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# AJNR

## Stretch-Resistant Coils for Intracranial Aneurysms: One Step Forward or Two Steps Back?

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*AJNR Am J Neuroradiol* 2014, 35 (3) 414-416

doi: <https://doi.org/10.3174/ajnr.A3727>

<http://www.ajnr.org/content/35/3/414>

This information is current as  
of July 16, 2024.

control CT showed that our needle was too deep and the glue had reached the hypothalamus. The patient spent a week in the intensive care unit, and though he completely recovered, it still gives me goose bumps to think about it.

There is no consensus about the most comfortable temperature. The way we perceive temperature has a lot to do with the humidity accompanying it. For example, if the humidity is 0%, 24°C will feel like 21°C, while with a 100% humidity, 24°C will feel like 27°C. The most comfortable humidity levels are between 40% and 50% (levels also said to prevent upper respiratory tract infections). In places with extreme outside temperature variations, it is recommended that inside temperatures be kept at 21°–23°C (69°–73°F).<sup>9</sup> In the United States, the Occupational Safety and Health Administration recommends a range of 20.5°–24.5°C (68°–76°F) and humidity between 20% and 60% at workplaces.<sup>10</sup> Another anecdote: Upon arriving in Panama City, my colleague and friend, Dr Ilka Guerrero asked me if I had brought a sweater because the city was about the coldest place on earth. After entering my hotel, I understood what she meant. Air conditioning thermostats were kept at 16°C (62°F). Those of us who grew up elsewhere in warmer latitudes never cease to be amazed by how cold buildings are kept in the United States (they are even colder in the United Kingdom where regulations dictate temperature at the workplace be “reasonable”—that is, 16°C (61°F))<sup>11</sup>

Cold inside buildings is a luxury, and it has been documented that the most expensive stores (Hermes, 20°C) are kept colder than the least expensive ones (Old Navy, 27°C).<sup>12</sup> Apparently colder spaces encourage us to buy more and also save electricity. We radiologists must work in cold environments because computers and monitors (not to forget the view boxes of the past) generate a lot of heat and reading rooms can only be kept comfortable by lowering the thermostat. Work productivity is better at stable and slightly lower temperatures<sup>13</sup> but colder temperatures are uncomfortable and the New York Public Library allows their workers to accrue compensatory time when its temperature drops below 20°C (68°F).

It is a common belief that heavier individuals are more sensitive to heat (and conversely will feel cold to the touch), while skinny ones are sensitive to cold (but will be hot to the touch). Subcutaneous fat serves as an insulator, but women, who as a general rule have more of it, are more sensitive to cold than men.<sup>14</sup> Malnourished individuals with little fat may experience hypothermia in temperatures of only 15°–18°C.<sup>15</sup> An intriguing observation is that hot and cold result in nearly identical brain responses. (When ice first arrived in Maconada in Garcia Marquez’s *One Hundred Years of Solitude*, people could not tell if it was hot or cold.) With fMRI, the response to noxious hot and cold stimulation was studied, and it was shown that extreme temperatures both activated similar networks.<sup>16</sup> While this study and others confirm the activation of unified neural networks for different intensities of temperature, other studies show that the perception of pleasantness or unpleasantness associated with temperature changes occurs in different brain regions.<sup>17</sup> More or less neuronal firing in these areas occurs as temperature changes.

Our feeling of well-being is tied to what we believe is a comfortable temperature, and some of our activities are immediately associated with temperature. Reading by a source of warmth such as a fireplace comes to mind except when it comes to *AJNR*, which I think can be read when it is cold or hot.

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## EDITORIAL

### Stretch-Resistant Coils for Intracranial Aneurysms: One Step Forward or Two Steps Back?

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**E**ndovascular treatment of cerebral aneurysms was boosted by the introduction of the Guglielmi detachable coil system (Boston Scientific, Natick, Massachusetts) in 1991. The concept of

<http://dx.doi.org/10.3174/ajnr.A3727>

“detachability” made the selective placement of long coils into the lumen of an aneurysm much safer: Inserted coils could be repositioned when needed or even withdrawn and replaced by another coil. When the position of the coil in the aneurysm was satisfactory, the coil could be electrolytically detached. Occasionally, operators experienced unintended unraveling of the primary coil winding, on withdrawal or retrieval of the coil. This unraveling of the proximal part of the coil could occur when the distal part was stuck inside the mesh of previously inserted coils. An unraveled coil cannot be repositioned, and further withdrawal either leads to the removal of the remaining part of the coil or to coil fracture, resulting in thrombogenic coil material left in normal cerebropetal vessels.

To solve this technical problem of coil unraveling and fracture, manufacturers built in a filament centrally in the primary winding of the coil. The filament was made of nitinol, polyglycolic acid, or polypropylene and was attached to the proximal and distal ends of the coil. These coils were called stretch-resistant (SR) coils. In these SR coils, the force of withdrawal is transmitted by the inner filament and not by the winded coil wire itself. The concept of stretch resistance appealed to many operators and manufacturers, and all manufacturers currently have ranges of SR coils.

However, later it was suggested from clinical and experimental studies<sup>1,2</sup> that the SR filament had a negative influence on the physical properties of the coil, such as coil softness, shape memory, and flexibility. In the experimental study of Miyachi et al,<sup>2</sup> various types of SR coils caused hardening and straightening of the last few millimeters of the coil. The straightening phenomenon was due to relative SR line shortening and subsequent condensation of pitches of the first loops at the coil end. Coil tail flexibility was lost, and the SR coil for the last part behaved like a stiff wire. This straightening of the last few centimeters of the coil caused catheter kickback and thus progressive difficulty in inserting the final part of the coil. This technical issue was specific to SR coils and did not occur with standard coils.

When the last part of the coil is straightened and cannot be placed inside the aneurysm, the coil has to be withdrawn. With more manipulation, the risk of complications increases. In addition, the handling drawback of SR coils may also result in placement of fewer coils in comparison with standard coils and thus in lower packing attenuations and possibly more recurrences at follow-up. To test the hypothesis of lower packing attenuations obtained with SR coils by impaired handling, we compared the packing attenuations of 74 aneurysms treated with newly introduced SR Galaxy coils (Codman & Shurtleff, Raynham, Massachusetts) with those of 74 volume-matched aneurysms treated with standard Trufill/Orbit coils (Codman & Shurtleff) (Table). The recently introduced SR Galaxy coils only differ from the standard coils in the presence of the SR filament; all other properties are equal.<sup>3</sup> The mean packing of aneurysms treated with standard coils was 29.3%, and the mean packing of aneurysms treated with new SR Galaxy coils was 25.7%. This difference of 3.6 percentage points was statistically significant ( $P = .0021$ ).

The result of this comparison confirmed our personal and subjective experience in the handling properties of the 2 compared coil types. Standard coils produce less catheter kickback, are less stiff, and are easier to deliver. While oversizing of the first coil

**Clinical and aneurysm characteristics of 74 aneurysms treated with Galaxy stretch-resistant coils and 74 volume-matched controls treated with standard Trufill/Orbit coils**

	Galaxy	Trufill/Orbit	P Value (t test)
No. of aneurysms	74	74	
Women/men	55:19	45:29	
Median age (yr)	57	50.5	
Anterior circulation	63	57	
Posterior circulation	11	17	
Ruptured/unruptured	62/12	58/16	
Procedural morbidity	2	0	
No. of angiographic follow-ups	58	62	
Additional treatment	4	3	
Aneurysm volume (mm <sup>3</sup> )			
Mean	110	111	.98
Median	75	74	
SD	110	107	
Aneurysm size (mm)			
Mean	5.8	6.4	
Median	6	6	
Range	3–21	3–18	
Packing attenuation (%)			
Mean	25.7	29.3	.0021
Median	25	28.5	
SD	7.0	6.9	

is mostly possible with standard coils, with the new SR Galaxy coils, undersizing is imperative to accommodate the first coil. The better handling properties of the standard coils, therefore, result in higher packing attenuations. In our view, the importance of packing attenuation is 3-fold: First, the relation of high packing attenuation and stable aneurysm occlusion at follow-up has been firmly established. Therefore, it is sensible to place as many coils as possible in a cerebral aneurysm. Second, packing attenuation is the only objective parameter available in comparing the handling performance of different types of coils. Finally, high packing attenuations reflect the ease of use and therefore safety: When coils can be easily and quickly placed inside an aneurysm, the procedure is effective and safe. On the other hand, when coils are difficult to place with repeated catheter kickbacks, the operator will likely, after a period of several futile attempts, withdraw the final coil resulting in lower packing attenuation and increased risk of complications due to microcatheter manipulations.

Although both experimental and clinical data indicate better handling and thus better obtained packing attenuations for the standard coils, most coils available on the market are stretch-resistant. Apparently, the fear of unintended stretching and unraveling of coils during withdrawal generally outweighs the impaired handling. In balancing the pros and cons of stretch resistance, one should know the frequency and impact of the stretching phenomenon. However, there are no data on the incidence of this technical problem and its clinical implications. In our experience, stretching and unraveling on withdrawal of the standard coils can be largely avoided. First, if friction is encountered during delivery of a coil, it is unsafe to try to force the coil into the aneurysm: The coil may be damaged or kinked. When withdrawal is then necessary, unraveling is likely to occur (forced in = stretched out). Second, if a coil has to be withdrawn, it is better to withdraw the microcatheter first for a few millimeters to align the coil with the catheter without kinking at the tip. Third,

when an aneurysm is completely occluded, it is not necessary to try to force another (“last”) coil in, with subsequent risk of the need for retrieval.

With these technical precautions, unraveling of a coil during withdrawal will be rare. We believe that the drawback of possible coil stretching and unraveling in standard coils without stretch resistance is only a minor clinical issue that is outweighed by the shortcomings of the SR filament in terms of handling, safety, and obtained packing attenuation.

Standard coils are hardly available on the market any more. We plead for a renewed appreciation of the better physical properties of standard coils without SR filaments, so that operators can choose between standard or SR coils in every coil type.

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## EDITORIAL

# Will A Randomized Trial of Unruptured Brain Arteriovenous Malformations Change Our Clinical Practice?

L. Pierot, J. Fiehler, C. Cognard, M. Söderman, and L. Spelle

**A** Randomized Trial of Unruptured Brain Arteriovenous malformations (ARUBA) was stopped on April 15, 2013, because of the superiority of the medical management group.<sup>1</sup> We congratulate the ARUBA investigators for designing this trial and being able to include 223 patients.

The ARUBA study was designed to determine whether medical management is superior or noninferior to interventional therapy for the prevention of the composite outcome of death from any cause or symptomatic stroke in the management of unruptured brain arteriovenous malformations (bAVMs), and whether it decreases the risk of death or clinical impairment (modified Rankin Scale score of  $\geq 2$ ) at 5-year postrandomization. The evaluation of the interventional treatment efficacy for bAVM was not an aim of the study.

The primary end point (death or symptomatic stroke) was reached in 10% of patients in the medical management group and in 31% in the interventional therapy group (hazard ratio, 0.27). Unfortunately, the causes of death (AVM-related or not) were not given. “Stroke” was defined as “a clinically symptomatic event (any new focal neurologic deficit, seizure, or new-onset headache)

that was associated with imaging findings of hemorrhage or ischemia.”<sup>1</sup> Unfortunately, the respective percentage of patients with new focal neurologic deficit, seizure, or new-onset-headache was not given. Imaging findings were also not precisely described, and the respective number of patients with subarachnoid hemorrhage, intraventricular hemorrhage, and parenchymal hematoma was not given. Ischemic lesions were also not described. Due to the absence of these data, a precise analysis of the primary end point is nearly impossible. Additionally, it is also not possible to correlate the primary end point with the 36-month risk of death and neurologic disability because no specific information was provided. In the limited number of patients (87) with 36 months’ follow-up, the risk of death and neurologic disability (modified Rankin Scale score of  $\geq 2$ ) was significantly lower for the medical management (14%) compared with the interventional therapy (39%) group.

Brain AVMs represent a very heterogeneous group with regard to clinical presentation (hemorrhage, seizures, headache, focal neurologic deficit), anatomic characteristics (feeding arteries, nidus, draining veins), and modalities of treatment (surgery, radiation therapy, embolization, or combination of modalities).<sup>2–4</sup> For unruptured bAVMs, the strategy of treatment is a matter of debate because the balance between therapeutic risks and the risk of natural history is difficult to determine and is dependent on several factors, including the ones mentioned above.<sup>2,5</sup>

In certain bAVM subgroups with specific anatomic characteristics (ie, deep location or deep venous drainage), the risk of bleeding is higher, thus requiring specific treatment strategies or modalities. However, the clinical outcomes even within a subgroup of patients will vary depending on the treatment strategies used because strategy differs as to the mode of action and complication type and rate.

Indeed, one shortcoming of the study design was inclusion of a heterogeneous population of AVM types and their treatment options. The AVM population included 62% of AVMs smaller than 30 mm; diverse Spetzler-Martin-grade AVMs, including 29% grade 1, 32% grade 2, 28% grade 3, and 10% grade 4; associated aneurysms in 16%; and any deep venous drainage in 33% of cases. Furthermore, the treatment modalities were quite heterogeneous: neurosurgery alone (5%); embolization alone (32%); radiation therapy alone (33%); embolization and neurosurgery (12%); embolization and radiation therapy (16%); and, finally, embolization, neurosurgery, and radiation therapy combined (1%). No details were given regarding the precise modalities of treatment (glue or Onyx [Covidien, Irvine, California] for embolization; gamma knife or linear accelerator for radiation therapy). By study design and due to the relatively small population included in the trial before stopping, subgroup analyses will not be conducted.

Therefore, the ARUBA trial data suggest that in a very heterogeneous population of patients with AVM with a mix of different therapeutic approaches, there is a higher short-term risk of death or stroke. However, the generalizability of ARUBA results is quite debatable.

Thirty-nine active centers recruited 226 patients during 6 years, with an average rate of inclusion of 1 patient/center/year. Among the 39 active sites, 7 (18%) included  $>10$  patients; 7