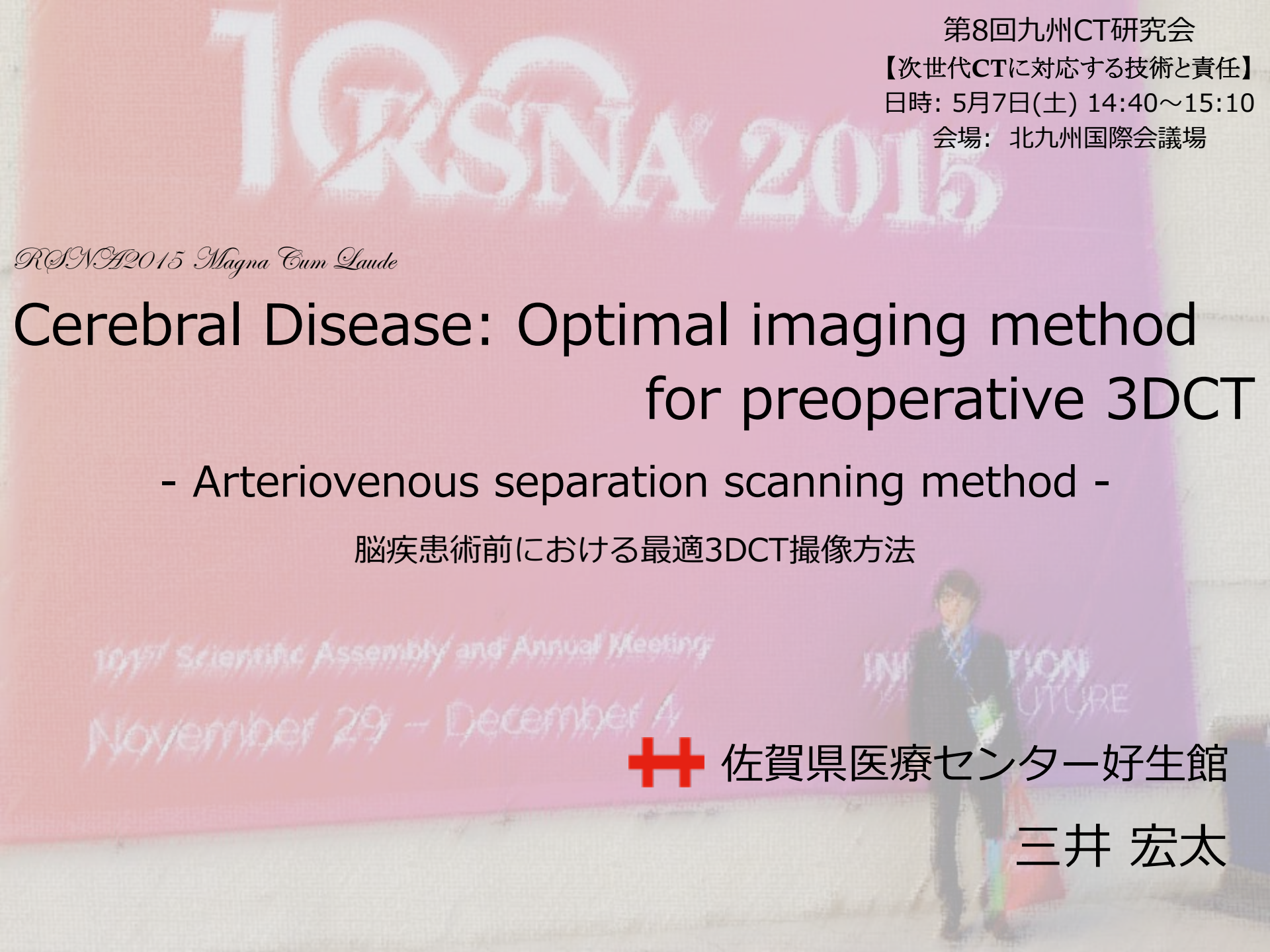
第8回九州CT研究会
【次世代CTに対応する技術と責任】
日時: 5月7日(土) 14:40～15:10
会場: 北九州国際会議場

RSNA2015 Magna Cum Laude

Cerebral Disease: Optimal imaging method for preoperative 3DCT

- Arteriovenous separation scanning method -

脳疾患術前における最適3DCT撮像方法



佐賀県医療センター好生館

三井 宏太

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1. RSNAについて
2. RSNA2015 発表演題

   Cerebral Disease: Optimal imaging method for preoperative 3DCT

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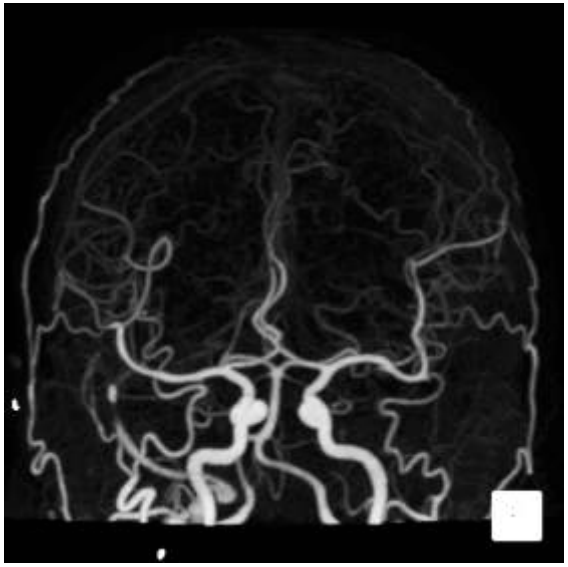
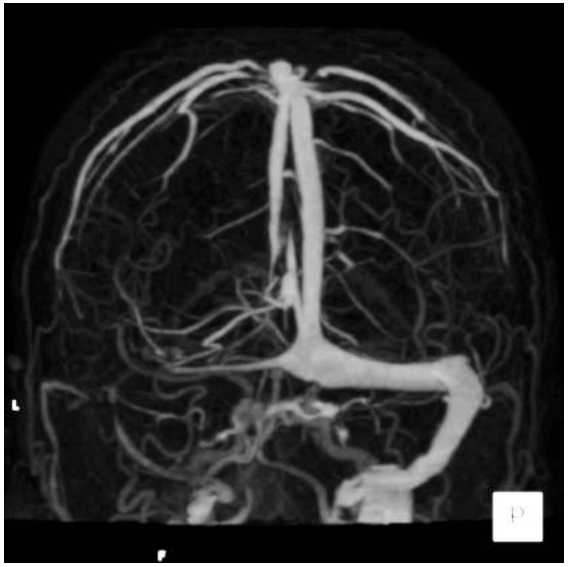
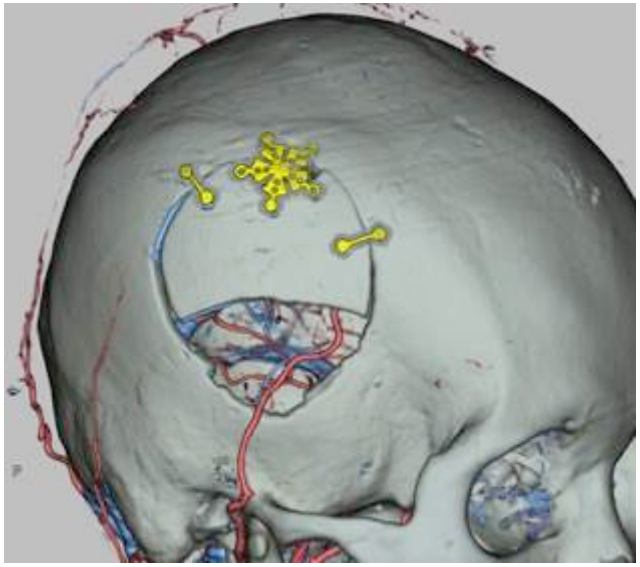
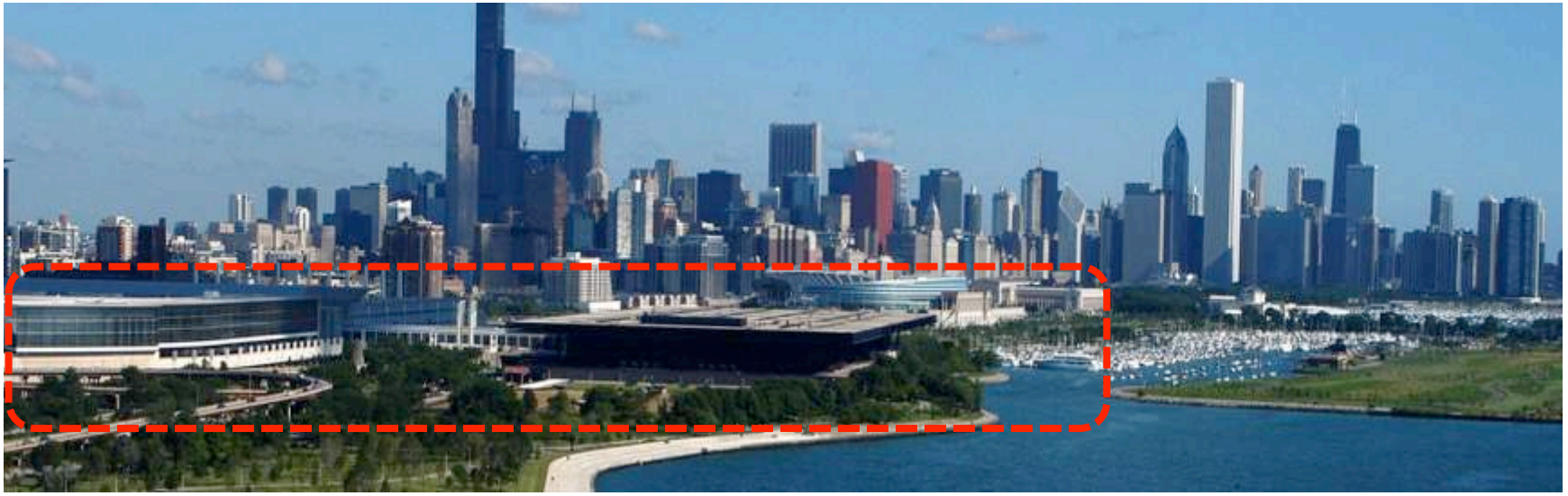




RSNA2015

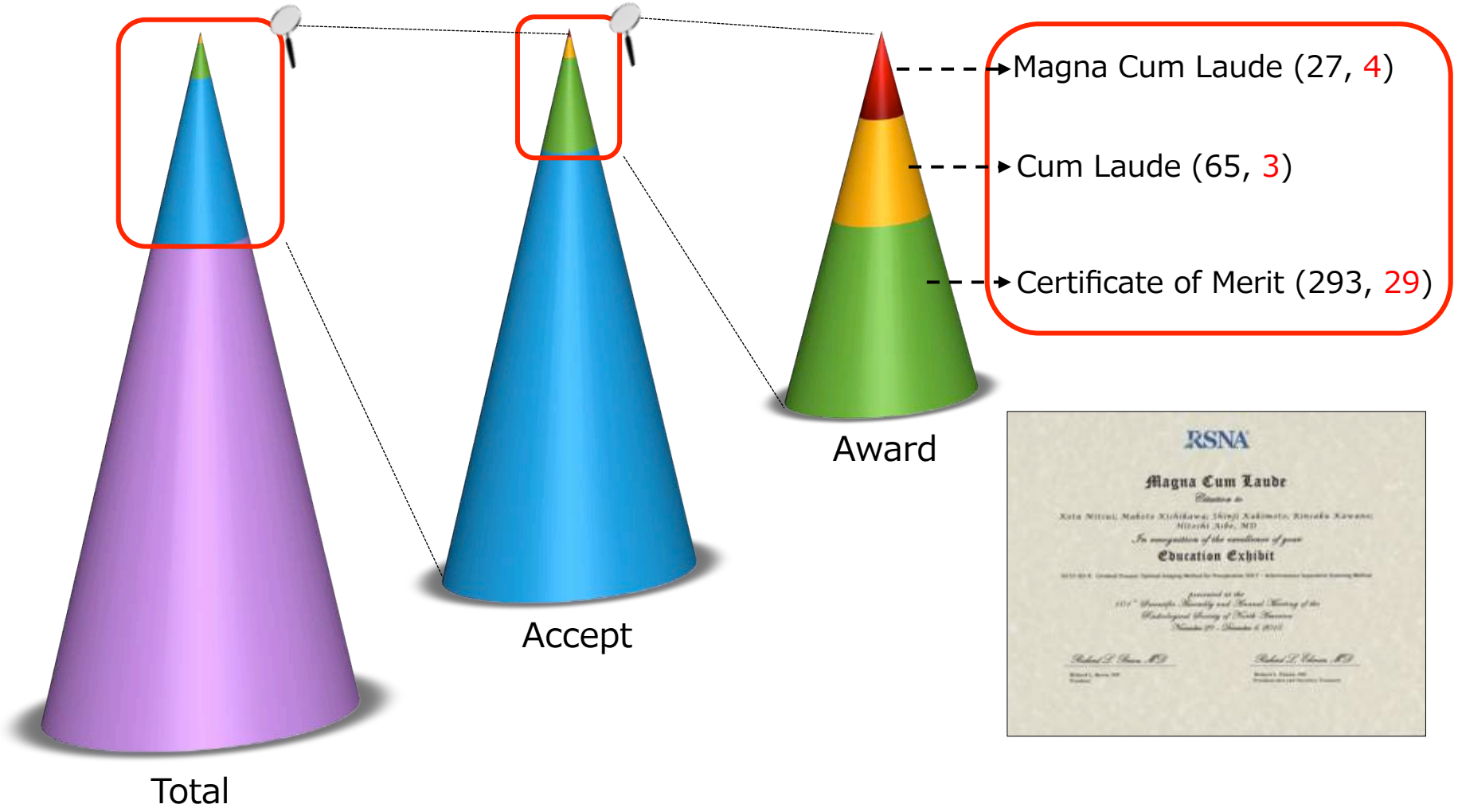
RSNA (Radiological Society of North America)

- 101回目の開催
- 開催期間: 2015/11/29(土) ~ 12/4(金)
- 開催地: アメリカ, イリノイ州, シカゴ
  McCormick Place



RSNA2015: Category

- Scientific Presentation (papers: 1728, posters: 921)
- **Education Exhibits** (1762)



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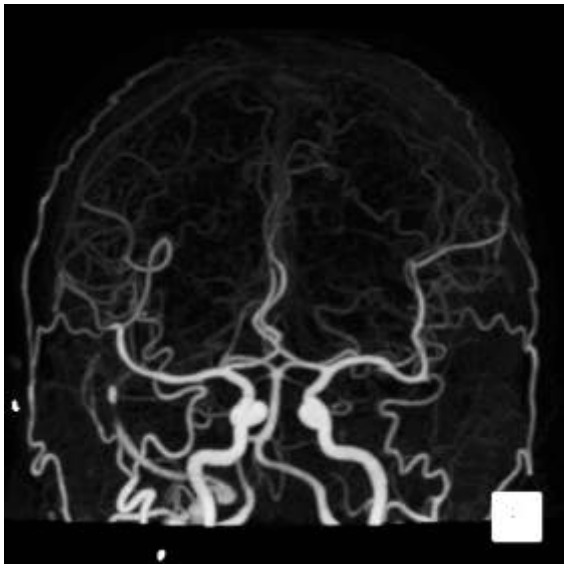
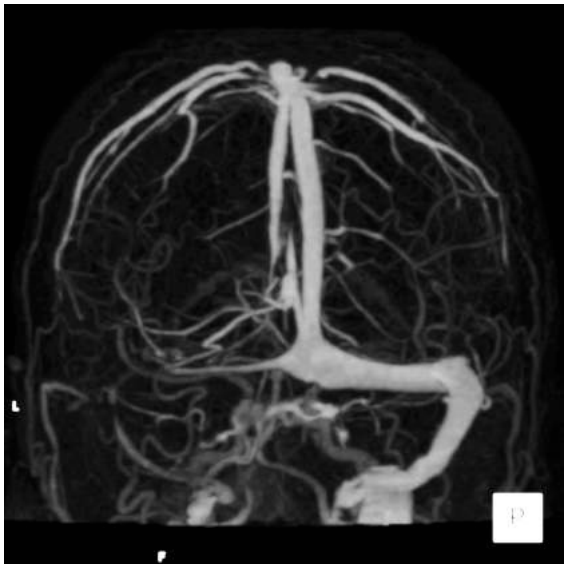
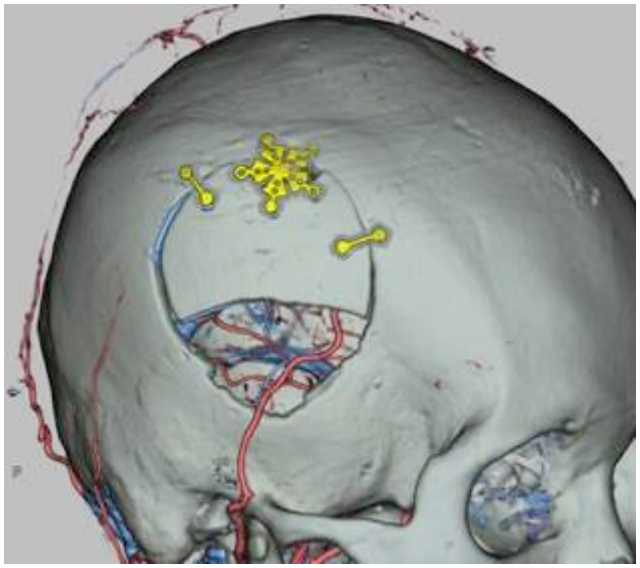




本研究のきっかけ

当館の頭部動静脈撮影は…

1. 検査時間は短くしたい
2. 画像処理時間も短くしたい

→ TI法の選択は難しい

動静脈分離撮影は必須

↓

脳循環時間は短い (~~6s程度~~)

↓

分離させるためには造影剤注入時間を短く設定

↓

撮影タイミングが困難

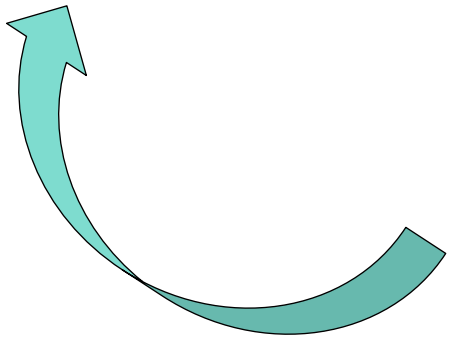
↓

TBT法の選択が良いのではないか?

↓

2相撮影では最大CT値の低い方に基準を置きたい

TBT法のモニタリング位置を
静脈にしたらどうだろうか?



Cerebral Disease: Optimal imaging method for preoperative 3DCT

- Arteriovenous separation scanning method -

Kota Mitsui [1)], Makoto Kishikawa [1)], Shinji Kakimoto [1)]
Rinsaku Kawano [2)], Hitoshi Aibe [2)]

1) Saga-Ken Medical Centre Koseikan, Division of Radiology
2) Saga-Ken Medical Centre Koseikan, Department of Radiology

Introduction

- In resent years, 3D-CT arteriography (CTA) & venography (CTV) has been widely used for preoperative evaluation of brain surgery.
- Progress in 3D-CT technology has made arteriovenous separation possible on CTA and CTV, especially with the advent of Multi-slice CT and Area-Detector CT.
- However, various factors, such as time to contrast medium detection, time to peak contrast enhancement and cerebral circulation time, have affected the timing of visualization of cerebral vessels on CTA and CTV, particularly superficial cerebral veins, that sometimes makes the preoperative evaluation of superficial brain tumors difficult.
- The usefulness for various scanning method, such as 'Bolus Tracking method' and 'Test Bolus method', has been reported. However, there are no known investigators focused on the optimal scanning method separating the cerebral arteries and veins due to the complexity of procedure and accuracy, particularly in visualization of superficial cerebral veins.
- Here we represent the precise CT scanning method of the cerebral arteriovenous separation, especially for improving the depiction of the cerebral veins for brain surgery.

Outline

1. The optimization of injection method of contrast medium for arteriovenous separation to aim at visualization of superficial cerebral veins in preoperative 3D-CT for brain surgery

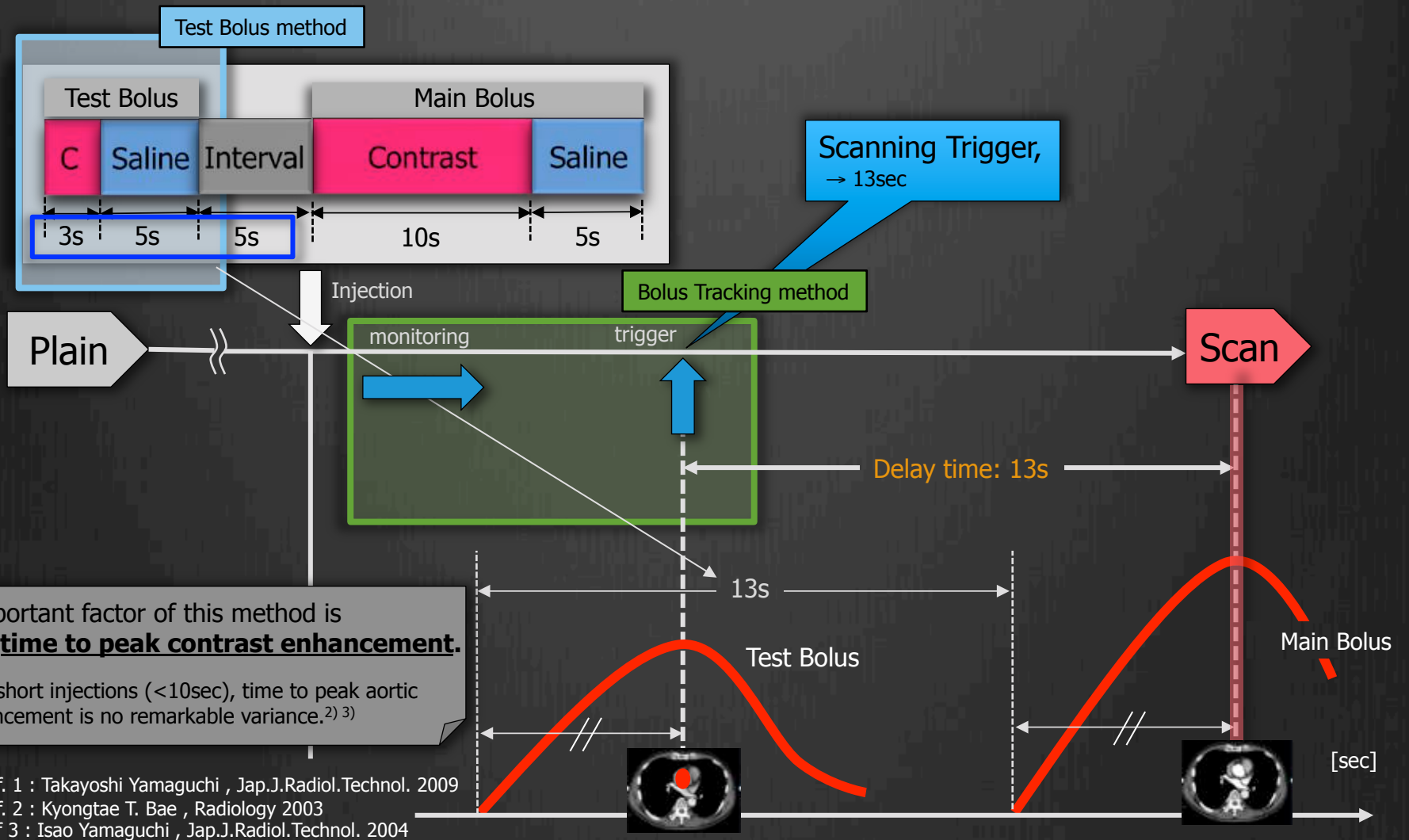
    1. Test Bolus Tracking method
    2. Preliminary Study for the optimization of injection method of contrast medium
    3. Construction of the optimization of CT scanning & clinical applications

2. The optimal 3D-imaging techniques

    1. Reconstruction
    2. Subtraction
    3. 3D-Image processing

What is Test Bolus Tracking method ?

- Test Bolus Tracking (TBT) [1] method is a new method by combining of 'Test Bolus method' and 'Bolus Tracking method' in Japan in resent year.

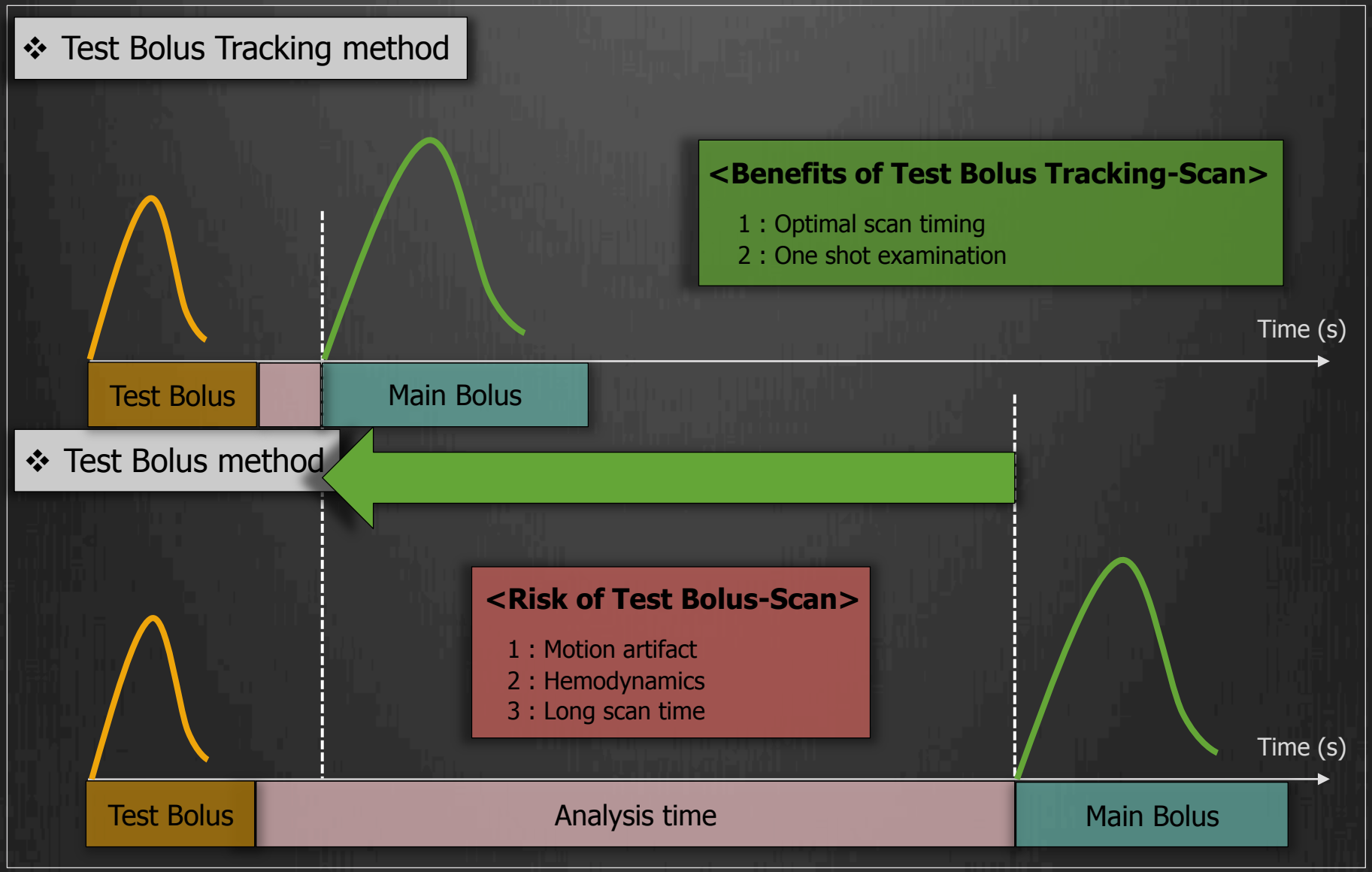


➢ Important factor of this method is **time to peak contrast enhancement.**

With short injections (<10sec), time to peak aortic enhancement is no remarkable variance.[2) 3)]

1) Ref. 1 : Takayoshi Yamaguchi , Jap.J.Radiol.Technol. 2009
2) Ref. 2 : Kyongtae T. Bae , Radiology 2003
3) Ref 3 : Isao Yamaguchi , Jap.J.Radiol.Technol. 2004

Comparison of Test Bolus Tracking method & Test Bolus method



Preliminary Study - Analysis of 4D-CTA -

1. Time to peak contrast enhancement ($T_{to\ peak}$)

$T_{to\ peak}$ of the artery (ICA C2 : C2) and the vein (Sigmoid sinus : SS) is analyzed from the data of 4D-CTA (Injection duration : 10s) and Test Bolus (Injection duration : 3s).

2. Cerebral circulation time

= ($T_{to\ peak}$ of the vein [sec]) − ($T_{to\ peak}$ of the artery [sec])

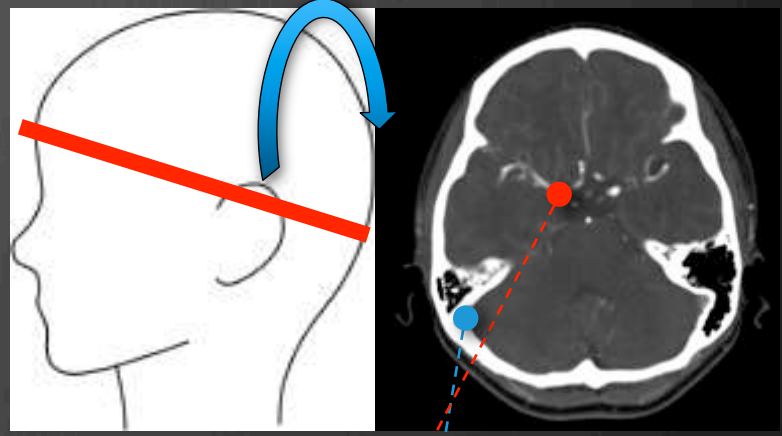
The cerebral circulation time is analyzed from the data of 4D-CTA

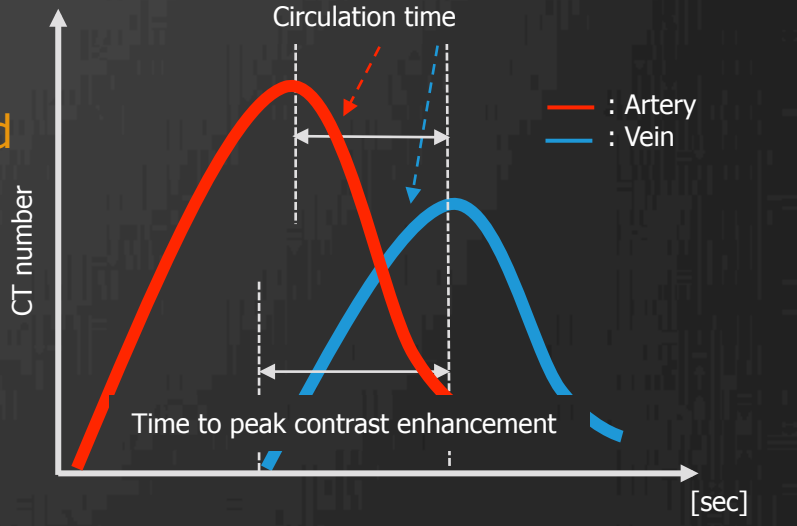
3. Monitoring position of Test Bolus Tracking method

3D-CT images are reconstructed from the data of 4D-CTA, considering either the artery (ICA C2) or the vein (Sigmoid sinus) as monitoring position.

" ICA C2 vs. Sigmoid sinus "

Which is better as the monitoring position of Test Bolus Tracking method ?





Materials and Methods

❖ CT-system

Aquilion ONE

(Toshiba Medical Systems Corp.)

Japan

❖ Auto Injector

DUAL SHOT GX7

(Nemoto Kyorindo co., Ltd.)

Japan

❖ 3D-Workstation

ZIOSTATION 2

(Ziosoft, inc.)

Japan

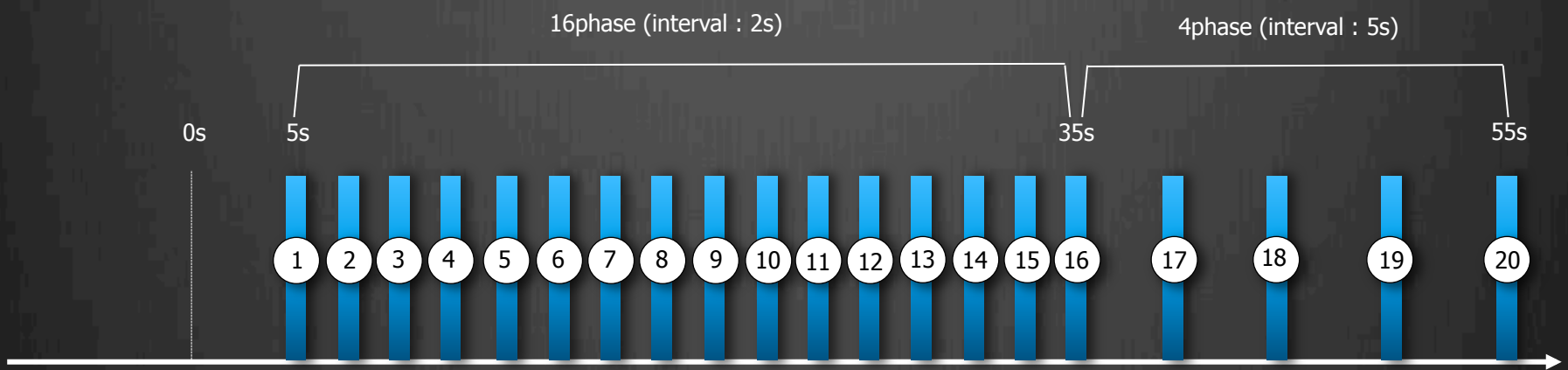
Materials : Preliminary study

- Patient backgrounds (4D-CTA)

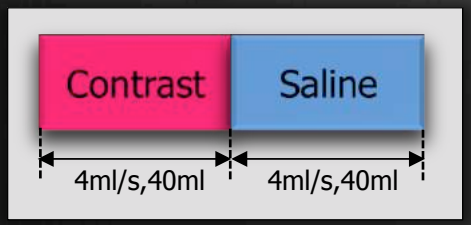
		Male	Female	Total
Number		12	22	34
Age (y)	Median	69	64	66
	Range	59-76	29-89	29-89
Height (cm)	Median	162	152	158
	Range	153-169	151-157	151-169
Weight (kg)	Median	60	53	55
	Range	50-84	45-65	45-84
BMI (kg/m^2)	Median	22.6	22.7	22.6
	Range	17.9-29.4	18.3-27.1	17.9-29.4

Methods : Preliminary study

❖ 4D-CTA scanning technique



Injection

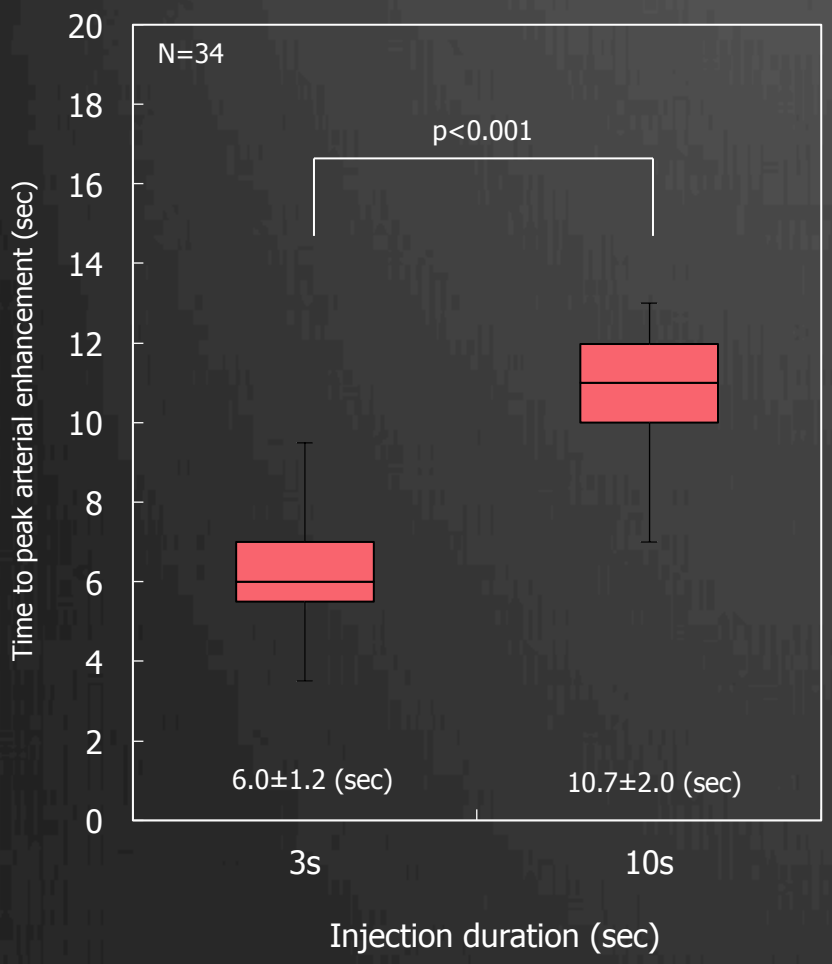


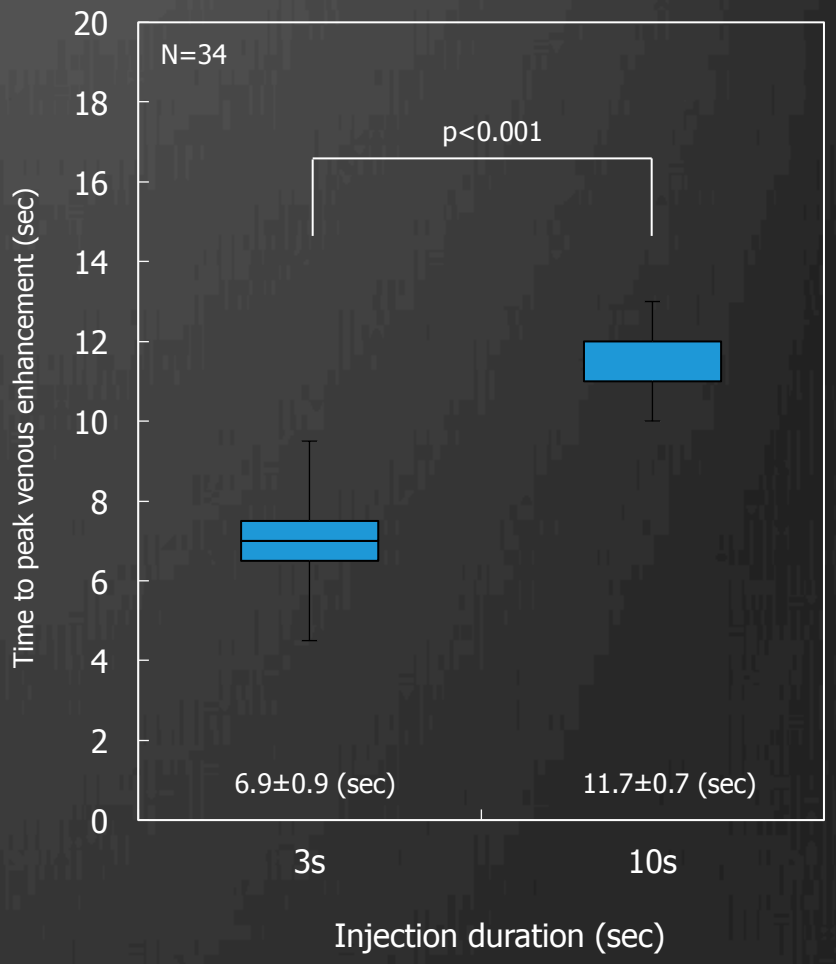
Scan mode	Voltage (kVp)	Current (mA)	Rotation time(s)	Collimation
Volume	80	100	1.0	0.5×320

Time to peak contrast enhancement

Time to peak contrast enhancement depends on injection duration.

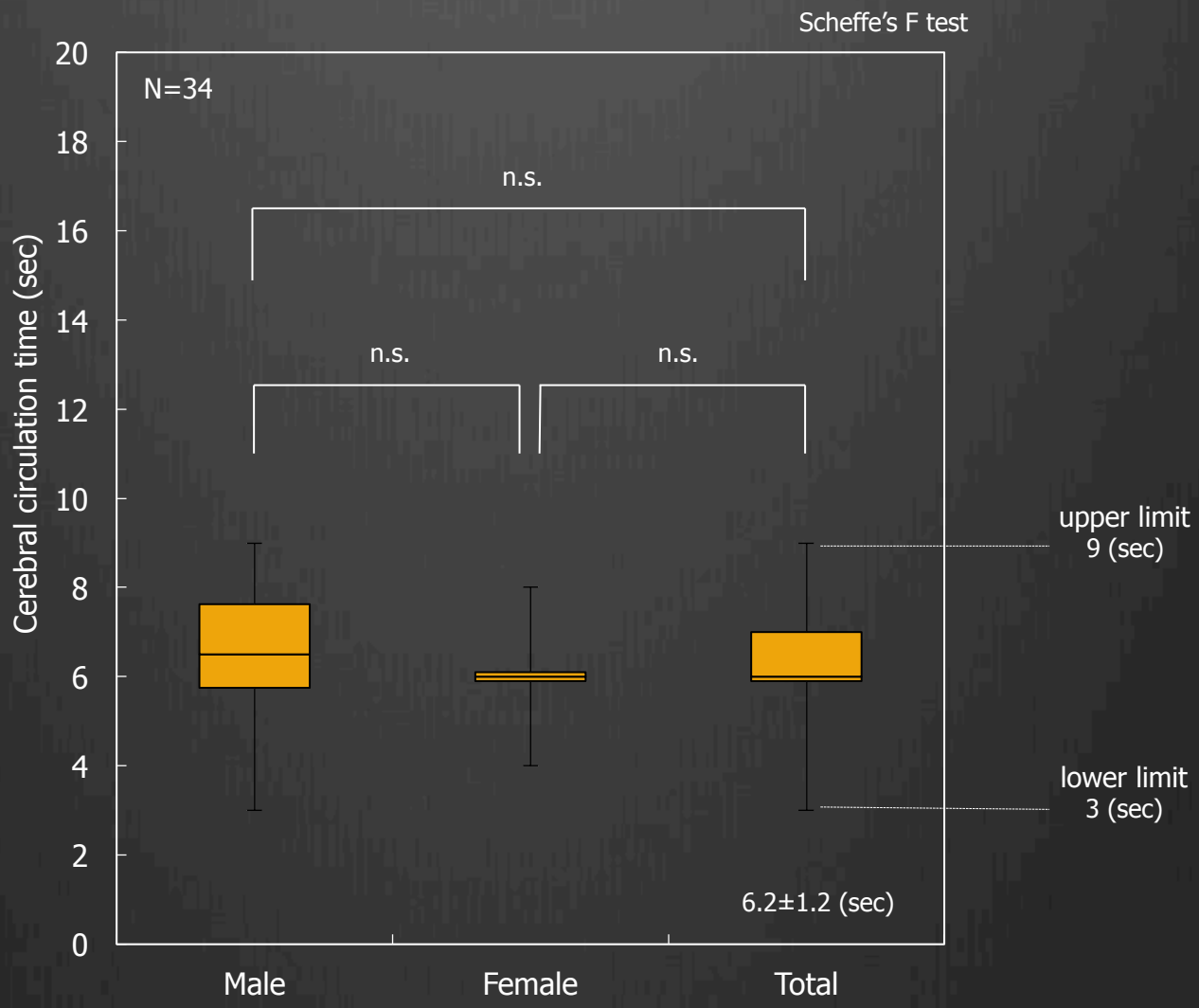
Student's t test





Cerebral circulation time

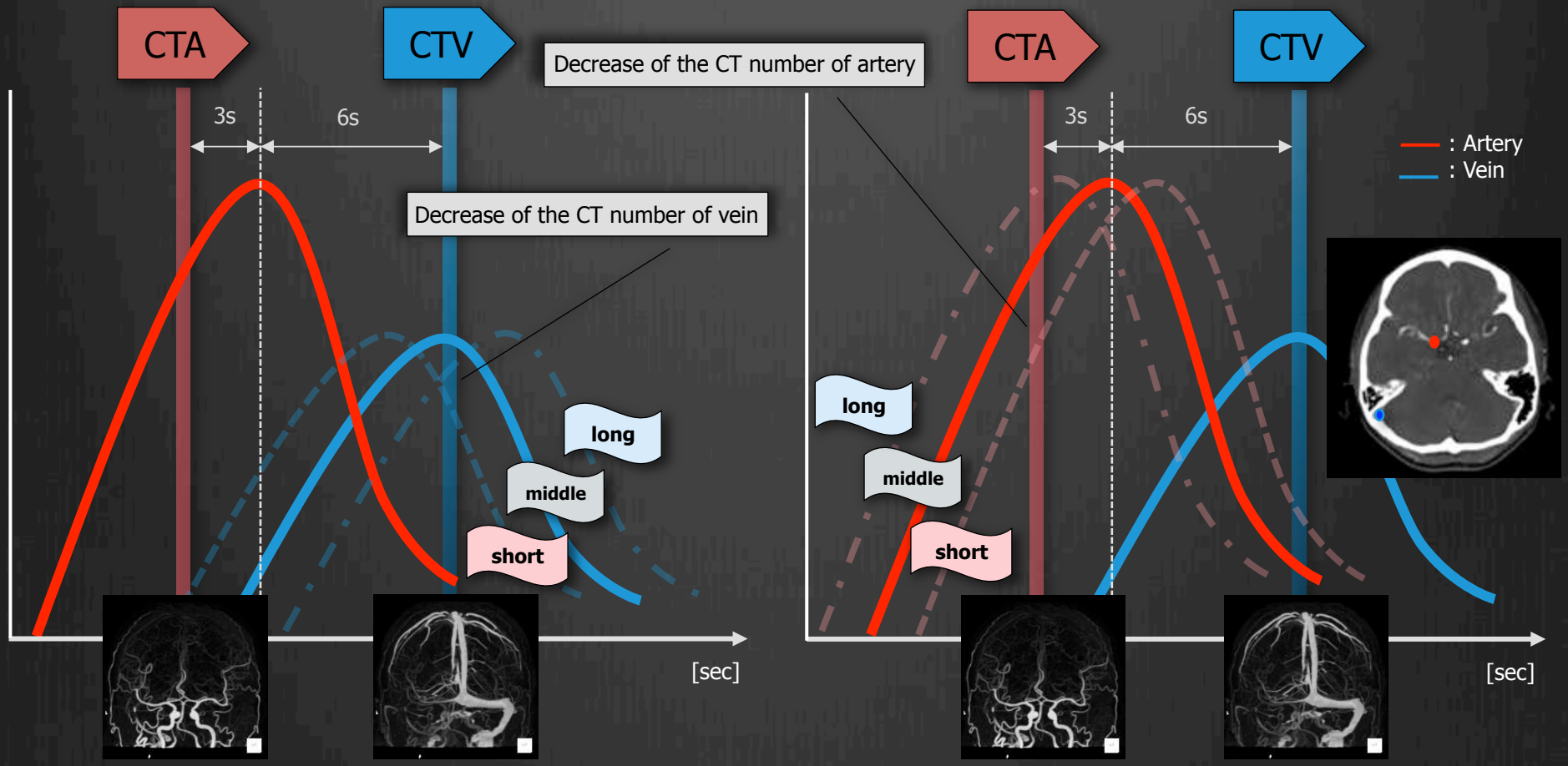
Cerebral circulation time : 6.2±1.2 seconds



Scan timing & monitoring position

❖ The monitoring position : **Artery**

❖ The monitoring position : **Vein**



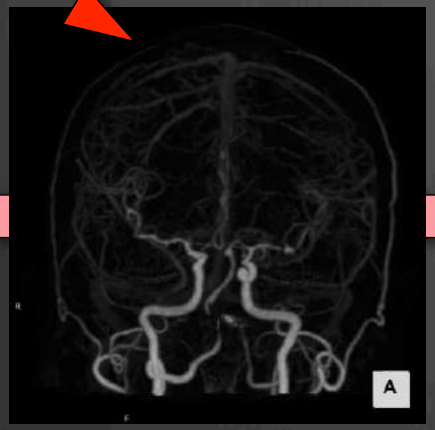
3D-simulation images have good image quality, if the difference between CT number of the artery and that of the vein is big .
The best scan timing of CTA depends on 3 seconds before peak arterial enhancement, and that of CTV depends on peak venous enhancement.

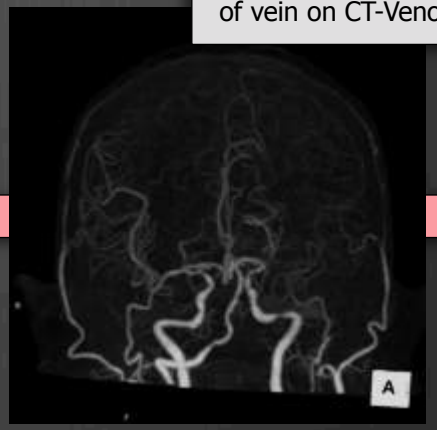
Comparison of MIP images in the case of monitoring **artery**

<Risk of this method>
Decrease of the CT number of vein on CT-Venography

Increase of the CT number of vein

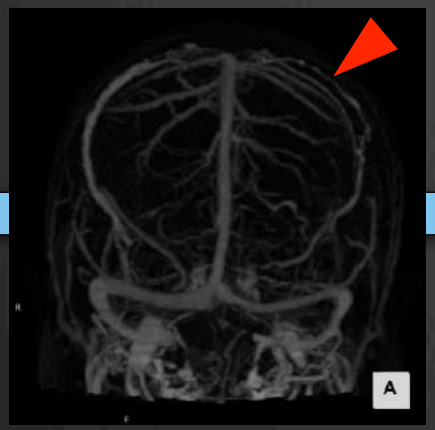
CTA



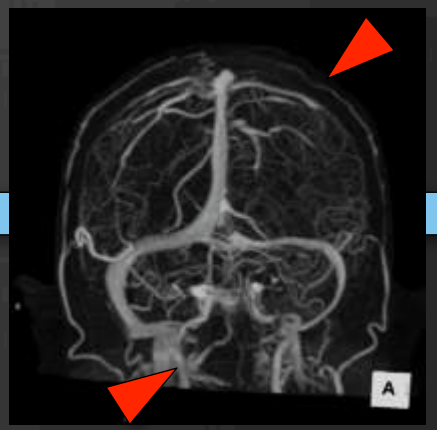


Interval : 9 (sec)

Decrease of the CT number of vein



Decrease of the CT number of vein



CTV

Increase of the CT number of artery

Cerebral circulation time
- short -

Cerebral circulation time
- middle -

Cerebral circulation time
- long -

Comparison of MIP images in the case of monitoring **vein**

The effect of cerebral circulation time is small
if the monitoring position is put on the vein in Test Bolus Tracking method.

CTA

Interval : 9 (sec)

CTV

Cerebral circulation time
- short -

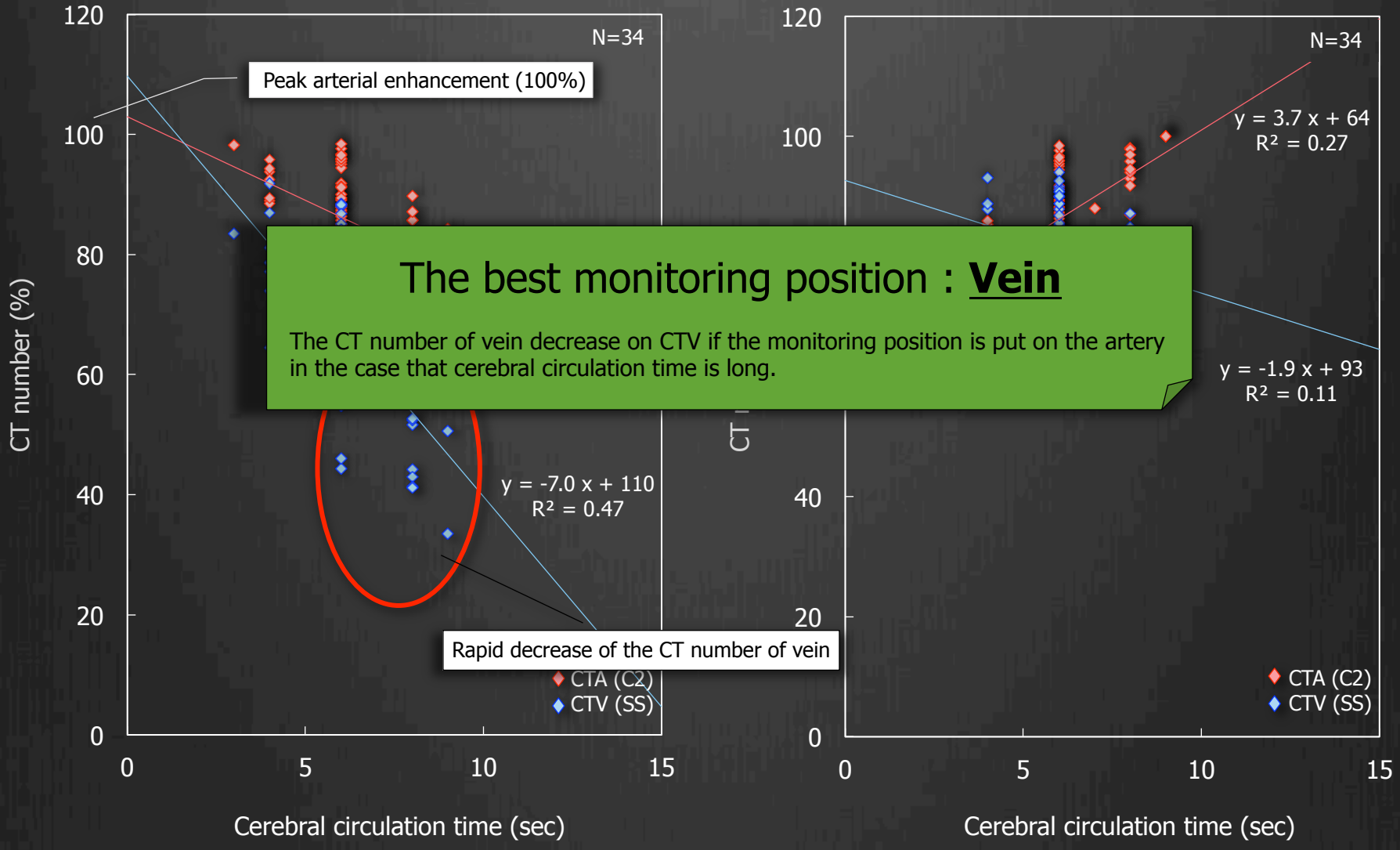
Cerebral circulation time
- middle -

Cerebral circulation time
- long -

The best monitoring position ?

❖ The monitoring position : **Artery**

❖ The monitoring position : **Vein**



The best monitoring position : **Vein**

The CT number of vein decrease on CTV if the monitoring position is put on the artery in the case that cerebral circulation time is long.

Summary

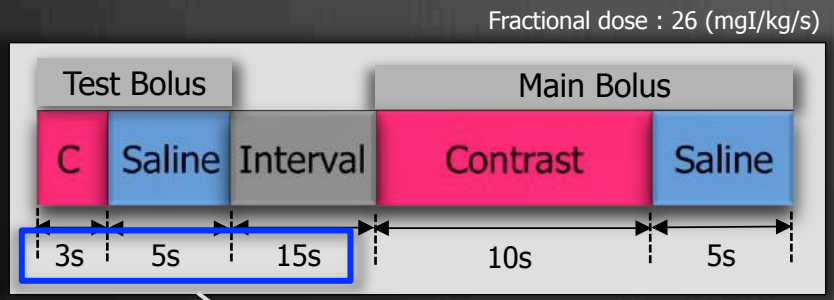
1. Time to peak contrast enhancement
   - Time to peak contrast enhancement of cerebral artery and vein depends on injection duration, and be no remarkable variance with injection duration (3seconds and 10seconds).

     → It is possible to use Test Bolus Tracking method for preoperative 3D-CT of brain surgery.

2. Cerebral circulation time
   - Mean cerebral circulation time is 6.2 seconds.
   - No significant variance of cerebral circulation time.

3. The monitoring position of Test Bolus Tracking method
   - Cerebral circulation time rarely contributes to quality of 3D-simulation image if the monitoring position of Test Bolus Tracking method is put on the vein.

3D-CT protocol for arteriovenous separation by Test Bolus Tracking method

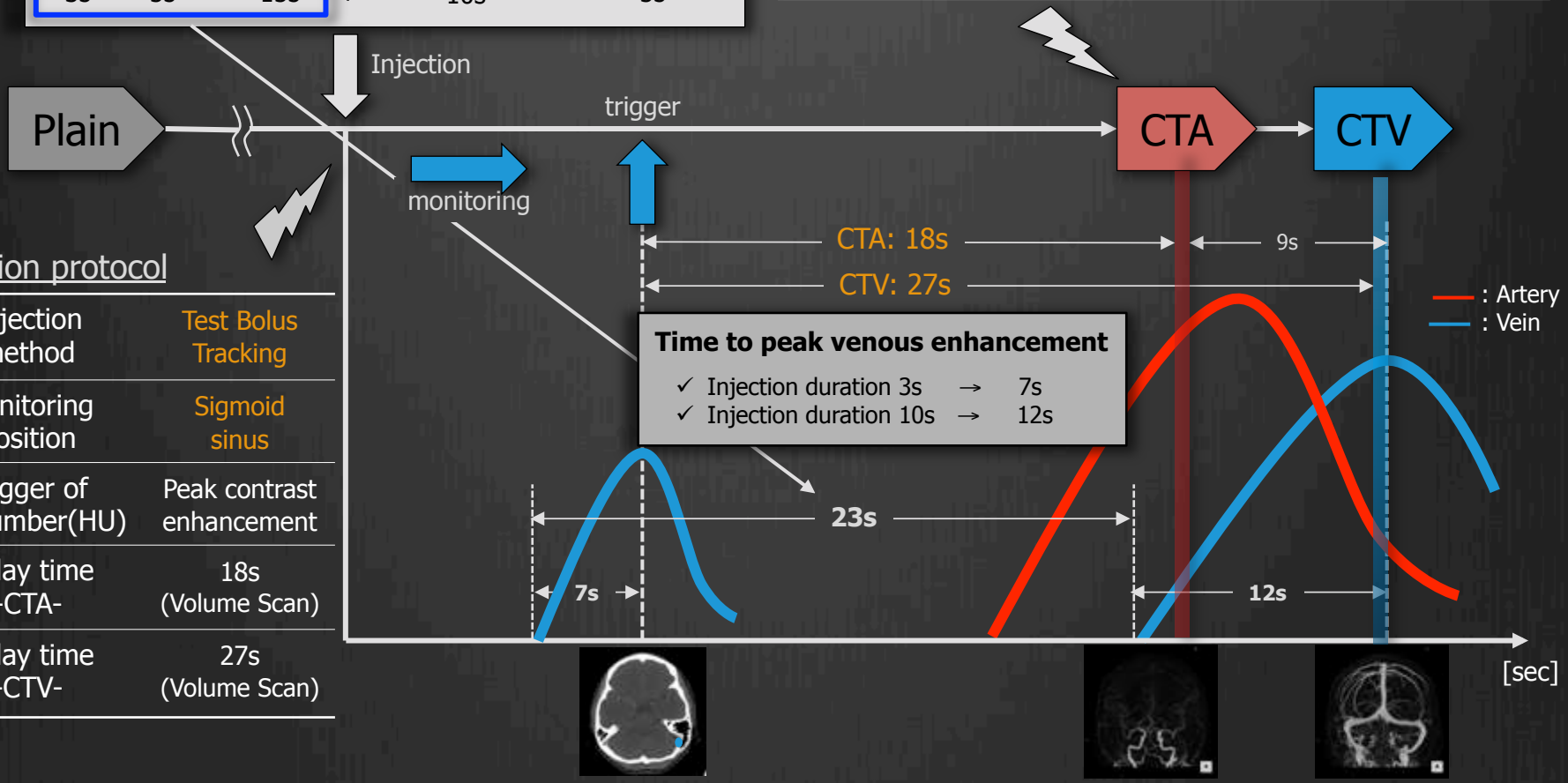


Scan protocol

Scan mode	Voltage (kVp)	Current (mA)	Rotation time(s)	PF	Collimation
Helical	120	300	0.75	0.85	0.5×100
Volume	120	300	1.0	-	0.5×320

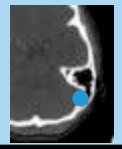
Injection protocol

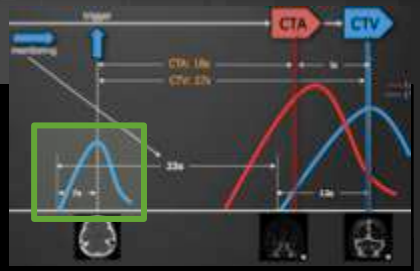
Injection method	Test Bolus Tracking
Monitoring position	Sigmoid sinus
Trigger of CT number(HU)	Peak contrast enhancement
Delay time -CTA-	18s (Volume Scan)
Delay time -CTV-	27s (Volume Scan)



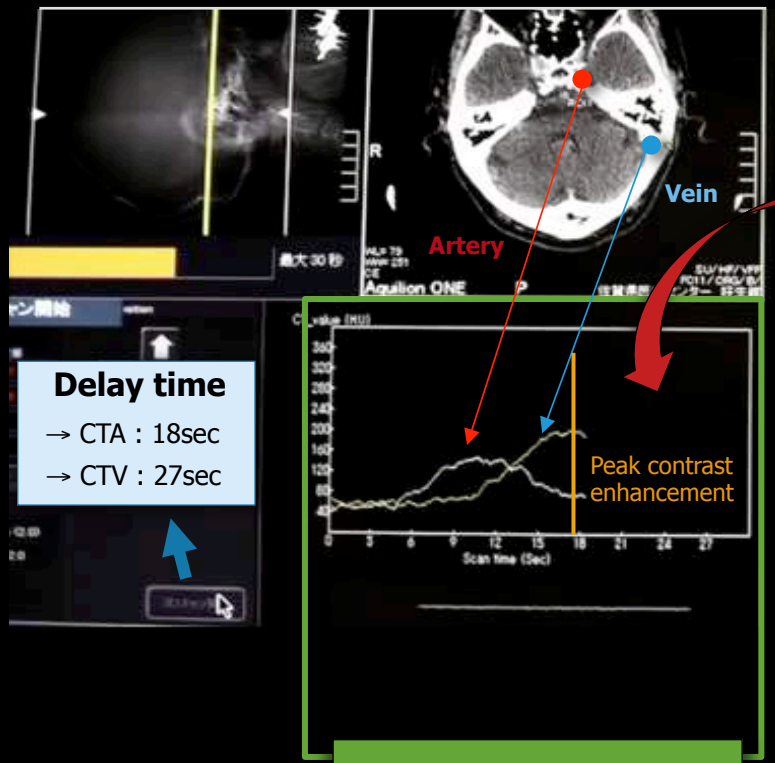
Clinical CT scanning for Test Bolus Tracking method (Movie)

Monitoring position : **Sigmoid sinus**

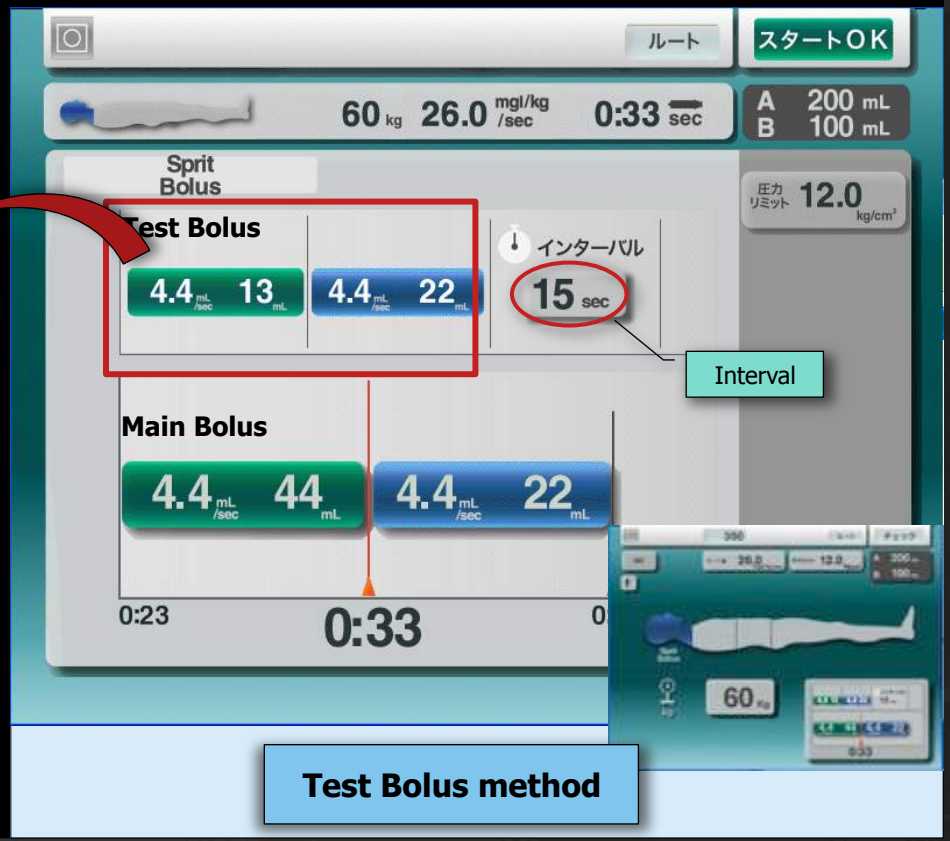




- **CT-system**
- **Auto Injector**



Bolus Tracking method



Test Bolus method

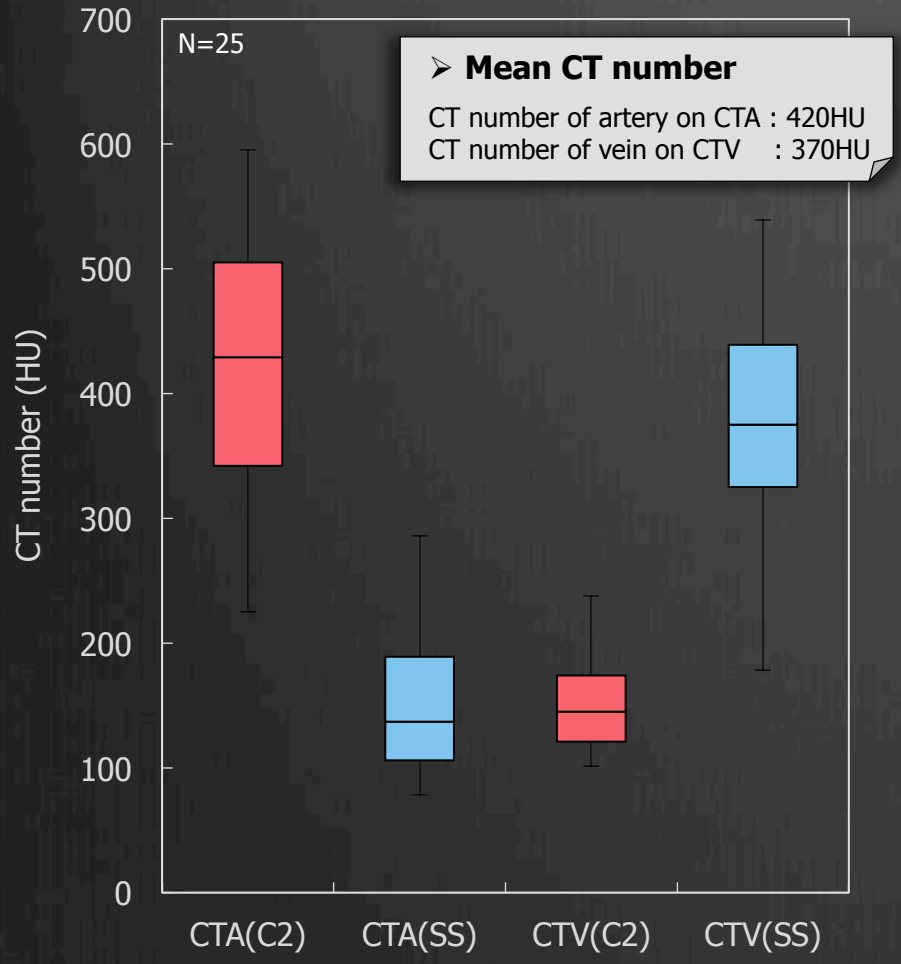
Materials : Optimization of CT scanning

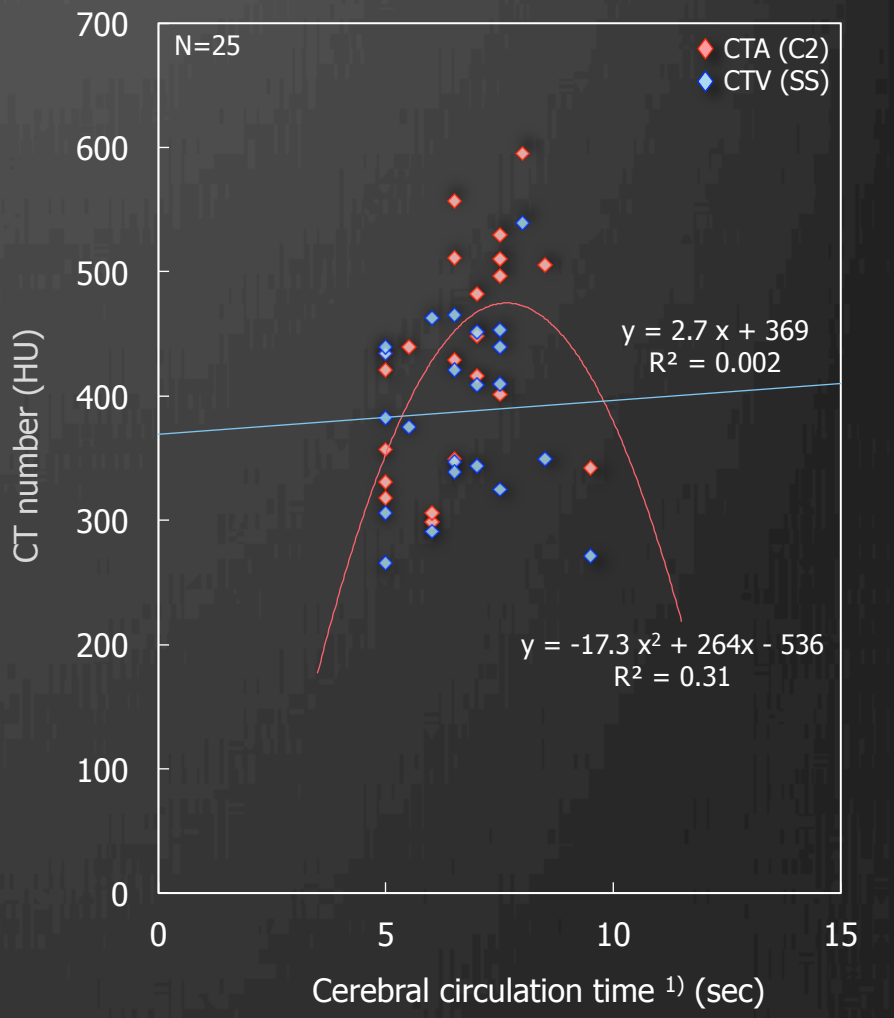
- Patient backgrounds (Test Bolus Tracking method)

		Male	Female	Total
Number		10	15	25
Age (y)	Median	66	60	62
	Range	42-83	34-73	34-83
Height (cm)	Median	165	152	157
	Range	156-171	137-163	137-171
Weight (kg)	Median	62	53	56
	Range	53-80	39-75	39-80
BMI (kg/m^2)	Median	22.7	21.7	22.7
	Range	18.8-29.4	17.5-30.0	17.5-29.7

CT number on CTA and CTV on Test Bolus Tracking method

- Regardless of cerebral circulation time, arteriovenous separation is possible on Test Bolus Tracking method putting ROI on the vein.

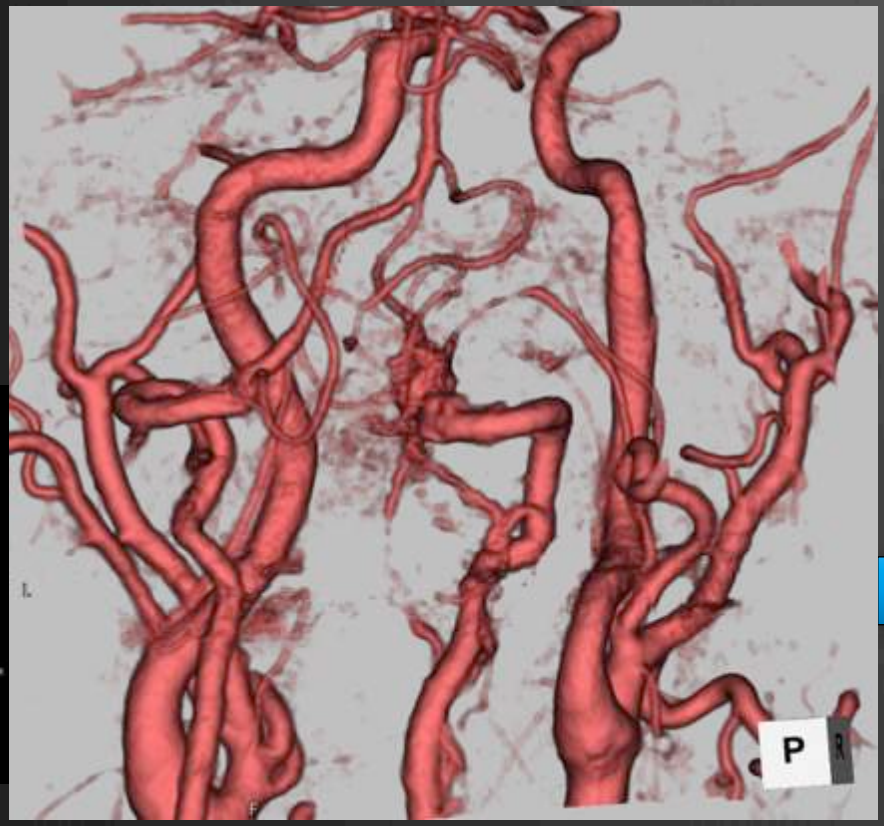




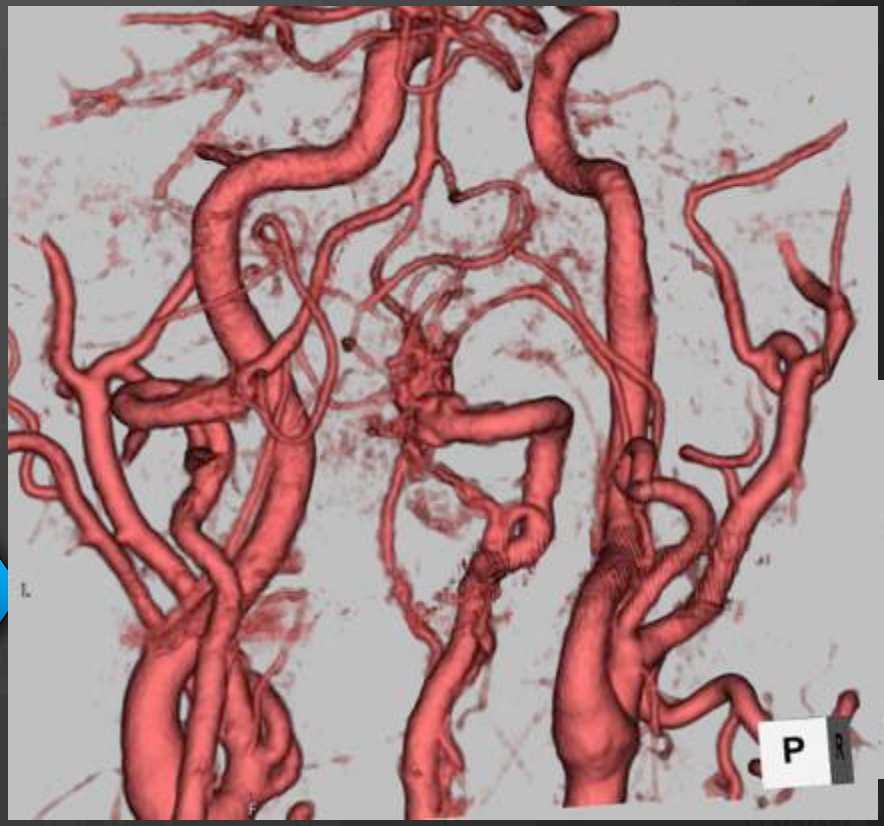
1): Analyze the cerebral circulation time from the date of Test Bolus.

The optimal 3D-imaging techniques - Zooming reconstruction -

The visualization of micro vessel is superior at zooming reconstitution.

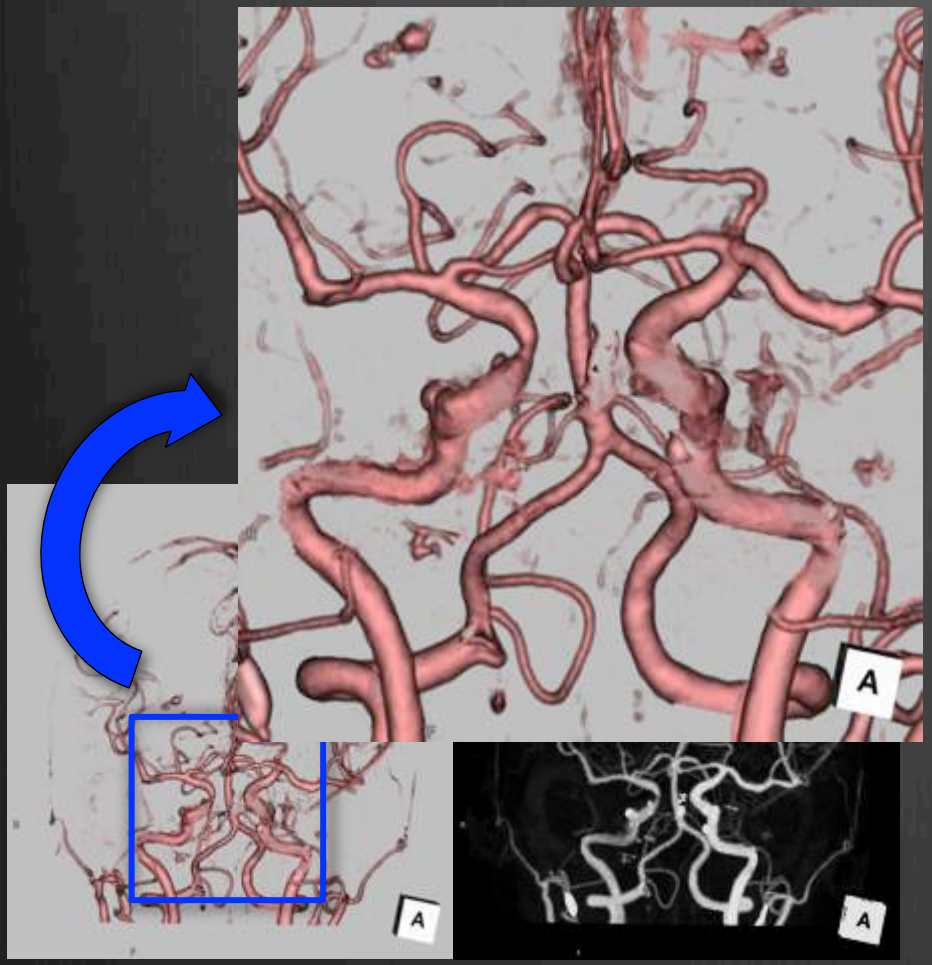


FOV : 240mm

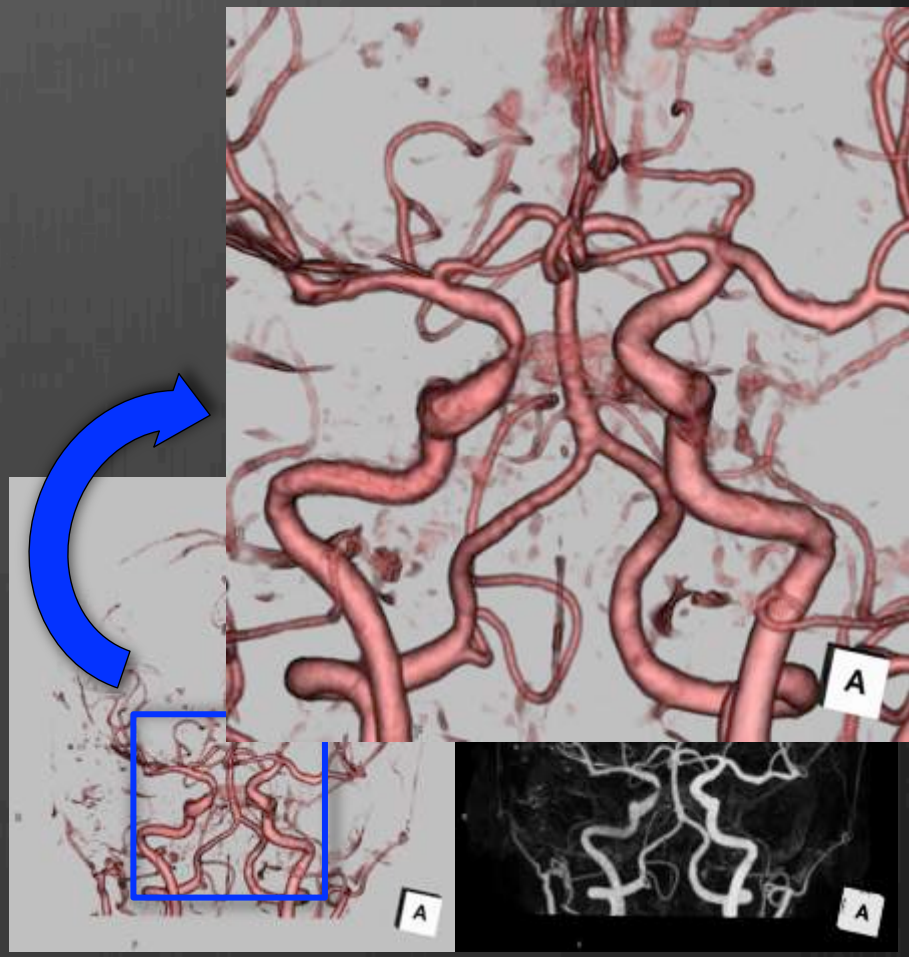


FOV : 120mm

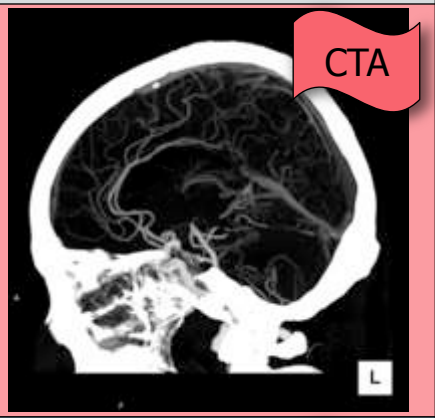
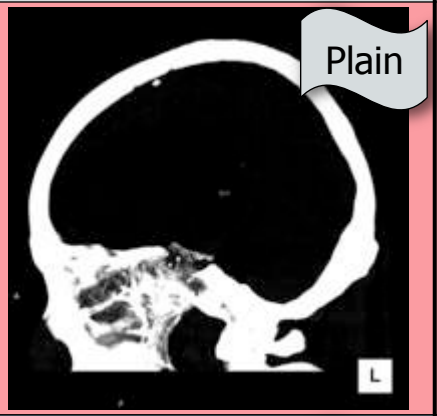
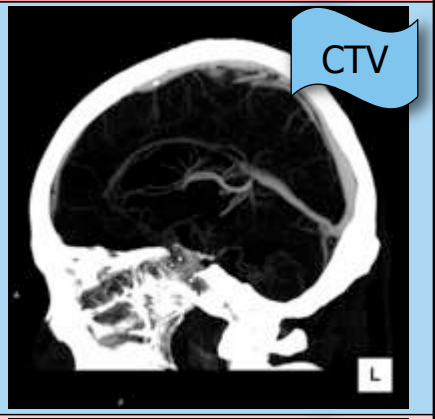
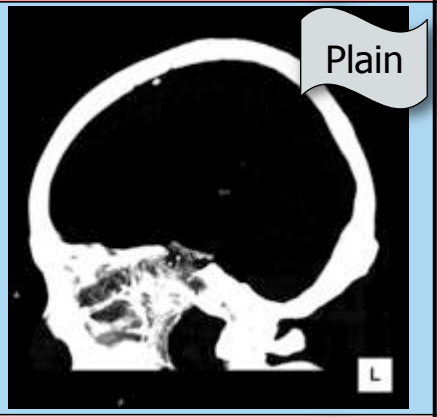
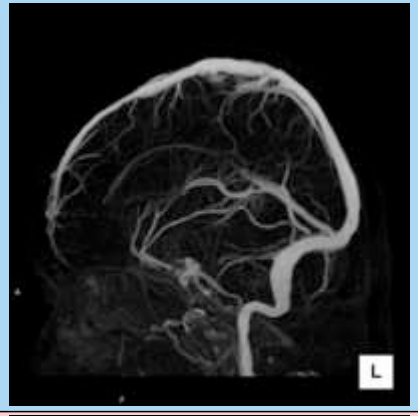
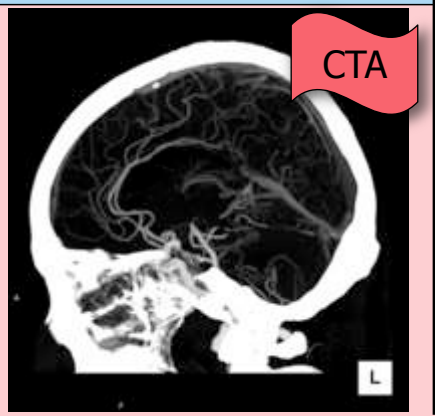
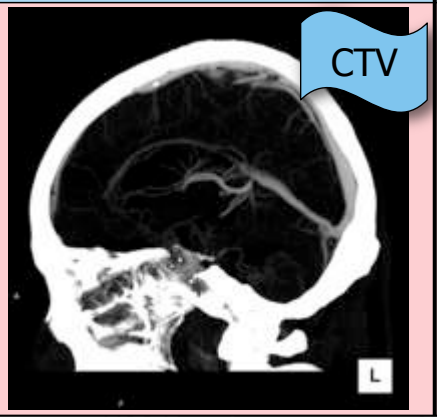
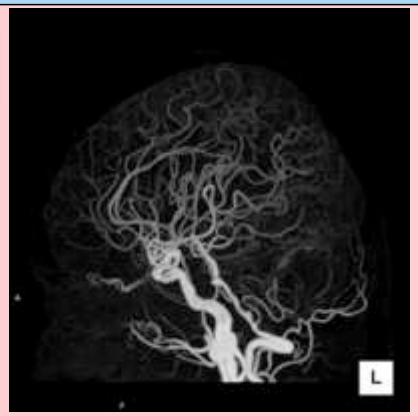
The optimal 3D-imaging techniques - Automatic processing vs. Subtraction -



3D-Workstation (Automatic processing)



Subtraction

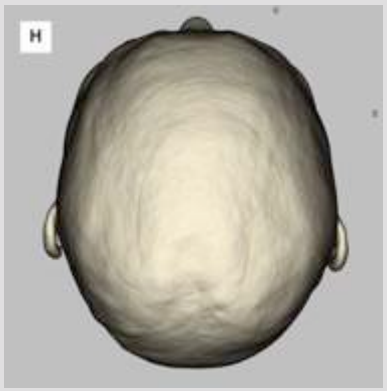
	A	B	A – B
CTA-Subtraction (CTA – Plain)			
CTV-Subtraction (CTV – Plain)			
CTA-Subtraction (CTA – CTV)			

❖ 3D-Image processing

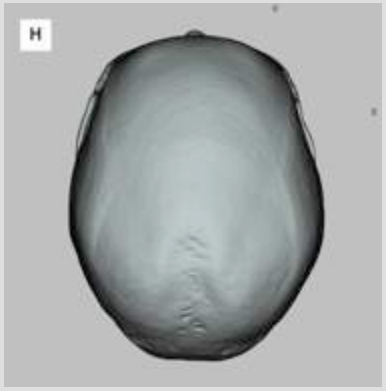
➢ Imaging Data

A : Plain
B : CT-Arteriography – Plain
C : CT-Venography – Plain
D : CT-Arteriography – CT-Venography

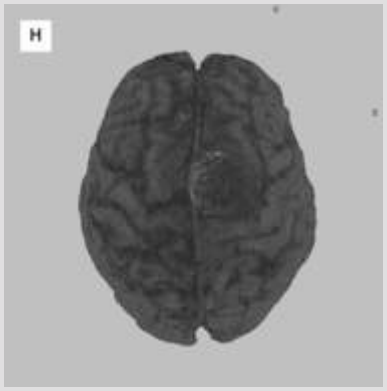
Data A | Data B | Data C | Data D



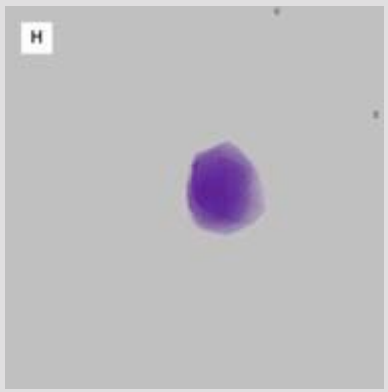
Skin (Data A)



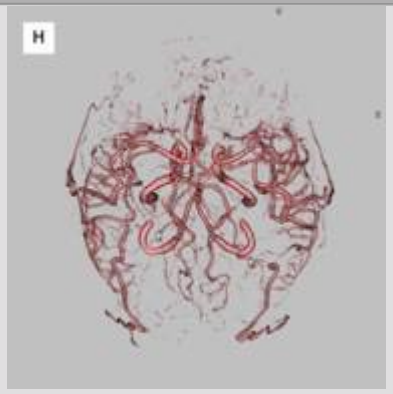
Born (Data A)



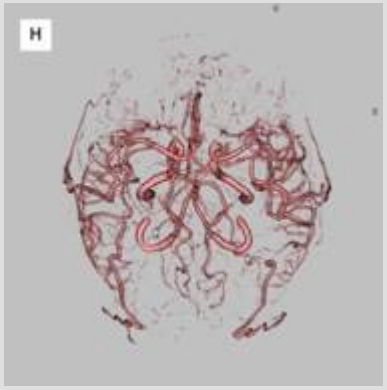
Brain (Data A)



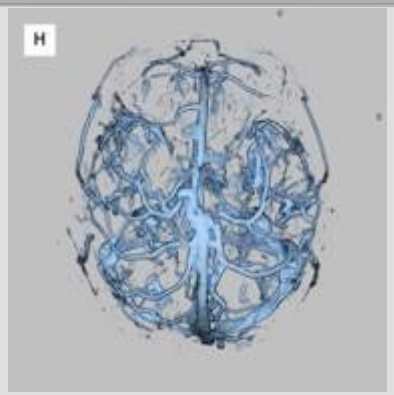
Tumor (Data A)



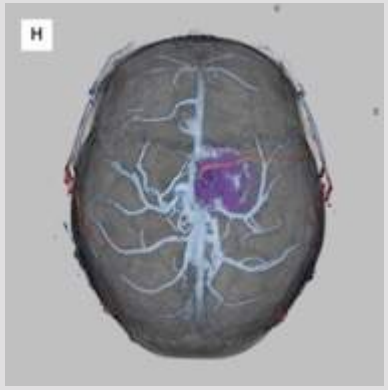
Artery (Data B)



Artery (Data D)



Vein (Data C)



Combination

Discussion

- With Test Bolus Tracking method putting ROI on the vein, visualization of peripheral superficial cerebral veins, that were difficult to be identified on CTV, has become possible in all cases.
- In addition, small perforating branch arteries are sufficiently visualized on CTA using Test Bolus Tracking method, even though the monitoring position is put on sigmoid sinus. Because the maximum CT number of the artery is higher than the maximum CT number of the vein, so the CT number of the artery is obtained sufficiently even if we put ROI on the vein.
- Because the differences between CT number of the arteries and that of veins were more than 200HU in cavernous sinus, precise preoperative information of both cerebral arteries and veins has been easily obtained by combining of subtraction and zooming reconstruction.
- Furthermore, the Test Bolus Tracking method has made it possible to shorten the scan time as compared to the Test Bolus method. In addition, using Volume Scan as well as this method, decrease in various artifacts, such as the contrast agent artifact and helical motion artifact, and radiation dose reduction have been obtained.

Conclusion

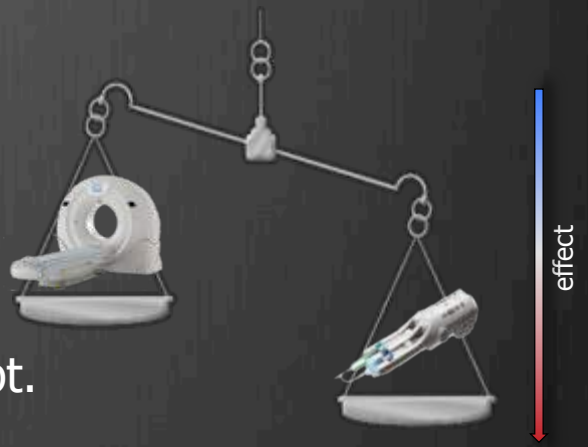
- With Test Bolus Tracking method, arteriovenous separation and superficial cerebral vessel anatomy have been obtained clearly with relatively short CT scanning time.
- Test Bolus Tracking method putting ROI on the vein is very useful to visualize precisely the superficial cerebral vein, which is important for preoperative evaluation for brain surgery, especially for that of superficial brain tumor.

Limitation of Test Bolus Tracking method

1. Limited by the device (CT-system, Power Injector)
   - If it's possible to set parameter in Power Injector,
     the effect of the specs of the CT-system is small.

2. If there is possibility of the body motion, it can't adapt.
   - Motion artifact is less for the preoperative examination.

3. Effects of between operators
   - Important to identify peak contrast enhancement
     → Training
   - Setting of scanning time and delay time
     → Preparation for manual



Test Bolus Tracking method

motion