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Endovascular Treatment of Patients with Isolated Mesenteric Artery Dissection Aneurysm: Bare Stents Alone Versus Stent Assisted Coiling

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WHAT THIS PAPER ADDS

Endovascular stenting has been used successfully in the management of symptomatic isolated mesenteric artery dissection (IMAD) aneurysms. However, no study has compared the use of bare stents alone versus stent assisted coiling in IMAD aneurysms. The results of this study indicate that bare stents alone and stent assisted coiling have high technical success rates and demonstrate good mid-term patency in patients with IMAD aneurysms. Bare stents alone may serve as an alternative to stent assisted coiling for the management of IMAD aneurysms.

Objective: The aim was to evaluate the outcomes of endovascular treatment with bare stents alone versus stent assisted coiling in isolated mesenteric artery dissection (IMAD) aneurysms.

Methods: Patients with an IMAD aneurysm who underwent endovascular stenting between February 2010 and February 2017 at one of three institutions were included in this study. Data regarding technical success, procedure time, symptom resolution, complications, changes in IMAD aneurysm, and stent patency were recorded.

Results: A total of 38 patients (35 men) were included, 27 treated with bare stents alone and 11 treated with stent assisted coiling. Technical success was achieved in 100% of patients treated with bare stents and in 81.8% of those treated with stent assisted coiling ($p = 0.078$). The mean procedure times were 62.6 $\pm$ 5.3 min for treatment with bare stents and 116.4 $\pm$ 8.4 min for stent assisted coiling ($p < 0.001$). A total of 23 patients had persistent symptoms before stenting; all symptoms were resolved within 3.0 $\pm$ 0.7 days. No procedure related major complications occurred. Over 30.2 $\pm$ 18.1 months of follow up, complete resolution of the IMAD aneurysm was achieved in all patients; good stent patency and in stent re-stenosis were achieved in 65.8% and 34.2% patients, respectively. There were no occlusions of the stented arteries.

Conclusions: Bare stents alone and stent assisted coiling have high technical success rates and demonstrate good intermediate patency in patients with an IMAD aneurysm. Bare stents alone may serve as an alternative to stent assisted coiling for the management of IMAD aneurysm

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INTRODUCTION

Isolated mesenteric artery dissection (IMAD) is an uncommon but potentially catastrophic pathology.[1] IMAD aneurysm is a subtype of IMAD with a natural history that is variable and unpredictable.[2,3] The dissecting aneurysm may rupture by dilation or compress the true lumen, potentially leading to intestinal necrosis or even patient death.[4]

The primary objectives of treatment in patients with IMAD aneurysm are to preserve the blood flow distally through the true lumen, limit the extent of dissection, and prevent dissecting aneurysm rupture.[1] Various treatment options have been used to manage IMAD aneurysm, including conservative management, endovascular stenting, and surgical treatment.[5] Although most cases of IMAD can be managed successfully with conservative therapy according to European Society for Vascular Surgery (ESVS) guidelines, approximately 20% of patients ultimately need

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intervention.[6] Endovascular stenting, using bare stents alone or stent assisted coiling, have been used successfully in the treatment of symptomatic patients with IMAD.[7–9] However, no study has compared these two stenting methods (bare stents alone vs. stent assisted coiling) in patients with IMAD aneurysm.

In this study, the outcomes of endovascular stenting with bare stents alone versus stent assisted coiling were compared to determine the most effective treatment method in patients with IMAD aneurysm who require endovascular intervention.

METHODS

Study design

This retrospective study was approved by all participating Institutional Review Boards with a waiver of informed consent. Consecutive patients with contrast enhanced computed tomography (CT) proven IMAD aneurysm who underwent stenting with bare stents alone or with stent assisted coiling at one of three institutions between February 2010 and February 2017 were included in the study. Interventional radiologists are clinically responsible for these patients at the three institutions. Patient demographics, clinical information, and procedural data were collected from patients' medical records, and imaging data were gathered from the Picture Archiving and Communications System.

Indications for stenting

Treatment decisions were based on patient symptoms and on the morphological characteristics of the IMAD aneurysm as seen on CT scans. The indication for endovascular stenting as first line treatment was symptomatic IMAD with a large dissecting aneurysm (at least 1.5 times larger than the normal mesenteric artery diameter, which was calculated at the site of the proximal mesenteric artery on the lateral projection of the mesenteric arteriogram); the indication for endovascular stenting as second line treatment was failure of conservative treatment (defined as persistence or aggravation of symptoms and signs, increasing size of the aneurysmal dilation after conservative treatment, or the new appearance of a large dissecting aneurysm during follow up).

Techniques

Femoral access was gained via a 5 F sheath, and conventional mesenteric arteriography was performed before endovascular therapy. The diameter and length of the dissecting aneurysm, the entry and re-entry points, the degree of true luminal stenosis, and the diameter of the normal proximal mesenteric artery were measured on the arteriogram.

The 5 F sheath was exchanged for an 8 F sheath. An 8 F guiding catheter (Vista Brite Tip Guiding Catheter, Johnson & Johnson Co. Ltd., Miami, FL, USA) was advanced through the 8 F sheath, with the curved tip placed at the orifice of the mesenteric artery. A 0.035 inch stiff guidewire was inserted distally into the mesenteric artery. An 8 F stent introducer was then advanced over the stiff guidewire, and a self expandable bare metal stent was deployed to open the stenosed true lumen. Protégé EverFlex or Protégé RX Tapered self expanding stents (Covidien, Plymouth, MN, USA) were used. The stent diameter was 10% greater than that of the normal mesenteric artery and was at least 10 mm longer than the dissecting aneurysm (5 mm each at the distal and proximal margins). For patients who underwent stent assisted coiling, the dissecting aneurysm was catheterised with stent mesh using microcatheters (Progreat, Terumo, Tokyo, Japan; or Headway17 Advanced, MicroVention, Aliso Viejo, CA, USA) and was subsequently coiled. A series of coils, including Cosmos/helical coils (MicroPlex coil system, MicroVention) and Hilal/Tornado embolisation microcoils (Cook, Bloomington, IN, USA), were used because of the various shapes of the dissecting aneurysms. Finally, mesenteric angiography was repeated to confirm resolution of the dissecting aneurysm, stent patency, and improvement of blood flow through the dilated true lumen.

Post-procedural care

All patients were monitored closely for procedure related complications and for potential worsening of symptoms and signs. Normal diet was resumed once complete resolution of symptoms was noted. All patients were treated with antiplatelet therapy, including oral clopidogrel 75 mg/day for at least three months and aspirin 100 mg/day for at least one year.[10]

Clinical follow up

Outpatient clinic visits were scheduled at one and six months during the first year and annually thereafter. More frequent evaluations were performed when necessary. During follow up, patients underwent color Doppler ultrasound examination, abdominal contrast enhanced CT, or mesenteric angiography at one and six months and annually thereafter for evaluation of the dissecting aneurysm and stent patency.

Definitions

The presence of persistent symptoms was defined as no change in or aggravation of symptoms after a week of conservative treatment. Technical success was defined as successful deployment of stents to the target locations in patients treated with stents alone and as successful deployment of stents and complete coiling of the dissecting aneurysm (with no residual dissecting aneurysm) in patients treated with stent assisted coiling. Procedure related complications were classified as major or minor according to the guidelines of the Society of Interventional Radiology.[11] Complete resolution of the dissecting aneurysm was defined as disappearance of the dissecting aneurysm on images; partial resolution was defined as $<$ 100% shrinkage of the dissecting aneurysm with residual dissecting

aneurysm visible on images.[12] Good stent patency was defined as patency of the stented arteries without any evidence of in stent re-stenosis.

Statistical analysis

SPSS version 17.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. The independent *t* test, the Fisher exact test, and the rank sum test were used to compare variables between the two groups. A p value < 0.05 defined statistical significance.

RESULTS

Patients

From February 2010 to February 2017, 107 patients were diagnosed with IMAD, including 66 without and 41 with dissecting aneurysm. Of these 41 patients with IMAD aneurysm, three patients were excluded because they had undergone successful conservative therapy; the remaining 38 patients (36 men, 2 women; median age, 51.5 years, range 39—69 years) with IMAD aneurysm underwent endovascular stenting and were included in this study. Risk factors, including Marfan syndrome, Ehlers—Danlos syndrome, cystic medial necrosis, and fibromuscular dysplasia, were tested for and not found in any patient. The median interval between the onset of symptoms and diagnosis of IMAD aneurysm was three days (range 4 h to two months). Based on Yun's classification,[13] all IMADs were type IIa (visible false lumen but invisible re-entry site). The median interval between the diagnosis of IMAD aneurysm and endovascular stenting was one month (range 0 days to three months). Table 1 summarises the clinical manifestations and imaging characteristics for all study patients.

Treatments

Of the 38 patients, endovascular stenting was performed as first line treatment in four patients (10.5%) and as second line treatment in 34 patients (89.5%) (Table 2). Of the 34 patients who underwent endovascular stenting as second line treatment, conservative treatment had failed in all patients. The reasons for conservative treatment failure included stability of the dissecting aneurysm with persistent symptoms ($n = 15$), increasing size of the dissecting aneurysm ($n = 14$), and new appearance of the large dissecting aneurysm ($n = 5$).

Of the 38 patients included in the study, stenting with bare stents alone was performed in 27 patients (71.1%) (Fig. 1), and stent assisted coiling was performed in 11 patients (28.9%). A total of 40 self expandable metal stents were used.

Outcomes

Technical success was achieved in 100% (27/27) of patients treated with bare metal stents and in 81.8% (9/11) of patients undergoing stent assisted coiling ($p = 0.07$; Table 2). In the two unsuccessful cases, the dissecting aneurysm was not completely coiled. The mean procedure times were 62.6 ± 5.3 min (range 55—75 min) for the bare metal stent group and 116.4 ± 8.4 min (range 105—135 min) for the stent assisted coiling group ($p < 0.001$). A total of 23 patients had persistent symptoms before stenting; all of the symptoms were resolved within 3.0 ± 0.7 days following treatment. No procedure related major complications occurred. One minor complication (subcutaneous haematoma) occurred in one patient treated with bare metal stents alone ($p = 0.711$), but this patient recovered without additional treatment. No patients developed intestinal necrosis.

Table 1. Baseline characteristics of study population ($n=38$)

Characteristic	All ($n=38$)	Bare stent group ($n=27$)	Stent assisted coiling group ($n = 11$)	*P*-value
Median age (range), years	51.5 (39, 69)	51 (39, 69)	53 (46, 68)	.528
Male patients	35 (92.1)	25 (92.6)	10 (9.9)	.653
History of hypertension	12 (31.6)	4 (14.8)	7 (63.6)	.017
Symptoms				
Abdominal pain	38 (100)	27 (100)	11 (100)	
Back pain	5 (13.2)	3 (11.1)	2 (18.2)	.615
Nausea/vomiting	3 (7.9)	2 (7.4)	1 (9.1)	.653
Bloody stools	1 (2.6)	0	1 (9.1)	.289
Presence of intestinal necrosis	0	0	0	
Characteristics of dissection aneurysm				
Mean length ± SD, mm	26.4 ± 3.6	25.7 ± 3.7	28.2 ± 2.4	.054
Median diameter (range), mm	7.5 (7, 9)	7.5 (7, 9)	7.5 (7, 9)	.922
Re-entry site of the dissection aneurysm visible	0	0	0	
Thrombus in the dissection aneurysm	0	0	0	
Median distance (range), mm[a]	18.5 (15, 34)	19 (15, 34)	18 (15, 24)	.658
Located at the anterior wall of the SMA	38 (100)	27 (100)	11 (100)	
True lumen stenosis (≥ 50%)	38 (100)	27 (100)	11 (100)	
Occlusion of the true lumen	0	0	0	

Data are presented as absolute numbers with percentages in brackets (%), if not indicated otherwise. SD = standard deviation; SMA = superior mesenteric artery.

[a] Distance between the ostium of the mesenteric artery and the entry point of the dissection aneurysm.

Table 2. Treatments and outcomes in the study population ($n=38$)

Characteristic	All ($n=38$)	Bare stent group ($n=27$)	Stent assisted coiling group ($n = 11$)	*P*-value
Endovascular stenting				.674
First line treatment	4 (1.5)	3 (11.1)	1 (9.1)	
Second line treatment	34 (89.5)	24 (88.9)	10 (90.9)	
Technical success	36 (94.7)	27 (100)	9 (81.8)	.07
Mean procedure time ± SD, minutes	78.2 ± 25.5	62.6 ± 5.3	116.4 ± 8.4	< .001
Complications in hospital				
Major	0	0	0	
Minor	1 (2.6)	1 (3.7)	0	.711
Complete resolution of the dissection aneurysm				
Immediately after treatment	13 (34.2)	4 (14.8)	9 (81.8)	< .001
6 months after treatment	35 (92.1)	24 (88.9)	11 (100)	.542
18 months after treatment	38 (100)	27 (100)	11 (100)	-
Stent patency[a]				.571
Good stent patency	25 (65.8)	18 (66.7)	7 (63.6)	
Evidence of in stent re-stenosis	13 (34.2)	9 (33.3)	4 (36.4)	

Data are presented as absolute numbers with percentages in brackets (%), if not indicated otherwise. SD = standard deviation.
[a] Stent patency during 30.2 ± 18.1 months (range 6–84 months) of follow up.

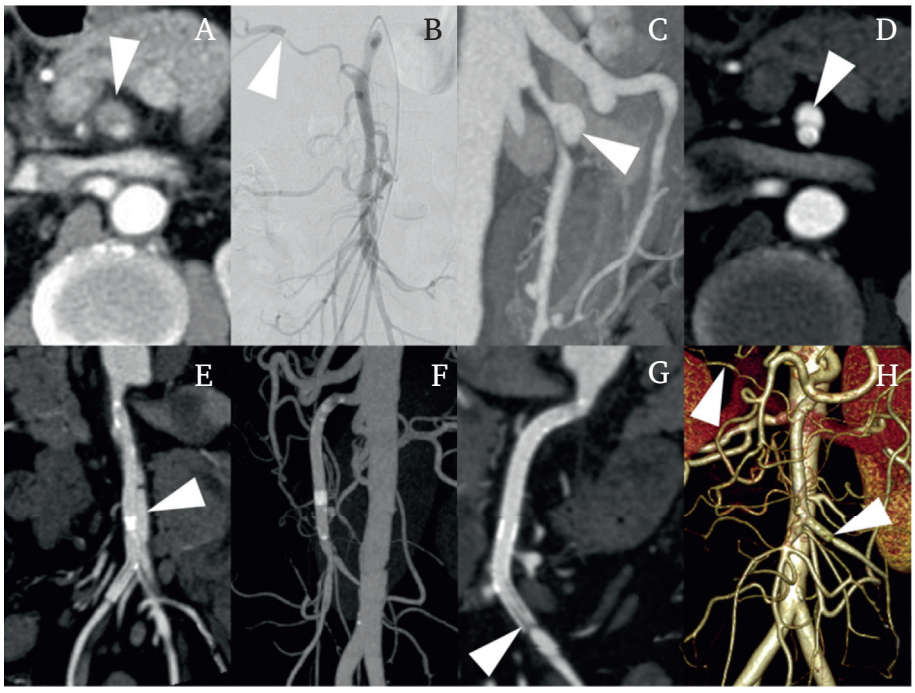

Figure 1. Endovascular treatment with bare stents alone in symptomatic isolated superior mesenteric artery dissection aneurysm. A 46 year old man presented with acute abdominal pain that had lasted for approximately 12 hours. (A) Contrast enhanced computed tomography (CT) demonstrated superior mesenteric artery (SMA) dissection with completely thrombosed false lumen (arrowhead), and true lumen compression. (B) Superior mesenteric arteriography demonstrated that the true lumen was compressed, and the hepatic artery was arising from the SMA (arrowhead). (C) A dissecting aneurysm was observed on the repeat contrast enhanced CT scan performed one month later (arrowhead), and the true lumen was almost occluded. (D,E) The dissecting aneurysm was dilated to distal branches of the SMA (not shown), and endovascular stenting with bare stents alone was performed. Partial resolution of the dissecting aneurysm was achieved after two self expandable metal stents were deployed to the target locations (arrowheads). (F) Complete resolution of the dissecting aneurysm had occurred six months after the procedure. (G) In stent re-stenosis at the distal end of the stent was observed on a CT scan performed 42 months after treatment (arrowhead). (H) Hepatic artery arising from the SMA demonstrated good patency (above arrowhead), and stenosis of the distal stented artery was observed on a contrast enhanced CT scan six years later (below arrowhead).

Clinical follow up

During 30.2 ± 18.1 months (range 6—84 months) of follow up, the dissecting aneurysm was completely resolved immediately after treatment in 14.8% (4/27) of patients treated with bare metal stents alone versus 81.8% (9/11) of patients treated with stent assisted coiling ($p < 0.001$). Complete resolution was seen at 6 months after treatment in 88.9% (24/27) of patients treated with bare metal stents alone versus 100% (11/11) of patients treated with stent assisted coiling ($p = 0.542$), and complete resolution was seen at 18 months after treatment in 100% (27/27) of patients treated with bare metal stents alone and 100% (11/11) of patients treated with stent assisted coiling (Table 2). In the two cases of stent assisted coiling that were technically unsuccessful, the residue of the dissecting aneurysm had resolved completely when examined on mesenteric angiography six months later. Of note, one patient treated with bare metal stents alone demonstrated recurrence of IMAD aneurysm; a new dissecting aneurysm appeared at seven months after treatment (Fig. 2). This patient underwent coiling via stent mesh using a microcatheter, and complete resolution of the new dissecting aneurysm was achieved after treatment. Among the 38 study patients, CT angiography or mesenteric angiography demonstrated good stent patency in 25 patients (65.8%) and evidence of in stent re-stenosis in 13 patients (34.2%). There were no cases of occlusion of stented arteries, delayed complications, or symptomatic relapse during the follow up period.

DISCUSSION

In this study, it was found that both bare stents alone and stent assisted coiling had high success rates and led to good mid-term patency in patients with IMAD aneurysm. Additionally, all symptoms resolved rapidly after endovascular therapy. However, approximately one third of the study patients demonstrated evidence of in stent re-stenosis.

Endovascular stenting is used widely in the management of IMAD.[1] According to the ESVS guidelines, endovascular stenting should be considered for patients with a symptomatic IMAD not responding to medical management and with suspected bowel ischaemia.[6] Covered stents can be used to seal the entry point and dissecting aneurysm; bare stents cannot be used for this purpose.[14,15] However, covered stents are not usually recommended for patients with IMAD because these stents can cause the obliteration of multiple side branches of the mesenteric artery, which may worsen intestinal ischaemia or even lead to intestinal necrosis.[7,16] This obliteration of the side branches does not occur with the use of bare stents alone or stent assisted coiling, and so these techniques are widely used in the management of IMAD.[7,15,17] Previous studies of endovascular therapy have demonstrated a high technical success rate for both bare stents alone and stent assisted coiling;[7,8,15,17,18] although this study demonstrated similar results, the numbers are small and there is a risk of a type II statistical error. Studies with larger sample sizes are needed to validate the findings.

For patients treated by stent assisted coiling in this study, although the dissecting aneurysm was not completely coiled in two patients, the residue of the dissecting aneurysm had resolved completely when examined on mesenteric angiography six months later. Based on the results of this study, it is suggested that microcatheters and a series of coils of appropriate dimensions should be used to coil the dissecting

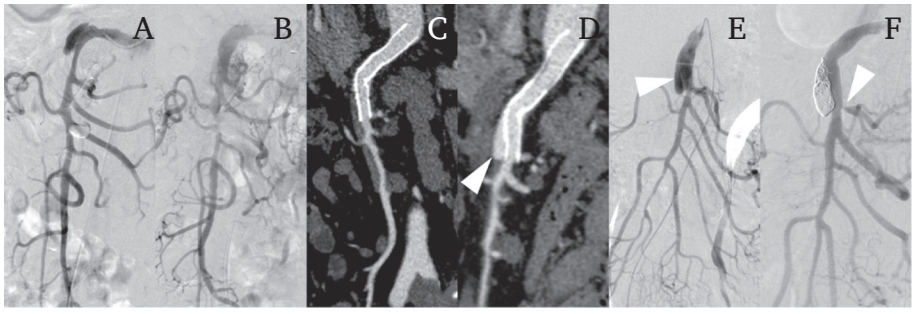

Figure 2. Endovascular treatment with stent assisted coiling in a superior mesenteric artery (SMA) dissection aneurysm that was not successfully treated with bare stents alone. A 50 year old man presented with acute abdominal pain that had lasted for three days. (A) Superior mesenteric arteriography demonstrated dissection aneurysm at the curve of the SMA, and the true lumen was compressed. (B) Superior mesenteric arteriography demonstrated complete resolution of the dissection aneurysm immediately after placement of two bare stents. (C) Contrast enhanced computed tomography (CT) demonstrated that the dissection aneurysm was completely thrombosed with good stent patency one month after treatment. (D) A new dissection aneurysm (arrowhead) was observed on the repeat contrast enhanced CT scan performed six months later. (E) Superior mesenteric arteriography demonstrated the dissection aneurysm (arrowhead), and complete resolution of the dissection aneurysm was achieved after coiling via the stent mesh using a microcatheter (not shown). (F) Complete resolution of the dissection aneurysm with good stent patency was observed one year after treatment. Severe stenosis of a branch of the SMA was also observed on superior mesenteric arteriography (arrowhead).

aneurysm completely. It was found that although 3D coils were helpful in coiling the dissecting aneurysm completely, 2D coils are less expensive. Overall, when comparing stent assisted coiling with the use of bare stents alone, catheterisation via the stent mesh using microcatheters and coiling the dissecting aneurysm led to longer procedure times, which in turn led to increased radiation dose for patients.

Multiple overlapping bare stents have been used in the treatment of patients with pararenal aortic aneurysms.[19,20] However, the use of multiple overlapping bare stents is not usually recommended for patients with IMAD aneurysm because of concerns regarding the obliteration of multiple side branches of the mesenteric artery. In this study, complete resolution of the dissecting aneurysm with bare stents alone was seen in 14.8% of patients immediately after treatment, in 88.9% six months after treatment, and in 100% 18 months after treatment. Although the rate of complete resolution immediately after treatment was lower in the bare stent group than in the stent assisted coiling group (14.8% vs. 81.8%), the mid-term results in the two groups were similar. These results suggest that the use of bare stents alone is an effective procedure for patients with IMAD aneurysm who require endovascular interventions.

Abdominal pain is the most common symptom in patients with IMAD.[21,22] In this study, all patients presented with abdominal pain. The 23 patients with persistent symptoms before endovascular stenting experienced rapid resolution of symptoms after treatment. These results suggest that endovascular stenting has the potential to reduce fasting time and hospital stay. Luan et al.[23] suggested that the severity of symptoms may be related to stenosis of the true lumen and the length of the dissection, but this potential relationship could not be analysed as all patients in this study had true lumen stenosis (>50%) and a dissecting aneurysm.

Several recent studies have demonstrated a high rate of mid-term patency with stent placement for IMAD;[14,15,17,24] this study demonstrated similar results. However, evidence of in stent re-stenosis was found in 34.2% of the patients after 30.2 $\pm$ 18.1 months of follow up. Previous research has suggested that this in stent re-stenosis is due to focal mild intimal hyperplasia caused by endothelial injury, neointimal hyperplasia, or chronic inflammation.[25–27] In this study, all cases of in stent re-stenosis occurred at the initial segment or distal end of the stent, suggesting that endothelial injury, neointimal hyperplasia, or chronic inflammation may have been involved.

The major limitation of this study was its retrospective nature, which may limit the generalisability of the results. The sample size was also relatively small (although larger than previous studies), and the follow up time was short. Also, the occurrence of in stent re-stenosis was identified by CT angiography rather than mesenteric angiography, which may have biased the results. Finally, the degree of in stent re-stenosis was difficult to identify due to the small diameter of the mesenteric artery, and the risk factor of edge stenosis after stenting for IMAD aneurysm was not analysed due to the small sample size.

In conclusion, endovascular stenting with bare stents alone or with stent assisted coiling has a high success rate and leads to good mid-term patency in patients with IMAD aneurysm. Bare stents alone may serve as an alternative to stent assisted coiling for the management of IMAD aneurysm. Although the mid-term stent patency was high with both of these techniques, approximately one third of the study patients had evidence of in stent re-stenosis. Studies of the long-term outcomes of endovascular stenting in patients with IMAD aneurysm are therefore needed.

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CONFLICTS OF INTEREST

None.

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