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Beth Israel Deaconess Medical Center

The Brain Aneurysm Institute
Multidisciplinary Care of Patients with Hemorrhagic and Ischemic Stroke

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Neurovascular News

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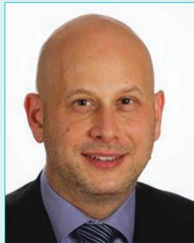

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First Patient Experience with the Innovative E-Shunt System for Treating Normal Pressure Hydrocephalus

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Normal pressure hydrocephalus (NPH) is the most common form of adult hydrocephalus, characterized by the enlargement of lateral ventricles despite normal lumbar puncture opening pressure. Described by Dr. Hakim and Adams in 1965[1], NPH typically presents with a triad of impaired gait, cognitive decline, and urinary disturbances (can be either urgency or incontinence)[2]. NPH primarily affects individuals around age 70, with gait disturbance often being the earliest and most noticeable sign. Although dementia and urinary symptoms are common in NPH, the presence of all three symptoms is not necessary to diagnose the condition. Diagnosis is based on clinical assessment and brain imaging (CT or MRI), though challenges exist due to misdiagnosis and overlap with neurodegenerative disorders and age-related ventriculomegaly[3].

The only definitive treatment for NPH currently is cerebrospinal fluid shunting. Recently, CereVasc Inc. has introduced the the endovascular shunt (eShunt) System (Figure 1)[4], a minimally invasive alternative to traditional cerebrospinal fluid (CSF) shunting, which often carries higher surgical risks and postoperative complications. The eShunt System, a miniature 3cm device with a proprietary delivery mechanism and permanent implant, has been tested in several pilot studies in Argentina and the United States to evaluate its safety and effectiveness in managing intracranial pressure and improving patient outcomes.

The eShunt System is designed to overcome common issues with standard CSF shunting, such as infections, over-drainage, and mechanical failures. By offering a less invasive approach, it potentially reduces the need for extensive surgery, prolonged hospital stays, and associated pain management. The eShunt mimics arachnoid granulations by directing excess CSF from the intracranial space into the venous system. Implanted at the inferior petrous sinus, it facilitates CSF flow between the subarachnoid space and venous drainage. It features a slit valve that ensures unidirectional flow, preventing venous blood backflow into the intracranial space and maintaining a controlled drainage rate of 10 mL/h, effectively treating hydrocephalus.

We are excited to announce that Beth Israel Deaconess Medical Center (BIDMC) recently treated the first patient in Boston with NPH using the eShunt System. The patient, a 76-year-old female with worsening gait and cognitive decline over six months, had an initial MRI showing significant ventriculomegaly. As part of the institutional protocol, a lumbar drain was placed to assess shunt responsiveness, and she showed over a 20% improvement in gait speed, indicating a likely benefit from shunting. After meeting the inclusion

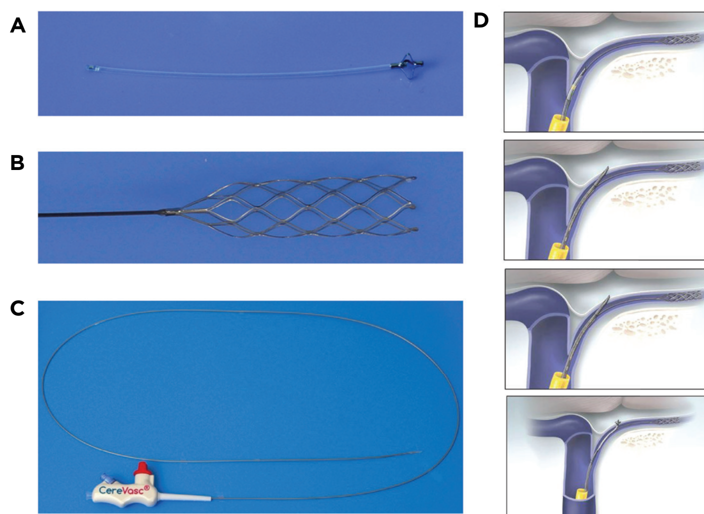

Figure 1. The eShunt System. (A) eShunt Implant; (B) eShunt Anchor; (C) eShunt Delivery Catheter; (D) Deployment of the eShunt Implant through the eShunt Delivery Catheter, leveraging the natural IPS curvature to facilitate the needle pivoting off-axis from the flat rail. The self-expanding anchor can be seen deployed distal to the target implantation site.

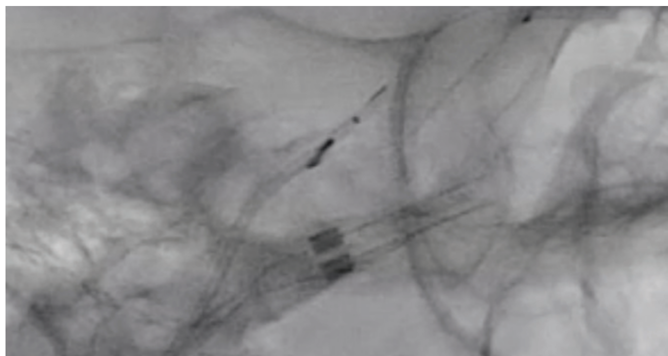

Figure 2. A lateral X-ray of the intraprocedural view during e-shunt deployment.

criteria, which ensured optimal anatomy for device deployment and absence of cardiac anomalies (including heart failure or abnormal atrial or ventricular septal defects), the procedure was performed (Figure 2). Post-procedure follow-up showed significant improvements in stride length and gait speed, and a CT confirmed the device's correct positioning, absence of intracranial hemorrhage, and improvements in ventriculomegaly.

Looking ahead, CereVasc Inc. is preparing to launch a Phase III clinical trial to further evaluate the safety and effectiveness of the eShunt System compared to the current standard of care, which involves the use of ventriculoperitoneal (VP) shunts. The trial, named "STRIDE," aims to enroll approximately 230 patients across 30 sites, including BIDMC, with participants being randomly assigned to receive either the standard VP shunt or the eShunt System. The primary goal of this study is to determine whether the eShunt System can provide comparable safety and effectiveness to existing treatments, with clinical outcomes being evaluated at the six-month mark.

The introduction of the eShunt System represents a promising advancement in the treatment of NPH, offering a potential new standard of care that emphasizes patient safety, reduced invasiveness, and improved quality of life of patients with NPH requiring from CSF flow diversion.

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Computational Fluid Dynamics to Study Intracranial Aneurysm Growth, Rupture, and Post-Treatment Shear Force Modifications

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Introduction

Computational fluid dynamics (CFD) is an intersection of fluid mechanics, numerical methods, and computer science used to solve fluid flow fields and predict their behavior. It has various applications, one of which is the flow of blood in vascular systems.[1] A CFD simulation is carried out in several stages. It starts with defining the study objective and constructing the 3D geometric model of the vessels and aneurysm from digital subtraction angiographies (DSAs). Next, the geometry is discretized into elements, forming the mesh where the equations will be solved. The physics are then configured by setting boundary conditions and selecting the appropriate flow models. The flow is often matched to the age and gender of the patient to approximate physiological conditions. Lastly, the processing stage involves computing the equations, followed by post-processing, which includes analyzing the results.

CFD helps calculating parameters such as wall shear stress (WSS), hydrostatic pressure, oscillatory shear index (OSI), and transmural pressure. These parameters not only predict the frictional forces impacting the aneurysmal wall but also provide insights into the nature of the aneurysm wall and the hemodynamic behavior within the aneurysm and its surrounding vasculature.

CFD has transitioned from simplifying assumptions to more sophisticated models, including wall movement, in contrast to most studies done previously that considered the wall rigid. These advancements, though limited in number, hold promise for enhancing our understanding of aneurysm rupture, for targeting devise interventions for intracranial aneurysms (IAs), and most importantly, to comprehend hemodynamic factors driving failure of endovascular interventions. Moreover, if the primary aim is to categorize aneurysms based on their hemodynamic behavior using CFD, the future will aim in integrate hemodynamics with

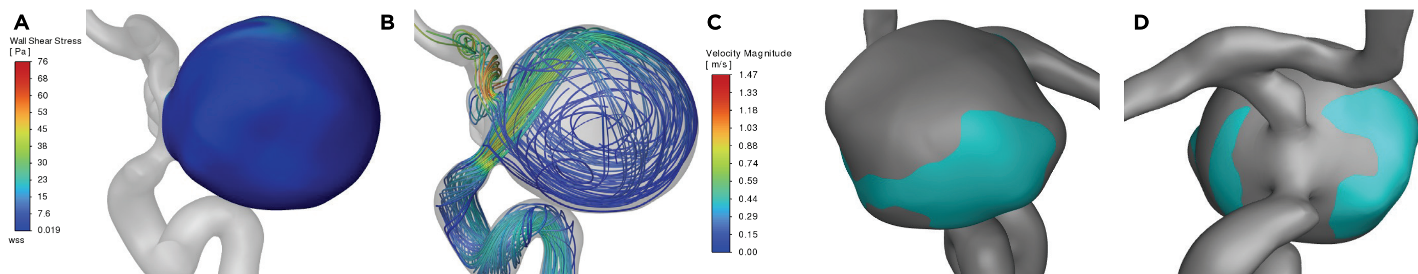

Figure 1. This 45-year-old male presented to our institution with an acute subarachnoid hemorrhage secondary to a large, ruptured posterior communicating aneurysm, measuring 19 x 18 mm, with a 6 mm neck. The dome of this aneurysm was successfully secured with endovascular coil embolization, achieving a Raymond Roy 2 occlusion due to persistent filling near the neck. Computational Fluid Dynamics (CFD) simulation with pre-treatment angiography demonstrated the highest WSS in the upper dome (A), where most of the velocity vectors were directed (B). Low shear areas (LSA) prior to coiling are shown in the medial (B) and lateral (C) views of the 3D reconstruction and represented 33.4% of the aneurysmal surface.

the morphological features of the aneurysms (geometry) and individual risk factors, to predict their stability, growth, or rupture.

Growth Assessment

Aneurysms typically develop in weakened areas at the convexity of vessels, or at sites of bifurcation, towards the direction of the parent artery's flow, where hemodynamic stressors are the highest. Shearing forces significantly contribute to the development and progression of aneurysms, wherein inflammation and weakening of the aneurysm wall are interrelated. Consequently, most CFD simulations have explored WSS as the most important factor predicting aneurysm evolution over time. WSS is defined as the ratio of the local frictional force exerted by the blood flow against the area of the aneurysm or vessel wall.[2] WSS can be either analyzed in the average or geographically, in which the areas of the aneurysms are segmented according to the hemodynamic forces. High WSS can trigger inflammation, influencing the remodeling of aneurysm shape and structure.[3] Similarly, observations from animal models have shown that elevations of WSS can cause fragmentation of the internal elastic lamina of blood vessels. Even more, some past analyses have demonstrated that bifurcation angles can lead to abnormally enhanced hemodynamic stressors, making aneurysms in this location more prone progress over time and even recur after treatment.[4]

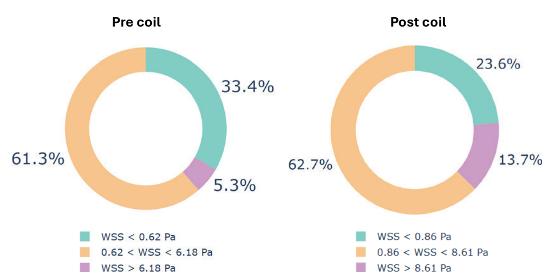

Figure 2. Circular graphical representation of the wall shear stress (WSS) areas before (A) and after (B) coiling in the case illustrated in Figure 1. In this case, the average WSS increased from 1.73 Pa to 4.76 Pa, and the low shear areas (LSA; <0.48 Pa) decreased from 33.4% to 23.6%.

Rupture Risk

The relationship between hemodynamic forces and aneurysmal rupture remains complex and not fully understood. There is ongoing debate regarding whether high or low WSS contributes to aneurysmal rupture, as both conditions can potentially compromise wall stability and increase rupture risk.[3] Low shear areas (LSA), characterized by WSS values below 10% of the mean WSS of the parent artery, are somewhat more frequently associated with rupture, particularly as these areas expand with aneurysm growth. In a recent analysis of ruptured posterior communicating artery aneurysms that were endovascularly treated at our Brain Aneurysm Institute, we found that aneurysms with the highest volumes also had the highest LSA (Figure 1). In line with our findings, Axier et al. conducted a systematic review on this subject, revealing that their analysis of hemodynamic parameters from 1,373 IAs identified LSA as a significant risk factor for aneurysm rupture.[5]

Changes in Aneurysm and Hemodynamics After Treatment

In the same analysis described previously, we looked at the influence of acute coiling and delayed flow diversion (ACFD) in the hemodynamics of ruptured posterior communicating aneurysms and their downstream vasculature. We found that after coiling, there was an expected reduction in the aneurysmal volume and surface area, but there was a tendency towards an increase in the average WSS within the aneurysm (Figure 2). As the aneurysm diminished in size, the reduced blood volume available for circulation results in increased shearing forces on the smaller surface area. The increase in WSS is significant as it indicates that, despite the reduction in aneurysm size achieved through coiling, the unintended rise in stress on the aneurysm walls could affect its long-term stability and potentially require further intervention. Interestingly, the geographical analysis revealed that the highest shearing forces were concentrated at the neck of the treated aneurysm, correlating with a common site for recurrent aneurysms (Figure 3).

Flow diversion produces a progressive decline in the average WSS until the aneurysm becomes fully excluded, a phenomenon observed in all six cases analyzed with CFD. Similarly, a trend observed in most cases (5 out of 6) was an increase in average WSS in the vessels downstream of the aneurysm as endovascular procedures were performed, with a sequential rise post-coiling and following FD, though this did not directly correlate with the increase in velocities (Figure 4). The velocities preferentially increased in the middle cerebral artery (MCA) rather than in the anterior cerebral artery (ACA) as the MCA has a much larger caliber. Similarly to what occurs with aneurysmal shearing forces, the redistribution of flow away from the aneurysm leads to an increase in WSS and velocities in the downstream vasculature.

In the same line with our analysis, other studies have revealed that FD induces pulsatility changes and differential pressure in the downstream vessels at the site of deployment, which appears to

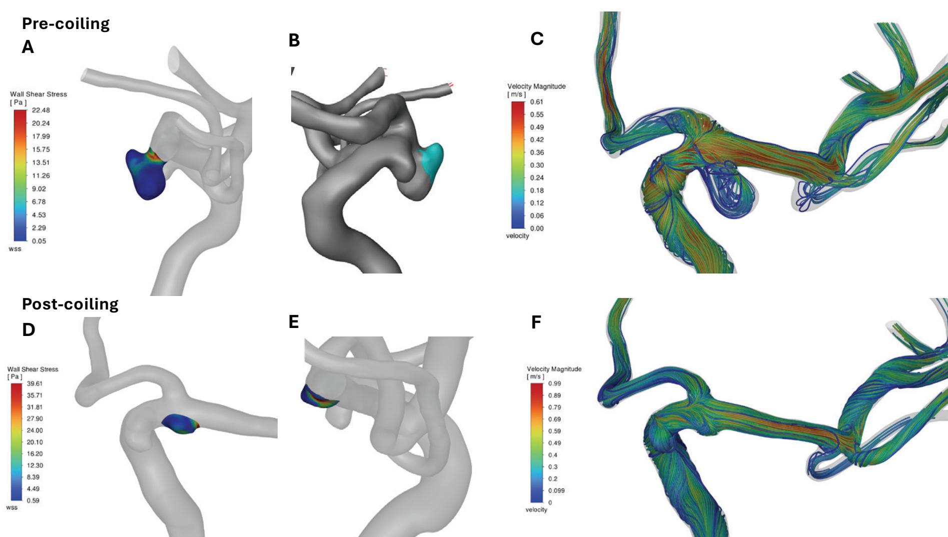

Figure 3. A 67-year-old female was documented to have two supraclinoid aneurysms, a communicating segment 2-mm aneurysm, and a 6-mm ruptured multilobulated anterior choroidal aneurysm, which was successfully treated with Target coils. CFD analysis pre-coiling revealed high wall shear stress (WSS) areas at the neck of the aneurysm and at the posterior wall (A), and the low shear areas (LSA) were at the tip of the daughter sac, which correlated with the site of rupture (B). Vector analysis revealed increased turbulence at the site of bifurcation and at the proximal middle cerebral and anterior cerebral arteries (C). On follow-up angiography 6.5 months later, there was minimal filling of the neck where the WSS was the highest (D-E), but there was less turbulence in the bifurcation and proximal vessels (F). This aneurysm was ultimately treated with pipeline embolization as the adjacent 2 mm aneurysm that was being managed conservatively displayed growth during follow-up.

be more evident as the aneurysm size increases.[6] All these factors need consideration and should be correlated clinically to emphasize the importance of adequate blood pressure control after endovascular treatment of IAs. In fact, sudden de-stabilization of large and giant aneurysms, from poor blood pressure control has been reported as a potential trigger of aneurysmal rupture following treatment with flow diversion.

Hemodynamic Changes in Recurrent Aneurysms and Future Directions

Currently, our research group aims to determine the differences in hemodynamics between recurrent aneurysms after coiling and those clipped. Preliminary data suggest a complex interaction between stability and rupture risk, with high WSS and LSA both influencing rupture risk. Future simulations will provide a more detailed analysis of the blood-aneurysm wall dynamics, incorporating OSI analysis to reflect hemodynamic forces exerted within the aneurysm during each heartbeat. Additionally, we aim to investigate the impact of these hemodynamic forces on the dynamic changes in vessel diameters within the circle of Willis. This phenomenon has been of great interest for our research group as we have seen changes in the collateral vessels following side branch coverage of large arteries with a flow diverter. The latter appears to be a flow mediated phenomenon, in which compensatory remodeling of arteries is thought to occur from initial disturbances caused by the device. Future simulations will replicate more complex vascular disorders, such as vessel tortuosity, calcification, and atherosclerosis. Similarly, some of the hemodynamic simulations will be integrated with functional perfusion and cerebral blood flow analyses (such as SPECT and dynamic perfusion CT) as well as investigate for brain metabolic consumption.

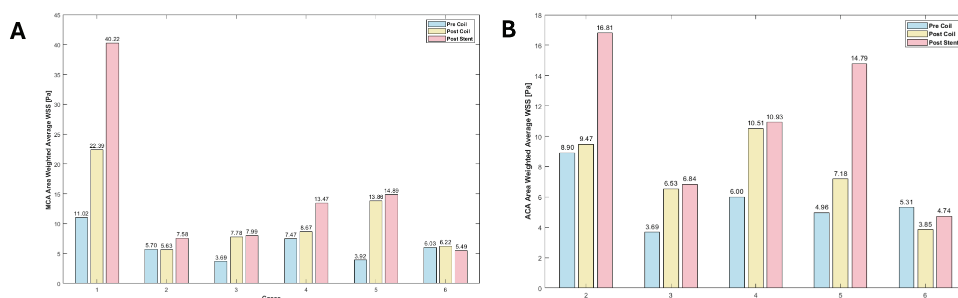

Figure 4. Graphical representation of the percentage change in the average WSS in the middle cerebral artery (MCA; A) and the anterior cerebral artery (ACA; B) in the six cases with ruptured posterior communicating aneurysms treated using an acute coiling and delayed flow diversion (ACDF) strategy, analyzed with computational fluid dynamics. The common trend observed in the cases was an increase in the shearing forces in the downstream vasculature after stent deployment.

Conclusion

The field of CFD has significantly advanced, providing insights beyond the basic understanding of aneurysm progression and rupture risk. Future developments in CFD aim to facilitate individualized hemodynamic analyses of aneurysms, thereby informing clinical decisions regarding aneurysm wall stability. As our understanding of CFD simulations deepens, integrating numerous variables will enhance model accuracy, enabling better replication of hemodynamics after the treatment of complex aneurysms.

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Artificial intelligence in brain aneurysm detection: current applications and future projections

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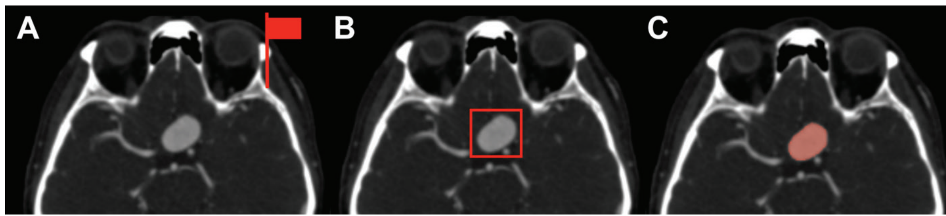

Figure 1 A) The output image from a deep learning model (DLM) trained to detect a brain aneurysm via the flagging approach. B) Image output of a DLM trained to detect using the segmentation (bounding box) approach. C) Image output of a DLM using semantic segmentation, with the aneurysm labeled in red.

The integration of artificial intelligence (AI) into the healthcare system has become increasingly significant in recent years. In the field of stroke, brain aneurysms have emerged as a key area of focus for AI developers, given that approximately 2-3% of the population harbors an aneurysm[1], often detected incidentally during diagnostic imaging of the head for other reasons. Deep learning, a specialized subset of AI, excels at interpreting images and distinguishing various pathologies from healthy tissues more quickly than radiologists. As a result, deep learning models (DLMs) have become a major focus of interest in current stroke research.

When it comes to detection, DLMs can be trained using three distinct methods, each with its own advantages and tradeoffs. The most straightforward approach is flagging, where a DLM is trained to alert radiologists that a scan might contain an aneurysm. In this method, the model is trained using a series of scans labeled with a binary indicator of aneurysm presence or absence (Figure 1A). This approach is the fastest and, therefore, most commonly used in the industry. However, it comes with a significant "black-box" effect, making it unclear how the DLM determines which scans to flag. Consequently, it is uncertain whether the DLM is flagging a scan because it has learned to identify an aneurysm, or because it has recognized larger structures associated with aneurysm formation, such as cerebrovascular anatomical variations. The application of flagging in brain aneurysm detection has not yet yielded satisfactory results. Last year, during the first large-scale validation of the Viz ANEURYSM DLM across eight certified stroke centers in the United States, it achieved a sensitivity of only 62%[2].

Segmentation is the second approach for DLM-based detection, where the DLM is provided with a series of scans. Instead of using binary labels, scans containing aneurysms are marked with a bounding box around the aneurysm, as illustrated in Figure 1B. The DLM learns to place bounding boxes in the same way when tested on new patient scans. While this approach effectively identifies the location of the aneurysm, as demonstrated in the literature, it does not provide information about the aneurysm's morphology and volume in the same way that the flagging approach does. Understanding the morphology and volumetrics of an aneurysm is valuable, as it is expected to become a crucial factor in treatment decision-making by the end of this decade[3]. Semantic segmentation paves the way for the integration of morphology and volumetrics into clinical practice in the near future.

Semantic segmentation is currently the most favored approach for brain aneurysm detection (Figure 1C). This method trains DLMs to classify aneurysms down to the individual pixels of a scan, thereby reducing the black-box effect. To achieve this, the scans used to train the model must be meticulously labeled at the pixel level by radiologists to distinguish aneurysm tissue from normal tissue. However, in both the literature and industry, this level of detailed labeling has not been competently achieved for CT-angiography (CTA) scans[4]. Existing studies that have developed DLMs for semantic segmentation are still experimental, often using a limited number of scans (ranging from tens to a few hundred), training on data from only one CT manufacturing brand, using post-processed skull-stripped CTAs, and lacking external multicenter testing.

At the Brain Aneurysm Institute, Beth Israel Deaconess Medical Center, our team is currently developing the first generalizable DLM-based brain aneurysm detection technology that allows for volume and morphology acquisition, as illustrated in Figure 2. Having been trained and tested on the largest cohort to date, totaling over 2,000 scans, and being the first model to be deployed internationally, this DLM is poised to become a leading tool in brain aneurysm detection in the coming years.

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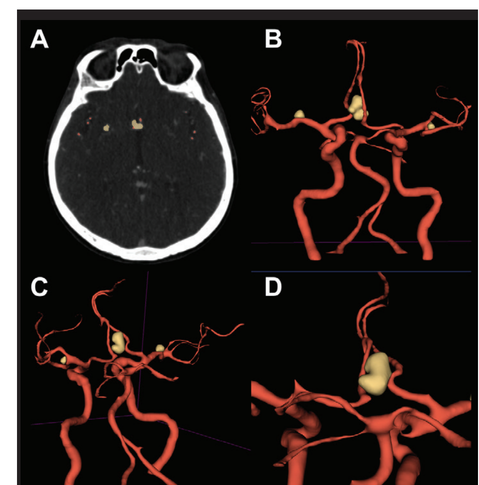

Figure 2 Outputs of the Brain Aneurysm Institute's (BAI) novel deep learning model (DLM) applied to a patient's CT-angiography scan. A) The initial output of the scan, with arteries marked in red and aneurysms marked in yellow. B) An anterior view of the 3D reconstructed output, showing the DLM's detection of all three aneurysms. C) A posterior-lateral view of the same patient scan output, providing an alternative perspective. D) A posterior view zoomed in on the right anterior cerebral artery junction, revealing a high-risk bi-lobed irregular morphology aneurysm, with a dome height of 4mm and a width of 10mm.

Characterizing Revascularization after Encephalo-Duro-Arterio-Synangiosis (EDAS) in Adult Patients with Moyamoya Disease Using the Orbital Grading System

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Moyamoya disease (MMD) is a rare, chronic cerebrovascular disorder that poses significant challenges in both diagnosis and treatment. MMD affects the blood vessels in the brain, particularly the internal carotid arteries, which are major arteries that supply blood to the brain. In people with this disease, these arteries gradually narrow, leading to the formation of tiny, fragile blood vessels at the base of the brain.[1] These new vessels try to compensate for the blocked arteries, but are weak and prone to causing strokes or hemorrhage, impacting the quality of life.[2]

Over the years, various surgical interventions have been developed to prevent ischemic complications associated with MMD. Providers often perform revascularization procedures such as Encephalo-Duro-Arterio-Synangiosis (EDAS). EDAS is an indirect bypass procedure and is among the most widely used. It aims to create new blood vessel collateralization to improve blood flow to the brain. Neurosurgeons use a branch from the superficial temporal artery (STA), the terminal branch of the external carotid artery. Next, a craniotomy is performed, and the galeal cuff is sutured to the dura edges, positioning the artery on the pial surface of the brain. Revascularization occurs through angiogenesis, driven by local hypoperfusion and ischemia, which may take up to one year after the surgery to fully develop.[3] Traditionally, patients who underwent this surgery get a follow up angiogram one year after their surgery, allowing the providers to evaluate the radiographic success or failure of the EDAS procedure. Providers have used a grading system called the Matsushima grading system to evaluate the success of the surgery.[4] However, this system has some drawbacks—it can be subjective, meaning that different providers might interpret the results differently, leading to inconsistent assessments. Therefore, the need for a more objective and reproducible method of evaluating the success of revascularization procedures has increased.[5]

Development of the Orbital Grading System

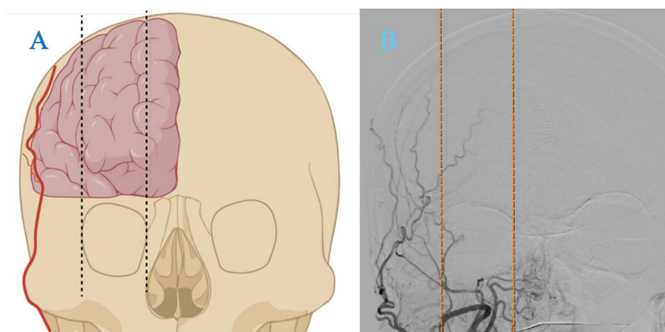
The BIDMC Brain Aneurysm Institute team conducted a retrospective review of a prospectively collected database from 2013 to 2023. Clinical and radiographic data of adult MMD patients, including age, gender, presenting symptoms (stroke, hemorrhage, seizures), comorbidities, smoking history, pattern of intravascular occlusion, Suzuki grading, procedural details, including adjunctive frontal and parietal burr holes, complications, and follow-up findings of new ischemic events, was collected through a review of electronic records and was used to characterize the patterns of arterial ingrowth and outcomes. Using this data, our team developed a new classification called the Orbital Grading System. This new classification system was developed to offer a more objective method for evaluating the success or failure of EDAS procedures in patients with MMD. It is designed to classify collateral vessel growth based on anatomical landmarks of the orbit, using anteroposterior view on digital subtraction angiography (DSA). The system categorizes vessel growth into four distinct grades: Grade 0 shows no collateral growth (Figure 1), Grade 1 shows poor collateral growth (Figure 2), Grade 2 shows moderate collateral growth (Figure 3), and Grade 3 shows excellent collateral growth (Figure 4). The Orbital Grading System presents a clear and systematic approach to grading, allowing for a more precise evaluation of revascularization success, which could ultimately lead to better clinical decision-making and improved patient management.

Our team wanted to determine the reliability and effectiveness of the Orbital Grading System by comparing its results with those of the Matsushima grading system. The findings revealed that the Orbital Grading System demonstrated strong agreement with the Matsushima grading system in identifying postoperative ischemic complications like stroke or transient ischemic attack ($p = 0.047$). This agreement suggests that the new system is not only consistent with established methods but also offers additional benefits in terms of objectivity and reliability.

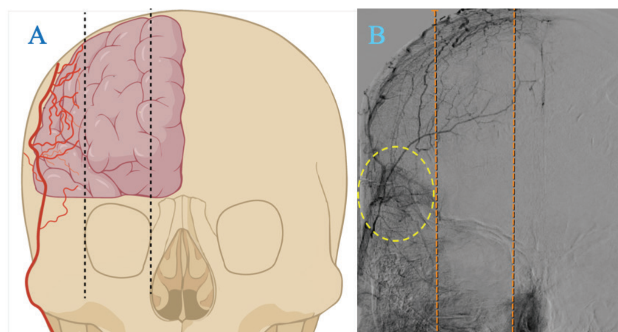
Advantages of the Orbital Grading System

One of the key advantages of the Orbital Grading System is its ability to provide a standardized assessment of collateral vessel development. It quantifies vessel ingrowth from the STA and/or middle meningeal artery (MMA) to the MCA and ACA on post-EDAS angiograms in MMD, patients which is not available in other grading systems like the Matsushima Grading system. The use of anatomical landmarks ensures that the grading process is based on objective criteria rather than subjective interpretation, which can vary between different medical providers. This standardization is particularly important in the context of MMD, where the success of revascularization procedures is heavily dependent on the development of robust collateral formation.

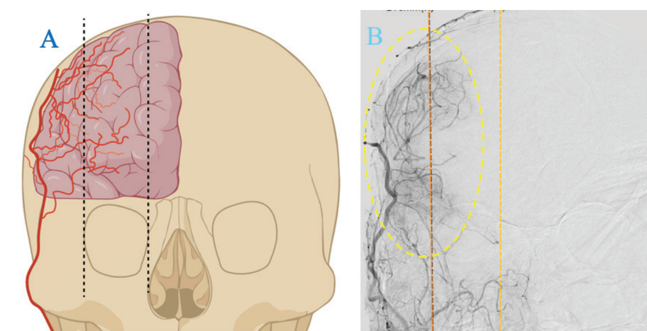
At the BIDMC we have established a Center of Excellence for patients with adult MMD. We have created an Orbital Grading System in predicting patient outcomes. We observed a significant reduction in ischemic complications in hemispheres that were categorized as Grade 2 or Grade 3 according to the Orbital Grading System. This finding suggests that the system is effective in identifying patients who are likely to experience favorable outcomes following EDAS procedures. By providing a more accurate assessment of collateral vessel ingrowth, the Orbital Grading System could help clinicians optimize



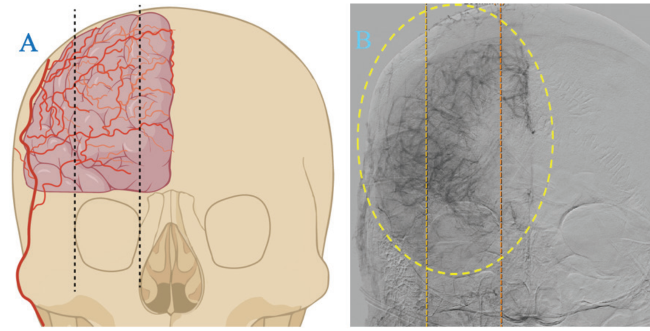
Grade 0: Absent growth of collaterals from the STA (A) on the anterior-posterior view of the post-EDAS DSA (B)



Grade 1: Growth of collaterals (dashed yellow circles) from the STA and MMA into the MCA territory without crossing an imaginary vertical line of the lateral orbit (A) of the anterior-posterior view (B) of the post-EDAS DSA.



Grade 2: Moderate collateralization (dashed yellow circles) from the STA and MMA to the MCA territory crossing the vertical line of the lateral orbit, but without reaching the medial vertical orbital line (A) on the anterior-posterior view of the post EDAS DSA (B)



Grade 3: Abundant collateralization (dashed yellow circles) from the superficial temporal artery and MMA into the MCA and the ACA territory crossing both vertical lines of the lateral and medial orbit (A) on the anterior-posterior view of the post EDAS DSA (B).

treatment plans to the specific needs of each patient, thereby improving the overall quality of care for MMD patients. In particular, patients who are identified as having poor collateral growth (Grade 0 or Grade 1) may benefit from more surgical interventions, such as direct bypass procedures or alternative surgical techniques. Conversely, patients with excellent collateral growth (Grade2 or Grade 3) may require less intensive follow-up and may be candidates for long-term conservative management strategies.

In addition to its clinical value on patient care, the Orbital Grading System could offer several practical advantages that could facilitate its widespread adoption in both research and clinical settings. The system's reliance on DSA, a widely available imaging modality, ensures that it can be easily integrated into existing diagnostic workflows. Furthermore, the clear and straightforward grading criteria make the system accessible to a broad range of healthcare professionals, including those with different levels of experience in interpreting angiographic images.

The implications of the Orbital Grading System extend beyond the immediate context of MMD. As the field of cerebrovascular surgery continues to evolve, there is a growing recognition of the importance of objective and reproducible outcome measures in guiding clinical practice. The development of new grading systems, such as the Orbital Grading System, represents a significant step forward in this regard. By providing a more reliable means of assessing the success of revascularization procedures, these systems have the potential to improve patient outcomes across a range of cerebrovascular conditions.

The introduction of the Orbital Grading System could raise important questions about the future direction of research in MMD. While the system has demonstrated considerable promise in the initial study, further research is needed to validate its effectiveness in larger and more diverse patient populations. Furthermore, future studies could investigate the feasibility of using the Orbital Grading System for evaluating the outcomes of other direct and indirect cranial bypass procedures.

In conclusion, the Orbital Grading System represents a significant advancement in the field of MMD treatment. By offering a more objective and consistent method for assessing collateral vessel ingrowth, the system addresses many of the limitations associated with traditional grading systems.

Our study provides robust evidence that the Orbital Grading System is both reliable and clinically relevant, with the potential to improve patient outcomes and enhance the quality of care for patients undergoing revascularization procedures. As further research is needed to validate and refine the system, it is likely that the Orbital Grading System will become an increasingly important tool in the management of MMD and other cerebrovascular conditions.

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Neurovascular Disease and Treatment for Neurosurgery Residents and Medical Students

The Essentials: A Hands on and Practical Course

COURSE OBJECTIVES This is a unique course focused on recent advances in the field of neurovascular disease including natural history of carotid disease, cerebral hemorrhage, and brain aneurysms and AVMs. Topics covered will include assessment, management, and specific issues of carotid disease, brain aneurysms, spinal and cranial dural AVMs and brain AVMs.

LEARNING OBJECTIVES Upon completion of this course, participants will be able to:

- Better understand carotid disease, including proper screening tests as well as treatment options, including medical, surgical and stent options
- Discuss management of unruptured aneurysms in the current technological era
- Appropriately perform hands on basic angiogram with type 1 arch and advance to more difficult type 2 and 3 arch
- Appropriately coil an aneurysm by hands on use of flow models to visualize stent deployment
- Accurately perform advanced simulator work, such as carotid stenting, stent/coil aneurysm, and difficult arch maneuvering
- Determine methods and efficacy of treatments of cranial and spinal dural AVMs management techniques of brain AVMs
- By hands on use of models, perform various approaches for anterior circulation aneurysms and posterior circulation aneurysms

TARGET AUDIENCE: Medical students with Neurosurgery interest, Residents and Fellows in Neurosurgical programs in New England

SAVE THE DATE

SATURDAY, OCTOBER 26TH, 2024

Under the direction of
Dr. Christopher S. Ogilvy

BIDMC Brain Aneurysm Institute

All sessions will be held at the Klarman Building 11th Floor at Beth Israel Deaconess Medical Center (BIDMC), 111 Francis Street, Boston, MA 02215

INQUIRIES By phone, please contact Deidre Buckley, NP 617-632-9713 or by e-mail: dabuckle@bidmc.harvard.edu