

# Estimation of Contrast Agent Motion from Cerebral Angiograms for Assessing Hemodynamic Alterations Following Aneurysm Treatment by Flow Diversion

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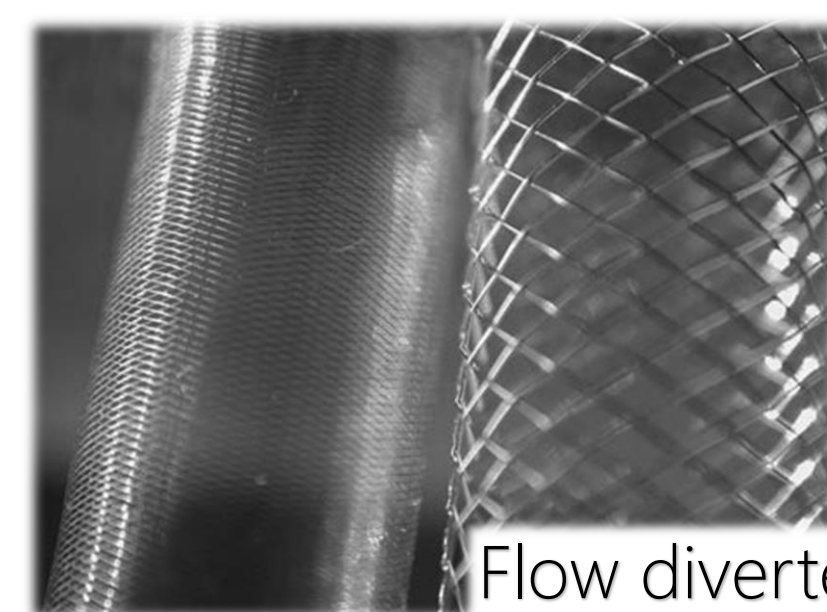
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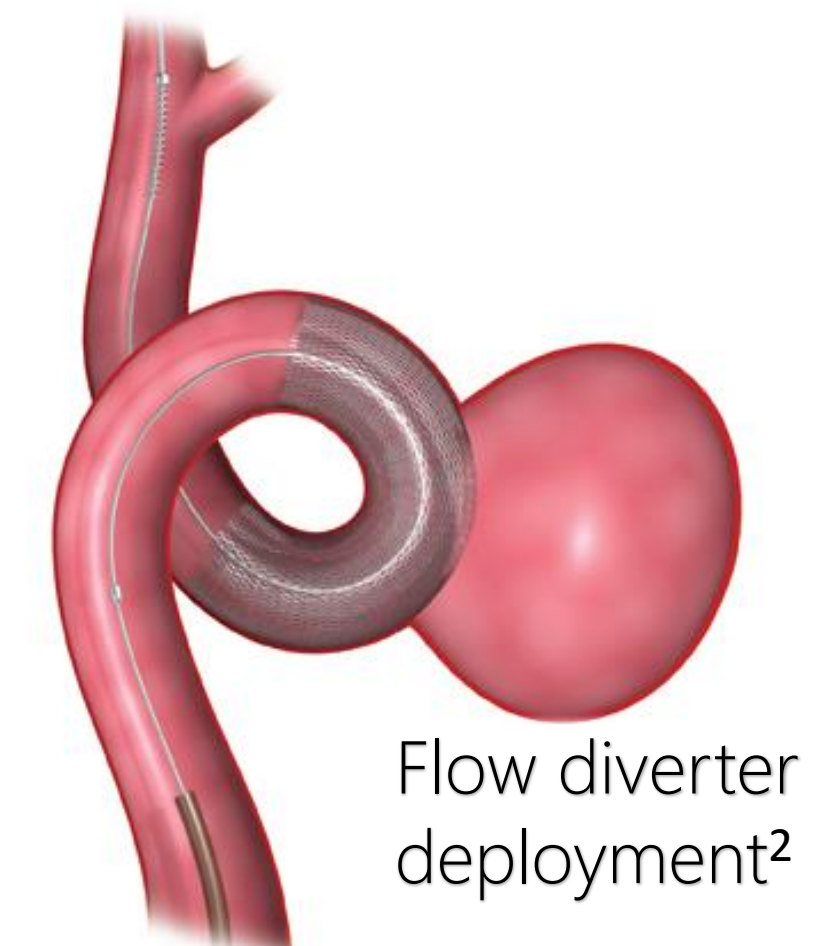
## Introduction

Flow diversion is an emerging treatment strategy for cerebral aneurysms that aims at restoring the healthy vessel anatomy by placing a tightly woven stent (flow diverter) across the opening of the aneurysm.

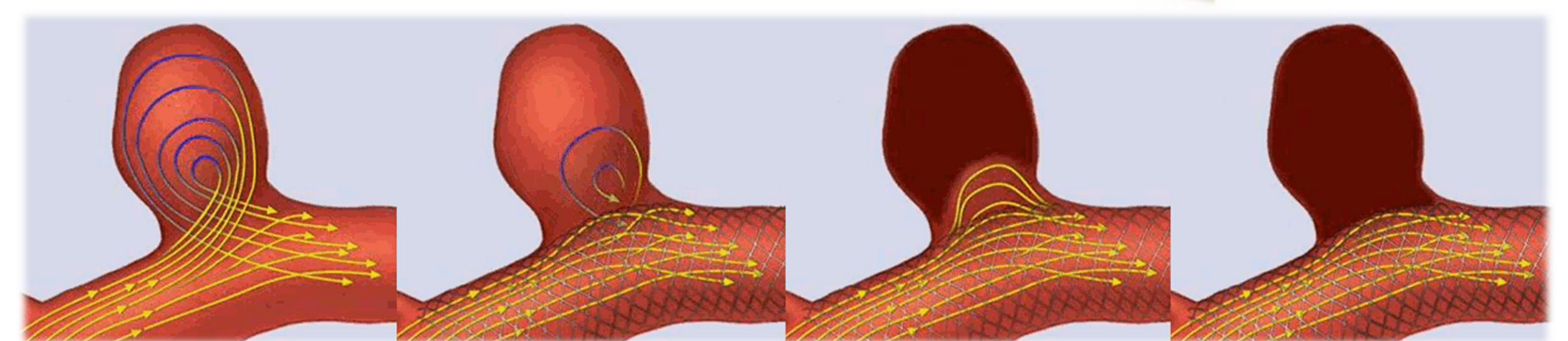
Once in place, the flow diverter (FD) redirects the blood flow away from the aneurysm and back into the parent vessel, thereby inducing flow stagnation and promoting aneurysm thrombosis.



Flow diverter vs. conventional stent<sup>1</sup>



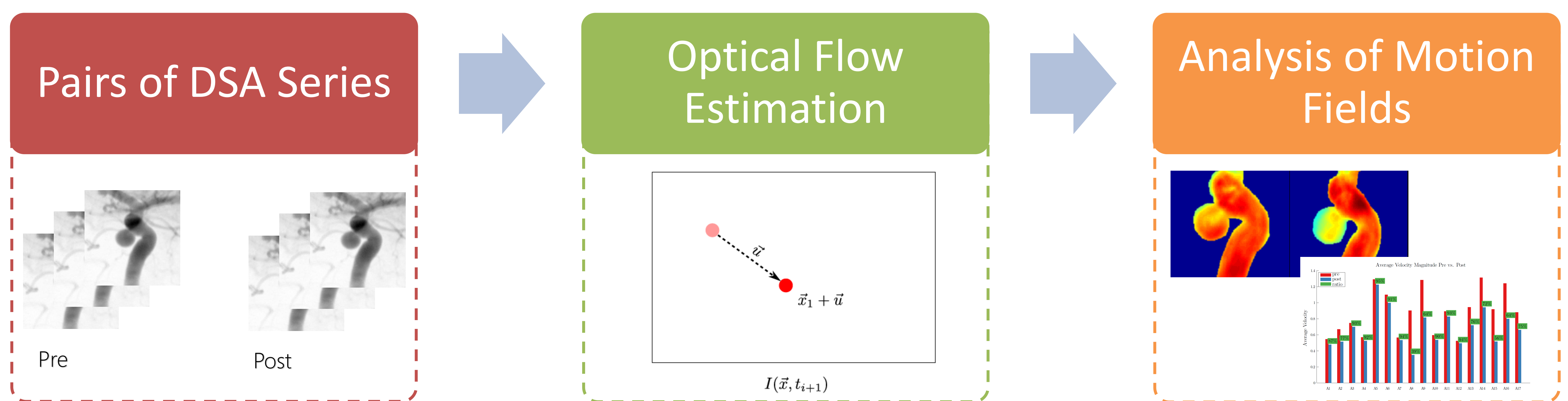
Flow diverter deployment<sup>2</sup>



Untreated aneurysm and gradual healing process after flow diverter treatment<sup>3</sup>

**Objective:** Angiographically decide whether the induced flow disruption is sufficient for aneurysm occlusion or whether additional therapeutic measures are needed.

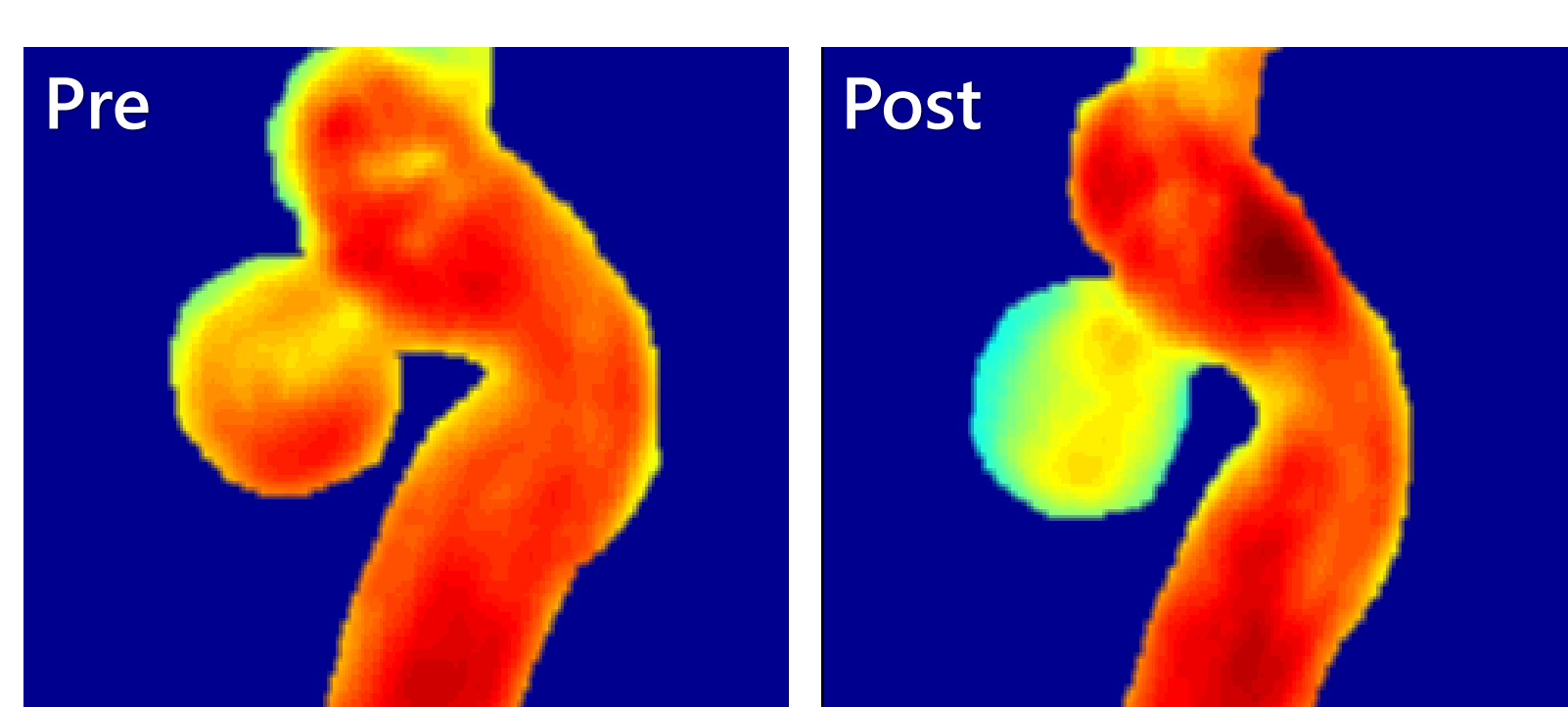
## Method



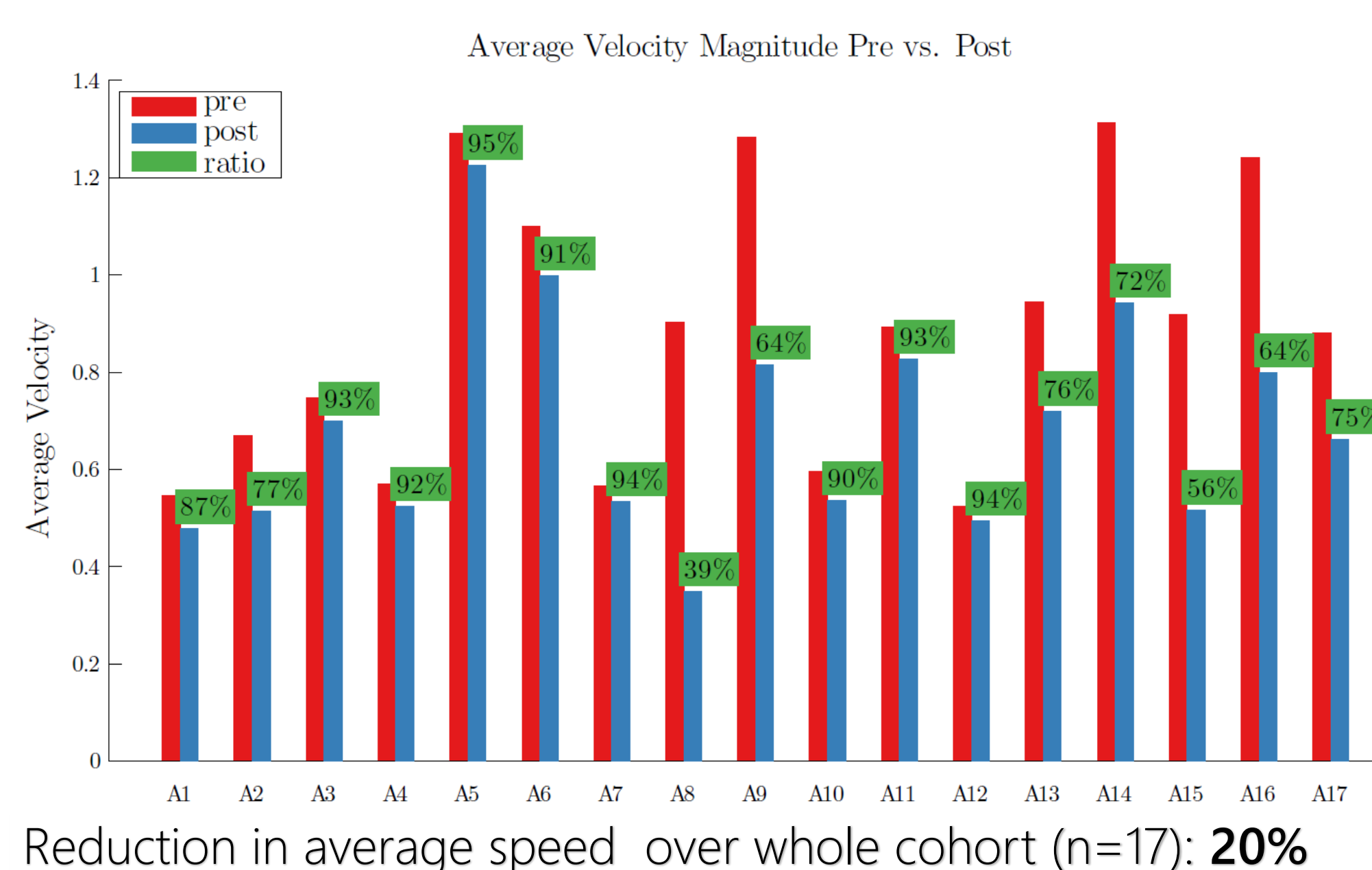
We recover dense contrast motion fields from pre/post pairs of Digital Subtraction Angiography (DSA) series by employing optical flow estimation based on *conservation of mass* [1] and *second-order div-curl regularization* [2]. Metrics that capture hemodynamic changes induced by FD treatment are derived from the obtained motion fields in regions of interest (e.g., average speed inside the aneurysm before and after FD treatment).

Data Term		Regularization Term	
$I_t + \nabla I \cdot \vec{u} = 0$ Constant brightness	$I_t + \nabla \cdot (I\vec{u}) = 0$ Conservation of mass	$\int_{\Omega} \ \text{div}(\vec{u})\ ^2 + \ \text{curl}(\vec{u})\ ^2$ First-order div-curl	$\int_{\Omega} \ \nabla \text{div}(\vec{u})\ ^2 + \ \nabla \text{curl}(\vec{u})\ ^2$ Second-order div-curl

## Exemplary Results



Case A16: reduction in average speed inside aneurysm: **36%**



### References

- [1] Wildes RP, Amabile MJ, Lanzillotto AM, Leu TS: *Recovering estimates of fluid flow from image sequence data*. CVIU 2000;80:246–266.  
 [2] Corpetti T, Mémin É, Pérez P: *Dense estimation of fluid flows*. PAMI 2002;24:365–380.

### Figure Credits

- <sup>1</sup>© Sadasvian et al., Stroke, 40(3):952–958, 2009.  
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<sup>3</sup>© Mayo Clinic, Rochester, MN, U.S.A.  
 All others courtesy of the authors.

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