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**Continued progress in the evolution of
endovascular therapy.**

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Continued Progress in the Evolution of Endovascular Therapy

Although there are no precise statistics regarding true prevalence, thromboembolic events represent perhaps both the most common and the most significant of all those adverse incidents that occur in association with endovascular therapy of vascular disease of the central nervous system. Unfortunately, the interventionalist's capacity to recognize rapidly and then to remedy such complications has lagged significantly behind the swift development and commercialization of the many new materials and devices that has occurred during the last decade. In this issue of the *AJNR*, the report by Cronqvist et al clearly illustrates one important approach to such complications that should be well positioned in the armamentarium of all those who practice interventional neuroradiology. Several points from this experience deserve comment.

See article on page 157.

First, these data complement previous experience suggesting that successful vascular recanalization seems to be associated with an improved clinical outcome. Even in circumstances that would seem to be optimal in which to carry out attempts at clot dissolution, however, success at recanalization was not always achieved and clinical outcome did not always correspond to the completeness of arterial recanalization. While many variables might have operated to produce these results, two are of particular significance. One is the characteristics of the thrombus causing the arterial obstruction. Fresh, red cell thrombus with poorly or incompletely cross-linked fibrin may, under conditions where it is exposed to adequate shear stress, virtually disaggregate and completely resolve spontaneously. Such thrombus might be expected to occur in areas of stasis as may occur in small arteries during and shortly after placement of catheters and coils into an aneurysm. Well-organized fibrous thrombus, such as that present in aneurysms previously treated with Guglielmi detachable coils (four [21%] of the 19 thromboembolic events occurred in patients who were undergoing a second coil procedure) or such as might be dislodged from an atherosclerotic lesion during placement of a guiding catheter (four [21%] of the 19 thromboembolic events occurred under such circumstances) may be almost totally resistant to dissolution by thrombolytic drug or attempts at fragmentation. A second variable that might have influenced the results is the robustness of leptomeningeal collateral blood flow providing supply to the parenchyma normally served by an occluded artery. Techniques for rapid stratification of individuals with thromboembolic strokes according to these two factors, the adequacy of collateral flow and the characteristics of the thrombus causing arterial obstruction, are sorely needed. When available, they will greatly enhance the ability to improve therapy not only in the circumstances described in this article, but

also in many other circumstances associated with ischemic stroke.

Second, despite what seems, in this population, to be a trend for both better anatomic and better clinical results in those individuals treated with the technique of clot disruption by some degree of fragmentation followed by infusion of thrombolytic drug distal to the thrombus, as compared with those treated only by infusion of thrombolytic drug at the proximal face of the thrombus, the optimal technique for reopening an acutely occluded artery remains elusive. Almost certainly it varies from individual to individual, again depending to large degree on the anatomic and physiological nature of collateral arterial supply and the characteristics of the thrombus itself. Fragmentation and downstream displacement of embolic material into the arterial supply of parenchyma having no collateral supply would be expected to result in what is in essence an immediate closure of the "therapeutic window." Alternatively, fragmentation of a thrombus to such a degree that flow is reestablished to a level that tissue remains ischemic but still viable may result in creation of a situation where the therapeutic window might remain open for many hours if not for days.

Finally, the thromboembolic events reported in this series occurred predominantly in patients being treated for aneurysms located on the middle cerebral artery or the anterior communicating artery. This association reflects both my personal experience and that of others long involved with this procedure. Why do thromboembolic events seem to occur more frequently in aneurysms in these locations than in others? It is often the case that because of complex branching and short distances, especially near the final stages of aneurysm treatment, visibility of the relationships between a middle cerebral artery (both M1 and M2 locations) aneurysm or an anterior communicating artery aneurysm and its parent artery is poor. This creates a situation in which inadvertent compromise of a parent artery can occur and thus establish an ideal venue for thrombus formation. Before aneurysm catheterization or placement of a coil within an aneurysm, great effort should be devoted to defining an angiographic projection that allows these relationships to be seen at all stages of the procedure. Improvement in imaging technology is greatly needed to assist the interventionalist with this problem.

A key element in the continued advancement of endovascular therapy lies in our ability to devise techniques to recognize quickly and to remedy complications that occur during and after a procedure. This report of aggressive but appropriate management of thromboembolic complications occurring in association with endovascular treatment of saccular aneurysms represents another step in the maturation of endovascular therapy.

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Senior Editor