CARDIO-RESPIRATORY EFFECTS OF PASSING POLARIZING CURRENT TO THE CEREBRAL CORTEX OF RATS*

By

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Lippold and Redfearn (5) observed various mental changes when polarizing current was passed through the human brain. Bindman, Lippold and Redfearn (1, 3) studied the effect of passing brief polarizing currents to the cerebal cortex of rat. This work was undertaken to study the effect on the heart as well as on the respiratory rates, of passing polarizing current to the cerebral cortex of rat.

MATERIALS AND METHODS

Experimental animals : Sixty one alibino-rats, each weighing about 200-500*g* were used. They were anaesthetised with 36% urethane (0.5*ml*/100*g* body wt) injected intraperitoneally. The primary sensory area was exposed by making trephine hole about 4*mm* in diameter on the skull. A polythene cup, as described by Bindman, Lippold and Redfearn (2) was attached to the skull. The body temperature was maintained at 37°C±2°C with a 12V heater controlled by a thermistor in the rectum.

Electrodes : Agar-gel wick electrodes were used for passing the polarizing current. They were prepared from polythene tube which was drawn into a pipette of about 6*cm* in length, having a tip diameter of about 1*mm*. A cotton wick, about 2*cm* long, was inserted into this pipette so that part of it remained protruded out of the tip. This pipette was filled with hot agar-gel solution prepared in saturated saline, taking care to avoid air bubbles entering into the pipette. A piece of coiled chlorided silver wire was introduced into the agar-gel portion of the pipette, opposite the tip. This electrode, thus prepared was allowed to cool and was stored in concentrated saline solution, with its tip dipped in it, till used.

Electrical recording : The chest leads were recorded by connecting them to a Cossor oscillos cope through a preamplifier. Respiration was recorded with the help of a thermister put infront of the nostrils of the rat, and was connected to the oscilloscope. EKG and respiratory rate were projected on to the separate sweeps of the oscilloscope and could be viewed on the fluroscopic screen and be photographed whenever desired. To get an exact idea of

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timings, leads from an electronic timer were also connected to tthe sweep recording the respiration.

In order to determine the optimum response of the polarizing currents, experiments were conducted by placing electrodes as given below : (1) cortex (in the centre of the polytheme cup) and neck, (2) cortex and tail, (3) neck and abdomen, (4) neck and tail, and (5) abdomen and tail. The former has been the stimulating, and the latter, the indifferent, electrode in all cases. The optimum effect was obtained in position (1), hence all experiments were performed keeping the stimulating electrode on the cortex and the indifferent electrode on the neck muscles. Polarizing current of known amplitude was passed to cerebral cortex of rat through the non-polarizable electrodes. Heart and respiratory rates were recorded every 15 minutes for 2 hours before, during and after passing the current.

RESULTS

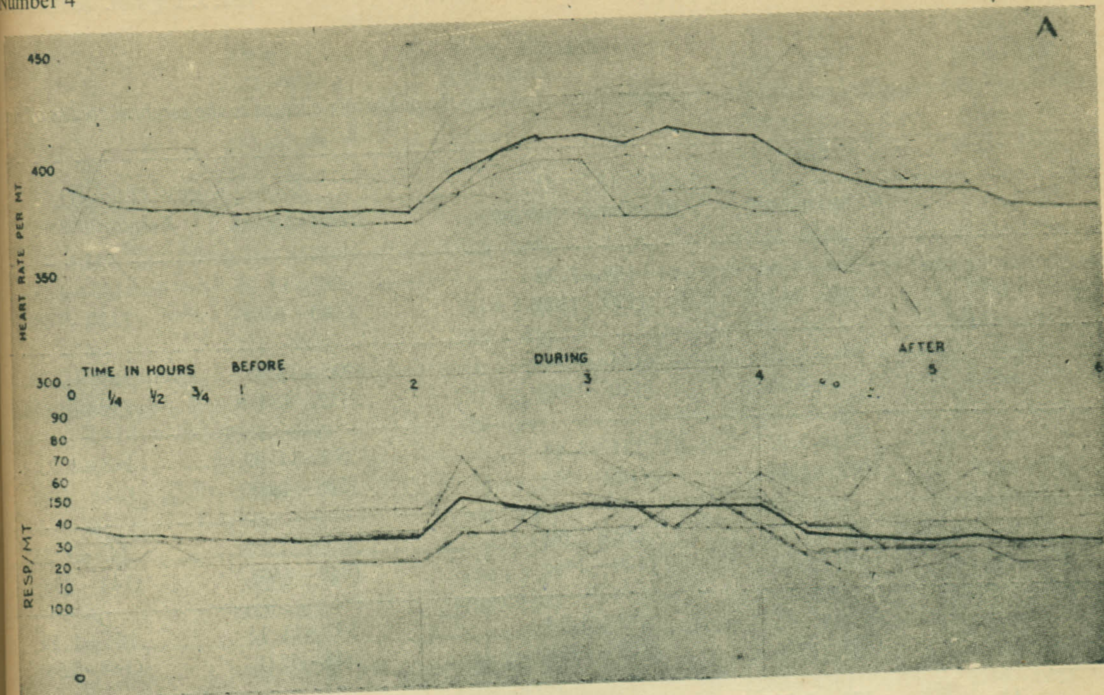
Surface-nagative current of 1.5 mA was found to be effective maximally, as attempts to raise it further proved to be fatal to the animal. It accelerated the heart as well as the respiratory rates (Fig. lA, Table 1). Surface-positive current of 2 mA could be tolerated well by the animal and produced the opposite effects (Fig. 1B, Table 1). Under both these conditions (Table I), variations in the heart rate were quite obvious as compared to the variations observed in the respiratory rate.

DISCUSSION

Passage of direct current produces changes in the electrical activity of the nervous tissue. Lippold *et al* (4) reported that depolarization of nerve terminals in muscle spindles increased the rate of discharge of nerve impulses while hyperpolarization decreased the frequency of discharge. Bindman, Lippold and Redfearn (1) also studied the effect of polarizing the cerebral cortex in rats and discovered that surface-positive polarization raised the firing rate of neurones while the serface-negative polarization reduced or completely inhibited it. Present studies indicated that the passage of surface-positive current to the cerebral cortex of rats resulted in depression of the cardio-respiratory activity (Fig. 1B), and the surface-negative current had the opposite effect (Fig. lA). This can be explained in the light of the previous findings (1, 4). As surface-positive polarization produced an increase in the firing rate of the cortical neurones which normally exert inhibitory control on the lower centres, so it had further enhanced this inhibitory influence and thus brought about the diminution in the cardio-respiratory rate. In a similar way surface-negative polarization had depressed the tonic inhibitory influence of the higher centers due to decrease in the firing rate of the cortical neurones, and thus had enhanced the cardiac as well as the respiratory rates.

SUMMARY

1. Effect of passing polarizing current to the cerebral cortex of rats, on their heart and respiratory rates have been studied.



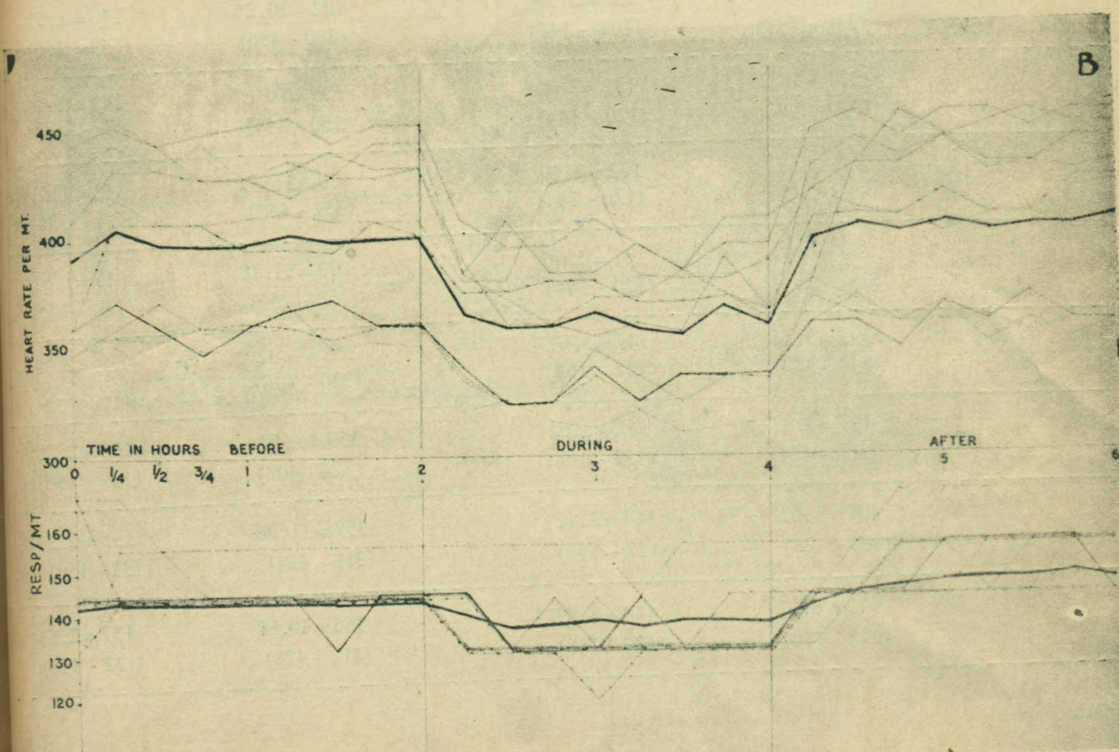


Fig. 1

Effect of passing (A) surface-negative current (1.5 mA), and (B) surface-positive current (2 mA) to the cerebral cortex

TABLE I

Effect on the heart and the respiratory rates of passing the polarizing current to the cerebral cortex of rats.

Time in hours	*Surface-negative* (1.5*mA*)		*Surface-positive* (2.0*mA*)	
	Heart rate/mt	*Respiratory rate/mt*	*Heart rate/mt*	*Respirator rate/mt*
Before passing current 0	394 ± 8.84 (348 - 432)	139 ± 7.24 (120 - 192)	392 ± 13.25 (340 - 456)	145 ± 4.30 (120 - 168)
¼	384 ± 5.11 (360 - 408)	134 ± 4.74 (120 - 168)	405 ± 12.49 (352 - 456)	148 ± 2.39 (144 - 168)
½	381 ± 5.95 (366 - 408)	134 ± 2.84 (120 - 156)	399 ± 11.99 (338 - 444)	148 ± 1.73 (144 - 156)
¾	380 ± 6.35 (330 - 408)	132 ± 2.80 (120 - 144)	398 ± 11.96 (348 - 448)	146 ± 1.51 (144 - 156)
1	377 ± 4.67 (336 - 394)	133 ± 3.14 (120 - 144)	397 ± 11.15 (348 - 452)	146 ± 1.51 (144 - 156)
1¼	379 ± 5.01 (336 - 394)	130 ± 3.59 (108 - 144)	402 ± 10.26 (360 - 456)	146 ± 1.51 (144 - 156)
1½	377 ± 4.82 (340 - 396)	131 ± 2.66 (120 - 144)	399 ± 10.67 (350 - 444)	145 ± 2.04 (132 - 156)
1¾	378 ± 4.62 (342 - 396)	132 ± 2.40 (120 - 144)	400 ± 11.69 (352 - 452)	146 ± 1.51 (144 - 156)
2	377 ± 5.03 (335 - 395)	131 ± 2.66 (120 - 144)	400 ± 11.78 (350 - 452)	146 ± 1.51 (144 - 156)
During passing current 2¼	393 ± 6.24 (348 - 420)	147 ± 3.67 (132 - 168)	365 ± 8.92 (320 - 408)	139 ± 2.00 (132 - 156)
2½	401 ± 5.87 (360 - 424)	145 ± 3.62 (132 - 168)	359 ± 9.50 (324 - 408)	134 ± 2.28 (132 - 156)
2¾	407 ± 6.62 (360 - 428)	144 ± 3.42 (132 - 168)	359 ± 11.08 (315 - 424)	135 ± 2.39 (132 - 156)
3	410 ± 6.32 (372 - 430)	140 ± 3.87 (120 - 168)	366 ± 10.54 (312 - 428)	137 ± 2.51 (132 - 156)

3¼	406±7.35 (372—432)	144±3.39 (132—168)	358±8.97 (320—396)	134±2.28 (120—144)
3½	411±7.06 (372—432)	143±3.13 (132—156)	369±9.24 (312—408)	136±2.39 (132—156)
3¾	409±6.35 (378—432)	141±2.51 (132—156)	360±9.09 (315—408)	136±2.39 (132—156)
4	408±7.03 (372—432)	141±3.03 (132—156)	394±7.25 (362—445)	136±2.39 (132—156)
After passing current 4¼	394±7.28 (360—448)	127±2.51 (120—144)	398±8.65 (360—448)	143±1.73 (132—156)
4½	388±7.45 (342—420)	126±3.16 (108—144)	405±10.80 (360—456)	128±1.73 (144—156)
4¾	382±5.34 (348—408)	124±5.11 (108—168)	401±12.24 (348—456)	152±2.39 (144—168)
5	381±5.92 (336—408)	123±3.13 (108—132)	406±11.90 (360—456)	154±2.84 (144—168)
5¼	381±4.69 (340—396)	125±4.23 (108—156)	401±12.12 (350—456)	155±2.71 (144—168)
5½	373±4.17 (336—384)..	122±3.00 (108—144)	404±11.34 (354—456)	155±2.04 (144—168)
5¾	372±4.67 (336—384)	123±3.13 (108—144)	404±12.63 (352—456)	157±2.04 (144—168)
6	373±4.04 (348—390)	121±3.13 (108—144)	407±12.38 (360—456)	155±2.71 (144—168)

Figures are Mean±S.E., figures in parentheses indicate range.

2. Surface-positive current (2 mA) produced a depression in the cardio-respiratory activity, and the surface-negative current (1.5 mA) showed the opposite effects.

3. These changes seemed to be due to the fact that higher centers exert a tonic inhibitory influence on the lower centers. As surface-positive polarization increased the firing rate of the cortical neurones, thereby augmenting their inhibitory effect which had brought about the depression in cardio-respiratory activity. Surface-negative polarization yielded the opposite effects.

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