

WFNS ACNS 2018, Myanmar, Yangon, Sep. 24, 2018

# CFD Analysis for Cerebral Aneurysms: WSS of the Aneurysmal Dome in Contact with Perianeurysmal Environment

Department of Neurological Surgery  
Ryofukai Satoh Neurosurgical Hospital

Toru SATOH, M.D.

Starting Now

Lecturers report no conflict of interest concerning the materials or methods used in this study.



# Hypothesis

Perianeurysmal environment (PAE) in contact with the aneurysmal dome (PAEC) can be an extrinsic factor that may affect the wall shear stress (WSS) induced by the intrinsic factor of the intra-aneurysmal hemodynamics.



# Methods

## Cases of Unruptured Aneurysms:

- ① with PAEC group (n=18)
- ② without PAEC group (n=16)

## PAEC Imaging:

3D multifusion image of 3D ASL-MRA & FSE-MRC

## CFD Analysis:

- ① WSSm (magnitude): WSSm-parent, WSSm-dome, WSSm-PAEC, WSSm-hetero
- ② WSSv (vector): WSSvV (vector variations)
- ③ SL: Streamline
- ④ WP: Wall pressure



# Intracranial Environment of Cerebral Aneurysm

## CFD Analysis

**Closed Space**

## Wall Factor

**Remodeling  
Endothelial injury  
Intramural thrombus  
Degeneration**

## Imaging

**Sequential Change**

## Intrinsic Factor

**WSSm·WSSv  
Low WSSm=Thin wall  
Inflow jet=Bleb formation  
Vortex=Complex flow**

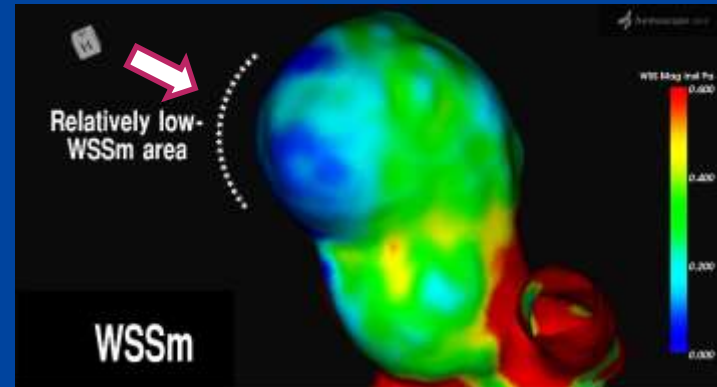
## Extrinsic Factor

**PAE·PAEC  
Soft (Brain·Nerve)  
Hard (Bone·Ligament)  
Contact=Immobility**



# Who knows real result with just intrinsic CFD?

## WSSm Animation: ACoMA Aneurysm

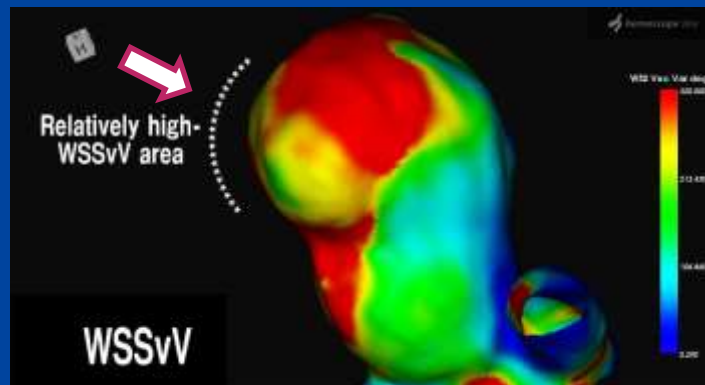


WSSm

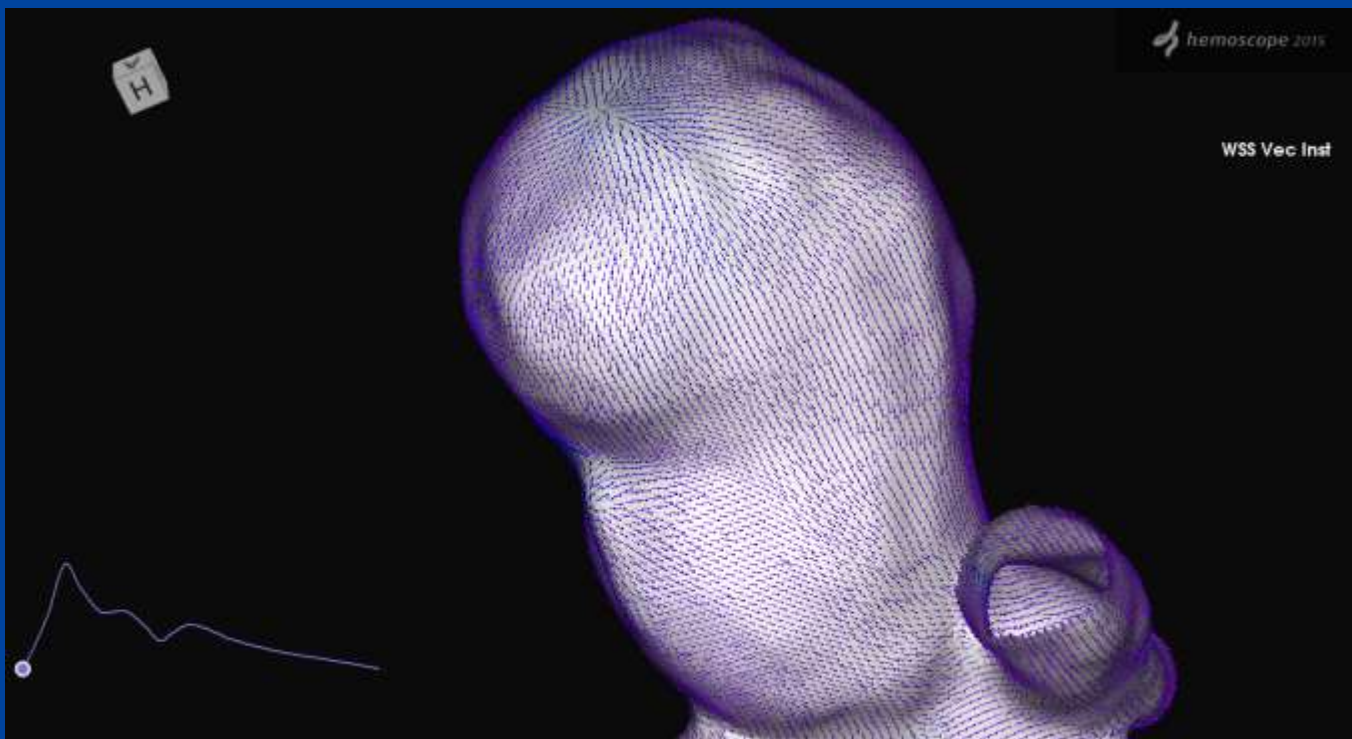


# Who knows real result with just intrinsic CFD?

## WSSv Animation: AComA Aneurysm

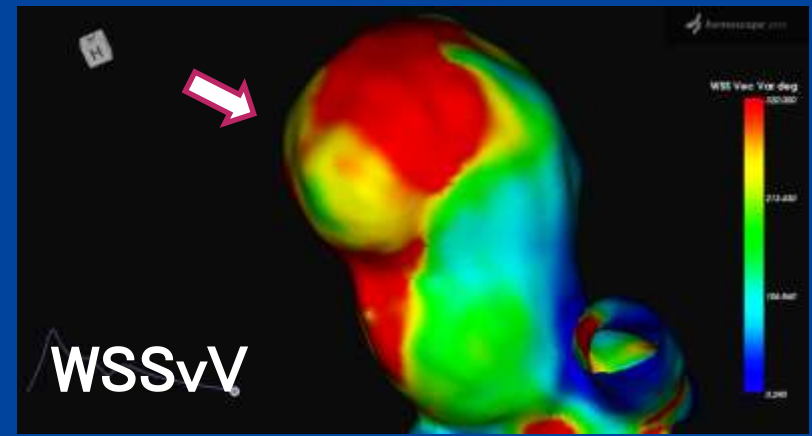
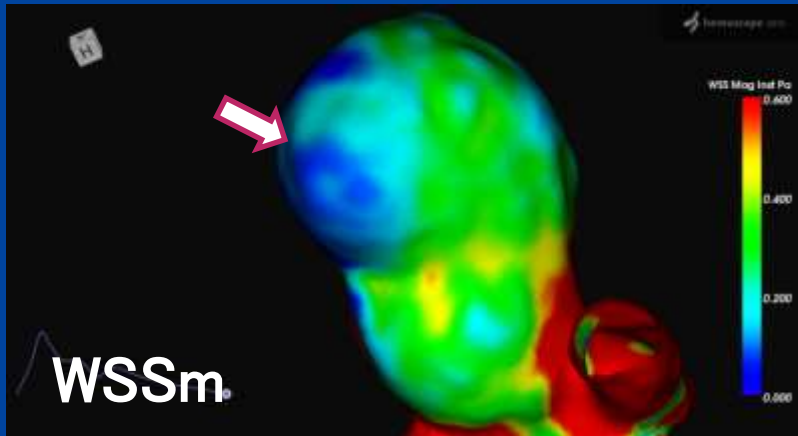


WSSvV

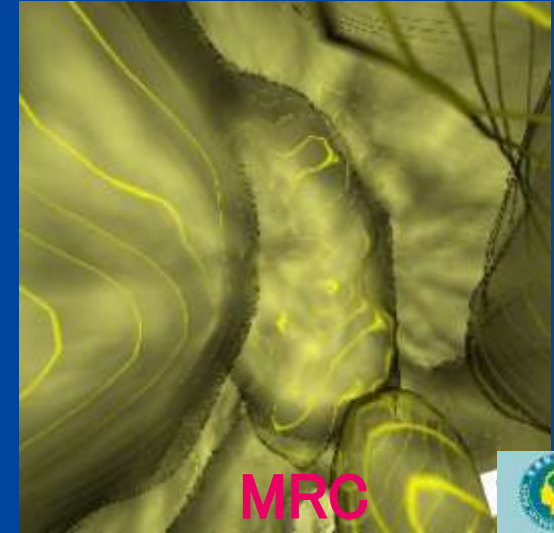
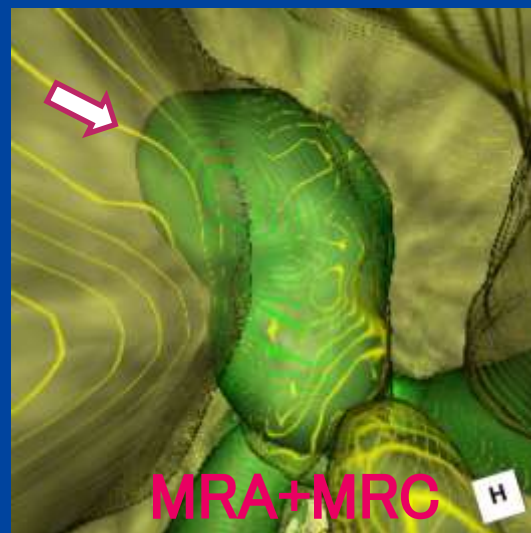


# We know why with intrinsic & extrinsic factors

## Intrinsic factor: CFD Analysis

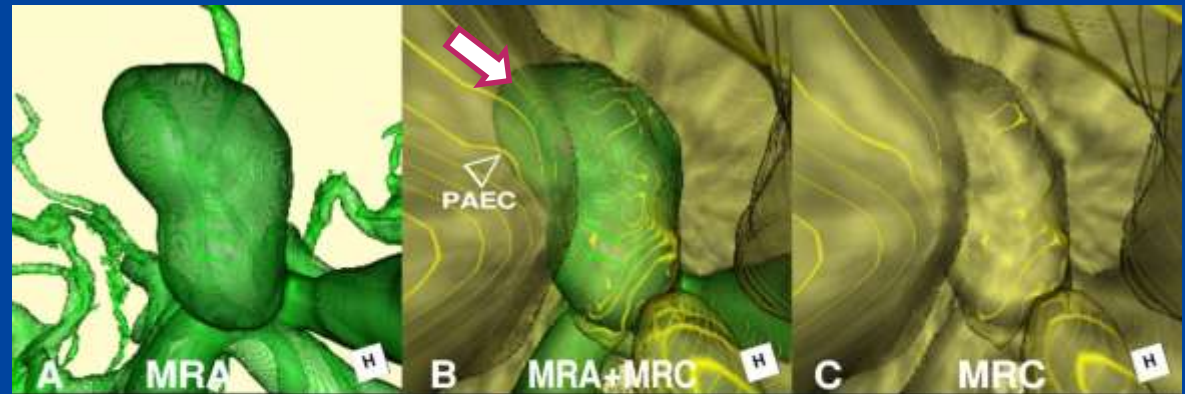


## Extrinsic factor: PAEC Imaging

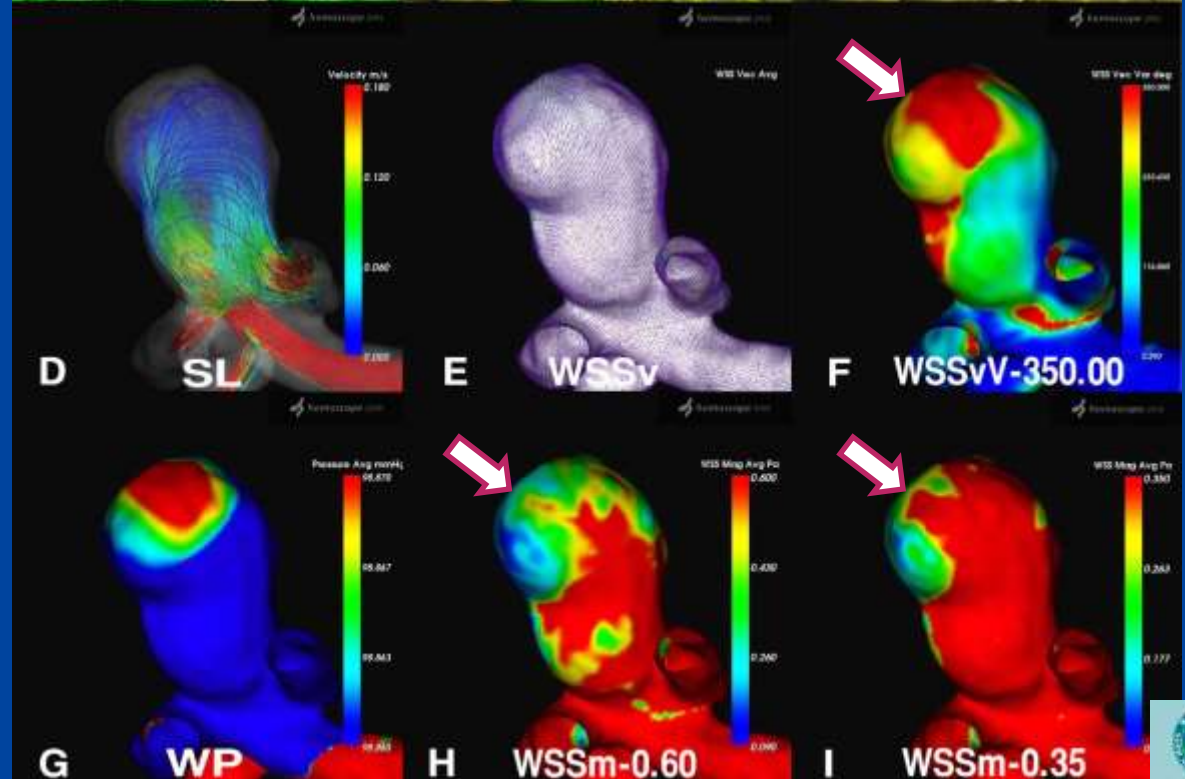


# Extrinsic & intrinsic factors: AComA An

Extrinsic factor:  
PAEC Imaging  
With PAEC



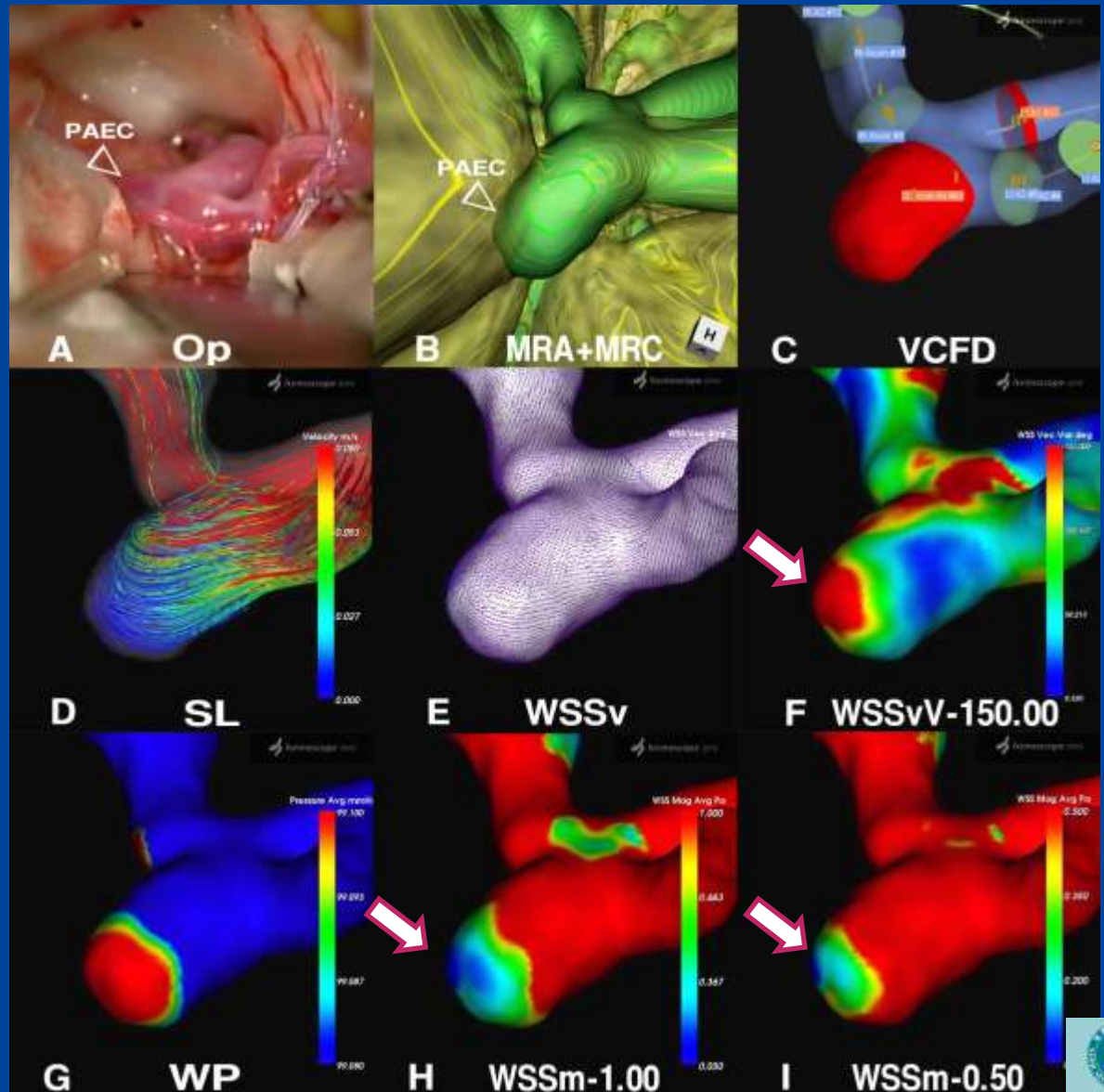
Intrinsic factor:  
CFD Analysis  
With PAEC





# Extrinsic & intrinsic factors: AComA An

Extrinsic factor:  
PAEC Imaging  
With PAEC

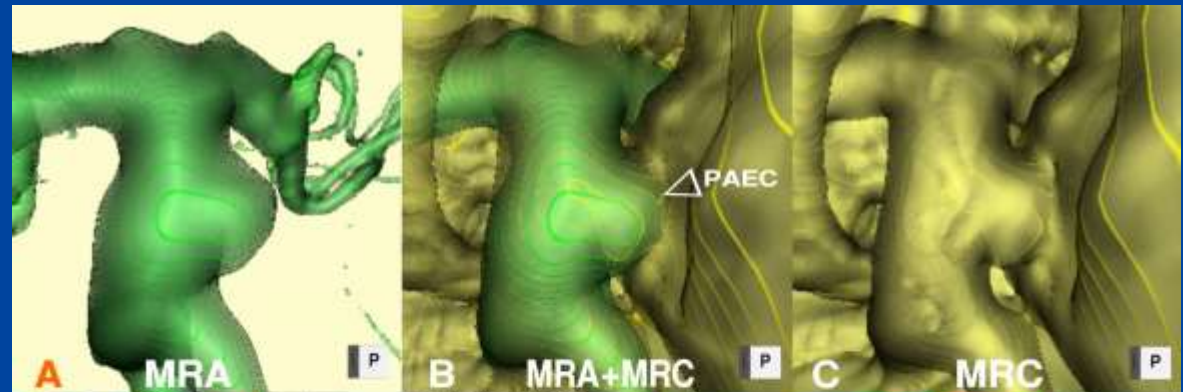


Intrinsic factor:  
CFD Analysis  
With PAEC

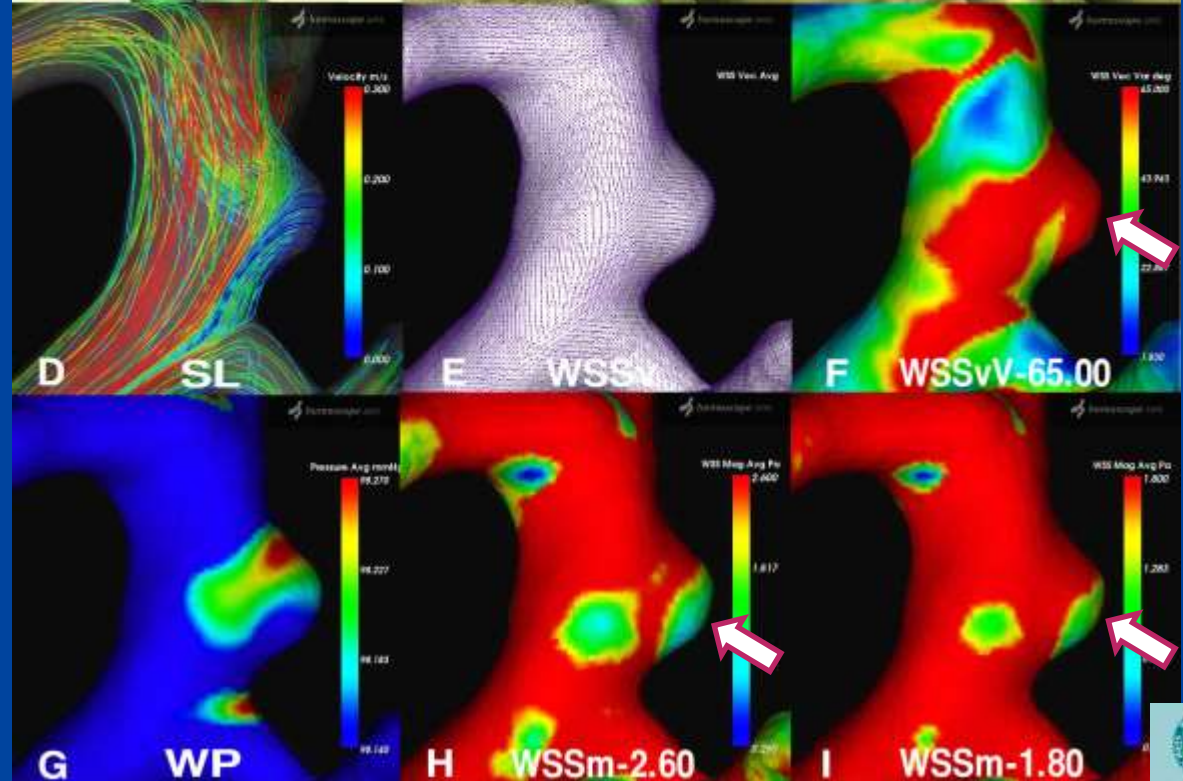


# Extrinsic & intrinsic factors: AChorA An

Extrinsic factor:  
PAEC Imaging  
With PAEC

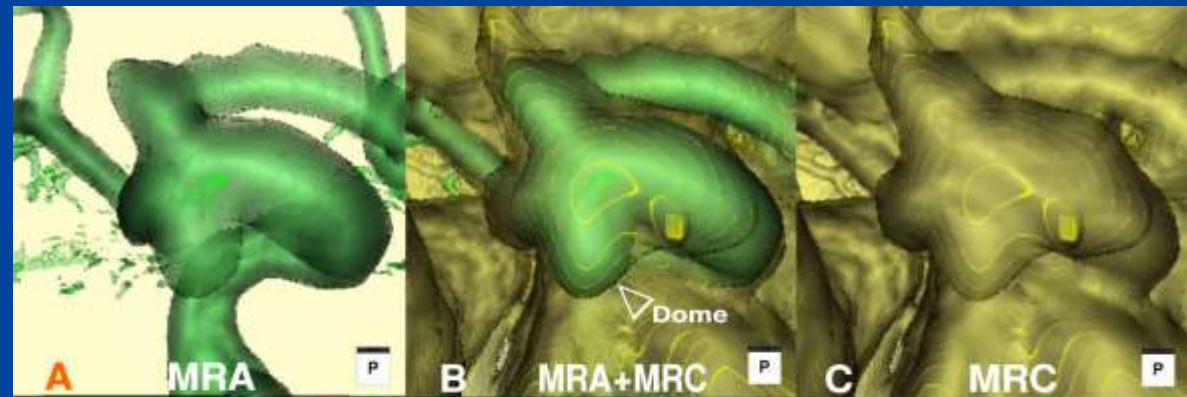


Intrinsic factor:  
CFD Analysis  
With PAEC

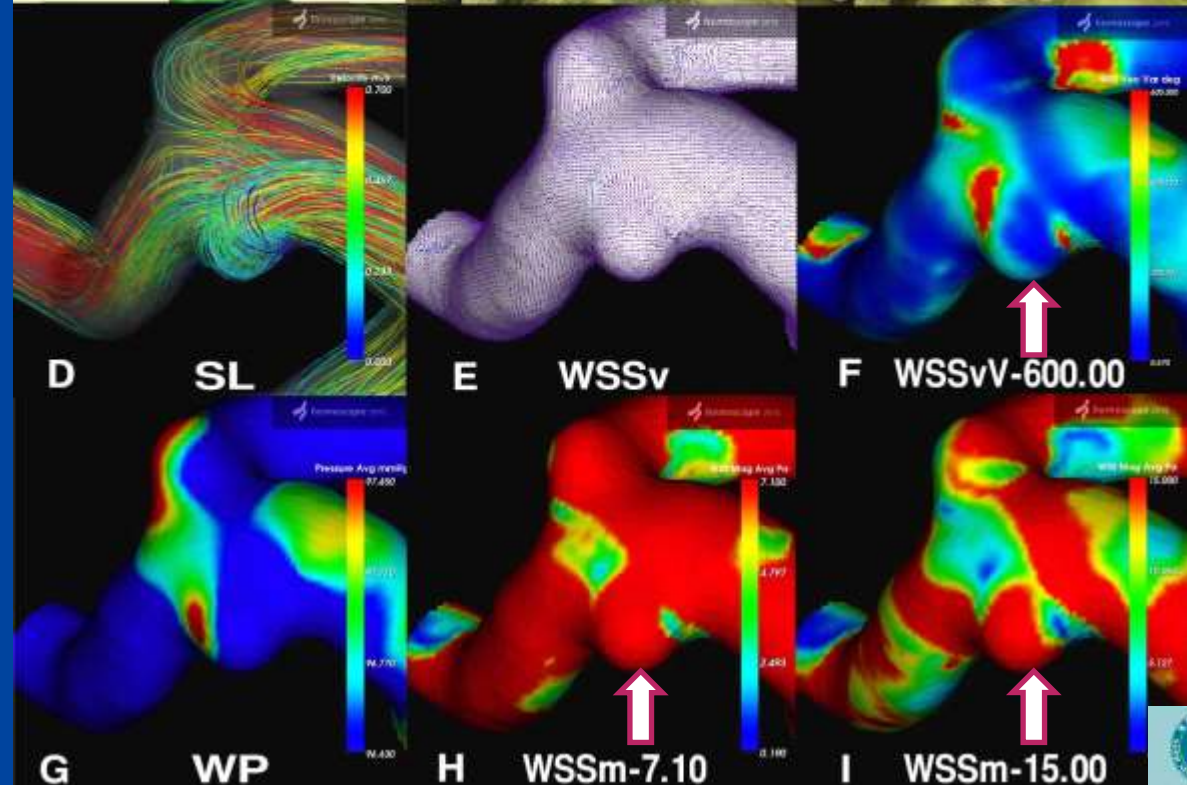


# Extrinsic & intrinsic factors: AChorA An

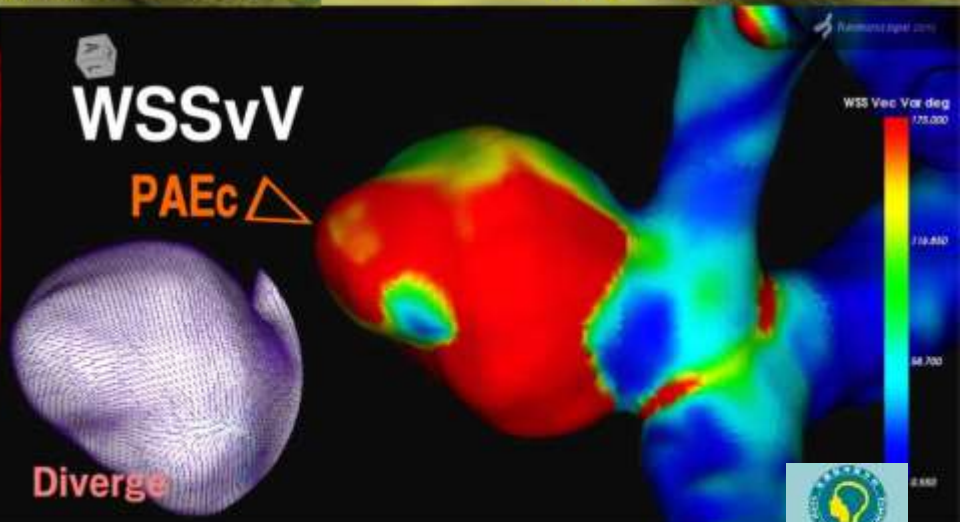
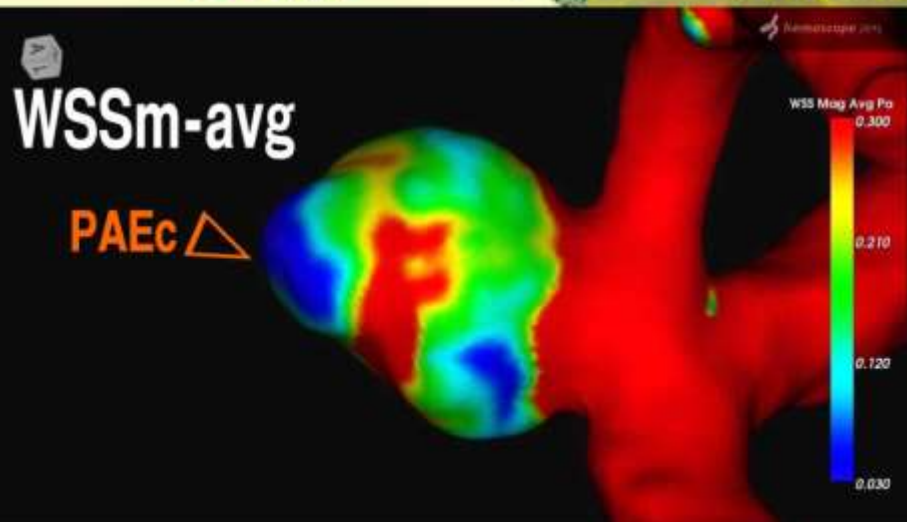
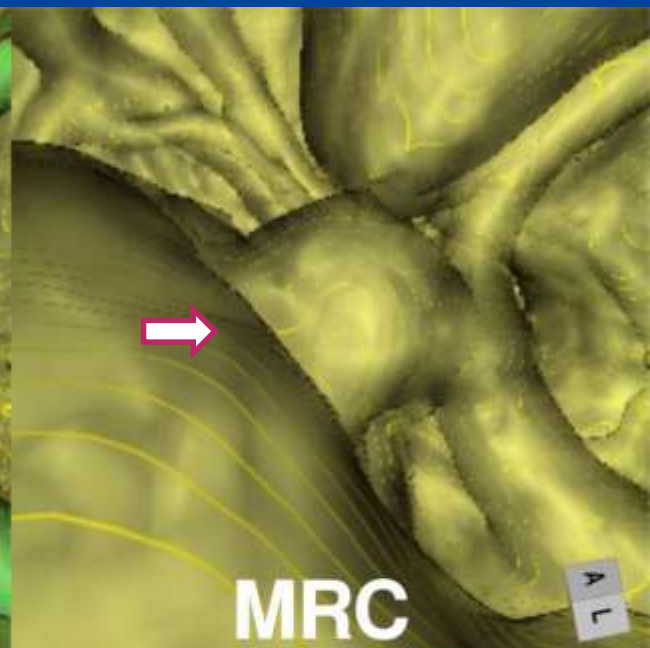
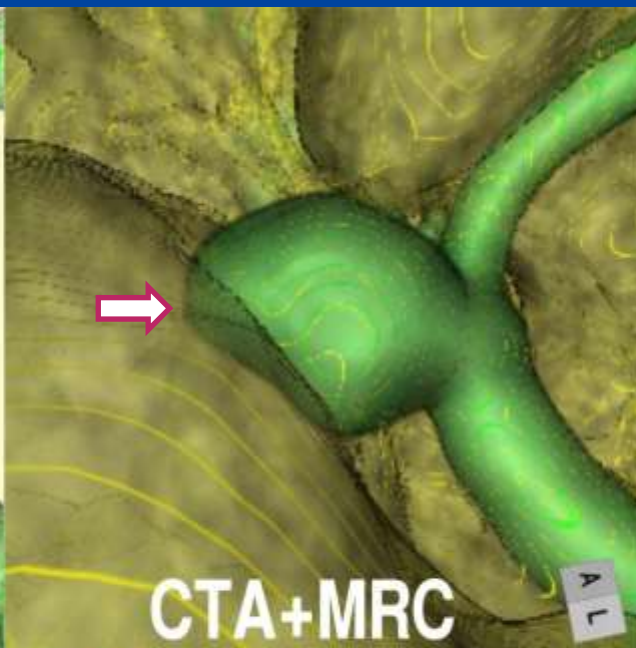
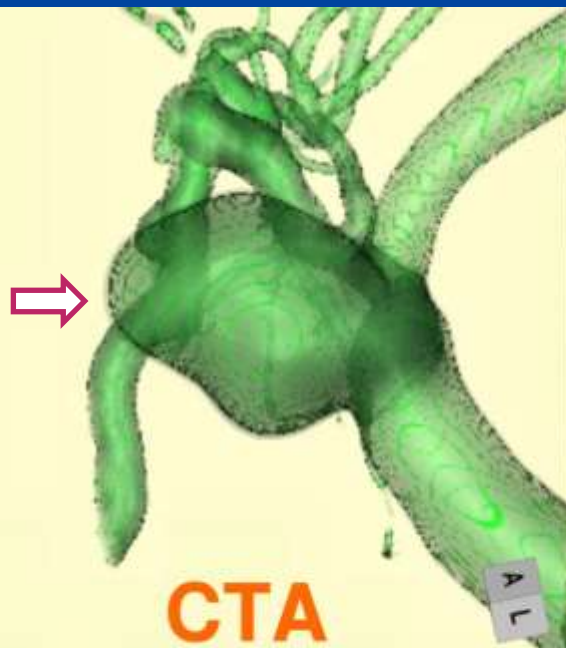
Extrinsic factor:  
PAEC Imaging  
Without PAEC



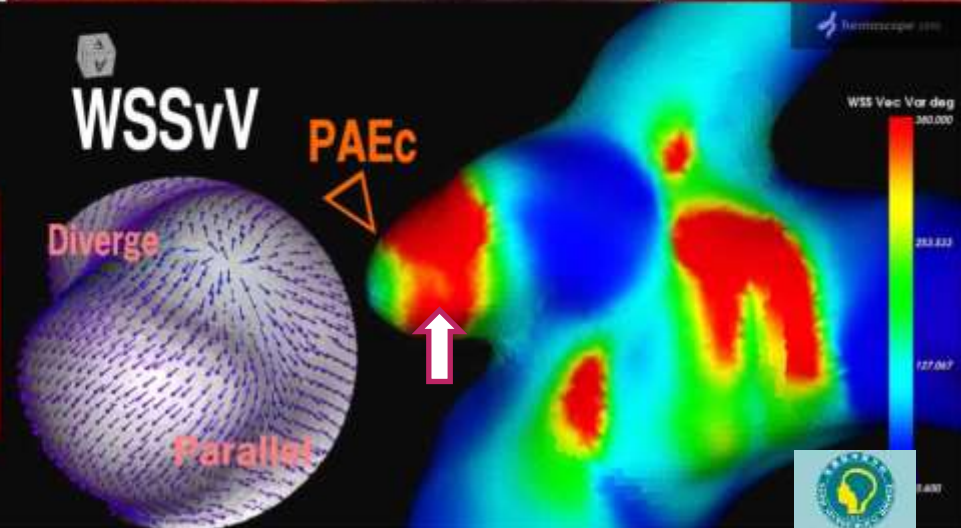
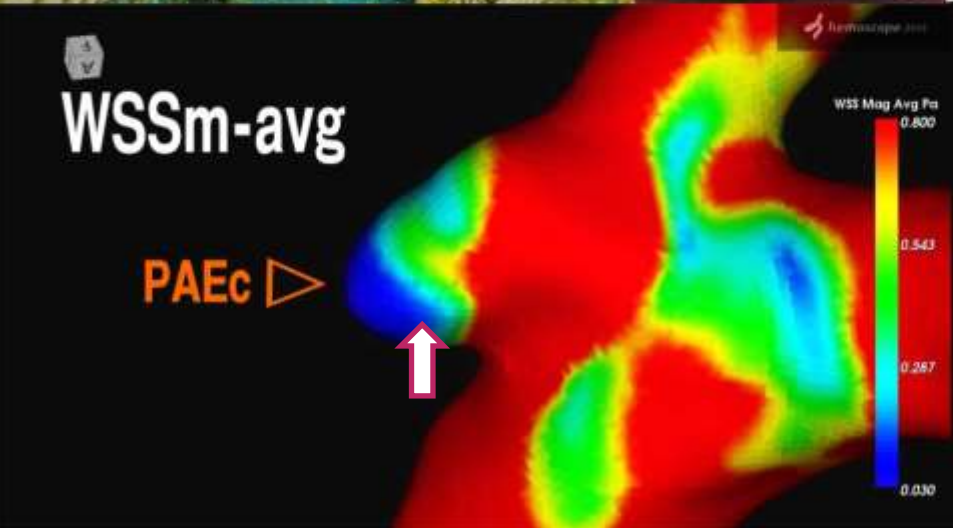
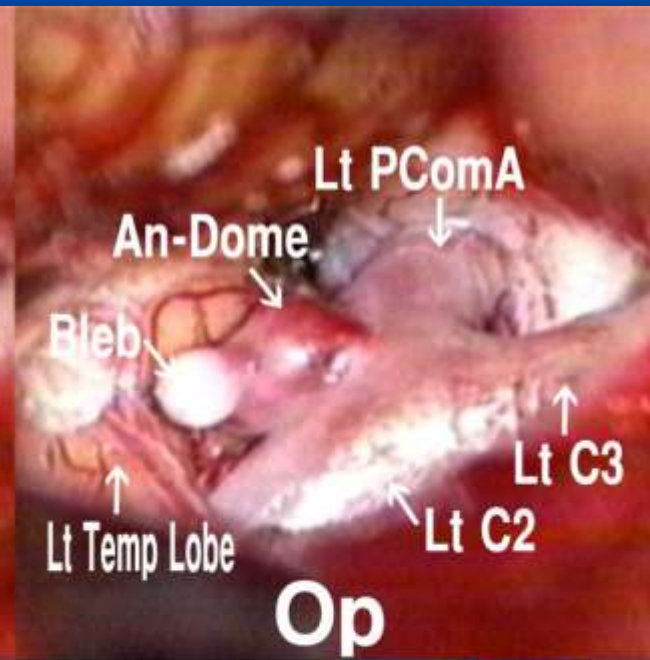
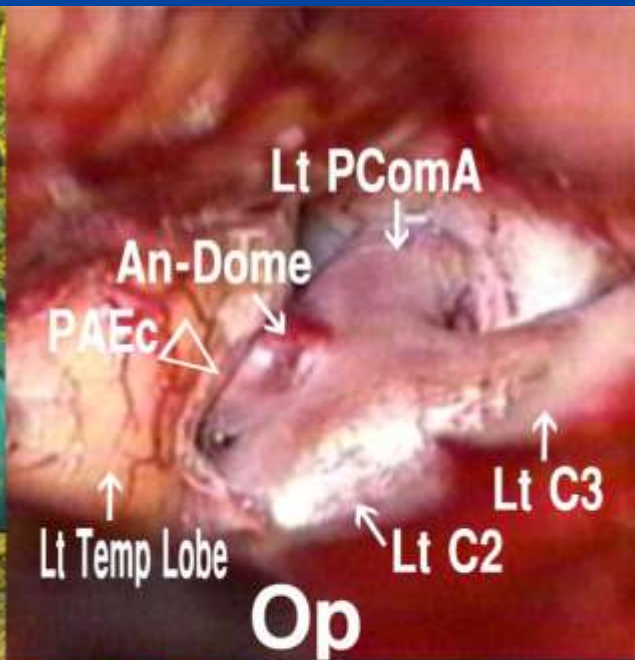
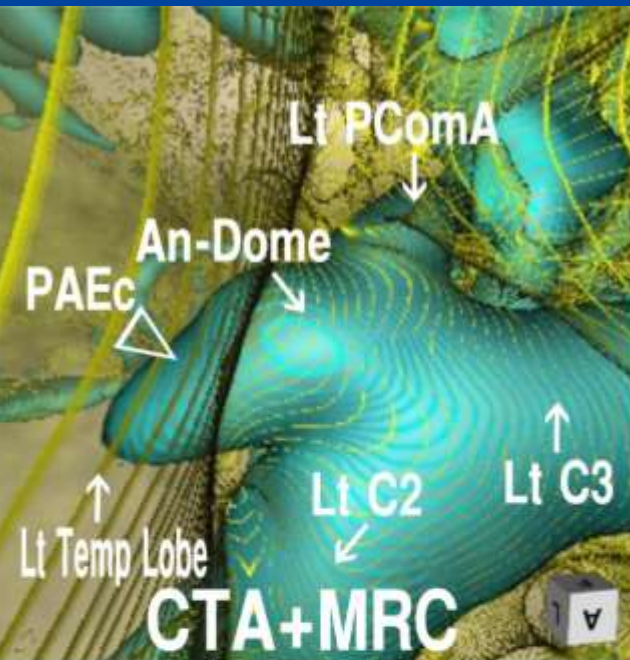
Intrinsic factor:  
CFD Analysis  
Without PAEC



# Extrinsic & intrinsic factors: MCA An



# Extrinsic & intrinsic factors: IC-PC An



# Interaction with Intrinsic & Extrinsic factors

## Intrinsic Factor

WSSm·WSSv  
Low-WSSm→thin wall  
Inflow jet→Bleb formation  
Vortex→Complex flow

## Wall Factor

Remodeling  
Endothelial injury  
Intramural thrombosis  
Degeneration

## Extrinsic Factor

### PAE·PAEC

Soft PAE: Brain·Nerve  
⇒ Protective effect  
Hard PAE: Bone·Ligament  
⇒ Detrimental result

### Pulsatile mobility

⇒ Brain·CSF·Artery

### Unsteady hemodynamics

⇒ Low-WSSm, high-WSSm-hetero,  
high-WSSv, high-WSSvV

### Variation in wall stress

⇒ resulting in rupture



# Conclusions

- ① Areas of relatively low WSS<sub>m</sub>, increased WSS<sub>m</sub>-hetero, frequent WSS<sub>v</sub> and high WSS<sub>v</sub>V of the aneurysmal dome may indicate the existence and location of **PAEC**.
- ② The extrinsic factors affected by the **PAEC**, interacted with intrinsic factors induced by intra-aneurysmal hemodynamics.
- ③ **PAEC** may provide an additional factor in the consideration of the natural history of a cerebral aneurysm in rupture.

Thank you for your kind attention !



WANS ACNS/ 20180923/ Myanmar, Yangon



Thank you for your kind attention



Fin

