Heart Rate and Fatal Course in Rabbits Asphyxiated by Respiratory Arrest

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In immobilized rabbits the fatal course asphyxiated by the cessation of artificial respiration was characterized by the sequence of events: disappearance of surface EEG, final bradycardia on ECG, disappearance of deep EEG (midbrain reticular formation) and final tachycardia. It was demonstrated that the stage of final tachycardia virtually might coincide with the stage of deprivation of brain stem function.

Our previous study (Fujimura and Komura 1973) has demonstrated that the fatal course in rabbits drowned by slow intratracheal injection of sea or fresh water is characterized by the sequence of events: agonal cramps, terminal respiration, cessation of spontaneous movements, persistent dilatation of the pupils, bradycardia on ECG, disappearance of surface EEG and that of deep EEG, followed by tachycardia with a variety of arrhythmias and progressive declines in rate and amplitude of cardiac beat by ECG tracing; the cardiac activity thus eventually diminishes in about an hour into a state that the patterns of ECG complex displayed can no longer be distinguished.

The study reported here was undertaken to investigate further the significance of tachycardia seen after disappearance of deep EEG in the above-described fatal course in rabbits immobilized and asphyxiated by cessation of artificial respiration.

MATERIALS AND METHODS

The experiments were performed in 16 rabbits with electrodes implanted in the specified areas of the brain as described previously (Komura et al. 1973). The animals were fixed on a table in supine position, immobilized with succinylcholine chloride, and placed under controlled respiration with a respirator for animal via tracheal intubation with a Y-shaped cannula by tracheotomy. Asphyxia and resuscitation of the animals were accomplished by mere discontinuation or re instituted of artificial respiration, respectively.

Asphyxia was repeated for different durations, each being preceded by an appropriate recovery time, till death of the animal. The blood pressure was recorded from the femoral artery by means of an electric manometer. Bilateral vagotomy was done at the level of the posterior end of the thyroid cartilage. EEG and ECG were recorded by the methods reported previously (Komura et al. 1973).

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RESULTS AND DISCUSSION

As anticipated from findings in the drowning experiment, the discontinuation of artificial respiration in the immobilized rabbits resulted in disappearance of the deep EEG (reticular formation) with subsequent maximal bradycardia (designated as final bradycardia) followed by the onset of tachycardia (designated as final tachycardia) (Figs. 1 and 2). Rabbits asphyxiated by cessation of controlled respiration were successfully resuscitated by reinstitution of the artificial respiration even at the stage just after the disappearance of deep EEG. The point of time at which complete final tachycardia sets in was found to be the critical stage for such success in resuscitation of rabbits, whilst animals at stages of asphyxia later than that did not revive by mere reinstigation of artificial respiration. The blood pressure fell to almost the zero level at the time of final bradycardia and, therefore, it was impracticable to assess interrelations between blood pressure change and other physiological parameters during the stage of final tachycardia. It is generally recognized that cardiac beats are dependent primarily on autonomic innervation wherein influence of the cardiac branch of the vagus is predominant (Levy et al. 1966; Robinson et al. 1966). In view of this, further asphyxiation experiments were conducted under the same condition as described above in bilaterally vagotomized rabbits to investigate the effect of final bradycardia on the vagus of the heart. These animals undergoing asphyxiation showed a slow decline in cardiac beat but displayed no final bradycardia, nor any other significant change. These findings seem to suggest that vagotonia is largely involved in the final bradycardia

![Fig. 1. Surface EEG (Cm, cortex sensitivo-motorius), deep EEG (RF, reticular formation) and ECG (Lead I).](image-url)
while the final tachycardia represents a stage in which the myocardium is liberated from the vagus-predominated central innervation and thereby begins its proper rhythmic contraction.

Since the vagal cardiac nerve arises from the nucleus of vagus in the medulla oblongata, it may be that the time at which the heart is liberated from innervation by the vagal cardiac nerve represents that of loss of brain-stem function, and it would follow that the stage of final tachycardia virtually coincides with the stage of deprivation of the brain-stem function.

Further studies to observe whether final tachycardia develops subsequently to final bradycardia in fatal courses by other causes are under way at our laboratory.

References

1) Fujimura, K. & Komura, S. (1973) Cortical and subcortical EEG, ECG and other findings in experimental sea water and fresh water drowning. Proceedings of the 57th Conference of the Medico-Legal Society of Japan (Jap.), p. 120.