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A Method for Temporary Arterial Occlusion During Intracranial Aneurysm Surgery

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Abstract

*Introduction***:** The strategic use of temporary intracranial arterial occlusion is an important technique in aneurysm surgery. Metal clips similar to permanent aneurysm clips are employed but they are not ideally suited to the task.

Methods: Balloon occluders placed around intracranial arteries at the Circle of Willis can provide immediate control of intra-luminal flow. These remotely controlled devices can be positioned in advantageous locations before they are needed and deployed if the situation arises.

Results: The feasibility of balloon occluders was demonstrated in a patient with an anterior communicating artery aneurysm. A balloon occluder can be positioned without excessive dissection and permits the operating surgeon to proceed expeditiously and in a less crowded field.

Conclusions: Hydraulically activated vascular occluders may offer a degree of technical refinement to the performance of temporary arterial occlusion.

Key Words: balloon occlusion • temporary occlusion • cerebral aneurysm • subarachnoid hemorrhage • innovation

The judicious use of temporary arterial occlusion is an important technique in the operative treatment of intracranial aneurysms. Metallic clips of the same design as permanent clips are employed. This choice of design seems to be a

consequence of historical evolution and creative necessity. Early "temporary" clips were standard clips applied to the anterior cerebral arteries to facilitate dissection of the anterior communicating artery complex (7). Recognition that intimal damage could result from high clip pressure (1-4, 8, 10) led to the development of low closing pressure temporary clips deliberately designed to minimize intimal trauma (11). These temporary clips are positioned and removed by the same instruments as their permanent counterparts and are distinguished by color coding. There are obvious advantages to this approach but there are also notable disadvantages.

There are two basic scenarios for temporary clipping (10). The surgeon may have completed initial dissection of the aneurysm complex and determined that definitive delineation of the aneurysm and permanent occlusion can be most safely accomplished with temporary clips in place. The reasons for this include dense adhesions, treacherous or unclear anatomy, or the occasional aneurysm amenable to clipping only when no longer turgid or frankly deflated. The other scenario is inadvertent/premature rupture or hemorrhage produced while attempting to position a permanent clip. In this setting temporary clips may salvage a catastrophic situation but there is some urgency in their application. Despite the nostrum that appropriate temporary clip sites should be prepared in advance, misadventures occur. The field can be crowded by the temporary clips, particularly when they are applied under duress. Permanent clip placement may be sub-optimal as a result.

A different strategy for temporary arterial occlusion would be to position unobtrusive remotely controlled occluding devices in advantageous locations and have the assistant deploy them if the situation arises. Hydraulically activated vascular occluders may be an effective means to achieve temporary arterial occlusion.

Description of the Device

Inflatable cuffs for constriction or occlusion of blood vessels in laboratory animals were described in the 1960's (6) and are still in use today. The soft and malleable occluder is positioned circum-

ferentially to the vessel of interest and the eyelet secured with a suture (Fig. 1).

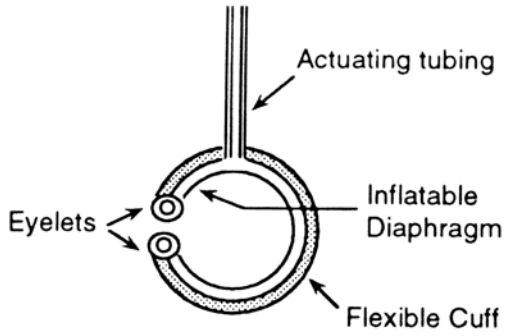

Fig. 1 Schematic design of vascular occluder device. The eyelets may be secured by a suture or a small vascular clip

The suture is necessary so that the inflating diaphragm compresses the vessel rather than straightening the "C" shaped curve. An integrated catheter 30 cm in length permits remote activation of the occluder by a fluid filled syringe (Fig. 2).

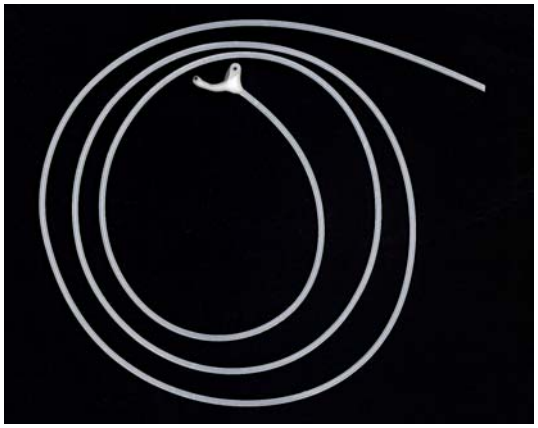

Fig. 2 Vascular occluder with integrated 30 cm catheter. Filling of the catheter dead space and complete cuff inflation requires approximately 1.5 cc of fluid.

Lumen diameters of 2 mm to 10 mm with cuff widths 3 to 7 mm are commercially available (In Vivo Metric, Healdsburg, California).

A 3 mm diameter 3 mm width occluder was easily positioned along the A-1 segment in a patient with an anterior communicating artery aneurysm. The "C" curve was secured by a partially closed small hemoclip rather than a suture. The catheter was tucked beneath a cottonoid and trailed to the assistant's position. The entire arrangement created very little compromise of the operative field. Brief inflation produced cessation of distal flow as determined by a microvascular doppler probe (Mizuho America, Beverly, Mass.). The occluder was removed and the operation completed.

Discussion

The principle advantage lies in the immediate control of arterial flow by the assistant, permitting the surgeon to proceed expeditiously and uninterrupted. There may be other subtle technical advantages. After permanent clip application, the surgeon could examine the results closely and without the visual impediment of a temporary clip remover

as the occluders are sequentially deflated by the assistant. This may permit more ready identification of a hemorrhage site, to be followed by re-inflation of the occluder(s) and clip repositioning. One disadvantage is that somewhat more dissection is required to position these devices than for conventional temporary clips.

The design and construction of the vascular occluders could be improved, particularly by a manufacturer of neuro-endovascular balloons. The 3mm width precludes positioning along an artery if perforating branches are more closely spaced than this. The closing pressure needs to be determined at various inflation volumes. Values above 80g for temporary metal clips are known to produce intimal damage (9) and should be avoided, particularly if the balloon compresses a longer arterial segment than would a clip. It might be possible to minimize vessel trauma by determining the smallest inflation volume needed to abolish distal flow (3) as determined by intraoperative micro-doppler recordings. This degree of flexibility is not possible with metallic clips. This approach is not novel. Dr Heifetz designed a quite similar occluding device for the extracranial carotid artery (5). If properly refined, balloon vascular occluders may facilitate temporary intracranial arterial occlusion and safe aneurysm surgery.

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Comments

The article is well and clearly written. This article describes an inflatable device for temporary occlusion of intracranial arteries during aneurysm surgery. This device may be less traumatic than temporary clips for the arterial wall. It was successfully applied in one patient with an anterior communicating artery aneurysm. Although this is a preliminary report that needs confirmation in a larger number of patients

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Bern, Switzerland

This article discusses a new method of securing proximal arterial control during intracranial aneurysm surgery. The prototype balloon occlusion described requires more dissection than temporary clips and is not calibrated and requires microscopy to confirm complete control. It is possible to exert a very high pressure which could damage the endothelium of the occluded artery. The requirement of a hemostat clip to secure the balloon adds to the problem. It is also possible for the occlusion to give way during critical part of the procedure with loss of control. It is also not suitable for low ICA aneurysms or ophthalmic artery aneurysms. However this device with modification and further in vitro evaluation may prove to be a useful invention for some cases. Its main competitive will remain proximal temporary clips and intravascular balloon occluders.

Mr MS Eljamel, MD (Hons) FRCSI
Dundee, UK

My feeling is that as a prototype the device may be an exciting advance. It will stimulate debate certainly and thought also. I feel that if it can be further refined so that it may be applied using standard clip applicators (this would require reduction in size) it may be adopted widely. The great benefit of such a device, if it can be developed in an easily applicable form , is that it may be pre-placed and used only when required.

Mr George F Kaar, BSc, BOA, PhD, FRCSI, FRCP (Edin)
Editor, Annals of Neurosurgery
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It would have been noteworthy if the author could have provided data on the pressures which are necessary to inflate the balloon and occlude the vessel. It would also be of interest to know how often they used this technique intra-operatively already. An additional intra-operative picture and the corresponding Doppler signals before, during and after occlusion would be ideal to increase the practicability and safety of this original idea.

Professor Dr.med Jürgen Meixensberger
Leipzig

***Author's reply**:* I have employed the temporary occluder for four aneurysms, two anterior communicating artery complex and two middle cerebral distribution, using 1.0 to 1.25 cc of sterile water to achieve vessel occlusion. I did not take photographs. I felt they would not add much to a presentation

Temporary clipping is an important adjunct in cerebral aneurysm surgery. The authors describe the use of a pre-placed, inflatable occluding device that is connected to a fluid filled syringe via catheter. The device is inflated for occlusion of the artery and can be re-inflated if the primary clipping is suboptimal.

The obvious advantages of this device are that it would eliminate crowding by multiple clips and minimize the intimal damage to the occluded vessel. However, having used temporary clipping in select cases, my feeling is that the actual application of this device may cause perforated damage especially in the anterior communicating area. There may be a higher than expected "fiddle" factor that may make it more difficult to use.

Although this is an innovative idea, I am not certain that it will be embraced universally due to its technical limitations. It would help to show an intra-operative picture of the device. Although this is a technological advance, its indications may be limited.

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