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EDITORIAL COMMENT

Editorial comment: sandwich carotid stenting: too much of a good thing?

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Abstract
This editorial comment refers to the article "Detection of in-stent protrusion (ISP) by intravascular ultrasound during carotid stenting: usefulness of stent-in-stent placement for ISP" by Okazaki T et al *Eur Radiol.*, July 2018.

> It has been well said that a hungry man is more interested in four sandwiches than four freedoms
>
> Henry Cabot Lodge, Jr

Significant carotid artery disease remains a common and treatable cause of cerebral ischemia and atherothrombotic embolism [1]. While some uncertainty persists on the comparative effectiveness and safety of carotid artery stenting in comparison to endarterectomy, it is established that carotid artery stenting encompassing embolic protection appears as a favorable intervention in patients with significant carotid disease and increased surgical risk [2]. In order to increase the safety of endovascular carotid therapy, several procedural approaches have been attempted, including alternative stent designs and embolic protection means. In recent meta-analyses, open-cell stents (with large uncovered gaps between struts) provided a decreased restenosis rate when compared to closed-cell stents (small free-cell areas), however without differences in periprocedural outcomes [3, 4]. To minimize embolic risk occurring with distal protection, proximal occlusion with or without flow reversal has been proposed as a more effective means, but studies have been inconclusive to date [5, 6]. Most recently, another approach based on routine dual protection and blood aspiration was also tested with multimodality imaging by Sakamoto et al [7]. The same Japanese group now reports in this issue of the Journal on a novel approach to treat in-stent protrusion during carotid artery stenting: sandwich stenting [8].

Specifically, they treated 137 patients with carotid stenting encompassing dual embolic protection and intravascular ultrasound, which disclosed in-stent plaque protrusion in 17 (11.9%). In all cases, in-stent protrusion could be successfully treated with sandwich stenting. Unadjusted predictors of in-stent protrusion were diameter stenosis, vulnerable plaque features at magnetic resonance angiography or duplex ultrasound, and stent length (all $p < 0.05$). Stent type was not significantly associated with in-stent protrusion rate ($p = 0.249$), despite a relative excess of such occurrence with Protégé (4 out of 10 [40.0%]) and Carotid Wallstent (13 out of 121 [10.7%]), in comparison to PRECISE (0 out of 10). Intriguingly, in-stent protrusion was associated with universal debris capture at blood aspiration and filter appraisal. The idea of acutely implanting two stents one inside the other, thus creating a veritable sandwich, is not necessarily new [9], and, intriguingly, this approach shares the inspiration of the Roadsaver device for carotid artery stenting (Terumo), which combines the features of an open-cell design with those of a closed-cell one, thanks to its double-layered micromesh design, or the similarly conceived CGuard device (InspireMD).

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Endovascular specialists should be aware that sandwich stenting is best considered as an adjunct to a comprehensive endovascular armamentarium which should include proximal occlusion systems for embolic protection and invasive imaging. Yet, preprocedural appraisal remains crucial in all patients in whom carotid artery stenting is envisioned, as recent clinical instability, soft plaque features at non-invasive imaging, and systemic inflammation might all contribute to an increased risk of in-stent plaque protrusion [10, 11]. Indeed, invasive imaging, based on intravascular ultrasound, possibly also encompassing color-flow imaging and virtual histology, notwithstanding the niche role of optical coherence tomography, can prove quite useful for complex interventions, highlighting subtle complications such as edge dissection, intervening thrombus, or plaque protrusion [12, 13].

Inasmuch as eating too many sandwiches may be detrimental to your health, a default sandwich stenting approach is clearly discouraged. Indeed, the main issues with sandwich stenting rest on the risk of squeezing in-stent material leading to its embolization, significant jailing of the external carotid artery, suboptimal stent expansion, heightened restenosis risk, and increased risk of stent thrombosis. Indeed, optimal post-dilation is required to minimize underexpansion, possibly compounded by drug-coated balloon post-dilation, whereas intensive peri- and postprocedural antithrombotic therapy is paramount.

In conclusion, sandwich stenting is a potentially appealing niche approach for patients undergoing carotid artery stenting in whom in-stent plaque protrusion or residual thrombus is demonstrated at invasive imaging. Further dedicated studies on this technique and comparative analyses including patients receiving double-layered carotid stents are warranted.

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