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Introduction

With the Food and Drug Administration's approval of the Guglielmi detachable coil, the safety and efficacy of endovascular treatment of aneurysms has increased. Development of new devices, such as stents, may also favorably impact aneurysm management. Nonetheless, the standard for treatment of most aneurysms remains conventional neurosurgical clipping. Endovascular therapy is an option for treatment in an appropriate clinical setting. Factors determining the appropriateness of using an endovascular technique for aneurysm treatment include aneurysm morphology, medical stability of the patient, and risk of endovascular treatment versus risk of surgical clipping. Decisions regarding the most appropriate form of treatment in individual cases are best made by a team of closely consulting physicians, made up of at least an endovascular physician and a neurosurgeon capable of complex open vascular approaches. The following are guidelines for choosing indications, monitoring safety and efficacy, and establishing practice standards. It is important to remember that these are only guidelines. For any particular patient, alternative treatment may be valid and may be preferred for sound clinical reasons.

Pre-procedural Guidelines

Complete diagnostic angiography should precede endovascular therapy. The results of this pre-procedural study should be permanently recorded and should be sufficiently detailed to fully characterize the pertinent vascular anatomy, aneurysm morphology, and presence or absence of vasospasm.

Neurosurgical Support

Endovascular treatment of an aneurysm should be performed in an environment in which appropriate open operative care and/or ventricular drainage can be instituted promptly. A readily available and qualified neurosurgeon should be aware of the procedure before its initiation.

Procedural Guidelines

During the procedure, the guidelines outlined under ''General Considerations'' should be followed. In addition, the following are recommended. For patients with unruptured aneurysms, systemic anticoagulant therapy using heparin may be considered during the procedure. Ideally, there should be the capability of obtaining rapid activated clotting time measurements. The need for anticoagulant therapy for patients with ruptured aneurysms should be at the discretion of the endovascular therapist and the neurovascular surgery team. A record should be kept of the number and size of coils or other devices used during the procedure. This should include detached coils as well as coils removed undetached from the body. For eletronically detachable coils, detachment times should be observed and any prolonged detachment times noted. In addition, any mechanical difficulties should be noted. Equipment, pharmaceuticals, and physician expertise to perform local intra-arterial thrombolysis should be available. Equipment, pharmaceuticals, and physician expertise to perform mechanical and chemical treatment of vasospasm should be available. Final control angiography of the appropriate territories should be performed to document the anatomic result. A CT scanner must be readily available in the facility.

Post-procedural Guidelines

After the procedure, the following guidelines should be maintained. Patients with unruptured aneurysms should be observed in a setting conducive to intense neurologic monitoring, typically overnite (ie, intensive care unit, neurosurgical step-down unit). Patients with ruptured aneurysms should receive standard neurosurgical observation and management.

Follow-up

Reasonable follow-up must be arranged with the endovascular physician, neurosurgeon, and/or referring physician. Follow-up may include pertinent history and physical examination, radiography of the skull, MR imaging, MR angiography, CT angiography, and/or conventional angiography. The length and type of follow-up may change as new procedural developments occur.

Definitions

To follow and evaluate the safety and efficacy of a therapeutic modality, outcome measurements need to be established. The following definitions will be used to establish outcome measurements for aneurysm endovascular therapy.

Success rate: The success rate or efficacy is the percentage of patients with positive clinical and/or imaging outcomes resulting from the procedure. The goal in instituting of any form of aneurysm therapy is to prevent aneurysm rupture or rebleeding or to stabilize or decrease symptoms of mass effect

caused by giant aneurysms. It is assumed that the clinical success rate of endovascular therapy of aneurysms is dependent on the degree of exclusion of the aneurysm from the circulation, either by direct coiling or parent artery occlusion. The ability to achieve technical success is related to several factors, including anatomy of the circulation, aneurysm morphology (ie, neck size), and collateral circulation.

Initial degree of occlusion: The initial degree of occlusion is defined angiographically as 100% minus the amount of residual aneurysm filling. Broad categories of this outcome measurement include 100% (complete occlusion), 90% to 100%, 70% to 90%, 50% to 70%, <50%, and technical failure (inability to treat).

Follow-up degree of occlusion: The follow-up degree of occlusion is defined angiographically as 100% minus the amount of residual aneurysm filling at the time of follow-up. This outcome measurement may be the same, greater (because of progressive aneurysm thrombosis), or less (because of coil compaction or migration) as compared with the initial degree of occlusion.

Determinants of Success

There are several factors that determine the technical success of treating each aneurysm. The anatomy of the circulation leading to the aneurysm is an important determinant of catheterization success. The morphology of the aneurysm is an important factor, especially for direct aneurysm coiling. Aneurysms with narrow necks (<4 mm) and small dome sizes (≤10 mm) have the highest potential success rate. Aneurysms with wide necks (neck:body ratio > 1.2 [ie, the neck as measured by quantitative cerebral angiography is > 50% compared with the body of the aneurysm, or aneurysm neck > 4 mm in size) have a reduced potential success rate. In cases of ruptured aneurysms, the initial clinical Hunt and Hess grade is an important marker for eventual patient outcome (ie, neurologic morbidity and mortality).

Determinants of Degree of Occlusion

The main factors determining the initial degree of occlusion are aneurysm morphology (ie, neck anatomy and relative neck and dome diameters) for parent vessel preservation procedures and degree of collateral flow for parent vessel occlusion procedures. The degree of occlusion at the time of follow-up for direct aneurysm coiling is determined by several factors. The tighter the original coil packing is, the better the long-term occlusion will be. In addition, the relationship of the aneurysm to the parent vessel is important. A side wall as opposed to a parent vessel terminus aneurysm has less of a tendency toward long-term coil compaction and recanalization. A large amount of thrombus within the aneurysm may lead to long-term coil migration and recanalization.

Indications

Cerebral aneurysms can be categorized as ruptured and unruptured aneurysms. Endovascular therapy of these groups of aneurysms can be further subdivided into parent vessel sparing and parent vessel occlusion.

Indications for parent vessel sparing in cases of ruptured cerebral aneurysms include poor surgical candidacy due to medical risk factors, poor clinical grade, high risk for surgical clipping due to location or size, failed attempt at surgical clipping, and significant vasospasm in vascular distribution removed from aneurysm location.

Indications for parent vessel sparing in cases of unruptured cerebral aneurysms include poor surgical candidacy due to medical risk factors, high risk for surgical clipping due to location or size, failed attempt at surgical clipping, patient and/or family refusal of open surgery, multiple aneurysms that would require more than one open surgery, and multiple craniotomies that might be treated by a combination of Guglielmi detachable coils and open surgery to decrease the number of craniotomies.

Indications for parent vessel occlusion in cases of ruptured or unruptured cerebral aneurysms include fusiform aneurysm; pseudoaneurysm secondary to trauma, infection, neoplasm, or spontaneous dissection; certain large or giant aneurysms; certain aneurysms in patients who have been shown to have adequate tolerance to occlusion (see balloon test occlusion [BTO] guidelines); certain aneurysms in patients who are at high risk for a revascularization procedure in the presence of equivocal BTO results for whom post-occlusion medical management beyond that typically used is anticipated, at the management team's discretion; certain aneurysms in patients who have undergone revascularization; and certain aneurysms in patients who are hemodynamically stable.

Threshold: When <95% of the procedures are performed for the above indications, a review should be conducted.

Efficacy

Thresholds for success related to endovascular treatment of aneurysms are presented below.

Parent Vessel Sparing Indicator	Threshold (%)
90–100% Immediate occlusion	>70
<50% Immediate occlusion	<5
Technical failure	<5
Recanalization	<10

Parent Vessel Occlusive Indicator	Threshold (%)
Non-filling of the aneurysm	>80
Minimal filling of the aneurysm	<20
Moderate filling of the aneurysm	<5
Stabilization of mass effect symptoms	<50

Safety

Thresholds for complications related to endovascular treatment of aneurysms are presented below.

Unruptured Aneurysms Indicator	Parent Artery Occlusion (%)	Parent Artery Sparing (%)
Death in hospital	0	0
All neurologic complications (procedure related)	10	8
Permanent neurologic complications (procedure related)	5	3
Inadvertent vessel occlusion	N/A	8
Vessel perforation	0.5	2
Aneurysm rupture during procedure	1	1
Aneurysm rupture after procedure	2	2

Ruptured Aneurysms Indicator	Parent Artery Occlusion (%)	Guglielmi Detachable Coil Parent Artery Sparing (%)
Death in hospital:		
Hunt and Hess Grade 1	5	5
Grade 2	15	15
Grade 3	40	40
Grade 4	60	60
Grade 5	75	75
All neurologic complications (procedure related)	8	8
Permanent neurologic complications (procedure related)	3	3
Inadvertent vessel occlusion	N/A	8
Vessel perforation	0.5	2
Aneurysm rupture during procedure	5	5
Aneurysm rupture after procedure	5	5

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