THE EFFECT OF ANESTHESIA ON SCALP POTENTIAL *

W. E. Burge, Ph.D.
Urbana, Illinois

The motor area of one side of the brain of an etherized dog was exposed by removing the overlying skull. The scalp over the motor area of the opposite side of the brain was shaved. A small portion of the gastrocnemius muscle of the hind leg of the dog was exposed by clipping off a piece of the overlying skin.

Two nonpolarizable electrodes were connected by wires to a Leeds and Northrup type K potentiometer. One of these electrodes was attached permanently to the gastrocnemius muscle, which served as a point of reference, while the other electrode was placed alternately on the shaved scalp and on the exposed brain cortex.

When the dogs were lightly anesthetized, the scalp was found to be weakly positive and the brain cortex strongly negative to the gastrocnemius muscle. The results in 10 dogs chosen at random from a series of 50 dogs used in this investigation are shown in table 1. It will be seen that the average positive potential for the scalp of the 10 lightly

TABLE 1

Scalp and Brain Potentials in 10 Dogs

Dog	Scalp Potential in Millivolts	Brain Potential in Millivolts
1	+1	−11
2	+2	−25
3	+1	− 8
4	+4	−14
5	+2	−16
6	+1	−12
7	+2	−22
8	+4	−16
9	−1	−10
10	+3	−10
Average	+1.9	−15.2

Ratio 1.9 to 15.2 or 1 to 8

anesthetized dogs was 1.9 millivolts, and the average negative potential of the brain cortex was 15.2 millivolts, making a 1.9 to 15.2 or a 1 to 8 ratio between scalp potential and brain potential.

When the depth of anesthesia of the lightly anesthetized dogs was increased, both the positive potential of the scalp and the negative potential of the underlying brain cortex fell, and in deep surgical

* From the Department of Physiology, University of Illinois, Urbana, Ill.

anesthesia both approached the zero level. In profound narcosis there was a reversal in polarity in most of the dogs, the scalp becoming slightly negative and the brain cortex positive to the gastrocnemius muscle.

Upon discontinuing the anesthesia the polarity was again reversed, the scalp becoming positive and the brain cortex negative to the gastrocnemius muscle, the point of reference. With further recovery from the anesthetic, not sufficient, however, for the dogs to feel pain, the positive potential of the scalp and the negative potential of the underlying brain cortex rose and continued to rise until it reached its previous high level.

From the preceding it will be seen that scalp potential fluctuated with cortical potential with varying depths of anesthesia so that scalp potential may be used as an index to brain potential. An increase in the positive potential of the scalp during recovery from anesthesia indicates a rise in the negative potential of the underlying brain cortex, and a decrease in the positive potential of the scalp with an increase in the depth of anesthesia indicates a fall in the negative potential of the underlying brain cortex.

Furthermore, since scalp potential bears a 1 to 8 ratio to brain potential, a fall in the positive potential of the scalp of 1 millivolt indicates a corresponding fall of 8 millivolts in the underlying brain cortex. This parallel fluctuation of scalp and cortical potential makes it possible to study brain potential without exposing the brain cortex.

In another connection we have studied scalp potential of the goldfish and of the human in relation to physical activity and rest. The goldfish was placed in water in a cylindrical glass vessel between two platinized platinum disk electrodes and the electrodes were connected by wires with a galvanometer. When in swimming around the fish brought its head near one of the electrodes and its tail near the other, the deflection of the beam of light on the galvanometer scale was in such direction as to indicate that the head of the fish was positive and its tail negative. When the fish reversed its position in the chamber, bringing its head near the opposite electrode, a reversal in the direction of the current occurred, indicated by a reversal in the direction of the deflection of the beam of light on the galvanometer scale. The strength of this current rose with an increase in the activity of the fish and fell with a decrease in its activity. These observations show that the head of the goldfish, like the scalp of the dog, is positive. They also confirm in the goldfish an observation made by Michael Faraday on the electric eel a little more than a century ago, namely, that the head of the eel was positive to the posterior portions of the body.

In studying the scalp potential of the human a platinum disk electrode 1 cm. in diameter was attached to the forehead as near over the motor area as the receding of the hair would permit and another electrode was attached to the forearm with a potentiometer connected in the circuit by wires. The forehead, or scalp, of the human, like the scalp of the dog and head of the fish, was found to be positive to the forearm. This positive potential of the scalp of the human was of the order of magnitude of 80 millivolts. If the 1 to 8 ratio found in the dog holds for the human, then the positive potential of the scalp of 80 millivolts in the human indicates a negative potential of the underlying brain cortex of 640 millivolts.

The positive potential of the scalp of the human was increased by physical activity and decreased during rest. It was also decreased during sleep, and in very deep sleep there was a reversal in polarity, the scalp becoming negative to the forearm. In this respect, profound sleep in the human produced the same effect as profound anesthesia in the dog, that is, both caused the brain cortex to become electropositive.

SUMMARY

Scalp potential of dogs was studied in relation to brain potential and the scalp was found to be positive to the underlying brain cortex. The positive potential of the scalp fluctuated with the negative potential of the underlying brain cortex, increasing with a rise and decreasing with a fall in cortical potential. Hence, scalp potential may be used as an index to cortical potential, thus affording a method for the study of cortical potential without exposing the brain. An increase in the positive potential of the scalp as occurs during recovery from anesthesia indicates a rise in the negative potential of the underlying brain cortex, and a decrease in the positive potential of the scalp with an increase in depth of anesthesia indicates a fall in the negative potential of the underlying brain cortex in a 1 to 8 ratio. That is, a rise or fall of 1 millivolt in the positive potential of the scalp indicates a corresponding rise or fall of 8 millivolts in the negative potential of the underlying brain cortex.
