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BLOOD-PRESSURE RESPONSES TO ELECTRICAL STIMULATION OF THE CAROTID SINUS NERVE IN DOGS AND RABBITS

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The present authors have recently reported the effects of electrical stimulation of the carotid sinus nerve in cats (Neil, Redwood & Schweitzer, 1948, 1949). Stimulation of the carotid sinus nerve in these animals was found to produce blood-pressure responses which were dependent on the anaesthetic and on the type of stimulus employed. Thus, under chloralose anaesthesia, rectangular wave stimulation of the nerve with pulses of short duration (0·05–0·1 msec.) resulted in marked rises in arterial blood pressure. Pulses of longer duration (0·5–1·0 msec.) usually produced a rise in blood pressure but occasionally depressor responses were observed. Under nembutal (pentobarbital sodium) anaesthesia, however, or in decerebrate cats stimulation of the sinus nerve invariably lowered the blood pressure irrespective of the pulse duration of the stimulus employed.

Analysis of these phenomena suggested that chloralose anaesthesia diminishes the sensitivity of the vasomotor centre to baroceptor stimulation. Some evidence was also found that the sensitivity of the baroceptors of the carotid sinus to changes of intrasinusal pressure was diminished by chloralose. It was concluded that the pressor responses to electrical stimulation of the carotid sinus nerve trunk in cats under chloralose anaesthesia was due to excitation of the chemoceptor component of the nerve.

This study has been extended in an attempt to ascertain whether chloralose anaesthesia causes a similar modification of the response to carotid sinus nerve stimulation in rabbits and in dogs. In view of the position of chloralose as the anaesthetic of choice in the study of vasomotor phenomena it is of importance to exclude effects directly attributable to the anaesthetic used.

METHODS

Fourteen rabbits and nine dogs were used in these experiments. The animals were anaesthetized with chloralose (0·08–0·1 g./kg. body weight intravenously) or nembutal (Pentobarbitone) (35–40 g./kg. body weight, intraperitoneally).

The carotid sinus nerve was prepared for stimulation as previously described. Fine shielded silver wire electrodes mounted in perspex were used for stimulation of the nerve. In most experiments a rectangular wave electronic stimulator was used which allowed independent variations of frequency of stimulation (1·5–1000 cyc./sec.), pulse duration (0·02–100 msec.), and voltage output (1–100 V.). In some experiments an ordinary induction coil was used. The carotid sinus nerve was stimulated for periods of 20–30 sec.

Blood pressure was recorded from the femoral artery. Heparin was used in some experiments as an anticoagulant.

RESULTS

Electrical stimulation of the carotid sinus nerve in rabbits. In all experiments, stimulation of the carotid sinus nerve in rabbits under chloralose anaesthesia, using the rectangular wave stimulator (100 cyc./sec., 0·05–1·0 msec., 2 V.)

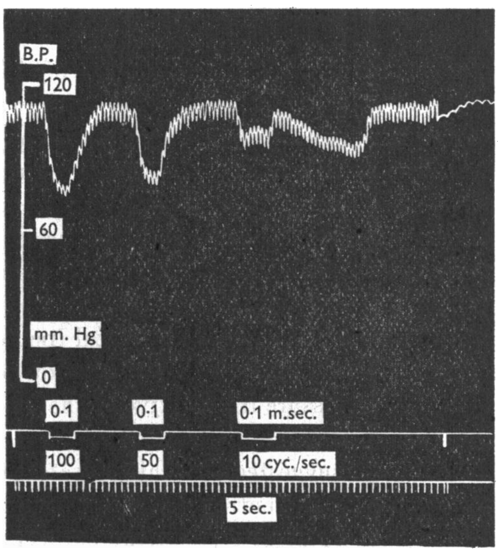

Fig. 1. Rabbit under chloralose anaesthesia. Records from above downwards: blood pressure, signal, time in 5 sec. left sinus denervated, left vagus cut. Stimulation of right carotid sinus nerve with 100, 50 and 10 cyc./sec., 0·1 msec. pulse duration and 2 V. Note absence of pressor responses.

produced a marked fall in arterial blood pressure. Induction coil stimulation of the nerve yielded similar results. Bilateral vagotomy and contralateral sinus nerve section did not affect the direction of the blood-pressure response to sinus nerve stimulation.

In a number of experiments the frequency of stimulation was altered, voltage and pulse duration being maintained constant (2 V., 0·1 msec.). The threshold frequency of stimulation was found to be 10 cyc./sec. Increase of the cycle frequency only intensified the fall in arterial blood pressure (Fig. 1).

In other experiments the duration of the stimulus was varied (0·05–2·0 msec.) frequency of discharge and voltage being kept constant (100 cyc./sec. and 2 V.). In each case a fall of blood pressure resulted from stimulation of the carotid sinus nerve (Fig. 2). This is in contrast to our previous observations in cats (Neil, *et al.* 1948, 1949). These experiments were repeated using rabbits under nembutal anaesthesia. The results were in no way different from those already described. Moreover, the intravenous injection of 0·1 g. of chloralose into such animals did not modify the blood-pressure response to sinus-nerve stimulation.

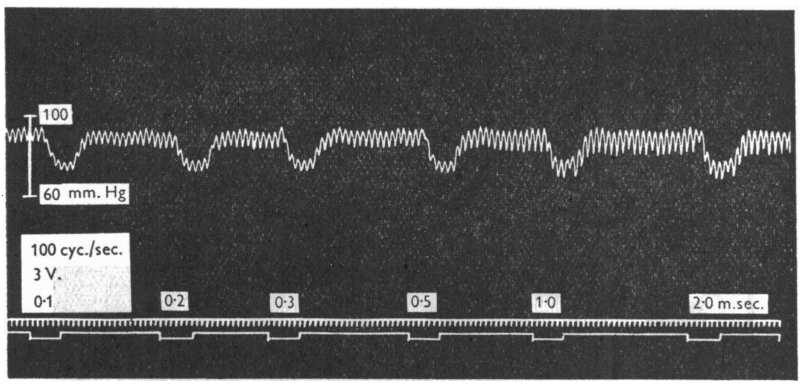

Fig. 2. Rabbit under chloralose anaesthesia. Records from above downwards: blood pressure, time in 5 sec., signal. Stimulation of right carotid sinus nerve with 3 V., 100 cyc./sec. and 0·1, 0·2, 0·3, 0·5, 1·0 and 2·0 msec. pulse duration. Note absence of pressor responses.

Electrical stimulation of the carotid sinus nerve in dogs. In dogs under chloralose anaesthesia, stimulation of the carotid sinus nerve, using the rectangular wave stimulator or induction coil, invariably produced a fall in arterial blood pressure. This response was obtained with all frequencies of stimulation used (10–100 cyc./sec.) and in no instance did a change in the pulse duration of the stimuli (0·05–1·0 msec.) affect the direction of the blood-pressure response (Fig. 3).

Similarly, stimulation of the carotid sinus nerve in dogs under nembutal anaesthesia produced a fall in arterial blood pressure, irrespective of the frequency and pulse duration of the stimuli, providing that threshold values of 10 cyc./sec. pulse frequency and 0·05 msec. pulse duration were exceeded (Fig. 4).

Neil *et al.* (1948, 1949) have previously reported that intravenous injection of chloralose into nembutalized cats causes a reversal of the depressor response to carotid sinus-nerve stimulation, marked rises of blood pressure being thus obtained.

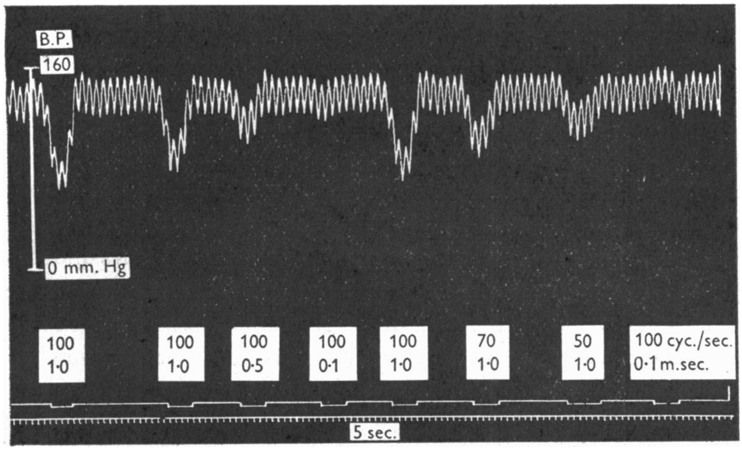

Fig. 3. Dog under chloralose anaesthesia. Records from above downwards: blood pressure, signal, time in 5 sec. Both vagi cut, left carotid sinus denervated. Right carotid sinus nerve stimulated with constant voltage 2 V. and varying pulse duration and frequency.

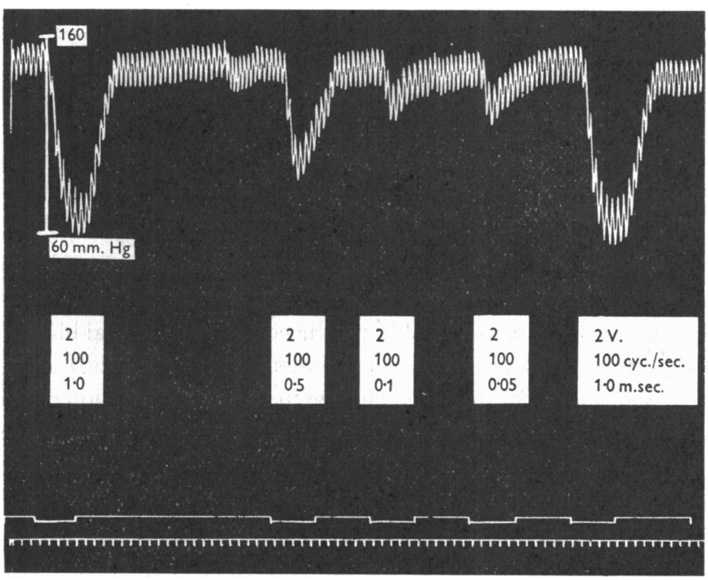

Fig. 4. Dog under nembutal anaesthesia. Records from above downwards; blood pressure, signal, time in 5 sec. Left carotid sinus denervated. Stimulation of right carotid sinus nerve with 2 V. 100 cyc./sec., and 1·0, 0·5, 0·1, 0·05 and 1·0 msec. pulse duration. Extent of blood-pressure fall varies with pulse duration.

These experiments were repeated in dogs. Fig. 5*a* shows typical results of responses to carotid sinus-nerve stimulation, using stimuli of varying pulse durations with constant frequency and voltage in a dog under nembutal anaesthesia. Fig. 5*b* was obtained from the same animal, 30 min. after the intravenous injection of 0·3 g. of chloralose. The responses to stimulation of the sinus nerve using identical variations of pulse duration can be seen to be unchanged.

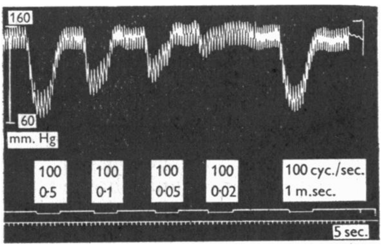

Fig. 5 *a*.

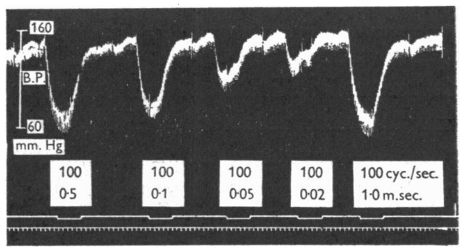

Fig. 5 *b*.

Fig. 5*a*. Dog under nembutal anaesthesia. Records as in Fig. 4. Stimulation of right carotid sinus nerve with 2 V., 100 cyc./sec. and 0·5, 0·1, 0·05, 0·02 and 1·0 msec. pulse duration.

Fig. 5*b*. Continuation of Fig. 5 *a*. 30 min. after intravenous injection of 0·3 g. of chloralose. Stimulation of right carotid sinus nerve with 2 V., 100 cyc./sec., and 0·5, 0·1, 0·05, 0·02 and 1·0 msec. pulse duration. Note absence of pressor responses.

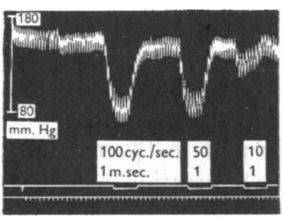

Fig. 6 *a*.

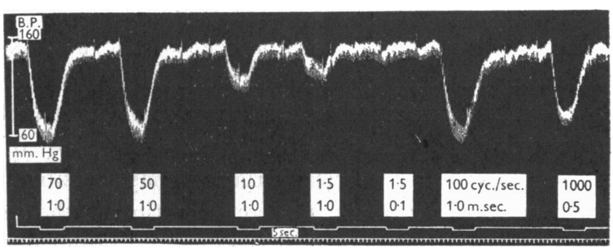

Fig. 6 *b*.

Fig. 6*a*. Dog under nembutal anaesthesia. Records as in Fig. 4. Stimulation of right carotid sinus nerve with 2 V., 1·0 msec. pulse duration and 100, 50 and 10 cyc./sec.

Fig. 6*b*. Continuation of Fig. 6*a*. 30 min. after intravenous injection of 0·3 g. of chloralose. Stimulation of right carotid sinus nerve with 2 V. and 70, 50, 10 and 1·5 cyc./sec. with 1·0 msec. pulse duration, followed by 1·5 cyc./sec. and 0·1 msec., 100 cyc./sec. and 1·0 msec. and 1000 cyc./sec. and 0·5 msec. pulse duration. No evidence of pressor response.

Figs. 6*a*, *b* show the responses to sinus-nerve stimulations using stimuli of varying frequencies with constant voltage and pulse duration, in a nembutalized dog, before and 30 min. after the intravenous injection of 0·3 g. chloralose. Again the blood-pressure responses to stimulation of the nerve are unaltered.

DISCUSSION

The carotid sinus nerve trunk contains afferent fibres from both the baroceptor and chemoceptor regions of the carotid bifurcation area. It is well known that excitation of the baroceptor mechanism by increasing the intrasinusal pressure produces a marked fall in the arterial blood pressure. Furthermore, activation of the chemoceptors by changes in blood composition causes a rise in blood pressure. Results of electrical stimulation of the nerve trunk, however, using stimuli of well-defined characteristics, have not been previously reported.

In cats, under chloralose anaesthesia, the authors have previously shown that electrical stimulation usually causes a rise in arterial blood pressure. This is in contrast to the results of such stimulation in decerebrate cats or in cats under nembutal anaesthesia in which depressor responses are obtained. It was further shown that injection of chloralose in decerebrate or nembutalized cats reverses such depressor responses. Analysis of these phenomena showed that chloralose diminished the sensitivity of the vasomotor centre to baroceptor stimulation in addition to decreasing the excitability of the baroceptors themselves. Stimulation of the nerve trunk was thus considered to produce a rise of blood pressure by activating the chemoceptor component.

The present investigation has been carried out in order to see whether similar findings could be obtained in rabbits and dogs. No evidence has been found, in these animals that chloralose causes any modification of blood-pressure response to carotid sinus-nerve stimulation. In all circumstances a depressor response to electrical stimulation of the sinus nerve was obtained, indicating that the effects of baroceptor fibre stimulation are predominant over those of chemoceptor fibre stimulation. It was not possible to differentiate between the baroceptor and chemoceptor components of the sinus-nerve trunk by varying the pulse duration or pulse frequency of the stimuli used.

This interesting species variation may possibly be related to the marked anatomical difference in the configuration of the carotid bifurcation between the cat on the one hand and the dog and rabbit on the other. In the cat, the internal carotid artery is extremely small and functionally unimportant (Davis & Story, 1943). In the dog and rabbit, however, the internal carotid artery is of notable size and would appear to be of greater functional importance.

SUMMARY

1. Electrical stimulation of the carotid sinus-nerve trunk in rabbits and dogs under chloralose and nembutal anaesthesia, using a rectangular wave electronic stimulator or an induction coil, produced marked depression of the arterial blood pressure.

2. Variation in frequency and in pulse duration of the stimuli did not alter the direction of the blood-pressure response.

3. Injection of chloralose into nembutalized rabbits and dogs did not modify the nature of the blood-pressure response to electrical stimulation of the sinus nerve.

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