Experimental lingual-basilar arterial microanastomosis

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A lingual-basilar artery microanastomosis was performed in 33 dogs; in 24, the cerebral arterial inflow was isolated to the lingual-basilar system. This experimental model demonstrated several factors influencing the use of extracranial vessels to enhance cerebral perfusion. The new lingual-basilar system increased in size to meet flow requirements formerly served by the normal vessels. Arterial spasm was present in the early postoperative period. Arteriography was detrimental if performed at the time of anastomosis or in the healing phase.

KEY WORDS · basilar artery · cerebral perfusion · lingual artery · microanastomosis

Attempts to relieve obstruction of intracranial vessels have generally been directed toward excision of the offending lesion. This has been accomplished by incision of the vessel wall, removal of the obstructing material, and simple closure of the vessel. Subsequent patency with preservation of good neurological function has been reported, but frequently the results have been limited by failure to maintain patency due to intrinsic disease of the vessel wall. Even with the added precision afforded by the operating microscope, enthusiasm for this procedure has been restrained.

The concept of using a normal extracranial vessel to supply intracranial vessels through anastomosis has been emphasized by Donaghy and Yaşargil who reported three patients in whom the superficial temporal artery was used to irrigate the middle cerebral territory by anastomosis to a temporal cortical branch. Yaşargil has performed this procedure in 16 patients. The author has utilized this procedure in four patients.

We have created an experimental lingual-basilar system as a model for exploring factors involved in the use of extracranial vessels to enhance cerebral blood flow.

Methods

Lingual-Basilar Anastomosis

Thirty-three large mongrel dogs were anesthetized with intravenous pentobarbital sodium (24 mg/kg). Each animal was placed in the supine position and the trachea intubated. A curvilinear incision was made to the right of the anterior cervical midline and a surgical plane developed between the midline structures and the carotid sheath. The hypoglossal nerve and underlying lingual artery were isolated. The artery was freed for a distance of 4 to 5 cm distally, by splitting the myohyoid and hyoglossus muscles in the direction of their fibers. All small branches were ligated and divided. The hyoid bone was exposed and fractured at its right anterior corner. This facilitated mobilization of the pharynx without perforation. The paired underlying longus capitus muscles were then sepa-
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rated from each other to expose the clivus between the tympanic bullae and posteriorly to the condylar notch.

The remainder of the operative procedure was performed under the Zeiss operating microscope at ×10, ×16, and ×25 magnifications. With a pneumatic drill, an opening of 7 × 10 mm was made through the clivus. The dura was opened and the basilar artery exposed. After a temporary clip was applied to the lingual artery near its origin, the distal end was sectioned and the lumen irrigated with normal saline. A small incision (Fig. 1) was made at the distal end on the side selected for the posterior corner of the end-to-side anastomosis. A segment of basilar artery was isolated between two temporary clips. Occasionally it was necessary to include one or two branches within the clips to achieve hemostasis. A "tear-drop"-shaped opening was then made through the wall of this vessel. The anastomosis was begun by placing a suture (9-0 nylon) at each end of the opening in the basilar artery to secure the thick-walled lingual artery in place. Two or three sutures (10-0 nylon) were then placed along each side to complete the anastomosis. The proximal basilar clip was removed first, and pulsation of the lingual artery confirmed that the anastomosis was patent. Any bleeding from the anastomotic site usually ceased spontaneously. The clip was next removed from the lingual artery to flush any fibrin deposition away from the cerebral circulation, prior to removal of the final basilar clip. The basilar artery was then ligated just proximal to the anastomosis. The longus capitis muscles were reapproximated to cover the bone opening and prevent CSF drainage. The lingual artery was routed to avoid possible kinking prior to routine closure of the wound.

Isolation of Circulation

The left common carotid artery was excised distal to its midcervical portion with special care to ligate the internal maxillary artery beyond its superficial temporal branch. All carotid branches were individually ligated. The right common carotid artery was excised distal to its lingual branch. All carotid branches proximal and distal to the lingual artery were individually ligated.

Arteriography

Arteriography was performed by injection of Hypaque-M 75% (5 cc) through a Courand needle placed in the right carotid artery. On occasion Hypaque-M 75% (1 cc) was injected directly into the lingual artery through a needle or catheter.

Results

A lingual-basilar anastomosis was performed in 33 dogs. Twenty-nine anastomoses were open when subsequently (average 3 months) studied by arteriography (Fig. 2) or autopsy. A histological section illustrates the excellent healing which resulted between the thin wall of the basilar artery and the thick wall of the lingual artery (Fig. 3). Two open anastomoses closed later, and two others became severely narrowed.

In 24 dogs, the cerebral arterial inflow was isolated (by staged procedures) to the new lingual-basilar system in order to evaluate its functional capacity. Nine survivors have been retained for long-term evaluation. The longest survivor was most recently studied 2 years following the initial surgery (Fig. 4). The lingual-basilar system enlarged after

Fig. 1. Drawing showing preparation for anastomosis. Precise intima-to-intima apposition was facilitated by careful preparation of vessels. The "tear-drop"-shaped opening in the basilar artery was made with a knife and microscissors. Placement of sutures close to tissue margins was essential to avoid stricture or an irregular surface (as illustrated in Fig. 5 B).
removing other sources of cerebral circulation.

Two animals were sacrificed by interruption of the lingual artery. Four animals died because of a technically faulty anastomotic lumen. In three of these, thrombotic occlusion became superimposed upon the stenosis. This is illustrated (Fig. 5B) by an animal that died 1 month following surgery. Arteriography 1 week earlier had inaccurately suggested an adequate lumen (Fig. 5A). One animal apparently died from anesthetic complications during arteriography.

Arteriography, when performed immediately upon completion of the anastomosis, uniformly revealed marked spasm of the lingual-basilar system (Fig. 6A) in comparison with later studies (Fig. 6B). One animal, in which a particularly good anastomosis had been accomplished, was subjected to immediate isolation of the circulation. Failure to survive was attributed to vascular spasm resulting from operative manipulation.

Preliminary observations suggested that arteriography at the time of anastomosis might be detrimental. Hypaque-M 75% (20 cc) was therefore injected into the right carotid artery of five dogs after completing the anastomosis. At subsequent arteriography, fairly good filling was observed for one or two injections, followed by profound reduction in the number and size of arteries visualized (Fig. 7) and death of the five animals in this group. A further observation, in some animals that had received Hypaque at the time of anastomosis or early in the healing phase, was the deposition in the vessel wall or lumen of thrombus containing an abundance of hemosiderin (Fig. 8). This resulted in severe narrowing of the lingual artery in two animals and was responsible for their death.

Discussion

For this investigation an end-to-side anastomosis was considered to offer several advantages. The thick muscular wall of the lingual artery could easily be adapted to the thin wall of the basilar artery while creating an orifice of maximum diameter and of optimal shape for hemodynamic efficiency. The tethering at each end of the intact basilar artery protected against distortion by any traction effect of the pulsating lingual artery. Removal of temporary clips in the appropriate sequence permitted flushing away of any fibrin particles which may have accumulated.
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while performing the anastomosis, thereby avoiding microembolic occlusion of tiny terminal vessels.

The lingual-basilar system increased in size as other sources of cerebral circulation were eliminated, reflecting the capability of a new vascular system to enlarge and meet flow requirements formerly served by other vessels. Conversely, anastomosis to a vessel with poor “run-off” is not likely to remain open.

It was of interest to learn that flow through the new lingual-basilar system became adequate to perfuse the entire canine brain and maintain survival without incident. White and Donald reported that ligation of the canine basilar artery accompanied by occlusion of carotid inflow, including both internal maxillary arteries, resulted in immediate apnea and death. In the present study significant reduction of flow through the lingual-basilar system because of ligation, stenosis, or spasm resulted in apnea and death. This observation confirmed the findings of White and Donald and provided an indication of the adequacy of flow through the new system.

The existence of severe spasm at the time...
of anastomosis is a significant deterrent in planning a procedure which would require immediate dependence on a new arrangement of arterial inflow. Preferably, time should elapse for the establishment of optimal flow before completing, at a later stage, a procedure requiring interruption of the original blood supply.

The complications encountered with those animals that had received Hypaque at the time of anastomosis were annoying obstacles in this experimental study and emphasize the need for caution in using arteriography to reveal patency of a clinical anastomosis.

Fields and associates⁴ have reported eight patients with especially effective collateral

Fig. 5. A. Arteriogram 22 days after surgery. Actual size. B. Photomicrograph from same animal, which died 31 days after surgery. Cross section through the posterior anastomotic lumen demonstrates technical failure. Fold (F) of arterial wall created partial obstruction between lingual artery (LA) and basilar artery (BA) resulting in an irregular surface, a source of propagating thrombus (Th). H & E, ×34.

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Fig. 6. A. Arteriogram at completion of anastomosis (arrow). B. Same animal 22 days later. Actual size.

Fig. 7. Arteriogram 12 days after anastomosis shows sparse filling of intracranial vessels during second injection. The internal carotid artery (IC) became occluded after the first injection, which had demonstrated filling comparable to Fig. 4 D. Posterior cerebral artery (PC); anterior cerebellar artery (ACB). Actual size.
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Fig. 8. Histological section through the lingual artery (LA) adjacent to anastomosis 27 days after surgery. Thrombus (Th) extends into the lumen (L) which it partially obstructs. Hemosiderin is prominent. H & E, ×83.

circulation who survived basilar artery occlusion. Anastomosis of an occipital artery to a cortical branch of a posterior cerebral artery might enhance perfusion of the vertebrobasilar system in those individuals threatened by basilar artery occlusion but demonstrating insufficient collateral circulation. Our experimental study has shown that even greater potential blood flow could be offered by direct anastomosis to the basilar artery; this fact has been clinically applied to the carotid system by Lougheed and associates.

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