THE BLOOD PRESSURE IN AVERITIN ANÆSTHESIA.

By WALTER P. KENNEDY (Beit Memorial Research Fellow).

(From the Department of Physiology, Edinburgh University, and the Royal Infirmary of Edinburgh.)

AVERTIN anaesthesia has already a very extensive literature and its technique and properties have been widely discussed. Among the latter is one which has aroused considerable objection to the use of this new anaesthetic, namely that of producing a fall in blood pressure. This fall is of almost invariable occurrence and has been stated to be from 15 to 20 mm. of mercury, though Church1 gives 30 mm. as the figure. In a preliminary communication2 on a series of 36 cases we stated the figure was even higher but that no untoward effects accompanied the fall. A more extended experience of 150 gynaecological cases has amplified our data.

The following details of technique are briefly stated, as discrepancies in the results of different workers may be due to variations of procedure. The avertin is made up in 2½ per cent solution of the fluid preparation (solid avertin in amylene hydrate) to a dosage of 0.1 gm. per kilo body weight. Tap water at body temperature is used, and the solution tested with Congo red. The preparation is done by the anaesthetist, and the actual administration to the patient in bed is carried out by a senior nurse specially instructed in the method. In no case was there any excitement stage during the induction. Prior to the instillation, which occupies from five to ten minutes, ¼ gr. morphine hydrochloride and 1/100 gr. atropine sulphate are given hypodermically. The avertin should be administered at least half an hour before the start of the operation, as otherwise the patient is apt to be easily aroused. Undue disturbance of the patient in the early stages should be carefully avoided for this reason. Certainly, smoothness of induction has a very beneficial effect on the course of the
subsequent anaesthesia; those patients who happen to be disturbed in the early stages are more liable to give trouble later. If the exigencies of operation day routine cause a further delay of half an hour, or perhaps even more, no difficulty arises.

The patient is removed to the ante-room, the reflexes are examined and open ether commenced. It should be emphasised that avertin is used as a basal anaesthetic, and ether is employed as a routine. In five cases of the series the avertin alone was sufficient and no ether was given; these were all minor operative procedures or examinations under anaesthesia. From this point it is necessary to have a cylinder of oxygen containing five per cent CO₂ at hand as a respiratory stimulant, as some inhibition of the respiratory centre tends to occur. This has always responded so readily to the stimulating action of CO₂ that it has not occasioned any anxiety, but the availability of this agent should be a necessary condition in the use of avertin. It is also advisable to have a solution of ephedrine hydrochloride at hand (50 mg. per c.c.) for administering hypodermically in doses of \( \frac{1}{3} \) c.c. to counteract the fall in blood pressure. Ephedrine is chosen rather than adrenaline, as the effect is more lasting although it is not produced with such rapidity. A mixture of the two substances should be useful, but we have no personal experience of it. The blood pressure was measured with a Baumanometer, using the auscultatory method, special care being taken to avoid fallacies.

The usual sequence of events is that the patient is asleep by the time the instillation is complete, or at least within the next five minutes. The pulse rate rises, the face becomes slightly flushed, and the blood pressure falls gradually, reaching the lowest point in about twenty minutes to half an hour, and if undisturbed the patient remains at this level for a considerable period. In the majority of cases the systolic pressure falls more than the diastolic, or, in other words, the pulse pressure is diminished. The administration of ether produces an immediate rise in both pressures and usually an increase in pulse pressure. This sudden rise may or may not be sustained, and it is more than probable that the nature of the operative procedures has an influence in this respect. For example, in the majority of the cases of abdominal section it
was observed that the systolic pressure fell sharply immediately the peritoneum was opened; similarly, in the case of pelvic floor repair a pressure which has been maintained fairly steadily during the anterior colporrhaphy will almost invariably fall 15 to 20 mm., or even more, with the commencement of the posterior colporrhaphy. After the rise due to the ether there may be a further rise, even above the pre-anaesthetic level; the level may be sustained steadily or irregularly or there may be a fall: individual differences are considerable. In nearly every case the status quo is maintained for some hours after the patient is returned to bed. From six to eight hours, or longer, after the operation consciousness returns, although the patient is drowsy and practically automatic. The next day there is little or no memory of events of the previous evening. The blood pressure twenty-four hours after the operation is commonly below the preoperative level by 10 to 20 mm. Sickness is present in just less than one-third of the cases, but it is usually slight and of short duration. It does not occasion so much complaint as the headache which occurs in about half the patients. This is readily controlled by pyramidon gr. v (repeated after four hours if necessary, though one dose usually suffices). Bronchial sequelae are absent. This, with the relative freedom from sickness, is particularly valuable in cases of pelvic floor repair. The ether required to obtain the requisite level of surgical anaesthesia is given with an ordinary Schimmelbusch mask, and the mask concentration is never so high as with ordinary inhalation anaesthesia.

In reading the blood pressure it is observed that the quality of the Korotkov sounds fluctuates considerably in individual cases, and variations from the normal inter-relations of the sounds are common. Frequently the clear slapping third sound merges gradually into the dull fourth instead of giving the sudden drop of tone and intensity normally found. This makes the estimation of the diastolic sometimes difficult; nevertheless, rarely is it impossible to detect a point where a definite change occurs. In four of the cases there was an apparent drop of the diastolic to zero; that is, when the armlet of the sphygmomanometer was completely deflated or, indeed, removed it was still possible to hear the third sound (or a
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continuation of it) in the artery. One of these cases (No. 81) is shown in Fig I, and the diastolic is charted as reaching zero: this must be understood to represent the apparent reading and not the true condition of the artery. In three other cases the diastolic fell below 20 mm. mercury, and in several others it passed the 40 mm. level, which is supposed to be incompatible with life. These readings occasioned considerable apprehension and ephedrine was administered; at the same time the accuracy of the figures was checked by an independent observer. However, the patients uniformly had a good colour and their breathing was easy, quiet, and rather shallow than deep—they appeared to be comfortably asleep. At the same time the pulse was very rapid, 120 to 140 per minute, and the skin flushed and hot. Sweating, in many instances, was profuse, but this is a phenomenon in the operating theatre in summer not confined to patients. The exhibition of ephedrine rapidly restored the pressure to more usual levels and coincidently the pulse rate fell. Increase of pulse rate was always found with avertin, and this was found to be higher than the first series of cases had indicated. As the rate fluctuated considerably it would require rather complicated methods to give an exact picture of the average increase: instead, the average of the highest recorded point in each of the cases has been calculated. These highest points ranged between 84 and 152 per minute, and the average was 122 per minute.

Similarly, taking the fall in blood pressure, the greatest drop of the systolic level from the pre-operation figure varied between 2 and 102 mm., with an average value of 41 mm., but in only nine cases out of a hundred and fifty was the fall less than 20 mm. The greatest diastolic drop varied between 0 and 80 mm, and the average was 28 mm., which would not have been so great but for the exceptional cases mentioned above. These figures give no true indication of the decrease of pulse pressure, as the points of greatest diminution of systolic and diastolic pressures are not necessarily contemporaneous; indeed, they are seldom so. The general tendency is for a lessening of the pulse pressure, but occasionally (as in the anomalous cases such as No. 81) it is apparently greatly increased. A similar example is seen in Fig III, in which the recorded pulse pressure of the cat increased six-fold. In con-
In connection with these figures it may be added that the average duration of the operation, excluding preliminary ether anaesthesia, was 14.5 minutes, or, including this, almost 20 minutes. The average amount of ether used was 2$\frac{1}{2}$ ounces, and this figure is probably somewhat in excess of the absolute requirements.

It should be emphasised that the clinical condition of the subjects who exhibited the high pulse rates and low pressures was good, and ocular observation gave no cause for anxiety. A number, however, showed marked cyanosis and greatly depressed respiration, apart from such unusual fluctuations as have just been mentioned. As has been said, CO$_2$ and oxygen rapidly restored normal colour. Latterly the number of these cyanotic cases had been reduced by the routine usage of an airway. The lower jaw is very lax under the influence of avertin, and unless this precaution is adopted constant observation is requisite.

Cases of this series have been given avertin despite the presence of valvular murmurs, and none of them gave any cause for anxiety or exhibited ill effects later. In view of the results obtained in the theatre and experimentally, however, it is considered that myocarditis and auricular flutter should be taken as contraindications to the use of avertin.

In the series of 150 cases one death occurred, and the responsibility cannot be laid on the anaesthetic. The patient was a short, very obese woman, aged 40, weighing 12 stone 10$\frac{1}{2}$ pounds, and the operation was for removal of a big and difficult fibroid and repair of a large hernia. It lasted 1$\frac{1}{2}$ hours, 12$\frac{1}{2}$ ounces of ether being used, and oxygen being administered throughout. The systolic pressure fell from 150 to 108 mm. and the diastolic from 84 to 68 mm. before the operation. On the administration of ether being started they rose to 134 and 84 mm. respectively, and were maintained, fluctuating only slightly, about that level during the operation. The patient died that night. She was a bad operation risk, and the result with any anaesthetic would probably have been the same.

The operations for which the anaesthetic was given were as follows:—Dilatation and cauterisation of the cervix, 55; dilatation and curettage (diagnostic and therapeutic), 19;
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pelvic floor repair, 24; insertion of radium, 12; removal of fibroid (1 with additional hernia), 8; hysterectomy, 7; incomplete abortion, 6; diagnostic examination, 4; laparotomy, 4; insertion of tents, 2; tubal insufflation, 2; appendicectomy, 2; and one each, removal of vaginal papilloma, repair of urethral fistula, Gilliam, pelvic sympathectomy, and simple dilatation of cervix.

In the wards in which this investigation was carried out up to date avertin has been used in 734 cases, and there have been four deaths, none of which could be ascribed to the anaesthetic. A full report of the series will be published when a thousand cases have been obtained.

It was thought well to investigate the physiological aspect of the great apparent fall in diastolic pressure. A search through the literature yielded little help, save in a paper by Davies and Holmes who studied the effect of warm immersion baths on the circulation, and who describe a similar drop of the diastolic to zero which appeared to be associated with a diminution of peripheral resistance and some alteration in arterial elasticity. We therefore made a series of observations on healthy young adults exposed to great external heat, and used a Turkish bath for the purpose. The record of one typical experiment is given in Fig. II. The blood pressures and pulse pressure first fell; but after almost half an hour, and the increase of temperature to 164°F., the pulse pressure and rate increased, the diastolic pressure falling, and on the temperature being raised to 194°F. the diastolic reached 40 mm., while the pulse was 143 per minute. The subject sweated profusely and felt no distress, indeed he could only be persuaded with difficulty to leave the hottest room. One other subject became readily distressed; his pressure, after a small preliminary fall, rose to 32 mm. above normal, and his pulse rate rose also. It was observed that he scarcely perspired, and therefore the experiment was not proceeded with in his case. In one of the series a zero diastolic reading was obtained, but it is not figured, as the observer doubted its reliability owing to the fact that the great heat caused such loud carotid pulsation in his own ears when the stethoscope was applied, that it was extremely difficult to be certain of the sounds in the brachial artery.
Only ten such experiments have been conducted so far, but sufficient data has been obtained to make it clear that a very considerable temporary drop in blood pressure can be tolerated without ill effect. The main factor responsible for the fall is the great vasodilation due to the activity of the heat-regulating centre; at the same time it is probably not the only one. The great increase in heart rate is consistent with such a fall, and when the efficiency of the cardiovascular system is not seriously impaired by disease it appears to be able to cope with the situation easily. Of course, in a Turkish bath no physical work is done and the supine position is assumed, both conditions also obtaining in the case of anaesthesia. The beneficial effects, with sensation of euphoria, after a Turkish bath are well known, and it is also a commonplace that they are inadvisable for people who suffer from what the laity call “weak hearts.”

A number of acute experiments were performed on cats and rabbits, and the results are parallel to those found clinically. In the case of rabbits a soft rubber catheter can be inserted into the bowel readily and anaesthesia induced in two to three minutes without any struggling or excitement of the animal; cats, however, resent this treatment and are therefore first lightly anaesthetised with ether and then brought under the influence of avertin. It was found to be an admirable anaesthetic for long continued experiments, and the fall of blood pressure and diminution of respiratory movement was easily counteracted by the use of ephedrine. The figure shows the increase in blood pressure and diminution of pulse pressure with the deepening of respiration—which has become shallow with avertin—when the ether was reapplied. In several experiments the blood pressure was allowed to fall without interference; but in doses of up to 0.2 gm. per kilo, after a period of approximately one hour the pressure rose slowly. The anaesthesia in some of the animals began to be light at this point and further doses were injected. Some experiments were also performed with intravenous administration of the solution, which showed more rapid onset of the effects.

In a recent report of the Council of Pharmacy and Chemistry of the American Medical Association the advantages claimed for avertin are listed as follows:
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1. Absence of so-called psychic shock or mental distress (authorities are almost unanimous). 2. Absence of irritation of the respiratory tract, with less post-operative bronchitis and pneumonia. 3. Absence of direct injurious action on the heart, kidneys, or other organs, with the possible exception of the liver. 4. Convenience for operations about the face, especially when a cautery must be used. 5. Usefulness in long operations when deep anaesthesia is not necessary. 6. Less frequent vomiting than after ether or chloroform. 7. Lasting sleep after operation, frequently making it unnecessary to use morphine for the relief of post-operative pain. 8. Amnesia. 9. Absence of injury after repeated administration (as in tetanus). 10. Rapid elimination (implying less toxic action).

Among the comments we have to offer on this list it should be said that it is hardly possible to overstress the value of the mitigation of "psychic shock." The integrative function of the nervous system plays so important a rôle in all physical activity that its protection becomes a matter of considerable account. This beneficial action is particularly noticeable in women patients. The diminution of respiratory complications is marked, and is especially valuable in abdominal and pelvic floor repair operations. The period of amnesia and post-operative analgesia lessens the suffering of the patients considerably.

The disadvantages mentioned in the report include a higher death rate than after ether. This still remains to be established, and we submit that a death rate of four per 734, i.e. 0.55 per cent, for gynaecological operations is not an unfavourable one. Depression of respiration and circulation (2 and 3) we have dealt with; and (4) acidosis, said to be as active as after chloroform, has not caused any trouble except its being possibly the cause of the severe headaches. The muscular relaxation said to be insufficient (5) was found here to be excellent. Falling back of the tongue (6) is met with the use of an airway, which is left in situ when the patient returns to bed, being fastened to the nightdress by a strip of bandage. The objection of lack of control from moment to moment is to be met with the reminder that avertin is a basal anaesthetic, and is to be used as such. Inhalation anaesthesia
is superadded to it and gives the necessary delicacy of control. The eighth disadvantage is the want of exact dosage, but a dose of 0.1 gm. per kilo body weight—varied, certainly, if there appears to be any special indication such as advanced cachexia,—would seem to be well within the margins of efficiency and safety. The alleged narrowness of the zone between fatal and anaesthetic dose (9) requires further definition, while the disadvantages “inherent in mixed narcosis” are probably more apparent to American readers than to those brought up in the Edinburgh tradition. We agree, however, that there is at present a lack of pharmacological investigation and exact knowledge as to the indications and contraindications.

SUMMARY.

A series of 150 cases of avertin anaesthesia were observed, with special reference to the blood pressure changes. These were found to be greater than previously reported and, indeed, greater than would commonly be considered safe. At the same time no untoward results were observed, and similar changes are reported in young men exposed to very high external temperatures. These are discussed. From the experiences of the series the conclusion is drawn that avertin provides an advance in anaesthetic practice of prime importance.

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REFERENCES.

Legend for Figures.

**Figure 1.**
The upper solid lines in each case represent the systolic blood pressure, the lower the diastolic, and the dotted lines the pulse rate. E marks the start of administration of ether; Ep the injection of \( \frac{3}{4} \) c.c. ephedrine hydrochloride; O the commencement of operative procedures, and F the finish of operation and removal of the patient to bed. The perpendicular line at the right of the curves indicates the pressure and pulse rates after 24 hours.

Case 139. Myomectomy; six ounces of ether. Case 43. Pelvic floor repair; six ounces of ether: the second fall coincided with the posterior part of the operation. Case 81. Removal of tents and clearing out uterus; one ounce of ether. The apparent fall of the diastolic to zero will be noticed (see text); \( \frac{3}{4} \) c.c. pituitrin was given at point marked P.

**Figure 2.**
Blood pressure changes on exposure of healthy young adult to great external heat. 1. Enters room at 119°F.; 2. into room at 164°F.; 3. to room at 194°F.; 4. return to room at 164°F.; to cool room and massage; 5. pressure just after diving through cold pond, 58°F.; 6. after half-hour's rest.

**Figure 3.**
Carotid blood pressure of cat; ether anaesthesia. At point A 13 c.c. 2\% solution of avertin was instilled into the rectum and the drum stopped for ten minutes. Each subsequent figure indicates stoppage and restarting of drum after 3, 3, 3, and 6 minutes. Ether was administered at point marked E. The horizontal lines indicate pressure of 120, 80 and 40 m.m. respectively; the lower curve is respiration.
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Fig. 2.