(c) warnings of the possible effects of unsuitable cleansing agents and home remedies (good soaps, vegetable oils, and liquid paraffin allowed); (d) emphasis on the advantages of cleanliness.

5. Selection of suitable personnel for work in the pit.

6. Application of protective substances to the skin.

7. Warnings of the increased risks of working when ill or insufficiently recovered from illness.

8. Prevention of fungus infection of the feet—a difficult matter: (a) New workers should be examined before they are admitted to the baths. (b) To prevent contact between the feet and the bath floors, slippers should be worn and sterilization of these be periodically carried out. (c) Infected men should have separate baths.

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INTRAVENOUS ANAESTHESIA

CONTINUOUS POSITIVE-PRESSURE DRIP SALINE WITH INTERMITTENT PENTOTHAL

BY

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Many articles have recently appeared on pentothal anaesthesia with drip-feed continuous saline, and each of the various methods has its advantages and disadvantages.

Criticisms of Previously Described Methods

Drs. Roberts and Sellick (1944) have answered Mr. O'Connor (1944) satisfactorily, by stressing the fact that the metal stand used in the gravity technique is both cumbersome and often in the way of the surgeon or assistant. A further disadvantage of this method is seen when the operating table has to be moved during the operation—as, for example, during a meniscectomy, when the surgeon, having been operating with the leg bent over the end of the table and the light shining over his shoulder into the joint, starts to sew up with the leg straight and the light directly overhead. This entails moving the whole table some distance, so that the drip has to be moved also. Care has to be taken not to dislodge the needle or connexions as the tubing sways, the container has to be steadied in case it becomes unhooked or is broken, and at the same time the anaesthetic machine, if in use, has to be moved also.

Dr. Griffin (1944) overcomes this difficulty to a certain extent by affixing the drip-container to a bar on the Boyle's table model. This type of machine is, however, by no means universal, and I for one would hesitate to make such an alteration to a McKesson machine or to my own portable apparatus.

Mr. O'Connor had criticized the apparatus described by Drs. Roberts and Sellick (1943) by suggesting that leakage of blood may occur back from the vein during intervals of injection or if the pressure in the saline bottle should drop. Drs. Roberts and Sellick counter this criticism by saying that a clip can be fixed distal to the bellows to prevent leakage of blood back. They point out that the ideal method is to use a flow of oxygen to produce the necessary pressure. Besides being wasteful, I cannot quite see why a minor explosion does not occur in the saline bottle when the tubing is pinched to admit the pentothal, unless the oxygen supply is turned off during this procedure, thus adding an extra manipulation. This could, of course, be avoided by fitting an automatic mercury manometer or blow-off valve; but this only adds further complications and, to my mind, disadvantages. It is my intention to describe a simple method that will obviate these difficulties, still employing the bellows method of producing pressure for the drip.

Having used the gravity method for a considerable time, I decided to try the positive-pressure method, when I was

confronted with the difficulty of having no stand on which to hang my saline reservoir, and by the fact that I had been anaesthetizing for a fairly large series of meniscectomies (sometimes 6 in a morning) and becoming more and more tired of lugging a heavy metal stand to different positions. Also people in the theatre frequently tripped over the metal base. I had a mental picture of the surgeon one day stepping back and losing both his balance and his dignity.

There are a number of disadvantages in using the technique described by Drs. Roberts and Sellick.

1. Constant pricking of the tubing raises the question of sterilizing the puncture site at every injection, with consequent delay at a time when the patient requires a further dose immediately.

2. The need to pinch the tubing to avoid backwash, thereby possibly obscuring the drip chamber, means that the anaesthetist's hand is taken from the patient's jaw and his attention from the general condition.

3. Towels that may be in the vicinity of the operation have to be touched, and are perhaps disarranged, which may interfere with the surgeon or assistant.

4. The question where to place the syringe during intervals between injecting and the question of the sterility of the needle.

5. The eventual destruction of the rubber tubing (it is better to have thin-walled tubing, as it is lighter on the needle), with consequent leakage, which seems to occur most often at the start of a new case, thus not setting out with a 100% efficient system.

The aspiration indicator described by Drs. Roberts and Sellick is a most useful adjunct after induction of the patient in his bed or on a stretcher; with it we can be quite sure the needle is in the vein when making the puncture on the operating table. I have, however, made it a rule to avoid all extra glass tubes, indicators, adapters, and wire bindings which perish the tubing, so as to minimize leakages from the system.

Regarding Dr. J. L. Griffin's method, the main disadvantages seem to be:

1. The apparatus is cumbersome to sterilize.

2. The risk of breakage opens up the question of expense and possibly difficulty in replacing the containers immediately.

3. The length of tubing necessary.

4. The U-tube method, with two containers and one drip chamber, makes it difficult to estimate the exact dose that is required immediately. There must be some delay while the saline in the tube distal to the drip is run through, and the surgeon does not wait before exciting any strong stimulus, which may not have been adequately anticipated. Again, the patient, having been placed at a required depth, will proceed to become a certain degree deeper when the saline is readmitted, from the pentothal still remaining in the tubing. This allows an error to occur in the estimation of dosage. I note, however, that Dr. Griffin uses $2\frac{1}{2}\%$ solution and analeptics, and tubing of very narrow bore; but the margin of error still remains, and can be entirely overcome by the method described below.

An Effective and Simple Method

To overcome the above disadvantages I now use a three-way tap, which is situated close to a needle of medium length to facilitate removal of the syringe. One hand turns the tap, which is easily found even if covered with towels, and the same hand injects the pentothal, which is therefore admitted almost at the site of venepuncture, thus entirely overcoming all question of dead space. At the same time the flow of saline automatically ceases, and there can be no backwash or leakage up any tubes. The third arm of the tap runs to a reserve supply of pentothal in a gallipot slung in a ring on a metal stand. This stand is clamped to the arm-rest or a table, if the leg is being used, and consists of an upright metal bar about 6 in. high, on top of which is a platform holding the metal clip from the box in which all Record syringes are supplied. The 20-c.cm. syringe rests in this, and is quite secure and out of the surgeon's way. The syringe here comes easily to the hand of the anaesthetist, who remains seated at the head. About 6 in. of narrow-bore thin-walled tubing runs from an adapter on the syringe to one arm of the three-way tap. Another arm carries the tubing from the drip bulb and bottle; a metal sinker holds the tubing in the reserve pentothal supply.

There is one slight theoretical disadvantage when using the positive-pressure technique—namely, on turning the tap to inject pentothal the drip saline continues unless the clip proximal

to the drip is turned off. This, however, requires an extra movement of the hand, with consequent delay. In practice I have never seen the drip chamber fill up during this procedure—in fact, I keep the meniscus of saline right at the bottom of the drip chamber all the time, and see no use for the employment of a side-tube and clip. Here I must admit that the turning of the three-way tap does in one motion cut off the drip in the gravity method. I insert an air filter similar to those found on the Bristol blood sets, fitted between the bellows and the saline bottle. This may hold up certain bacteria which might otherwise reach the saline.

FIG. 1

The great advantage of this method is that it is only necessary to sterilize the metal rods which pierce the rubber bung (which is encased in sterilized "cellophane"), the drip chamber, and tubing. I have these autoclaved after every operation session in which they have been used. All I need to change between cases is the needle. Bottles containing sterile normal saline are stored ready.

With this technique an accurate dose can be administered immediately with the least amount of effort or movement by the anaesthetist, and if the operating table has to be moved, all that he need move is the table on which the bottle stands, which may also be the anaesthetic machine in the case of Boyle's table model. It is important to ensure that the rubber bung, the rods piercing it, and all joints are airtight.

Strength of Solutions Used.—I see no advantage in inducing with one strength—say, 5%—and continuing with 2½%, which, as Drs. Robert and Sellick point out, only confuses the estimation of dosage. I use 5% all the time for fit cases, and 2½% all the time for weaker or shocked patients, or for longer cases with a minimum of trauma—as, for example, in the application of a plaster-of-Paris spica.

Use of Analeptics.—I consider the use of analeptics during the operation, besides predisposing towards post-operative vomiting, an admission of lack of faith in the technique: the maintenance of blood pressure, amplitude of respiration, and oxygenation must be ensured by an adequate airway and the use of oxygen and/or supplementary nitrous oxide (see below).

Technique.—In practice, pressure is raised, the bellows clip tightened, and saline run through to the three-way tap; the flow is then stopped, pentothal is run through from the syringe to the three-way tap, and the syringe is refilled from the reservoir. In the Army it has been my practice to induce all patients on the operating table with their arm outstretched and bandaged down in position on a pillow on the arm-rest. Ill patients or those with severe painful fractures are induced in their beds, the syringe being removed and a fresh puncture made when they are in position. Here the aspiration indicator would be useful, but without proper adapters I found that glass tubing with two rubber joints very quickly became leaky. As soon as induction is complete and the patient is at a depth suitable for the proposed operation the syringe is removed, the three-way adapter connected to the needle, and the saline drip begun. Pentothal is added at fairly frequent intervals at the start, in 1 to 2 c.cm. doses and, later on, at much longer intervals.

Uses and Limitations of Intermittent Pentothal and Importance of Supplementary Anaesthesia

Concerning the use of oxygen and supplementary anaesthesia, oxygen alone, except as a resuscitative measure, is not satisfactory, as very much larger doses of pentothal are required, and I aim at keeping the total dosage of that drug below 2 g. If the operation is likely to be long I always use $N_2O + O_2$ to supplement and cut down the dosage of pentothal. I do not start supplementary anaesthesia until the operation is well under way—say, 15 minutes—and the patient is well settled; then I add $N_2O + O_2$, preferably with partial rebreathing and not closed-circuit technique, and add just enough pentothal to obtain adequate relaxation and quiet breathing, and to cut out the shock stimuli from the surgical trauma. This enables the patient to move his "bases" adequately, and is of great benefit in the post-operative condition, especially of Army patients undergoing herniorrhaphy, in which "chesis" are so common after all forms of anaesthesia.

I consider operations of longer duration than 1½ hours generally to be unsuitable for pentothal, as are also those in which there is considerable surgical trauma and strong stimuli are evoked which would necessitate larger doses of the drug, causing it to produce its cumulative effects and give it the status of the long-acting barbiturates with their marked post-operative depression. I noticed this particularly in three cases recently—viz., nephrectomy (heavy stimuli and degree of relaxation required for exposure and delivery); colporrhaphy (duration of operation and surgical stimuli); colostomy (weakened condition of patient).

In my experience this form of anaesthesia is also unsuitable for abdominal explorations and for appendicectomies in robust individuals: here a spinal block, regional block, or cyclopropane is the best method of achieving the relaxation required. It is highly suitable for all orthopaedic cases of less than 1½ hours' duration—skin grafts, nerve explorations, and tendon suture operations, herniorrhaphies, Trendelenburg's operation for varicose veins, traumatic surgery, lacerations of scalp, and possibly for women and young adult "abdominals."

I have used intermittent pentothal with a saline or glucose drip for very long operations such as cholecystectomy, gastrectomy, anastomotic operations, and Gallie's herniorrhaphies performed under spinal analgesia. This may stimulate reprisals, but I would stress the fact that in these cases it is used in absolutely minimal doses simply to keep the patient asleep where control by $N_2O + O_2$ may be difficult, or where premedication is wearing off and cyclopropane is contra-indicated owing to its depressant respiratory action. For craniotomies also it may be useful when avertin is wearing off and lipid-soluble supplements to $N_2O + O_2$ are inadvisable.

Figs. 1 and 2 are diagrams of this apparatus, which has proved efficient and simple, and for which I claim no originality, since it has been culled from the numerous and varied ideas of other authors writing on the subject.

FIG. 2

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