Acta Neurochir (Wien) (1992) 115: 123–126

Acta Neurochirurgica

Transclival Approach to Rabbit Basilar Artery for Experimental Induction of Chronic Vasospasm

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Summary

An experimental technique for producing delayed cerebral vasospasm in a rabbit model is described. The basilar artery is punctured via the transclival route and angiographic verification is illustrated.

Keywords: Cerebral vasospasm; subarachnoid haemorrhage; basilar artery; transclival approach.

Introduction

Cerebral vasospasm after subarachnoid haemorrhage (SAH) is a serious clinical condition that may have an unfavourable prognosis. Clinical and experimental studies now available suggest that mechanical, chemical, and neurogenic factors are responsible for the occurrence of cerebral vasospasm after SAH[1, 2, 5, 19, 22].

Although numerous studies have investigated the factors that influence the development of cerebral vasospasm, it is apparent that intracranial vasospasm cannot be defined simply. Furthermore, its aetiology and pathogenesis are still not well understood, and no animal model has successfully simulated all the key aspects of human cerebral vasospasm[1, 3, 4, 6, 7, 8, 10, 15].

This study attempted to define a new model for experimental SAH which is cheap, reliable, sufficiently effective to be considered as a severe vasospasm and that can be verified angiographically.

Materials and Methods

Experiments were performed on 8 adult rabbits (New Zealand albinos) of both sexes (2.5–3.0 kg). The animals were anaesthetized with intravenous sodium thiopentone (30 mg/kg). After induction of anaesthesia and intubation, a transclival exposure was performed through a right submandibular incision under sterile conditions. The incision extended from the mandible to the jugular fossa. Sternohyoid and sternomastoid muscles were retracted laterally, and the intubated trachea and oesophagus were gently retracted with a self-retaining retractor to expose the capitus muscle lying on the clivus. With the aid of an operating microscope, the capitus muscle was coagulated and cut. A high speed-drill was used to remove the clivus in a circular manner with a 3 mm diameter. The dura was exposed and kept intact (Fig. 1 a). The basilar artery was easily visualized transdurally and perforated with a 22 G needle electrode (Fig. 1 b). Electrocardiography (ECG) and blood pressure were continually monitored during the procedure.

On the first and fifth postoperative day, selective vertebral angiography was accomplished by transfemoral catheterization with a 4F catheter. Preoperatively, the diameter of the basilar artery was measured in all eight rabbits at the midpoint of basilar artery (Fig. 2 a).

After angiographic evaluation and measuring the diameter of the basilar artery on the fifth postoperative day (Fig. 2 b), the basilar artery was re-explored transclivally to confirm the presence of angiographic vasospasm. The sternohyoid and sternomastoid muscles were again retracted and a tracheostomy was performed. Using an operating microscope the capitus muscle was removed and the basilar artery was exposed from the rim to the level of the posterior cerebral artery with a high speed drill. The dura mater was incised and retracted. The diameter of the basilar artery and changes from SAH were documented (Fig. 1 c).

Results

The preoperative mean diameter of the basilar artery was 737.5 ± 56.5 microns. The spastic mean diameter of the basilar artery on day five was 237.5 + 29.8 microns, which was a 68% reduction of the mean diameter compared to the preoperative mean (Fig. 3 and Table 1). The angiographic and photographic visualization of a spastic basilar artery is shown in Figs. 1 c and 2 b. The results were statistically evaluated using the Students t-test ($p < 0.001$). The mean diameter of the spastic basilar artery was considered to be significantly reduced.

There were no significant changes in the ECG and BP of rabbits during the procedures.

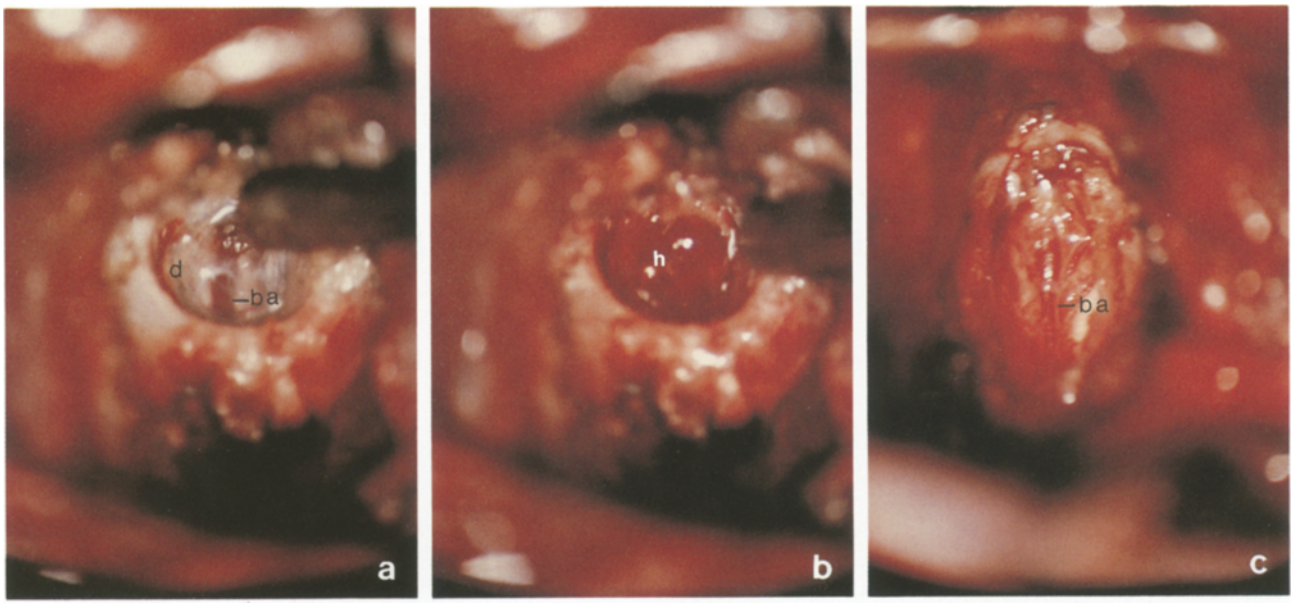

Fig. 1. Microphotographic representation of the basilar artery (*ba*) from an anaesthetized rabbit showing normal view (a), haematoma (*h*) induced by puncturing the basilar artery (b) and spastic basilar artery on the 5th day after haematoma production (c). (*d*) Indicates dura

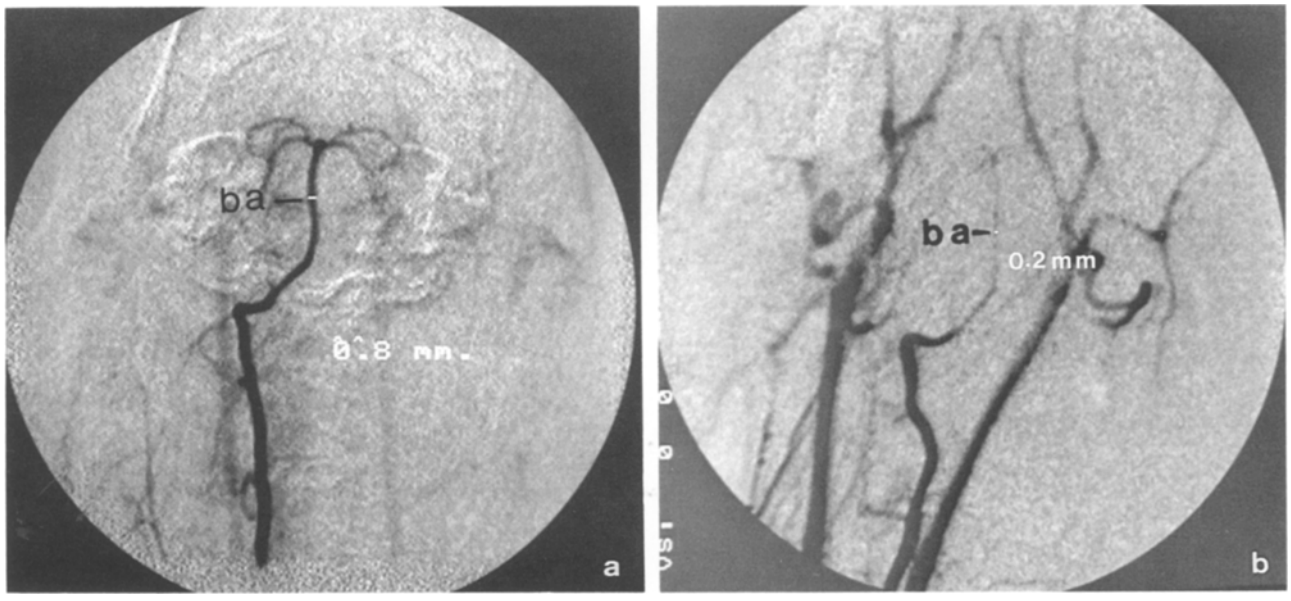

Fig. 2. Angiographic representation of basilar artery (*ba*) from anaesthetized rabbits. (a) Indicates normal angiographic figure of basilar artery. (b) Shows spastic basilar artery 5th day after a haematoma was induced around basilar artery

Discussion

Several animal models of SAH are available[1, 2, 3, 4, 7, 8, 12, 15, 18, 19, 21, 24]. Intracisternal injection of fresh autologous blood is the preferred technique, and monkeys, cats, dogs, and rabbits are the favourite experimental animals. Cisternal injection of dogs has been done selectively through the cisterna magna under sterile conditions[1, 4, 9, 10, 11, 13, 15, 16, 23, 25, 26]. Zabramski *et al.* modified this method by increasing the amount of blood injected[25, 26]. Chan *et al.* used a midline suboccipital incision to inject fresh autologous, well-heparinized arterial blood into the cisterna magna of rabbits[2]. After the injection, the diameter of the basilar artery was reduced 55% compared to baseline angiography

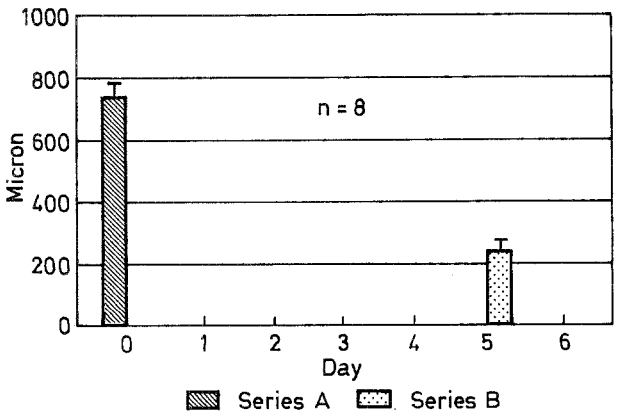

Fig. 3. Calculated results of the measured diameter of basilar artery before SAH (series *A*), 5th day after inducing basilar artery haematoma (series *B*)

Table 1. *Basilar Artery Diameters of Rabbits Before and Five Days After Induced SAH*

Rabbit	Day 1	Day 5
1	800 μ	200 μ
2	900 μ	200 μ
3	700 μ	200 μ
4	700 μ	260 μ
5	700 μ	200 μ
6	600 μ	260 μ
7	1000 μ	400 μ
8	600 μ	200 μ
Mean	737.6 ± 56.5	237.6 ± 29.8

although a high volume of arterial blood was injected into the cisterna magna (1.25 ml/kg). Compared with this model our model causes a 68% reduction in the mean diameter and it could be accepted as severe vasospasm.

Handa, Findlay and Nosko showed the effects of autologous blood clot on chronic vasospasm in monkeys[6, 11, 17, 18]. The monkeys underwent a right fronto-temporal craniectomy, and an autologous blood clot was carefully placed around the exposed artery. Frazee *et al.* also used a right fronto-temporal craniectomy, but they placed a 0.4 mm, round, stainless steel needle through both walls of the carotid artery[7]. An attached suture was buried subcutaneously. These two models, applied in monkeys, should be considered perfect models for cerebral vasospasm but they are expensive methods for initiating trials with new drugs in the treatment of vasospasm. There remains a great need for a simple and inexpensive model giving reproducible delayed arterial spasm for investigation of the pathogenesis of vasospasm.

Duff *et al.*[3] used the transclival approach in cats. They made a midline vertical incision over the larynx under sterile conditions. With the aid of an operating microscope, the lower clivus was exposed and this portion of bone was removed with microrongeurs so that the basilar artery could be visualized through the dura. Fresh autologous blood (0.5 to 0.8 ml), which was acquired from the exposed common carotid artery, was injected into the prepontine cistern. Our technique minimizes clival exposure, which permits the procedure to be accomplished quickly. Instead of puncturing the carotid artery for fresh arterial blood, the basilar artery was perforated. This aspect is an advantage of our method. SAH is produced under conditions similar to those that would be expected with rupture of an aneurysm bleeding under arterial pressure without predissection of the subarachnoid membranes and cisterns. The model produces reliable delayed cerebral vasospasm with an average 68% reduction in vessel diameter five days after haemorrhage. Only multiple injection models have produced similar degrees of spasm.

Our method of inducing vasospasm is unique because it uses the rabbit to produce a reliable model of severe vasospasm. It uses the transclival approach to the rabbit basilar artery and offers angiographic verification of vasospasm. There is little or no risk of infection since we do not open the dura mater. Experiments for relieving vasospasm with new drugs could be planned with this technique.

Acknowledgements

The authors are grateful to Miss A. Yuzubenli for her assistance. This project was supported by the Ankara University Research Fund (87-09-00-59).

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