Cerebral Angiography in Systemic Hypotension
An Experimental Study in the Dog

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Summary. Serial cerebral angiography was performed in ten dogs during profound systemic hypotension induced by either infusion of Arfonad or hemorrhage. The most striking finding was the prolongation of the arterial phase, which occurred at the mean blood pressure of 30 mm Hg due to infusion of Arfonad and at 50 mm Hg after hemorrhage. Thereafter, the arterial phase was prolonged with decreasing pressure. The duration of the prolonged arterial phase correlated well with the degree of profound hypotension.

Angiographie cérébrale en cas d'hypotension. Une étude expérimentale chez le chien
Résumé. Une sérieangiographie cérébrale fut pratiquée chez dix chiens présentant une hypotension profonde provoquée par infusion d'Arfonad ou par hémorragie. La constatation la plus frappante fut l'allongement de la phase artérielle observé à la pression sanguine moyenne de 30 mmHg lors de l'infusion d'Arfonad et de 50 mmHg lors de l'hémorragie. Ensuite, la phase artérielle augmentait avec la diminution de la pression. La grande durée de la phase artérielle correspondait bien avec le degré d'hypotension profonde.

Cerebrale Angiographie in tiefer Hypotension. Experimentelle Untersuchungen am Hund
Zusammenfassung. An 10 Hunden wurde unter tiefer Hypotension eine cerebrale Serienangiographie durchgeführt. Dabei fand sich eine deutliche Verlängerung der arteriellen Kontrastmittel-Phase, die mit der Tiefe der Hypotension korrelierte.

The effect of systemic hypotension upon cerebral electrical activity has been observed by others [18, 26, 27, 28]. Wiederholt et al., [28] reported that an isoelectric EEG occurs when mean arterial pressure is lowered from 130 mmHg to 30–40 mmHg by rapid intravenous infusion of Arfonad (trimethaphan). However, during hemorrhagic hypotension, cerebral physiological functions are well maintained despite an 85–90% decrease in both mean arterial pressure and cerebral blood flow [27]. They concluded that profound systemic hypotension alone is not responsible for loss of EEG activity [27, 28]. In the study of the effect of controlled hypotension on the cerebral circulation it was found that, during hemorrhagic hypotension, autoregulation was maintained down to a mean pressure of 65 mm Hg; with drug induced hypotension autoregulation persisted to the lower level of approximately 35 mmHg [10].

The purpose of the present study is to perform serial angiographies in dogs during systemic hypotension induced by infusion of Arfonad and by hemorrhage to see whether there is any disparity between them, and to correlate the degree of hypotension with the duration of prolongation of the arterial phase.

Method

Ten dogs weighing between 12 and 26 Kg were used, five for Arfonad infusion and the other five for hemorrhagic study. The animals were anesthetized with intravenous sodium pentothal, 25 mg/kg body weight, and additional doses were given when necessary.

Bilateral paratracheal incisions were made to expose both common carotid arteries and one of the internal jugular veins. Two catheters were inserted into each common carotid artery near the bifurcation for injection of contrast medium and recording of blood pressure. A third catheter was inserted into the superior vena cava for infusion of Arfonad. A cuffed endotracheal tube was inserted and the animals were resired with a Harvard respirator at the rate of 10–15 per min, as needed. Each animal was ventilated with 40% oxygen and 60% air. Blood gas analysis was performed in each animal immediately before each cerebral angiogram. The PaCO₂ was held between 30 and 40 mmHg by adjusting the respirator. EKG and blood pressures were recorded on a Sanborn two channel recorder. Hemorrhagic hypotension was produced by bleeding the animals from one of the femoral arteries. It usually necessitated removal of approximately 1000–1500 ml of blood before blood pressure decreased to 50 mmHg. Removal of additional small quantities of blood (50–100 ml) was necessary to reduce the pressure further.

A mean systemic arterial pressure of 10–60 mmHg was rapidly induced either by intravenous infusion of Arfonad, 0.05 mg per milliliter in 5% glucose, or arterial bleeding. The mean arterial pressure was lowered in steps of approximately 10 mmHg. Graded hypotension was maintained either by infusion of additional Arfonad, or repeated small hemorrhage. Each dog had four cerebral angiograms performed within 20 min at each step reduction. Angiograms were made in the lateral view by means of a Sanchez-Perez film changer using a 2:1 magnification technique.
Twelve exposures in six seconds at 0.5 sec intervals were made in those animals in which the mean arterial pressure was above 40 mmHg. Twelve exposures in 12 sec at 1.0 sec intervals were used in those animals in which the mean arterial pressure was below 40 mmHg. A control angiogram was also performed in each dog.

Because it was often difficult to define maximal filling of the parietal veins in dogs and because the prolongation of the arterial phase was found to be the most striking finding in previous studies [20, 21], the time interval between maximal filling of the carotid siphon and the end of the arterial phase was calculated as reflecting part of the cerebral circulation time.

Results

Cardiac Function

With systemic hypotension induced by infusion of Arfonad, the heart rate (control range 130—180 beats/min) fell by 10—20% within two minutes of graded hypotension. In two animals, cardiac arrest occurred when the mean arterial pressure dropped below 25 mmHg for more than a few minutes. Myocardial ischemia (ST elevation and T wave inversion) was occasionally seen and usually returned to normal within a few minutes of the end of profound hypotension.

With systemic hypotension induced by hemorrhage, tachycardia and decreasing EKG voltage were noted in most animals during hypotension. Bradycardia was also seen sometimes. Transient myocardial insufficiency and extrasystoles occurred occasionally.

Angiographic Findings in Control Dogs. The entire angiogram from the beginning of the arterial phase to the end of the venous phase seldom lasted more than six seconds. The arterial phase usually required 2—3 sec followed by an equal period of time for the venous phase. The capillary phase was extremely short and rarely well visualized (Fig. 1).

Angiographic Findings During Systemic Hypotension. The most striking finding during systemic hypotension was a prolonged arterial phase in both the

Fig. 1. Normal angiographic findings in control dogs: The arterial phase usually requires 2—3 sec followed by an equal period of time for the venous phase. The capillary phase is extremely short. (Arrow represents the internal maxillary artery. Arrowhead represents the anterior cerebral artery)