GENERAL anaesthetic drugs are believed to have little effect on the peripheral nerves (Hewer, 1953). On the other hand, some anaesthetics, e.g. diethyl ether, are reputed to have a peripheral curare-like action (Gross and Cullen, 1943). It became necessary in the course of other work, to re-examine this position.

It was thought that a suitable test for peripheral blocking action would be provided by observing an alteration in the response of muscles to electrical stimulation of the nerve supplying them. Patients received one of two anaesthetic mixtures; either pethidine/thiopentone/nitrous oxide, or nitrous oxide/ether.

TECHNIQUE

Electrical stimulation was applied by a surface electrode to the ulnar nerve at the elbow. A low-frequency stimulator of conventional design was used, giving one-millisecond impulses at a selected rate. As it was desired to compare the anaesthetized with the unanaesthetized state, the first series of experiments was designed to determine the minimal voltage at which a twitch could be elicited in the supplied muscles using single shocks. With pethidine/thiopentone/nitrous oxide, this involved only two observations, one made with the patient conscious and one after the induction of anaesthesia. With nitrous oxide/ether additional observations were made in each plane of anaesthesia attained. The planes of anaesthesia were judged clinically.

In a second series of experiments the ability of the muscles supplied by the ulnar nerve to maintain a tetanus imposed by applying 16 impulses/second for about 5 seconds was assessed. There was some difficulty in evolving a suitable form of apparatus for demonstrating maintained tetanus. Three types of apparatus were tested.

(1) A large rubber ball lay between the palm of the hand and a modified "cock-up" splint. Contraction of the muscles supplied by the ulnar nerve caused an increase of pressure in the bulb. This pressure-change was transmitted to a second tambour, which carried a lever writing on a kymograph. The tambours were partially inflated at the outset with a sphygmomanometer bulb (figs. 1, 1A).

(2) Flexion of the little finger was arranged to compress an inflated tambour. The pressure-change was transmitted to a second tambour, which carried a lever writing on a kymograph. The tambours were partially inflated at the outset with a sphygmomanometer bulb (figs. 1, 1A). This apparatus was an improvement on the preceding one. However, it was not easy to show more than a certain range
Experimental set-up showing second form of apparatus. Electrical shocks are conveyed from the stimulator to the ulnar nerve. Contraction of the little finger causes an increase of pressure in the tambour carried on the back of the forearm. This pressure is carried to a second tambour which, by means of a lever, writes on a drum.

FIG. 1a
Detail from above.
of movement, and there was sometimes a certain asymmetry in the transmission of pressure from one tambour to the other.

(3) With the third apparatus the movement produced by flexion of the little finger was transmitted by a piano-wire running in a flexible metal sheath directly to a lever which produced deflections recorded on a kymograph drum (fig. 2). Movement of the wire was opposed by a cylindrical compression-spring. The apparatus was so constructed that different strengths of compression-spring could be inserted. By arranging the kymograph on the floor, so that the wire was reasonably straight, frictional effects could be reduced until they appeared to be unimportant.

With all these forms of apparatus used in the recording of tetanic contractions, supramaximal stimulation was used. It follows that no observations could be made when the patient was conscious. Observations with the pethidine/thio-

![Fig. 2](image_url)

The third form of apparatus used. The little finger is fastened by adhesive tape to the long lever carried on the fore-arm. Contraction of the finger moves the piano-wire to produce movement of the second lever, which writes on a drum. The movement of the finger is opposed by a cylindrical compression-spring.
pentone/nitrous oxide patients were therefore restricted to showing whether sustained tetanus was possible after induction of anaesthesia. With the nitrous oxide/ether patients, observations could be made in each plane of anaesthesia attained.

RESULTS

First series. Fifteen patients were given pethidine/thiopentone/nitrous oxide. There was no significant alteration in the voltage at which it was possible to elicit a minimal response before and after establishment of anaesthesia.

Twelve patients were anaesthetized with nitrous oxide/ether. It was thought justifiable to proceed to the third plane of third stage anaesthesia in ten of these patients. The fourth plane was attained in five of the patients. A slight rise in threshold to stimulation occurred in five patients in third plane anaesthesia, and a further slight rise took place in two of the patients in fourth plane anaesthesia. Such inconclusive results were highly unsatisfactory. In addition, there was a clinical impression of a decrease in the response to stimulation in the deeper planes of anaesthesia. Though an attempt was always made to obtain the minimal response of the supplied muscles, the response in the deeper planes of anaesthesia was less vigorous than in the earlier planes. The second series of experiments was designed to test the truth of this impression.

Second series. Another fifteen patients were given pethidine/thiopentone/nitrous oxide. All these patients were able to maintain tetanic contraction after the induction of anaesthesia. There was no falling-off in the amplitude of contraction when the burst of impulses was maintained for five seconds or more.

Twenty-two patients were also anaes-
RESPONSE TO STIMULATION OF THE ULNAR NERVE

thetized with nitrous oxide/ether. These patients were also able to maintain tetanic contraction during long bursts of stimuli. When using the second form of apparatus it was at first thought that there was some diminution in the force of contraction in the deeper planes of ether anaesthesia—shown by a decreased deflection in these planes. Subsequent experience attributed such an effect to a change in the baseline. The last fourteen patients were all tested with the third form of apparatus, and in no case was there any convincing decrease in the deflection in the deeper planes of ether anaesthesia. Two sample records are shown (figs. 3, 4). In figure 3 it will be noted that a minor instrumental fault had developed, so that in some deflections the up-stroke has not returned immediately to the base-line. This, however, does not affect the validity of the observation that not only is tetanus maintained, but there is no significant decrease in the total deflection produced in the deeper planes of ether anaesthesia.

**DISCUSSION**

Gross and Cullen found that the contraction of the gastrocnemius muscle elicited in the dog either by intra-arterially injected acetylcholine, or by electrical stimulation of the nerve, is less in dogs anaesthetized with ether, tribromethanol, or thiopentone, than in dogs anaesthetized with cyclopropane or ethylene. This effect of ether has been attributed to a curare-like action. Paton and Zaimis (1952) stated that a muscle partially paralysed with d-tubocurarine cannot maintain tetanus at its initial strength—that is to say it may begin a powerful contraction but this falls off rapidly. If we attribute a curare-like action to ether we might expect a difficulty in maintaining tetanus in the deeper plane of ether anaesthesia.

Clinically there is no doubt that ether does potentiate the action of d-tubocurarine. The results reported here, however, show that even deep anaesthesia with ether, given for short periods, does not produce a peripheral blocking action in man, presumably because the more susceptible parts of the nervous system are affected first. It is possible that a peripheral blocking action would appear if a deep level of anaesthesia were maintained but it was not considered justifiable to test this hypothesis.

There is no evidence of a peripheral blocking action in relation to thiopentone either. It was not possible to test this other than by alteration in the threshold of response to stimulation, and by showing that the muscles could maintain tetanus during anaesthesia. It seems likely that any peripheral blocking action which may

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**Fig. 4**

occur in man will appear only in very high dosage.

SUMMARY

Thirty patients were given pethidine/thiopentone/nitrous oxide. Thirty-four patients were given nitrous oxide/ether. All patients were tested with electrical stimuli applied to the ulnar nerve to determine either; (1) the minimal level of stimulation at which a twitch could be elicited in the supplied muscles; or (2) whether tetanus could be maintained after induction of anaesthesia, and at different levels of anaesthesia, where this was applicable.

It was concluded that there was no satisfactory evidence for any peripheral blocking action during the induction of a deep level of ether anaesthesia or during anaesthesia with pethidine/thiopentone/nitrous oxide.

ACKNOWLEDGMENTS

I wish to acknowledge my indebtedness to Dr. H. H. Pinkerton of the Department of Anaesthetics, Western Infirmary, for his encouragement; to Dr. A. G. Miller, also of the Department, for his ready co-operation; to Dr. R. Taylor for a helpful suggestion incorporated in the apparatus finally evolved. I am indebted to Professor C. F. W. Illingworth for granting me the facilities of the Department of Surgery; to his surgical staff for their forbearance; to his technical staff for their help, including the production of the illustrations. I am indebted to Dr. T. D. M. Roberts of the Institute of Physiology, University of Glasgow, for designing the apparatus shown in figure 1, and for making available the stimulator; to T. E. Hotham and A. Macdonald of the Western Infirmary workshop, for designing the apparatus shown in figure 2, and for making both forms of apparatus.

REFERENCES


ADDENDUM

My attention has been drawn to an important paper on this subject by Poulsén and Secher, 1949 (Poulsen, T., and Secher, O., Acta. Pharmacol., 5, 196). By experimental work on rabbits, Poulsen and Secher show that there is a peripheral curare-like action exerted by ether, that this takes some time to develop, and that the effect is more marked on the response to single shocks than on the response to tetanizing shocks. This might be taken to explain both the clinical impression in some cases of a less vigorous response to single shocks in deep ether anaesthesia, and the absence of a demonstrable effect when tetanizing shocks were applied during the induction of deep anaesthesia.