METHODS OF INDUCING HYPOTENSION*

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THE ESSENTIAL PROBLEM in the induction of hypotension is to make the cardiovascular system too big for the amount of blood it contains. It is possible to do this by reducing the total blood volume. It is also possible to attain this end by increasing the capacity of the vascular bed, and both methods have in fact been used.

The removal of blood to cause fall in blood pressure and therefore reduction in the amount of bleeding at surgical operations, was pioneered by Gardner and Hale of Cleveland nearly ten years ago, but even prior to this time a certain number of anaesthetists had deliberately under-transfused those who had lost blood in order to minimize further bleeding. The margin of safety between safe and excessive hypotension was, however, exceedingly small, and a relatively slight additional blood loss was liable to lower the blood pressure to levels which threatened permanent impairment of renal and possibly also of cardiac function. The contribution of Gardner and Hale (1), which made induced hypotension practicable for the first time, was the introduction of arterial canulation. This allowed much more accurate control of the degree of hypotension induced and afforded a certain method of immediately restoring the blood pressure to safe levels should any manifestation of intolerance appear.

The apparatus required for this technique of hypotension is, however, complicated and difficult to maintain. Also canulation of the radial artery is occasionally followed by circulatory insufficiency and even gangrene of the finger tips, and for these and other reasons, the method, though it gave satisfactory results in the hands of those who used it frequently, was generally regarded as either too complicated or too dangerous for routine clinical use.

The second possible approach to hypotension consists in the production of widespread vasodilatation. Let me remind you for a moment of the anatomy of the vasomotor control of the blood vessels. The main governing centres of this are found in the hypothalamus. Thence the efferents run down to the vasomotor centres in the medulla oblongata and from these to a second cell station in the intermedio-lateral column of grey matter in the spinal cord. The vasomotor efferent fibres leave the cord in the white rami communicantes which run to the ganglionated sympathetic cord in the thorax and abdomen. There is another relay here and the fibres are thereafter distributed to the periphery, either in the peri-arterial sympathetic plexuses or in the named nerves.

The vasomotor mechanism is vulnerable to paralysis by drugs throughout most of its extent. Thus hypotension can be induced by the administration of chlor-

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promazine, which depresses the function of the hypothalamic centres. Vasomotor instability is a regular accompaniment of the other medullary actions of analgesic drugs, such as morphine and pethidine (Demerol®), and it is not uncommon for the blood pressure to fall when the latter of these agents is used as a supplement to nitrous oxide and oxygen in a patient whose head is raised. These types of vasomotor paralysis are, however, too incomplete and too capricious in their incidence to make their routine use feasible. There is, however, no reason why hypotension arising fortuitously from one of these causes should not be employed to minimize blood loss during a surgical operation.

If it is necessary to obtain hypotension with comparative certainty, more peripheral block of the vasomotor system is required. For this purpose Gillies (2) and his colleagues in Edinburgh developed the technique of total spinal anaesthesia—although I should also like to draw attention in this connection to the work of the Canadian anaesthetists who have used spinal anaesthesia in major chest surgery since 1936 (3), and often left the accompanying hypotension relatively untreated to minimize blood loss. I have no personal experience of deliberate induction of low blood pressure by the subarachnoid injection of local anaesthetic drugs, but it seems to me that it is probably the most certain method of obtaining this result. The great drawback to it lies partly in the neurological complications which are liable to result from the method, and even more in the medico-legal results of such complications. I refer those of you who seek technical details to the excellent papers of Gillies and his co-workers on this subject.

Probably the most popular method of inducing hypotension for surgery, is block of the transmission in the ganglia of the sympathetic chain. The passage of impulses across synapses there is mediated by acetyl choline, and it is therefore susceptible to block by quaternary ammonium compounds of suitable structure. The best-known agents for this purpose are penta- and hexamethonium (4, 5), but other substances such as pendiomid (6) and pentolinium tartrate (7) have been used for the same purpose. These drugs, however, possess several disadvantages. First, the response to them is exceedingly variable and a dose which gives virtually no result in one patient may produce alarming, if not lethal, fall in blood pressure in another. Secondly, tachyphylaxis to all these agents develops rapidly, and it is virtually impossible to give them in fractional doses until the desired effect is obtained. Thirdly, the effect of a single dose may last anything from 40 minutes to several hours. Some degree of reversal of their action can, it is true, be obtained by inverting the patient and giving methedrine, but even so a pronounced vasomotor instability will persist for some hours after the administration of agents of this type. Patients must in consequence be most carefully postured after operation, at least until pupillary dilatation is gone.

My own technique of giving hexamethonium is as follows. A test dose of 20 mg. of the drug is given and the pressure changes followed carefully over the next 10 minutes. Thereafter a second dose which varies from 20 to 100 mg. is injected. The actual amount depends on the fall in blood pressure produced by the test dose. Little additional blood pressure fall can be expected from further doses of the drug and in resistant patients either increasing the head-up

slope or deepening the anaesthetic is all that can be done to increase the amount of hypotension.

When really major hypotension is required, for example, a blood pressure of 55 mm. of mercury for the ligation or clipping of an intracranial aneurysm, hexamethonium frequently proves insufficient. Several methods of overcoming this drawback have been described. Hewer (8) has suggested simple venesection. Saunders (9) has described a sort of negative pressure plethysmograph chamber which is applied to the lower limbs. Mason and Pellmore (10) suggested the use of procaine amide as a means of reinforcing hexamethonium, and showed that it was very effective. It is, however, my opinion that procaine amide owes its action to a poisonous effect on the myocardium, and I, for one, lack the courage to inflict on my patients the combined disabilities of inadequate coronary blood flow and direct poisoning of the cardiac muscle. It is noteworthy that sudden death has followed the injection of procaine amide both in cardiological (11) and in anaesthetic practice.

A considerable advance was attained in the induction of hypotension when Arfonad became available, for this agent not merely paralyses the ganglia but also has a peripheral vasodilatator effect on the walls of the smaller blood vessels. It is thus considerably more potent and more reliable than hexamethonium. Tachyphylaxis to its action can develop, though this can usually be overwhelmed by increasing dosage. Arfonad is extremely rapidly destroyed in the body and the prolonged period of vasomotor instability which is liable to follow the administration of hexamethonium and the other ganglion blocking agents, does not appear when this substance is used.

Arfonad (12) is given by intravenous drip in saline. The strength of the solution may vary from 0.5 to 1.5 mg. per ml. depending on the probable response of the patient to the drug; it is always necessary to slow down the drip rate markedly as soon as the blood pressure begins to fall in order to avoid the danger of excessive dosage, because allowance must be made for the action of those quantities of the drug which, although already injected into the vein, have not had time to exert their therapeutic effect. This safety pause is especially necessary when the drug is being injected into the saphenous at the ankle to allow for the long circulatory path which the drug must traverse before it reaches the point of its action.

Arfonad will, however, fail occasionally in the very robust, and apart from spinal anaesthesia, there is no method which offers real certainty in such cases. The depth of the accompanying general anaesthesia profoundly modifies the action of Arfonad as of all hypotensive agents. For this reason the first manoeuvre which should be adopted to deal with the apparent development of resistance, is administration of more general anaesthetic. It is also desirable not to replace all the lost blood in a patient who is proving or seems likely to prove resistant to the drug.

Finally, there are a few other methods of inducing hypotension which may have a place, or may yet win themselves a place in anaesthesia. During the operation for the removal of a phaeochromocytoma, the administration of a ganglion blocking agent is on theoretical grounds unlikely to be of much service

in controlling the rise in blood pressure which occurs. Indeed tetra-ethyl ammonium bromide may actually precipitate a hypertensive crisis. Specific adrenergic blockers must be used. For this purpose Regitin (13), which can be given by intravenous drip, is probably to be preferred. It is possible that this form of hypotension might be adopted for use in other fields of surgery too, for it is said to be reversible by nor-adrenaline. Secondly, some preliminary work of promise has been carried out on the administration of Serpasil (14). It has been found that a patient under the influence of this drug has a vasomotor system which is somewhat unstable; in such cases the head-up posture used for the operation combined with the effect of anaesthesia on the vasomotor stability may result in hypotension. Even when the blood pressure is normal at first, a relatively small blood loss will often induce a degree of hypotension sufficient to reduce markedly the amount of haemorrhage during major intracranial surgery, although no attempt has been made to produce the extreme hypotension required for aneurysm operations by this method. Lastly, and I mention this as a curiosity, it is at least possible to induce adequate hypotension by amyl nitrite given by inhalation. I have not followed up this work because the hypotension induced was so evanescent and because after-headache is frequently severe in volunteers to whom this drug is given. It may be, however, that there is a use for brief hypotension of this kind in certain specialized fields of surgery, and I leave the suggestion to you for what it is worth.

In conclusion, there are several ways of inducing hypotension each with its own special value in particular cases. Probably the most certain method is total spinal anaesthesia but it carries the risk of neurological sequelae. The next best method is the administration of Arfonad by a drip technique. If hypotension is required only for a short period it may be felt that the use of a drip is too elaborate, and that the administration of a single dose of Arfonad, or even of one of the longer acting ganglion blockers, is preferable. The place of Regitin, Serpasil, and the nitrites in such work still remains to be determined.

RÉSUMÉ

Pour provoquer l'hypotension, la clef du problème réside dans l'augmentation de la relation entre le système cardio-vasculaire et la masse sanguine circulante. On peut l'obtenir soit en diminuant le volume sanguin total soit en augmentant la capacité du lit vasculaire. Ces deux méthodes ont été mises à l'essai.

Quand on provoque l'hypotension par la méthode d'exsanguination, on constate une très petite marge de sécurité entre une hypotension sans danger et une hypotension trop prononcée qui serait susceptible de causer des lésions irréversibles au cœur et aux reins. D'ailleurs, cette technique d'hypotension requiert un appareillage compliqué et délicat d'entretien; de plus, la canulation de l'artère radiale, nécessaire pour un contrôle adéquat de l'hypotension, est parfois suivie de gangrène.

La deuxième méthode de provoquer l'hypotension consiste à produire une vasodilatation généralisée. Au moyen de certains agents, on peut paralyser le système vaso-moteur dans presque toute sa totalité. C'est ainsi qu'on peut produire l'hypotension en administrant du chlorpromazine qui déprime les

fonctions des centres hypothalamiques et possède également une action sur la moelle à l'égal d'agents analgésiques comme la morphine et le Démérol. On obtient une hypotension plus complète, cependant, par le blocage périphérique du système vaso-moteur. Pour y parvenir, on peut employer la technique de la rachianesthésie totale, mise à point par Gillies, ou cette méthode plus populaire qui consiste à bloquer les ganglions de la chaîne sympathique par des agents tels que l'hexaméthonium et l'Arfonad. Voici la technique d'administration de l'hexaméthonium telle que préconisée par l'auteur: on donne une première dose de 20 mg. suivie d'une deuxième, 10 minutes plus tard, qui varie de 90 à 100 mg. suivant la chute de la pression artérielle entraînée par la dose initiale.

L'Arfonad est un agent beaucoup plus puissant et plus sûr que l'hexaméthonium; on l'administre par voie I V., dans un sérum salé, en goutte à goutte, à une concentration qui varie de 0.5 à 1.5 mg. par cc., suivant la susceptibilité anticipée du patient à l'égard de cet agent. Une tachyphylaxie à l'Arfonad peut se produire. L'Arfonad est rapidement détruit dans l'organisme.

Chez des patients qui résistent à l'action de l'Arfonad ou de l'hexaméthonium, l'administration d'une plus grande quantité d'anesthésiques généraux ou l'abstention de donner une transfusion sanguine peuvent aggraver l'hypotension.

On peut employer la Régitine pour contrôler l'hypertension qui se produit au cours des opérations pour phéochromocytomes. On a déjà fait certains travaux préliminaires sur l'emploi du Serpasil.

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