

# Physiological Studies on "Choking" in Judo

## Part I

### Studies in General

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### Foreword

In order to study the effect upon the human body of "choking" in judo, the "Research Group for the Study of Choking in Judo" was formed within the Society for Scientific Research of Judo, Kodokan. "Choking" is a special technique used in judo, and it consists in strangling the neck of the adversary, thereby imparting pain or even making the opponent fall unconscious. Hence, the physiological studies on the effect of "choking" and its resulting unconsciousness is a matter of great import in order to obtain a proper understanding of judo, and also in the preventive aspect of the dangers accompanying judo.

The late Dr. K. Saito and his colleagues have made electroencephalographic studies during "choking", and have reported that changes observed while the subject was in a state of unconsciousness resulting from the "choking", was identical to those observed in a patient during an epileptic seizure. In the present paper we wish to report our further studies on the subject.

The following were the main objectives of our studies:

- 1) The differences in the effect of the various methods of "choking".
- 2) The duration of the effect of "choking" on the body.
- 3) The physiological mechanism of the resulting state of unconsciousness.
- 4) The prevention of the dangers accompanying "choking".

### I. Experimental Procedure

Our experimental subjects were the following: Mr. Matsumoto, a sixth grade judo expert performed the "choking" on four subjects of third grade, and one subject of fourth grade. On the same subjects three methods of "choking", the "Okurieri-jime", "Katajuji-jime", and "Hadaka-jime" were performed. In the "Okurieri-jime", the neck as a whole is squeezed, in the "Katajuji-jime" the region of the carotid carotid arteries is pressed, while in the "Hadaka-jime", the trachea is pressed.

The subjects were made to lie on a bed in a recumbent position in a condition of rest, and in the case of the "Katajuji-jime", the performer did the strangling from the front. In the "Okurieri-jime", and the "Hadaka-jime", the upper part of the body of the subjects was raised approximately thirty degrees and the performer did the "choking" from behind.

Studies were made on the central nervous system, the cardio-vascular system, and the respiratory system.

The following items were selected.

- 1) Electroencephalogram (E. E. G.)
- 2) Percentage oxygen saturation of blood in the helix of the ear.
- 3) Electrocardiogram (E. C. G.)
- 4) Arterial blood pressure.
- 5) Finger and forearm plethysmogram.
- 6) Skin temperature.
- 7) Respiratory movement.
- 8) Pupillary reflex.
- 9) Reaction of urine.
- 10) Cramp or convulsion.

At the first signal, the performer took the necessary position, at the second signal he performed the "choking", and let go his hold at the first sign of unconsciousness. The criteria for unconsciousness was the reflex dilatation of the pupils. Measurements were made at rest, then at the getting ready position, and finally throughout the "choking" period until five minutes after awakening. Subsequent measurements were made at 10, 15, 20, 25; 30 minutes. The room temperature at the time of measurement was 15.6—18.2°C (dry temperature), and 12.0—15.4°C (wet temperature). The atmospheric pressure was 755.0—771.3 mm Hg.

## II. Experimental Methods and Results

1) General symptoms. The subjects fell unconscious after approximately 10 seconds of "choking". The duration of unconsciousness was from 10 to 12 seconds and during this period, very often, the subjects developed clonic cramps. All subjects woke up spontaneously. While unconscious, the subjects sometimes had dreams which were not unpleasant. After awakening the subjects did not complain of any unpleasant feelings. The dilatation of the pupils was concomitant with the unconsciousness.

2) Electroencephalogram (E. E. G.). The subjects were put into an electrical shielding room, and with a unipolar lead, recordings were made from the frontal and occipital regions. The silver disc electrodes were 1.0 cm in diameter, and these were applied to the frontal region, occipital region, and the ear lobe. An ink recording apparatus was used, and the recording paper made to move at the rate of 3 cm per second. None of the subjects fell unconscious during the "Hadaka-jime", but with the "Okurieri-jime", and the "Katajuji-jime" all subjects lost consciousness. In all the cases in which the subjects fell unconscious the E. E. G. were similar regardless of the method of "choking". (see Fig. 1)

a) In the getting ready position, the  $\alpha$  waves were inhibited, and the  $\beta$  waves increased as compared to those at rest. This is due to the feeling of anxiety in anticipation of the

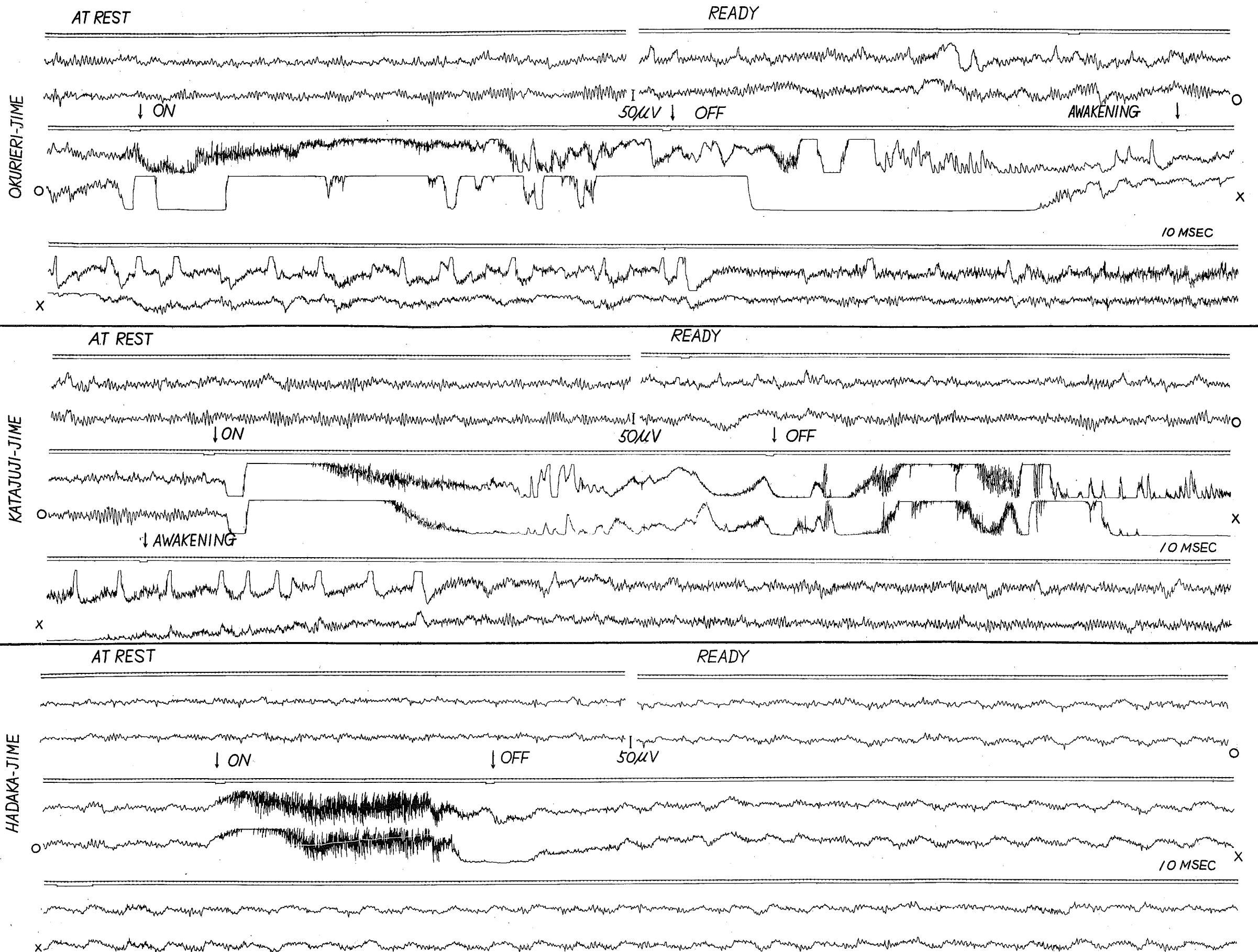


Fig. 1. Effect of choking on electroencephalogram. Upper curve: frontal EEG, Lower curve: occipital EEG. "ON": beginning of choking, "OFF": end of choking.

"choking".

b) In the early stages of the "choking", the amplitude and the frequency were increased, followed by a decrease in amplitude.

c) Just at the time the subjects fell unconscious, the amplitude markedly increased, and reached approximately  $100 \mu\text{V}$ , while the frequency decreased conspicuously attaining 3-5 per second, and recorded the so-called slow waves. This we consider to be the characteristic E. E. G. of the state of unconsciousness following "choking", and is very similar to the E. E. G. of epileptic seizure. During the middle period of the state of unconsciousness, superposed waves appeared, followed by a separation, and finally became 50-100  $\mu\text{V}$ , 3-10 per second waves.

d) As the subjects neared the awakening period, the  $\delta$  waves identical to those which appear during sleep were observed, and these were superposed by  $\beta$  waves.

e) On awakening, the  $\beta$  waves became conspicuous, and after 10 seconds of awakening the  $\alpha$  waves began to appear in addition. After 20 seconds of awakening, the E. E. G. showed a similar recording to that of the getting ready period. After 2-3 minutes the E. E. G. returned to that of the rest period.

In the case of the "Hadaka-jime", the E. E. G. showed an entirely different picture. Waves with wider amplitudes and higher frequencies appeared, but showed no slow waves. (see Fig. 1)

From the above six cases it is definite that changes in E. E. G. may be observed during the state of unconsciousness induced by "choking", but the duration is short, and 20 seconds after awakening the E. E. G. returns to normal and leaves no after effect, which is quite different from that of the case with a concussion of the brain. In all the above cases the performer let go his hold immediately after the subjects fell unconscious, thereby limiting the effect of "choking" to a short period, but if the "choking" had continued longer, the appearance of serious after effect is to be expected.

3) Percentage oxygen saturation of blood in the helix of the ear. The apparatus used was the ear-oxymeter. This instrument measures the percentage oxygen saturation of the circulating blood in the helix continuously without puncture. With the ear-piece attached to the helix, measurements were made after the capillaries had dilated and became arterialized. The percentage oxygen saturation of blood at rest condition was fixed at 95%. The measurements were taken at parallel intervals with the E. E. G.. These measurements were made in order to investigate indirectly, the percentage oxygen saturation of the circulating blood in the brain, as the internal carotid artery which perfuses the brain, and the external carotid artery which perfuses the helix of the ear branch from the common carotid artery.

The changes in percentage oxygen saturation of blood in the helix during the "Okurieri-jime" and the "Katajuji-jime", were similar to each other: The percentage lowered simultaneously with the commencement of the "choking", and the subject lost consciousness when the percentage dropped to 86%, and continued to fall for from 2 to 4 seconds, and reached a minimum of 82%. As the performer let go immediately after the subjects lost consciousness, the percentage rose quickly, and when it reached 90-92%, the subjects usually came to. Approximately 20 seconds after reviving consciousness the percentage regained the resting condition value. (see Fig. 2)

In the case of the "Hadaka-jime", as was stated, the subjects did not lose consciousness,

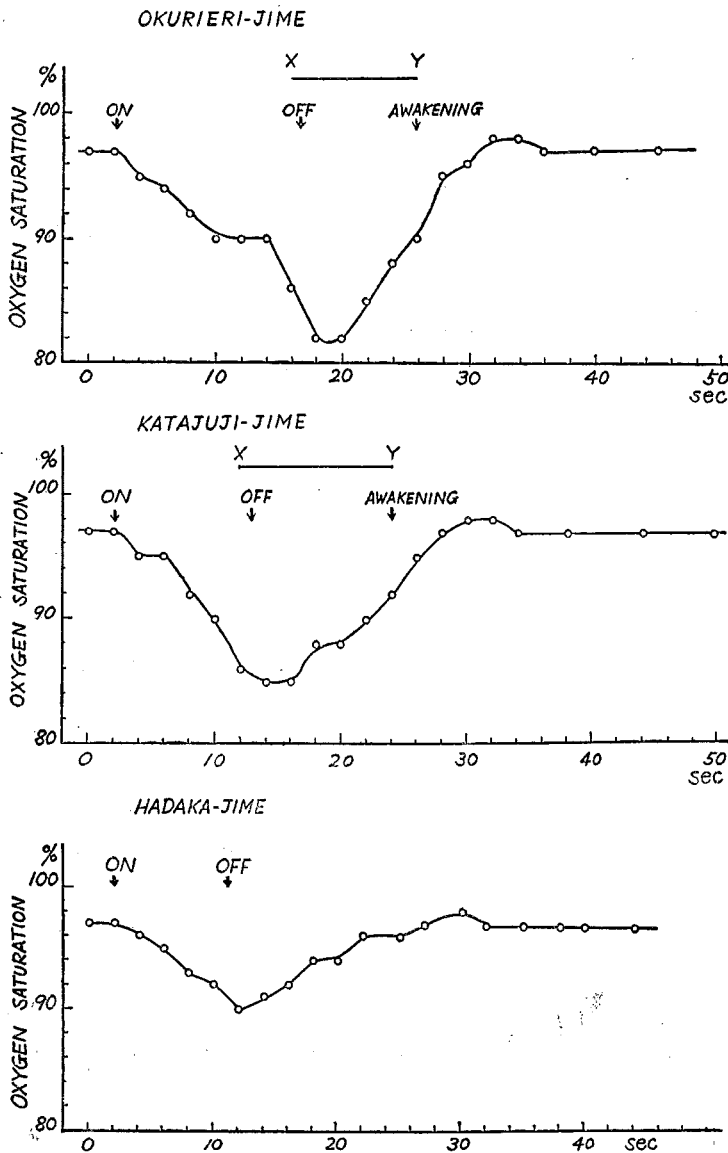


Fig. 2. Effect of choking on percentage oxygen saturation of the blood in the helix of the ear. X-Y, unconsciousness.

In the case of the "Okurieri-jime", and the "Katajuji-jime", the respiratory movement was inhibited in the inspiratory phase, with the commencement of the "choking". While unconscious the respiratory movement tended toward the expiratory phase, and temporarily ceased. With the awakening, the respiratory movement began to resemble that of the normal condition, but momentarily, the amplitude and the respiratory rate increased. Generally, normal respiratory movement was regained in one to two minutes.

During the "Hadaka-jime", respiratory movement was inhibited, and coughing set in which made the respiratory movement irregular. After letting go the hold, the acceleration

and the fall in percentage oxygen saturation was far less marked than in the other two methods. (see Fig. 2)

From the above results it was observed that the percentage oxygen saturation of the blood in the helix of the ear decreased as a result of "choking" and the subjects lost consciousness when it fell markedly. It may be concluded that the oxygen lack in the circulating blood in the brain is one of the factors causing unconsciousness, as a result of "choking". But the fall in the percentage oxygen saturation is not low enough to attribute it as a sole factor in the cause of the unconsciousness.

4) Respiratory movement. In order to record the respiratory movement, a manchette was wrapped around the thorax, the changes in air pressure therein was transmitted to a recording tambour, and from thence recorded on a kymograph.

of respiratory movement was not very marked. (see Fig. 3)

5) Electrocardiogram (E. C. G.) E. C. G. was taken by the standard limb leads. From the E. C. G. recordings, the form, voltage of each deflection, heart rhythm (R-R interval), auriculo-ventricular conduction time (P-Q interval), duration of ventricular contraction (Q-T interval) were observed.

a) Conspicuous changes were not observed in the form of E. C. G., but an occasional disappearance of P wave, or the appearance of U wave were noted. (see Fig. 4)

b) Voltage of each deflection of E. C. G.. In the "Okurieri-jime", the  $R_I$ ,  $T_I$  gradually became low from the beginning, and remained low for sometime after awakening, whereas the  $R_{III}$  and  $T_{III}$  became higher and remained high until after awakening. The  $R_{II}$ ,  $T_{II}$  showed the following values, respectively:  $R_{II} = R_I + R_{III}$ .  $T_{II} = T_I + T_{III}$  and generally maintained similar values, but during the unconscious period, the  $R_I$ ,  $R_{II}$  and  $R_{III}$  occasionally showed higher values.

The above changes in voltage is, no doubt, attributable to the change in the electrical axis of the heart, but further thought must be given also to the change in cardiac output as a causal factor.

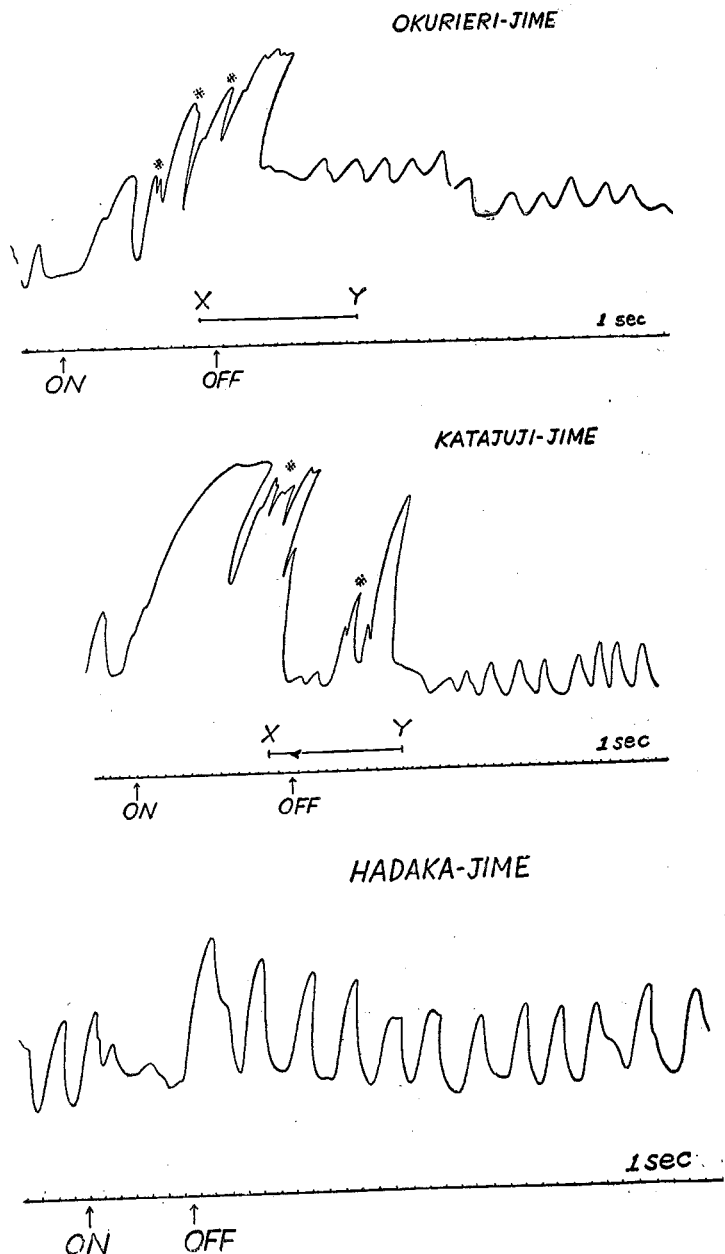


Fig. 3. Effect of choking on the respiratory movement. Upward stroke of the record represents inspiratory movement. \* indicate convulsions; X-Y, indicate period of unconsciousness.

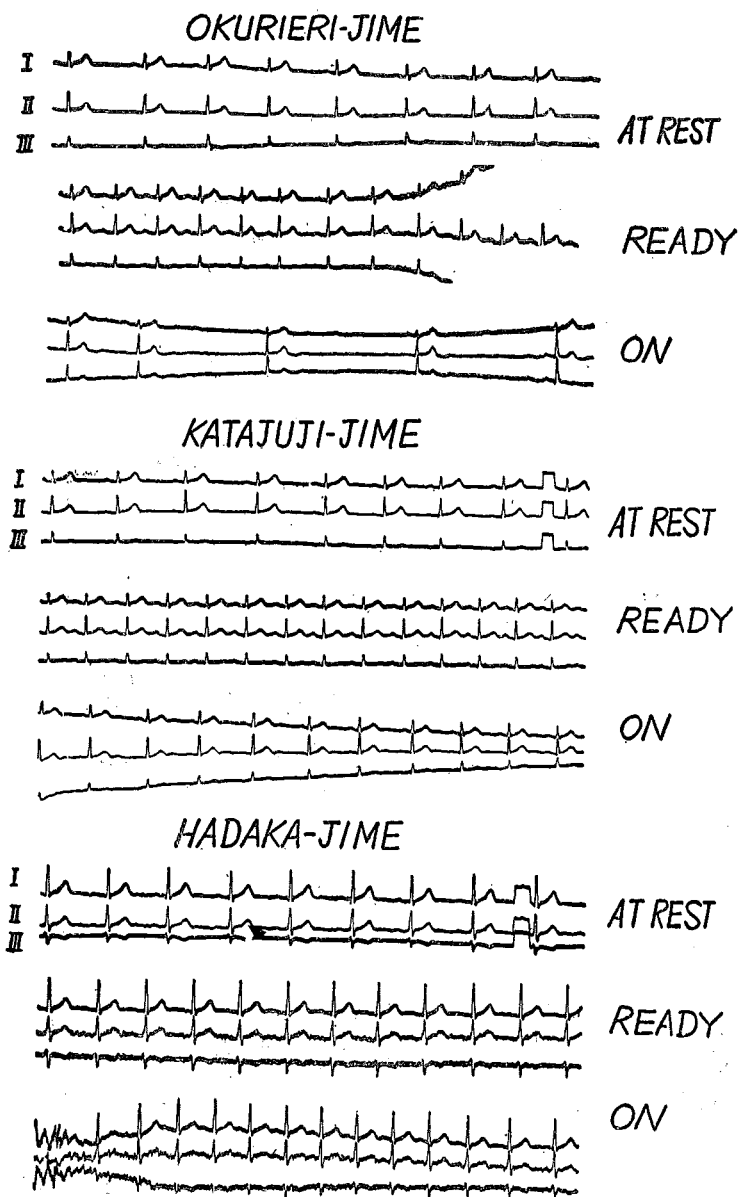


Fig. 4. Effect of choking on the pattern of electrocardiogram.

In the "Katajuji-jime", the changes were very similar to the foregoing, but the changes in the R—R interval were not so pronounced. In the "Hadaka-jime", no changes in the R—R interval were observed (see Fig. 6)

These changes in E. C. G., we assume, are the result of vagal inhibition on cardiac rhythm.

6) Arterial blood pressure. By means of the Tycos's sphygmomanometer, the blood pressure in the brachial artery was measured by the auscultatory method. During the "choking" act, it was rather difficult to measure due to the convulsions, but after awakening, the systolic blood pressure rose 30—40 mm Hg, and within five minutes returned to the value of the resting period. The diastolic blood pressure showed similar changes. (see Fig. 7)

7) Reaction of peripheral blood vessel. The volume changes of the fingers and forearm

In the "Katajuji-jime", and the "Hadaka-jime", the  $R_{II}$  and  $R_{III}$  sometimes showed a high value during "choking", but in general, no regular changes were observed. (see Fig. 5)

c) Interval of each deflection of E. C. G.. The R—R interval shows the heart rhythm. In all the methods of "choking", during the getting ready period, the R—R interval shortened. In the "Okuri-eri-jime", while the subject was unconscious, the R—R interval lengthened considerably, but with the awakening, it shortened, and later lengthened again before going back to the rest condition, five minutes after regaining consciousness. (see Fig. 6) Meanwhile, practically no changes in the P—Q interval, and the Q—T interval, were observed. Accordingly, the changes in heart rhythm observed were mostly during diastole.

were measured by the plethysmograph. During the "Oku-rieri-jime", and the "Katajuji-jime", the volumes of the fingers decreased, whereas that of the forearm increased. During the "Hadaka-jime", in which the trachea is mostly pressed, no such changes were observed. The changes observed during the "Okurieri-jime", and the "Katajuji-jime", were similar to the vaso-vagal syndrome (see Fig. 8).

8) Skin temperature. A micro-pyrometer was used, skin temperatures in the back of the leg of both sides, and the middle part of the lower lip were measured. The temperature observed in the back of the leg were similar on both sides, increasing directly after awakening and then gradually returning to the normal in 25 to 30 minutes. The changes in temperature observed in the three methods of "choking" were nearly all similar.

The skin temperature in the middle part of the lower lip fell directly after awakening, and in 20 to 30 minutes, returned to the value at rest (see Fig. 9).

The above changes in skin temperature is considered a part of the reaction of peripheral blood vessel.

9) No protein was found in the urine, before and after "choking".

### III. Discussion and Summary

From the results of the above experiments, the following conclusions may be drawn.

1) The differences in effect of the various methods of "choking". It is to be noted that the effects of "Okurieri-jime" and "Katajuji-jime" were similar to each other, whereas that of the "Hadaka-jime" was different, i. e. in the former two methods the one being "choked" fell unconscious without experiencing much pain, whilst in the latter method, if one continued the strangle hold and tried to force the opponent to

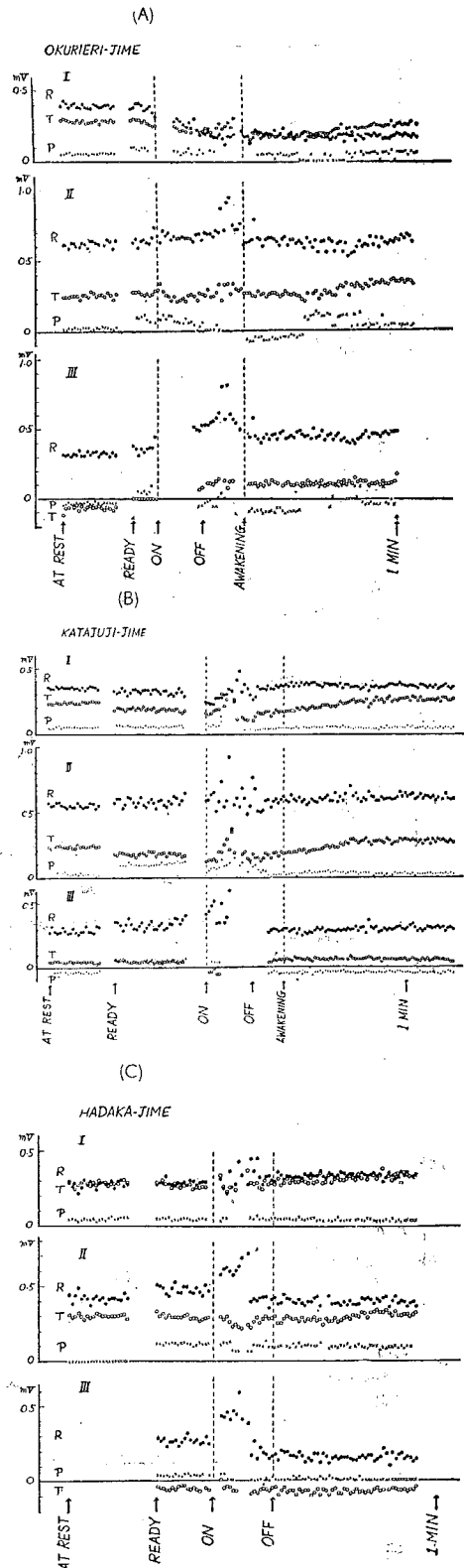


Fig. 5. (A. B. C) Effect of choking on the voltage of each deflection of electrocardiogram.



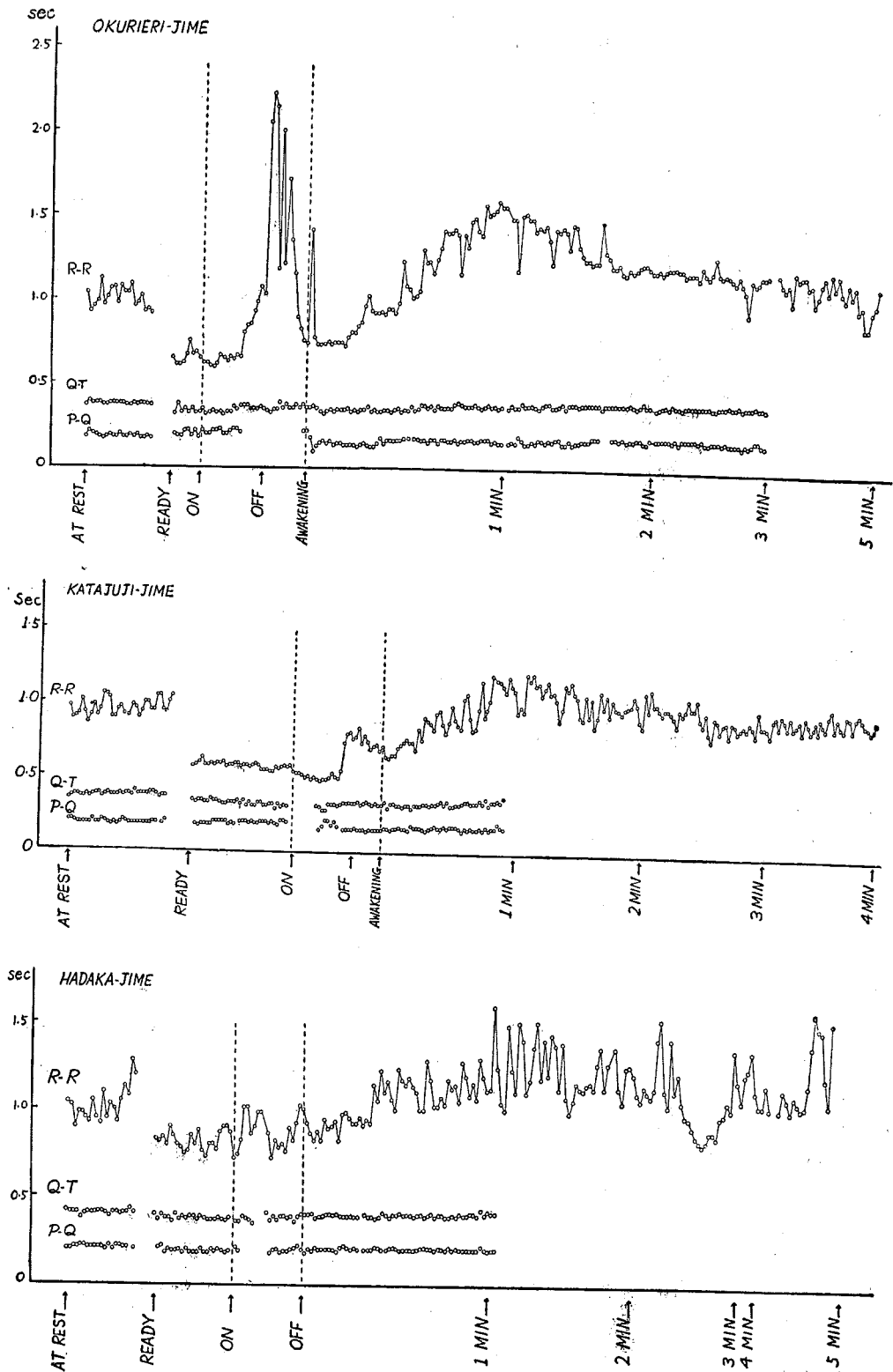
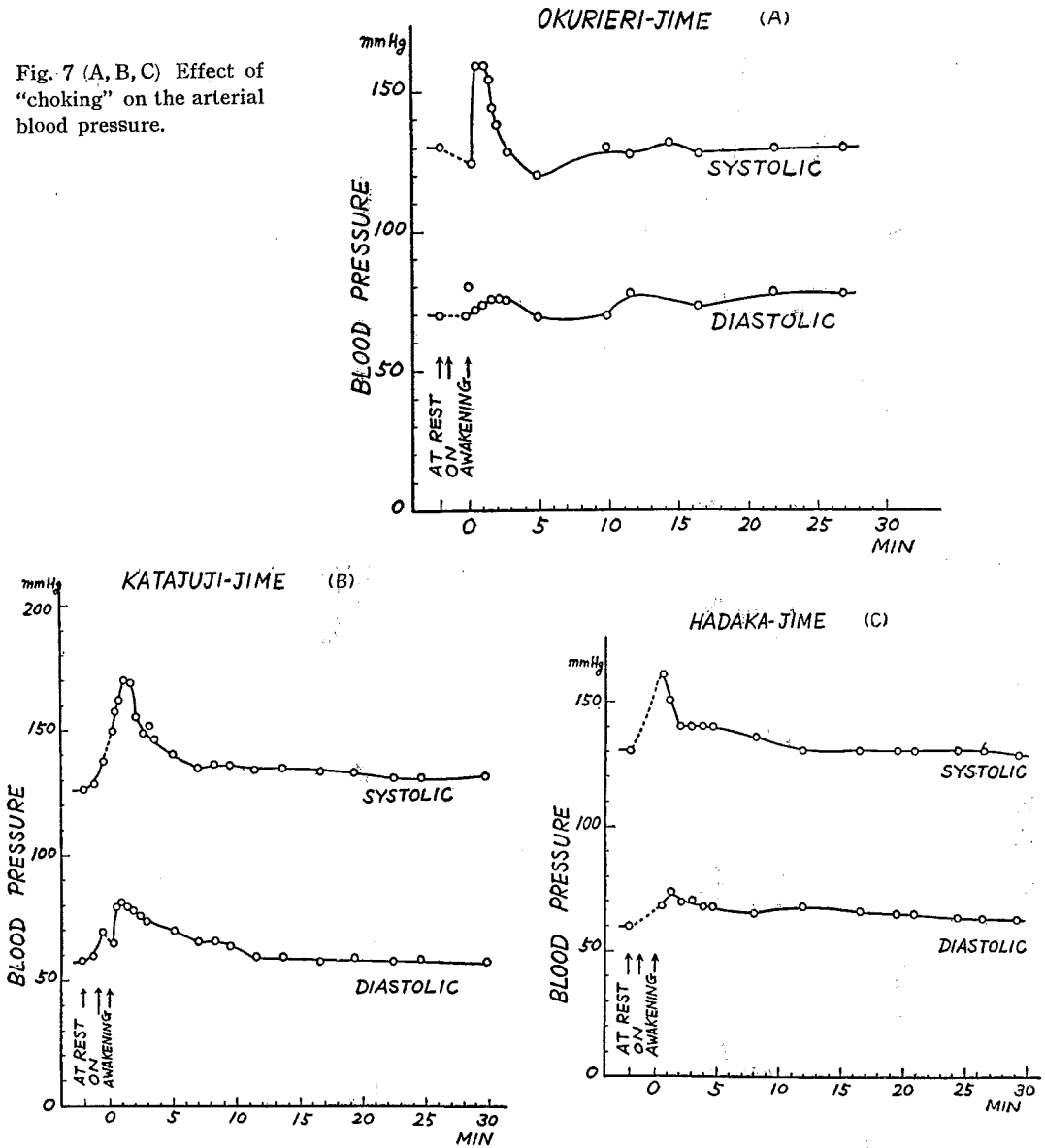


Fig. 6. Effect of choking on the interval of each deflection of electrocardiogram.

Fig. 7 (A, B, C) Effect of "choking" on the arterial blood pressure.



fall unconscious, the latter experienced excruciating pain.

The E. E. G. in the "Okurieri-jime" and the "Katajuji-jime" during the unconscious stage, showed slow waves with large amplitudes, whilst in the "Hadaka-jime" in which the subject did not lose consciousness, such findings were not observed. From this it may be inferred that the appearance of large amplitude slow waves is characteristic of the unconscious stage. This wave pattern is very similar to the one which appears during the petit mal of an epileptic seizure, i. e. the spike and wave or the dart and dome pattern (10). This wave pattern may also be observed in monkeys during clonic convulsions after electric shock (10), and it may be assumed that it is related to the onset of convulsions after being "choked". The common cause in both is the lack of oxygen in the brain.

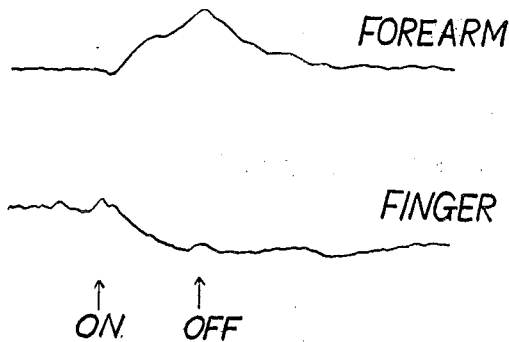


Fig. 8. Effect of choking (Okurieri-jime) on the volume of finger and forearm. Upward deflection represents increase in volume.

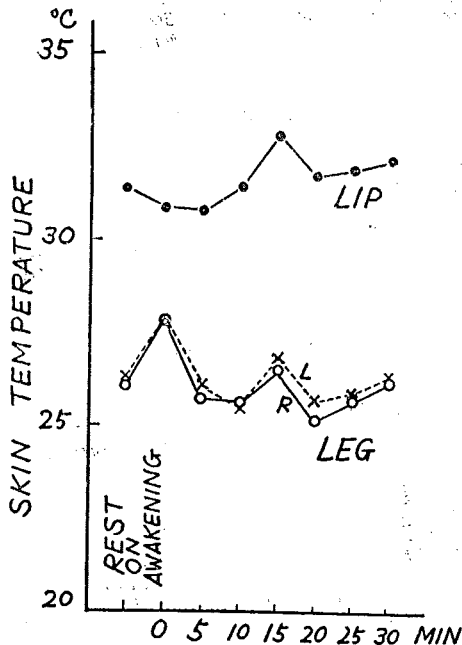


Fig. 9. Effect of "choking" on the skin temperature. No marked difference in the effect on the skin temperature was obtained by the three methods of choking. The skin temperature plotted in the figure is the mean of all the subjects. R: right leg, L: left leg.

Just prior to falling unconscious, rapid waves and spike were observed which resembled the E. E. G. of monkeys during tonic convulsions induced by electric shock. The analysis of the E. E. G. during "choking" has been reported by one of us (K. S.) (9).

The appearance of the afore mentioned findings during the unconscious stage indicates that there occur a diminution in the cerebral blood flow, and also a lack of oxygen in the brain. Oxygen saturation in the blood from the helix of the ear was determined, thereby indirectly ascertaining the oxygen saturation in the blood flowing through the brain, and was found to be lowered during the unconscious stage. However, as mentioned above the lowered percentage oxygen saturation was found to be 82–85 % which ordinarily would not cause unconsciousness. In the case of a gradual decrease in the percentage oxygen saturation in the blood flowing through the brain, unconsciousness is brought about when the percentage reaches 60% (2). Consequently, the lowering of the percentage oxygen saturation in the blood flowing through the brain, although an important causative factor cannot be said to be the main cause of unconsciousness.

Aside from the above mentioned functional changes in the head, changes in the respiratory and circulatory systems take place, of which some may be considered secondary changes resulting from changes in the head, however certain changes may be attributed to reflex action initiated in the receptor organs in the carotid sinus.

Respiratory movement in the "Okurieri-jime" and the "Katajuji-jime" was found to be tending toward the expiratory phase and thus inhibited, whereas in the "Hadaka-jime" it was inhibited in the intermediate phase. This inhibition of respiration may be attributed to the lowering of excitability of the respiratory centre due to cerebral anaemia(10). Furthermore, the rise in intracranial pressure and carotid reflex initiated by pressure upon the

neck must also be taken into consideration as contributing to the inhibition of respiration. From the fact that the respiratory phase shifted toward the inspiratory phase, it may be assumed that the inspiratory centre is more resistant to lack of oxygen than the expiratory or the alternating centres.

The elongation of the R—R interval in the E. C. G. at the moment immediately prior to the unconscious stage was found to be the longest in the "Okurieri-jime", followed by the "Katajuji-jime", and the "Hadaka-jime". It was found at this moment that P—Q, Q—T interval showed no changes. From this it may be inferred that the elongation of the R—R interval may be ascribed to the inhibition of the sinus rhythm. However, in the "Okurieri-jime" there were individuals with marked bradycardia, whilst in others it was not so marked. From this, the differences in the points of application of pressure relative to the carotid sinus must also be taken into consideration. The mechanism whereby the voltage of the R spike increased when the subject entered the unconscious stage could not be fully ascertained, however an X-ray study (4) revealed that at this stage changes in the position of the heart, and cardiac volume take place.

As regards the reaction of the peripheral vessels, in the "Okurieri-jime" and the "Katajuji-jime", a dilatation of the muscle vessels and a constriction of the skin vessels were observed.

Generally, during shock especially when accompanied by unconsciousness, bradycardia and hypotension are observed with dilatation of the muscle vessels. This condition is called vaso-vagal syndrome (1). The bradycardia and dilatation of the muscle vessels during the unconscious stage in "choking" is very similar to this. The exact cause of this condition during "choking" is not quite clear, however it is most probably due to are flex action initiated in the receptor organs in the neck, particularly those in the carotid sinus.

The contraction of the blood vessels in the skin continued for some time after awakening, after which gradual revival took place. This revival was parallel to the revival of skin temperature.

From the above it may be concluded that the acute lack of oxygen in the blood flowing through the brain is an important causative factor in the unconsciousness in "choking".

2) After effect of "choking" on the body. The unconsciousness resulting from "choking" recovered spontaneously in from 10 to 20 seconds. The changes in the readings of the E. E. G., and the earoxymeter, showed normal values after 20 seconds. The readings of the E. C. G., reaction of blood vessels, and blood pressure returned to normal values after 5 to 10 minutes. The changes in respiratory movement recovered after 5 minutes. Skin temperature readings registered normal values after 25—30 minutes. From the point of view of subjective symptoms, no unpleasant feelings were experienced. As mentioned previously, the performer let go his hold directly after the subjects lost consciousness, so the after effect was very slight, whereas if he had continued long after the subjects lost consciousness the after effect might have been quite serious.

3) Physiological mechanism of unconsciousness caused by "choking". From the fact that unconsciousness could not be induced in the "Hadaka-jime", in which pressure is applied mostly on the trachea, and from the readings of the ear-oxymeter, in those subjects "choked" by the "Okurieri-jime" and "Katajuji-jime", it may be assumed that lack of oxygen in the brain as a result of mechanical hindrance of the blood stream to the head plays an important role in causing the unconsciousness in "choking".

The appearance of slow waves in the E. E. G. during the unconscious stage is a sign of weakened activity of the brain cells due to lack of oxygen.

In man ligation of the common carotid arteries is said to cause immediate death (5). The resistance of the nervous system to lack of oxygen varies with the locality. Consciousness is a condition in which the function of the various parts of the nervous system is well coordinated, and when the activity of one part is decreased consciousness as a whole is disturbed and results in loss of consciousness. Gildea and Cobb (3) reported that in anaesthetized cats, if the blood flow to the brain is completely blocked, permanent damage to the function of the cerebrum results in a few minutes.

The convulsions which appear during the unconscious stage in "choking" is very similar to those of the petit mal of epilepsy, and from the similarity of the E. E. G. in both conditions, the convulsions in "choking" may be attributed to lack of oxygen in the brain.

On the other hand those with a hypersensitive carotid sinus are said to fall unconscious accompanied by bradycardia and epilepsy like convulsions very easily upon light pressure on the neck (10). Consequently, added to the lack of oxygen in the brain the action of the carotid sinus must also be taken into consideration. Actually there are individual differences as to the ease with which one falls unconscious, and these differences may be attributed to the differences in the sensitivity of the carotid sinus.

All things considered, the unconsciousness resulting from "choking" in judo is due to the combined action of the lack of oxygen in the brain, and carotid sinus reflex.

4) Prevention of the dangers accompanying "choking". Since the load to the heart and the rise of blood pressure is marked, it is dangerous to perform the "choking" hold on subjects with cardiac disorders or with hypertension. It is also dangerous for youngsters whose central nervous system and heart have not yet attained complete development. But for those trained in this field, it is quite harmless, although care must be taken, not to continue the hold after the subject falls unconscious.

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