional cases in which a patent foramen ovale or interventricular septal defect exists, when a proportion of the air may reach the main circulation. Cerebral and coronary air embolism are common sequelae of penetrating wounds of, and operations on, the lungs, and of the induction of artificial pneumothorax in the treatment of pulmonary tuberculosis (Chase, 1934; Hamilton and Rothstein, 1935). Many authors suggest that a proportion of the cases previously regarded as fatalities due to pleural shock have in fact been unrecognized cases of air embolism.

The Mechanism of Death in Air Embolism

The effects depend on whether the pulmonary or systemic circulation is invaded. In the former case the air accumulates in the right auricle and ventricle, and emboli are impacted in the pulmonary arterioles. If the volume of air is large and it enters the circulation quickly death takes place rapidly. It is still apparently not settled whether death is due to mechanical interference with heart function, to blockage of the pulmonary artery by froth with arrest of the circulation in the lungs, or to multiple emboli choking the finer arterioles in the lungs. If the volume of air admitted is smaller or its entry slower and life is prolonged, the air blocking the pulmonary arterioles may be absorbed in part. The remainder may escape through the capillaries and veins, thus finding its way to the left side of the heart and into the systemic circulation, to produce cerebral and coronary infarction. In the ordinary case of pulmonary air embolism this is rare, and the experiments of Jung and Pierre (1935) confirm that opinion. The work of E. and A. Curtillet (1939) and of Chase (1934) tends to show that the actual obstruction occurs in the arterioles, and that while there impacted the air bubbles become smaller owing to absorption. After a time the bubble, now reduced in size, escapes into the capillaries and so to the veins. In the average case, however, life is not prolonged sufficiently for this to happen. When the systemic circulation is invaded from the vessels of the lung, either primarily or as a sequel to pulmonary air embolism, the mechanism of death and the symptoms are different. The air blocks the vessels of the brain, interfering with the nutrition of the vital centres, and/or it lodges in the coronary vessels, producing cardiac infarction.

The Volume of Air

There seems to be no measure of agreement as to the volume of air required to bring about a fatal issue. Hamilton and Rothstein (1935) assert that small amounts of air can be introduced into the venous system with impunity, while Mathé (1929) believes that small volumes cause only mild transitory symptoms, which resolve when the air is absorbed. These opinions seem reasonable when one considers the numerous occasions on which intravenous therapy is administered, often by comparatively inexperienced operators, and the relative rarity of fatal air embolism during such a procedure. It seems almost incredible that in nearly all cases the operation is carried out without some small leakage of air into the vein through faults in the transfusion apparatus or directly when the vein has been opened to insert a cannula. Dible *et al.* (1938) consider that in nearly all cases of recorded fatalities considerably more than 100 c.cm. of air was introduced in a short period of time. Coles, Richardson, and Hall (1937), applying to man the results they obtained in experiments on

dogs—which may perhaps not be justifiable—conclude that a minimum of 480 c.cm. of air is required as a lethal quantity. It is probably not possible to arrive at a definite figure. According to Simpson (1942) the total volume of air that can be tolerated depends on the person's general condition and on how quickly the air is admitted. He claims that sometimes even 10 to 15 c.cm. may be fatal. In Mathé's (1929) opinion marked differences in resistance to air embolism exist in different individuals and different species.

Case Report

History.—Recently a case occurred which in several respects was unusual and which points to a danger probably not generally recognized. A woman aged 34 who had had three previous pregnancies complained of feeling in poor health on June 30, 1943, but attributed her symptoms to the onset of menstruation. She usually had dysmenorrhoea severe enough to require two or three days in bed. She began to menstruate on July 1. Next day no fresh symptoms appeared till 9.50 p.m., when she collapsed on her way to bed and died a short time later. No further details were available at the time of the necropsy, and there was nothing to suggest what the cause of death might have been.

Necropsy.—The examination began at 3 p.m. on July 3—i.e., 17 hours after death—and putrefaction had not started. There was a blood-stained sanitary towel between the legs, but the external examination revealed nothing of significance. On opening the abdomen a retroverted gravid uterus was observed which was not impacted and could easily be lifted out of the pelvis. The peritoneal surface of the genito-urinary organs was uninjured. The bladder and urethra were healthy and free from injuries, and the ureters and kidneys were also healthy. The external genitals and vagina were free from abnormalities. The cervix was soft, and an erosion was seen round the external os. The cervical canal was open, but the cervix showed no sign of injury. On opening the uterus the placenta was found low on the right lateral wall, and its lower edge was detached to a depth of one inch. The membranes were separated to a depth of two and a half inches. The uterus contained a foetus of three months' gestation in intact membranes. In the wall of the uterus there were a few small subserous fibroids. The ovaries and tubes were healthy, and in the right ovary there was a large corpus luteum of pregnancy. The trachea contained some fine froth, and the pleural cavities were dry and normal in every respect. The lungs were very oedematous. The pericardium appeared normal. The right side of the heart was dilated, and on opening it the auricle and ventricle were found to be filled with frothy blood. The pulmonary artery contained identical material. The tricuspid valve was relatively incompetent. The foramen ovale was patent, but the opening was valvular. The left side of the heart was healthy, as were the coronary vessels and the myocardium. The alimentary system presented no significant abnormality. The meninges were normal, but there was some congestion of the brain. No haemorrhages were seen on the surface or in its substance.

Histologically the brain was free from abnormalities. Sections of the lungs showed numerous small areas of infarction with normal lung tissue intervening. In the infarcted areas there was intense congestion, with abundant oedema fluid in the alveoli. Some of the alveoli were filled, partly or entirely, with packed red cells.

Discussion

In the entire absence of any history to suggest it, the possibility of air embolism was not thought of before the necropsy, and consequently the special technique usually followed in such cases was not adopted. However, the findings indicate conclusively that this was the cause of death. In the light of this discovery the obvious suspicion was that this case was one of criminal abortion, and further inquiries were instituted. These revealed that this woman had not missed a menstrual period, and on June 3, 4, and 5 she was medically attended for dysmenorrhoea. So far as can be ascertained neither her husband, relations, intimate female friends, nor her doctor knew that she was pregnant. There is definite evidence also that during one of her previous pregnancies she continued to menstruate for three months after the pregnancy began. From all the circumstances of the case there seems, therefore, to be some genuine doubt whether the deceased realized she was pregnant. She was accustomed to using a Higginson's enema syringe for vaginal douching and, though no definite evidence on this point was forthcoming, it seems likely that she douched immediately before retiring at 9.50 p.m. on July 2. The fatal douching which was responsible for the air embolism must have occurred shortly before her collapse, and the above seems a reasonable hypothesis. It therefore appears fairly certain that

this death was accidental, the woman being in ignorance of her condition and police inquiries having failed to reveal the possibility of interference by any third party.

It is of course accepted that air embolism may occur when an attempt is made to inject air or fluid, or both, through the cervix with the object of producing an abortion. There are three cases on record in which therapeutic vaginal insufflation during pregnancy had resulted in death from air embolism. So far as can be ascertained, however, there is no previous report of an instance in which simple vaginal douching led to air embolism from detachment of the placenta.

This case is one of pure pulmonary air embolism. The finding of the patent foramen ovale at once raised the possibility that air would be found in the cerebral vessels also. Presumably the valvular nature of the very slight septal defect prevented this.

Summary

The causes of air embolism are reviewed and the mechanism of death due to this condition is discussed.

A case of accidental death from air embolism due to vaginal douching during pregnancy is recorded.

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ACTIVE CONVALESCENCE OF HERNIAL REPAIRS

BY

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During investigations into the causes of the high incidence of post-operative respiratory complications in Service cases it was shown that the incidence and intensity of symptoms were lessened in those cases specially liable by early movement and, in particular, by getting up out of bed. The type of case with the highest incidence was the group of hernial repairs and to a lesser extent appendicectomies. It was therefore determined to get all these men up the next day after operation, and the consent of the consulting surgeon of the Command was obtained to take a course of action contrary to the usual practice and contrary to the instructions later issued in the *Army Medical Bulletin*.

At the beginning of this investigation various operations were used—viz., Bassini, simple removal of sac, fascial graft, and finally the slide repair as described by Tanner (1942). As the series went on the operation of choice became the simple removal of sac, and the value of this decision was later emphasized by the survey given by Maj-Gen. Max Page (1943) and others at the Royal Society of Medicine, which had not been published when this step was taken.

It has generally been agreed that the results of operations are not as satisfactory when a thorough investigation is made as is the impression of many surgeons who have not kept strict figures. Various critical reports have shown a recurrence rate between 0 and 20%, but among the most valuable published figures are those of St. Thomas's Hospital of 12% (1943).

The cases described have been an unselected series in men of military age. The great majority of them have been indirect inguinal herniae. Direct herniae have been operated upon only when there is evidence of a funicular sac coming down into the scrotum. Those with only a diffuse bulge have been advised against operation, as it is felt that the likelihood of strangulation is negligible. Nevertheless, some errors of diagnosis were made earlier in this series.

Many factors are involved in producing successful results, and in all probability no one factor is paramount. Much stress has been laid on the type of operation, but probably the truth is that no one type will meet all conditions and that a certain number of recurrences are the result of a faulty choice of operation.

There are several recognized factors of importance, of which some are the care of adequate haemostasis, strict aseptic technique, and the removal of the whole sac as far back as the "corn" which marks the position of the neck of the sac. I deprecate the use of gauze dissection as a means of separating the sac, though some have argued that good results follow the formation of a firm mass of inflammatory scar tissue. This, however, will certainly stretch under strain in a way normal tissue will not.

The great value of the Tanner slide operation where the inguinal ring is much enlarged is that the action of the arcuate fibres of the internal oblique is not interfered with. If their attachment to the conjoined tendon is slackened before suture their direction of pull remains normal. The hernial ring is closed against intra-abdominal pressure by the constriction of the arcuate fibres of the internal oblique, which, in contracting between its two attachments on Poupart's ligament and the conjoined tendon, flatten the arch, approximating the top of the arch to Poupart's ligament. It is essential that this muscular mechanism should be maintained in good activity. Therefore every opportunity must be taken, by free movements of the patients, to prevent adhesions forming between the internal and the external oblique. This is a matter of great importance, seeing that the likelihood of respiratory complications is so high. The strain placed on the inguinal canal by coughing is considerable, and it is apparent that anyone who could cough and vomit after operation certainly could sit in a chair without any increased risk and with greater comfort.

There is much difference of opinion in regard to the choice of suture material, and there are responsible advocates for the use of catgut or of more permanent sutures such as silk or linen thread. In this series I have used catgut throughout. Floss silk, so enthusiastically described by Maingot (1941), has not been employed at all, for I have had through my hands three cases of prolonged sepsis and sinus formation after the use of this material. Whether thread or catgut is chosen is probably a matter of no great importance so long as strict aseptic precautions are maintained. The post-operative dressing which has been used as a routine has been a thin layer of gauze stuck on healthy skin by mastisol. This has been done to avoid the inevitable moisture from sweating which is present when both elastoplast and bulky wool and bandage dressings are employed.

In the previous article (Martin *et al.*, 1943) we demonstrated that the choice of anaesthetic is a matter of little importance. I feel that the choice of an anaesthetist is of far greater moment. The only break with convention has been in the after-care. Active convalescence has been found to be of value in many conditions, and is practicable after herniotomies and appendicectomies when a muscle-splitting operation has been done. It has been found to accelerate recovery in bronchitis, pneumonia, and even carditis, where functional activity, carefully graduated, enhances convalescence. The scope of this form of convalescence has proved to be far more practicable than we imagined a few years ago. Hospitals with enthusiastic rehabilitation departments have demonstrated the value of this form of treatment.

The routine of activity that these men are encouraged to accept is as follows:

On the first day after operation they get out of bed and walk a few steps to a low armchair. They find they could sit in greater comfort than in bed and that the greater flexion of the hips helps to support the inguinal canal so that they can cough with less strain. They are allowed to sit up as long as they enjoy it. On