

# MRI for Congenital Heart Disease

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Seoul National University Hospital  
Department of Radiology

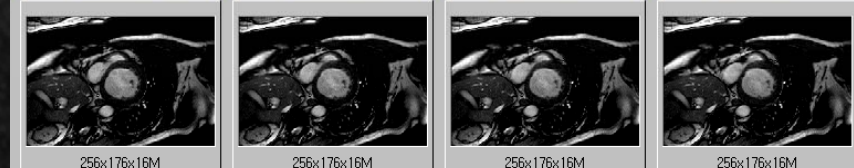
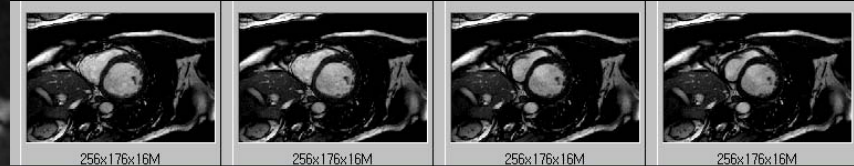
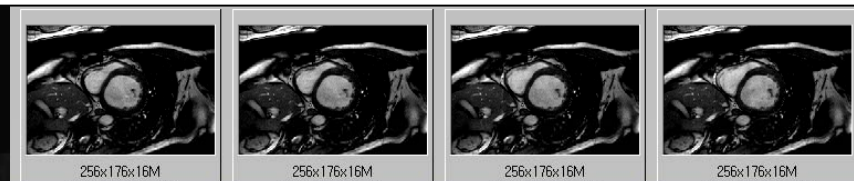
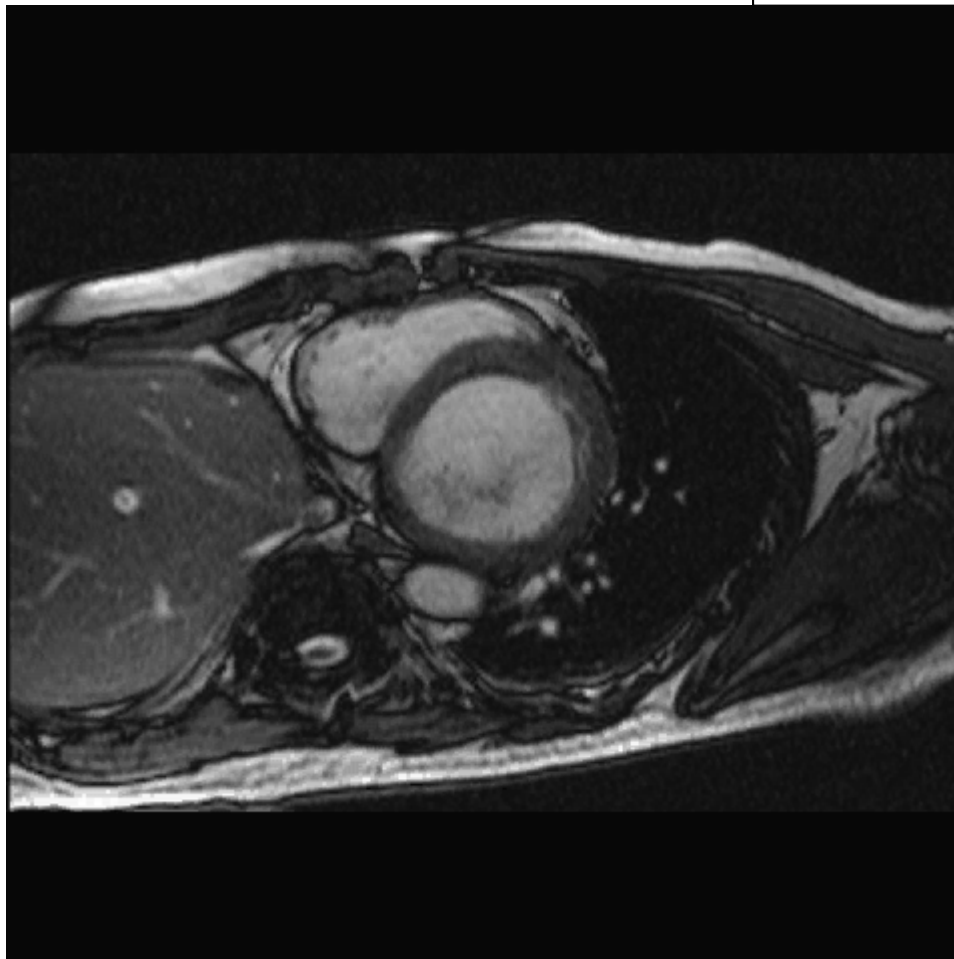
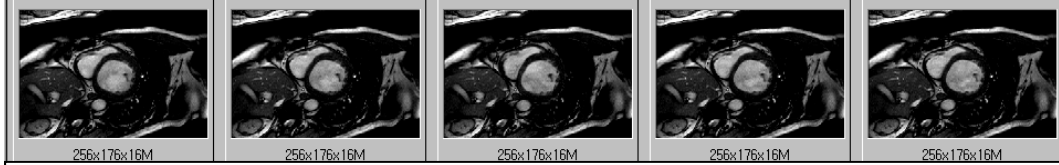
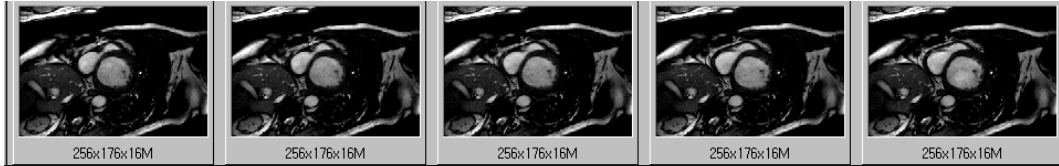
# Cardiac MRI for CHD

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- Cine
  - Ventricle function and volume
- MR angiography
- Delayed enhancement of myocardium
- Perfusion
- Flow-metry

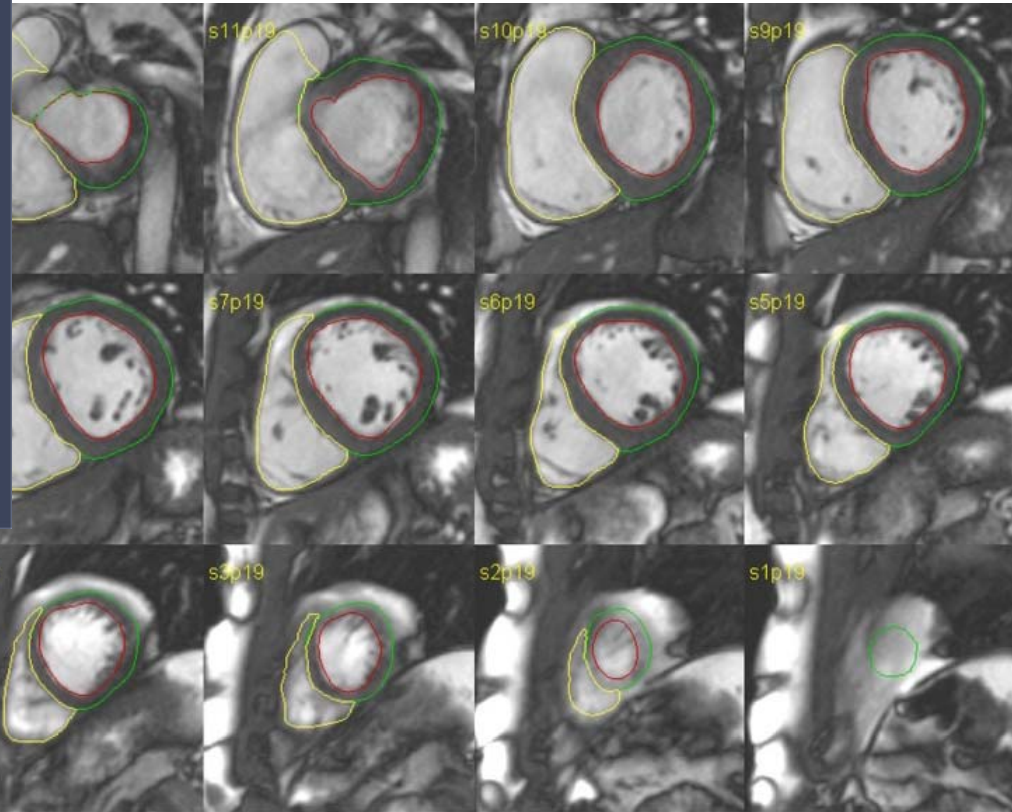
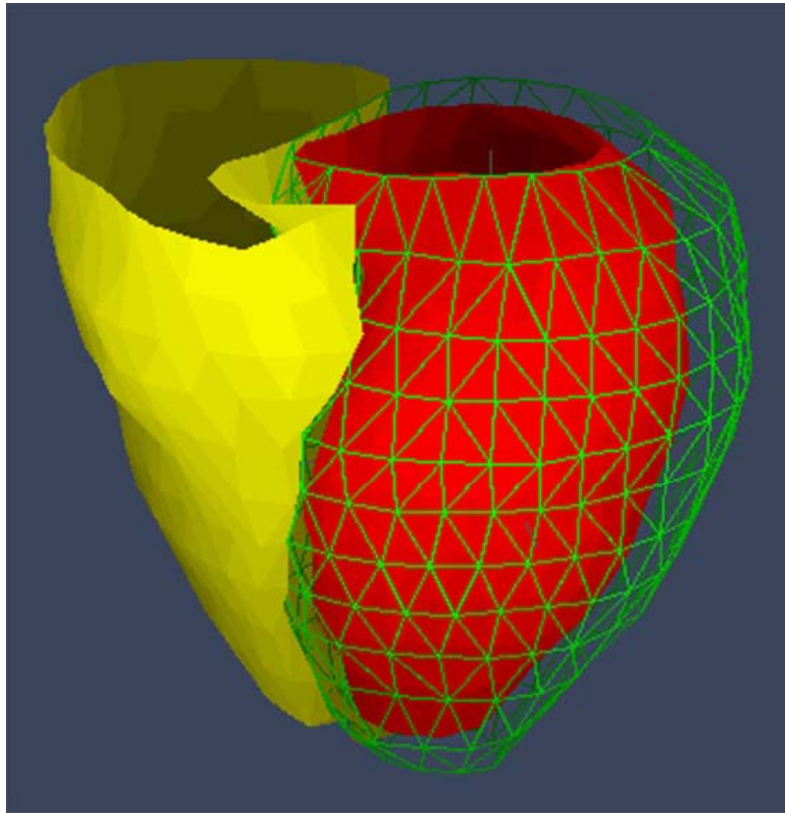
# CINE

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# Ventricle volume and Fx

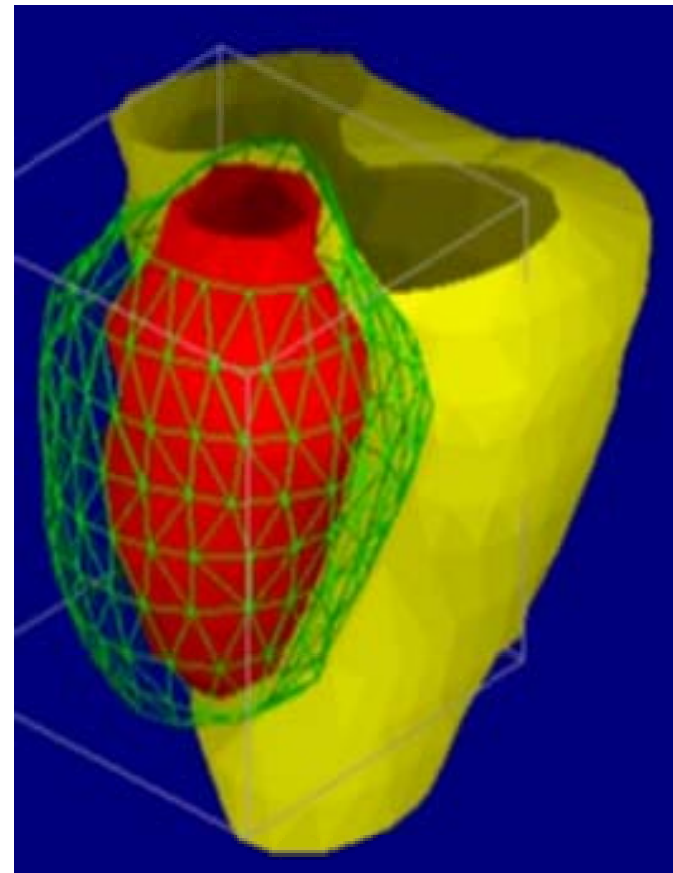
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# *BIVENTRICULAR vs UNIVENTRICULAR REPAIR?*

A NEW BORN WITH AORTIC ARCH HYPOPLASIA AND HYPOPLASTIC LEFT VENTRICLE

LVEDVi at Echo = 10.9 cc / m<sup>2</sup>



# *BIVENTRICULAR vs UNIVENTRICULAR REPAIR?*

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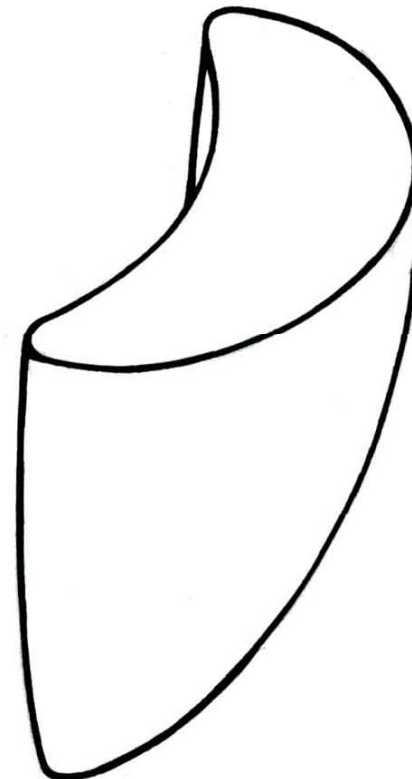
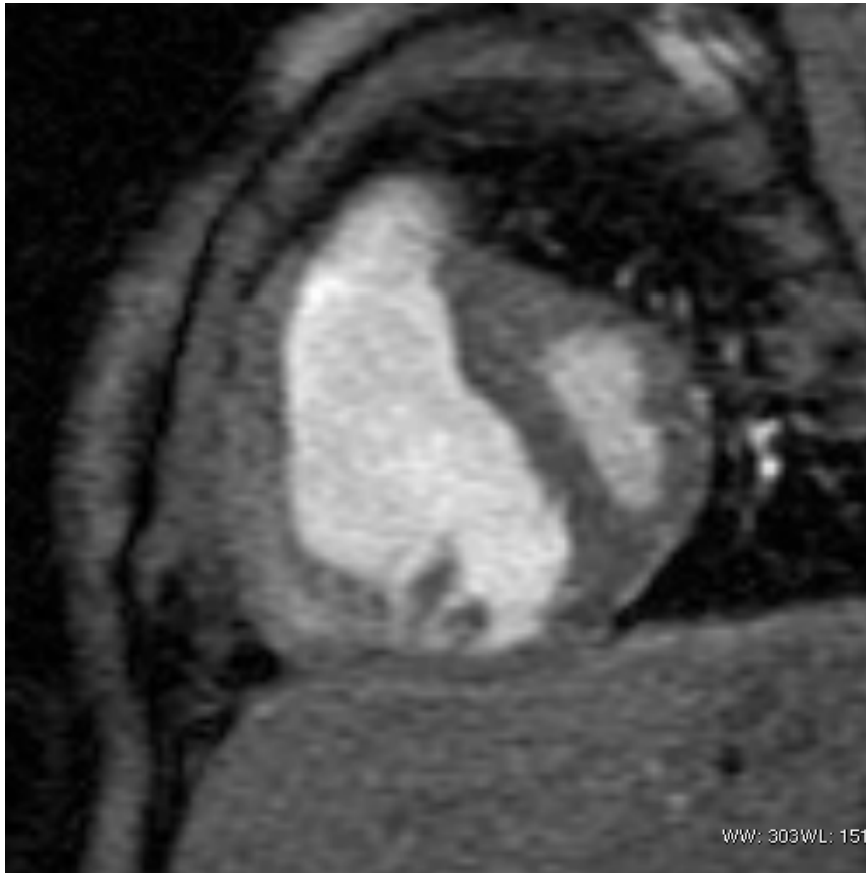
## *VENTRICULAR volumetry*

- LVEDV = 21 ml/m<sup>2</sup>
- LVESV = 9.9 ml/m<sup>2</sup>
- LVEF = 53%
- LVSV = 11.3 ml/m<sup>2</sup>  
(Asc Aorta = 11.9 ml/m<sup>2</sup>)
- LVI = 1.59 l/ min

# *BIVENTRICULAR vs UNIVENTRICULAR REPAIR?*

A NEW BORN WITH AORTIC ARCH HYPOPLASIA AND HYPOPLASTIC LEFT VENTRICLE

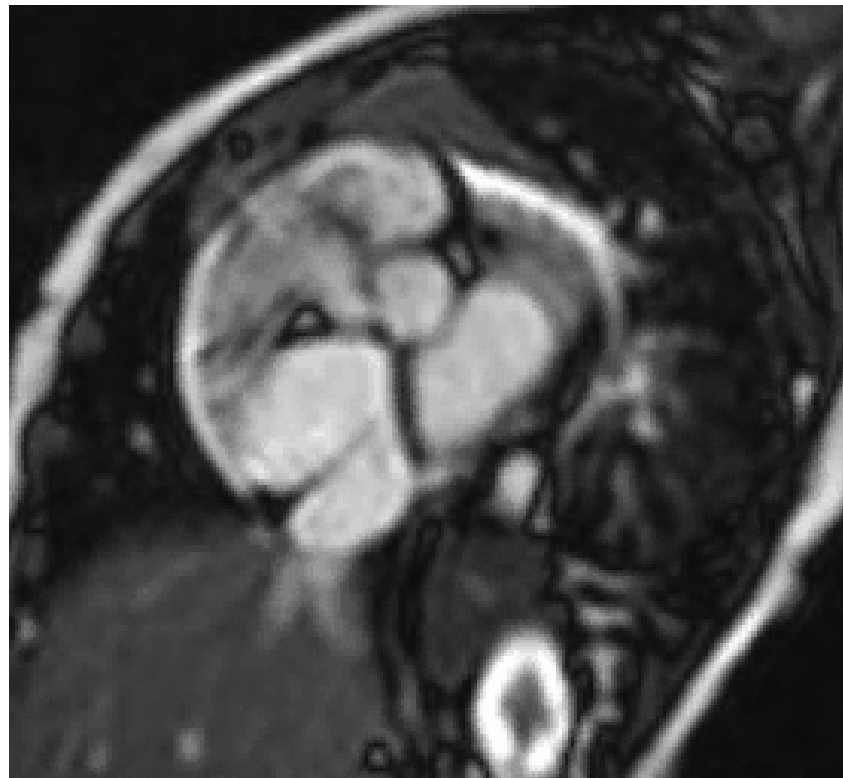
LVEDVi at Echo = 10.9 cc / m<sup>2</sup>



LVEDVi at Echo = 10.9 ml/m<sup>2</sup>

LVEDVi at MR = 21 ml/m<sup>2</sup>

# Cine MRI -Ebstein anomaly



Idx: 1105  
 Patient Name: BAKAYE EUN  
 Patient ID: 74204423  
 Patient Height: 66.00 cm. Patient Weight: 8.00 kg. R to R Interval: 513 ms  
 Examination Date: 2004-10-25  
 FOCUS: 74204423  
 DOB: 2004-04-26

	RV Absolute	RV Normalized
Cardiac Function		
Ejection Fraction	-7.35 %	
Cardiac Information		
Myocardial Mass (avg)	--- + --- g	--- + --- *
End Diastolic Volume	7.32 ml	20.20 *
End Systolic Volume	7.86 ml	21.68 *
Additional Cardiac Function Data		
Stroke Volume	-0.54 ml	-1.48 *
Cardiac Output	-0.06 L/min	-0.17 *
Peak Ejection Rate	--- ml/sec	--- EDV/sec
Peak Filling Rate	--- ml/sec	--- EDV/sec
Temporal Data		
Time to Peak Ejection Rate	--- msec	--- systole
Time from ES to Peak Filling Rate	--- msec	--- diastole
Heart Rate	116.96 Beats/min	
	* normalized to patient surface area	0.36 m <sup>2</sup>

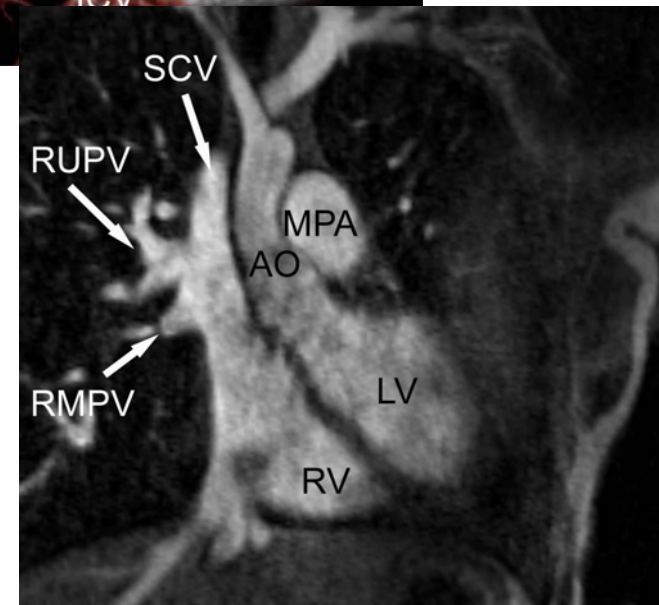
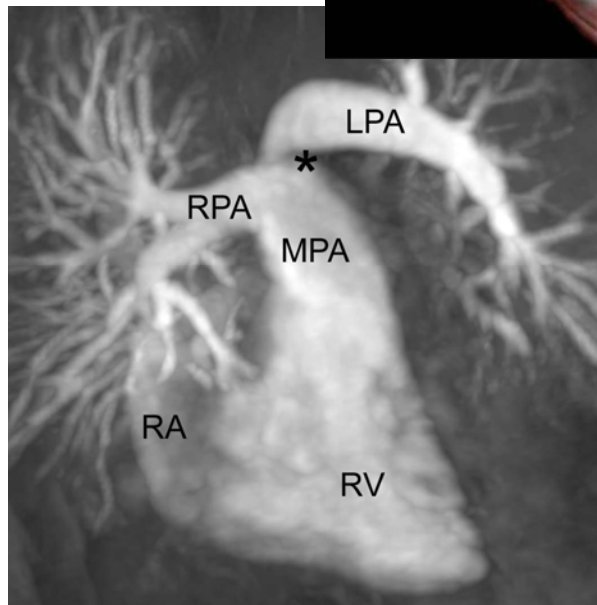
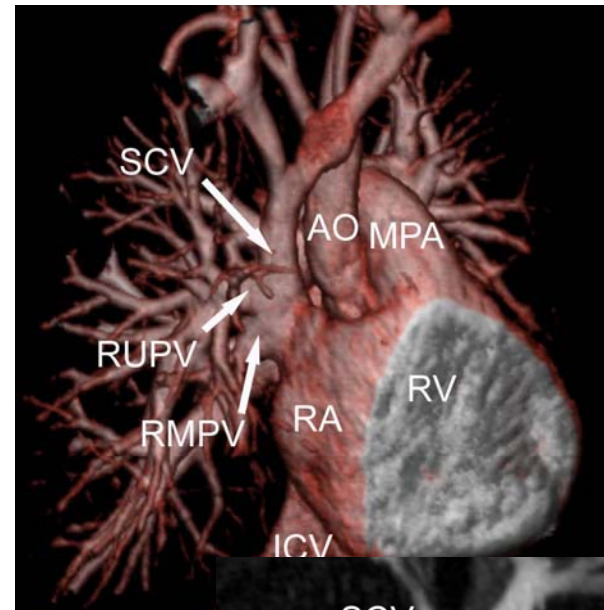
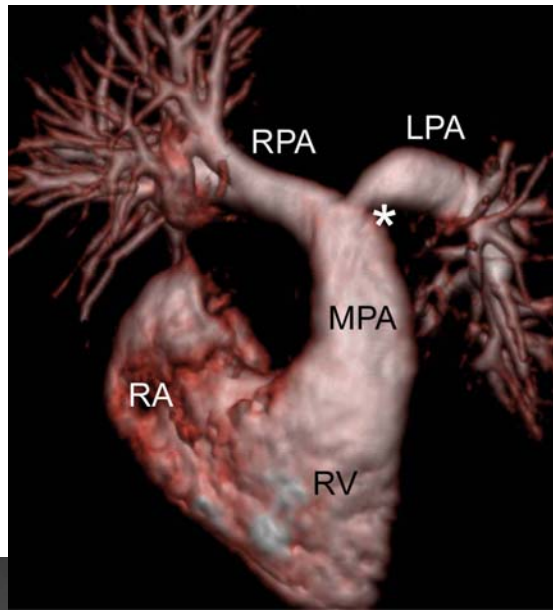
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 TR 0.0  
 TE 0.0  
 EC 0  
 FA 0.0  
 0.0thk  
 2004-10-25  
 21:16  
 Heart^Heart\_SNUH  
 Argus 200410252116

W -1  
 L 0  
 Z 100%



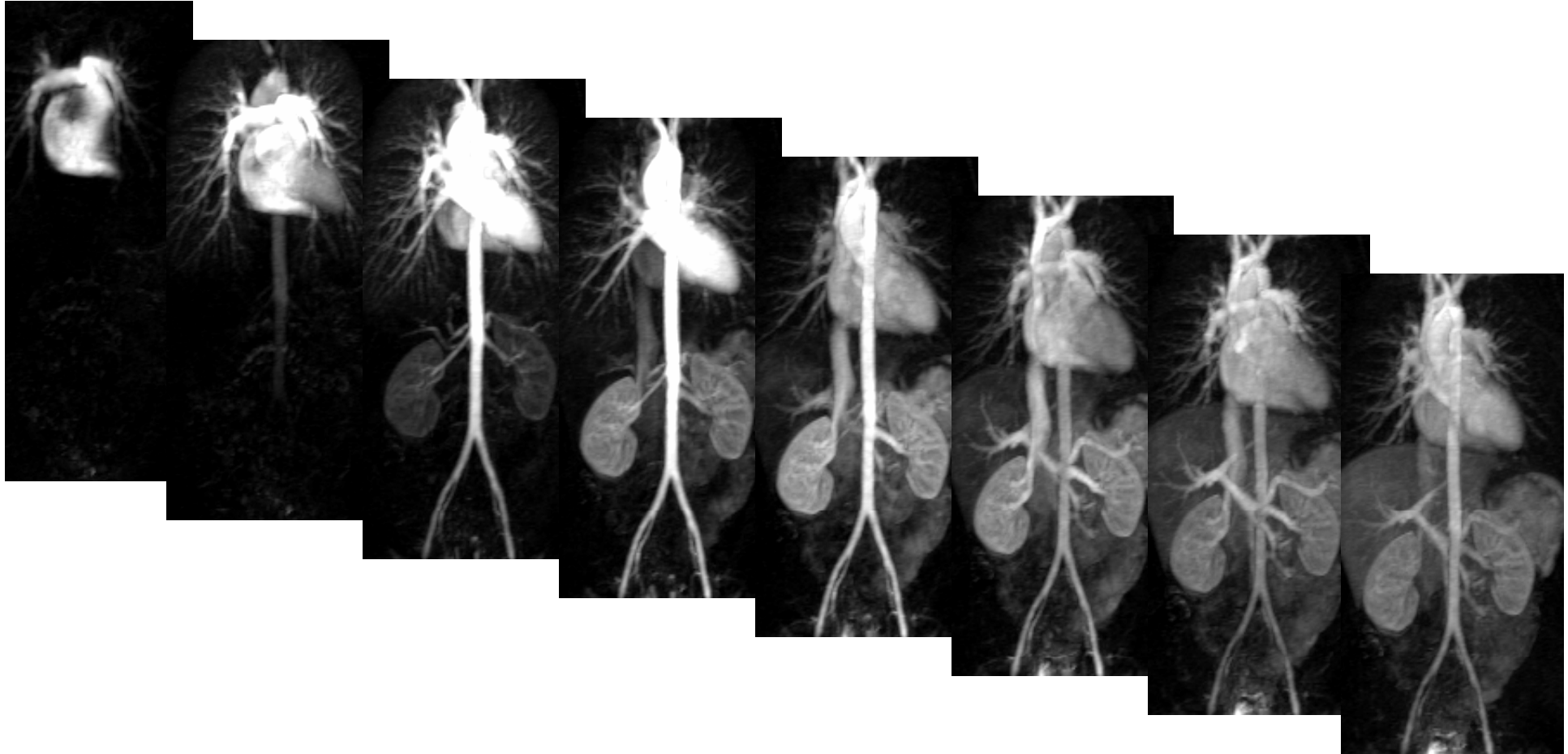
# MR Angiography

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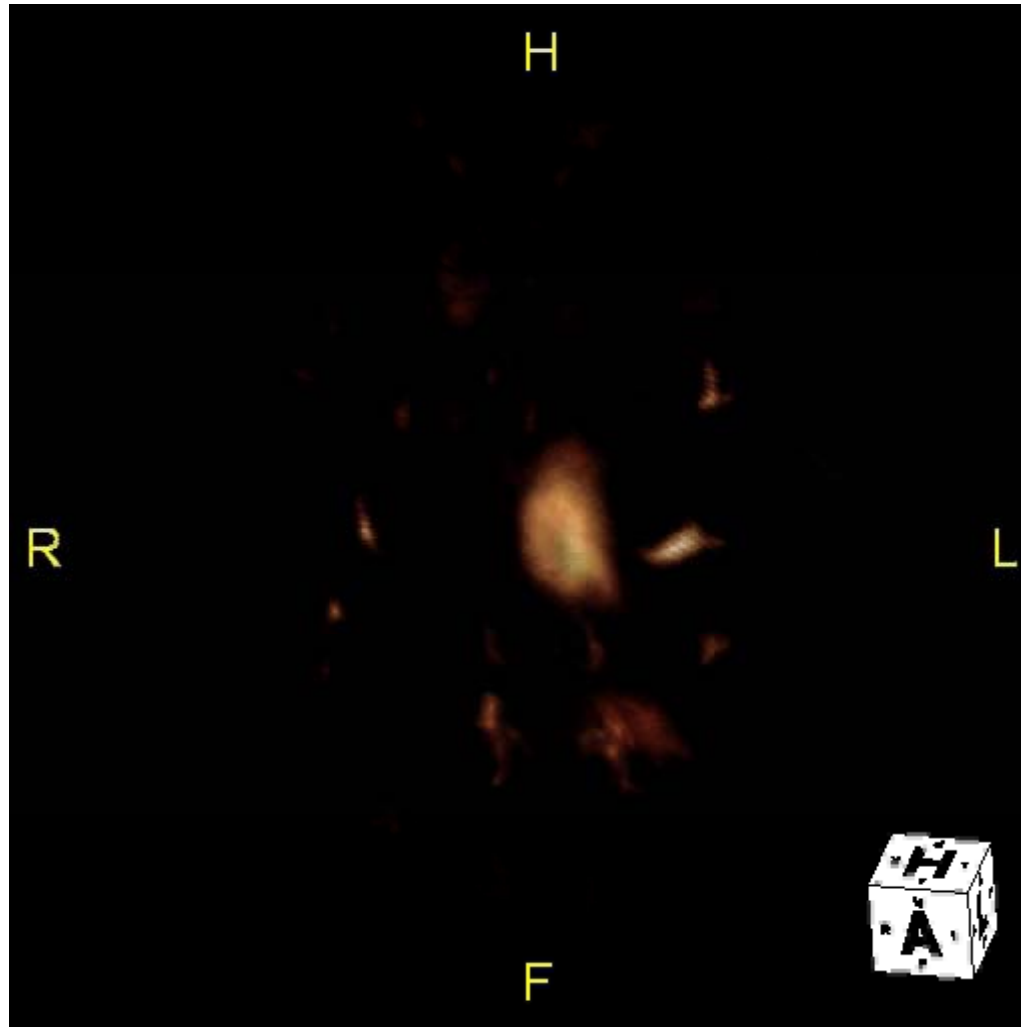
# Dynamic CEMRA

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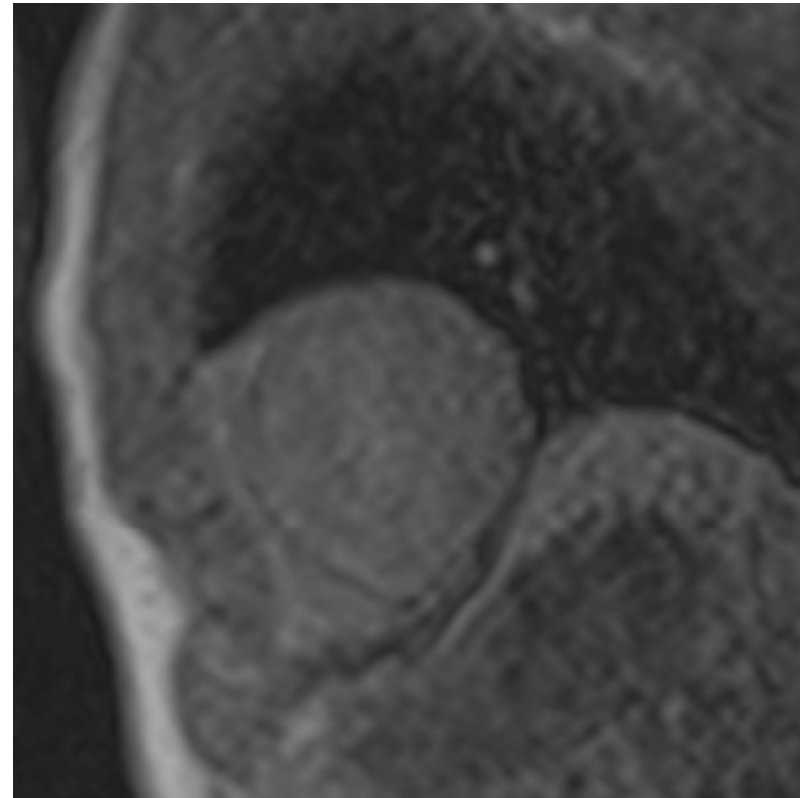
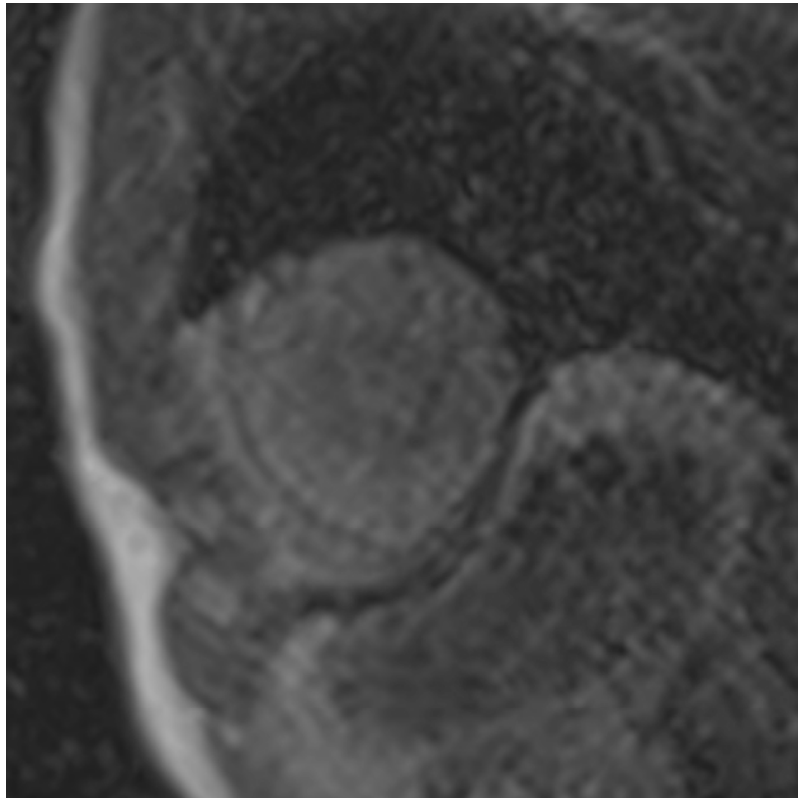
# 4D time resolved MRA

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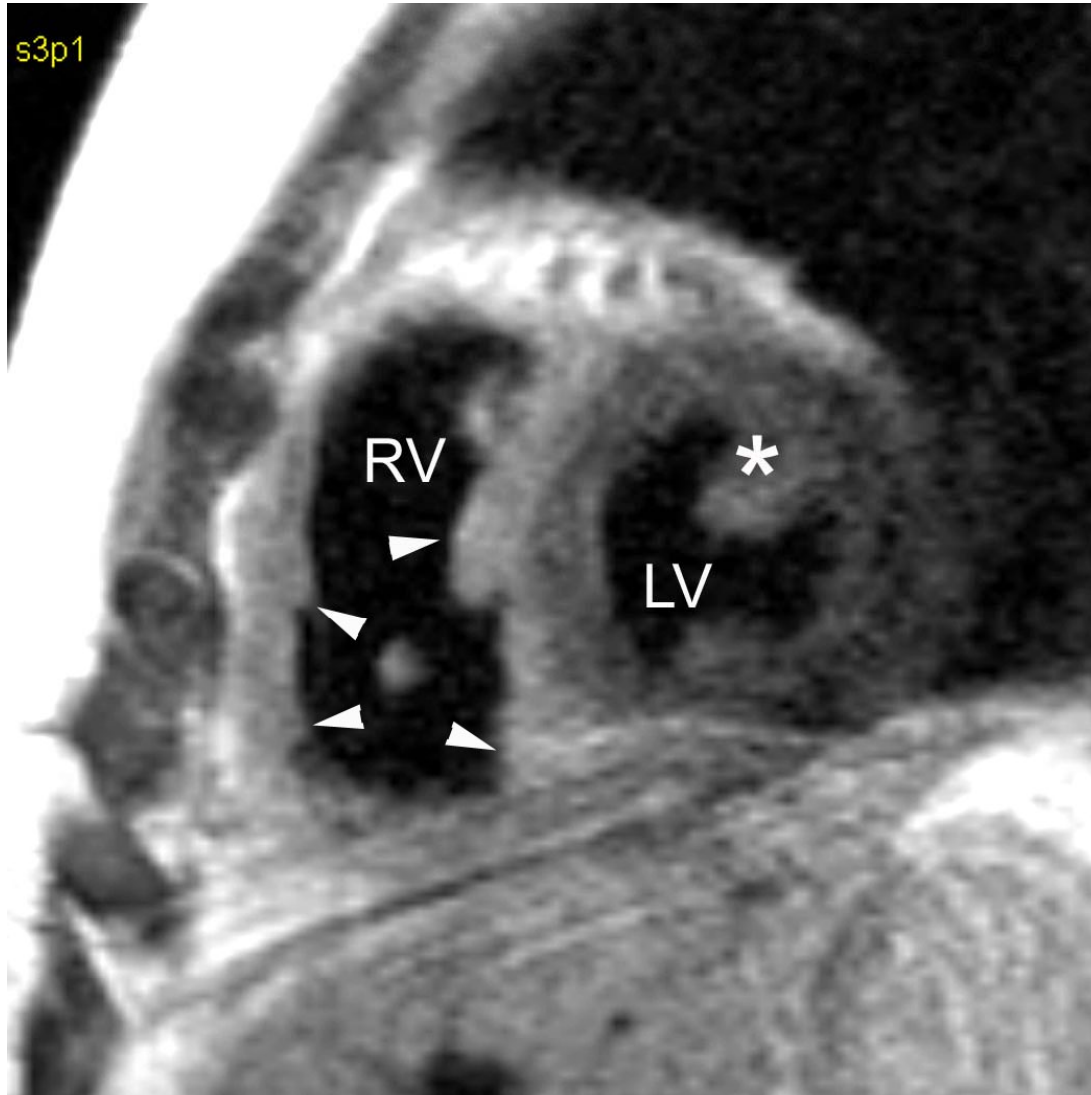
# Perfusion with stress test

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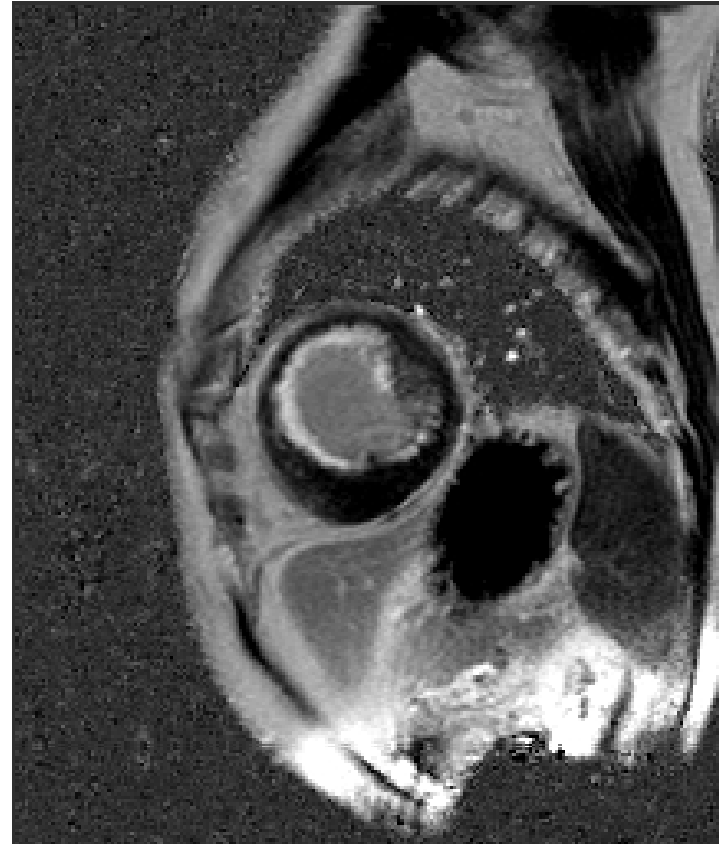
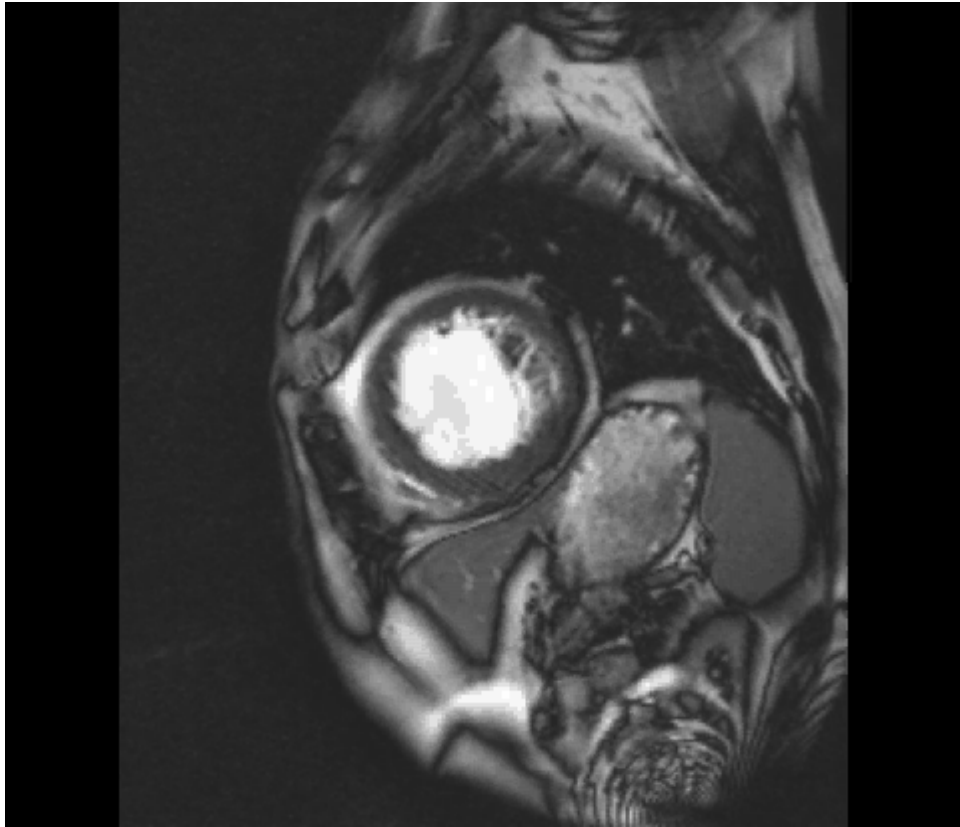
# Tissue characterization

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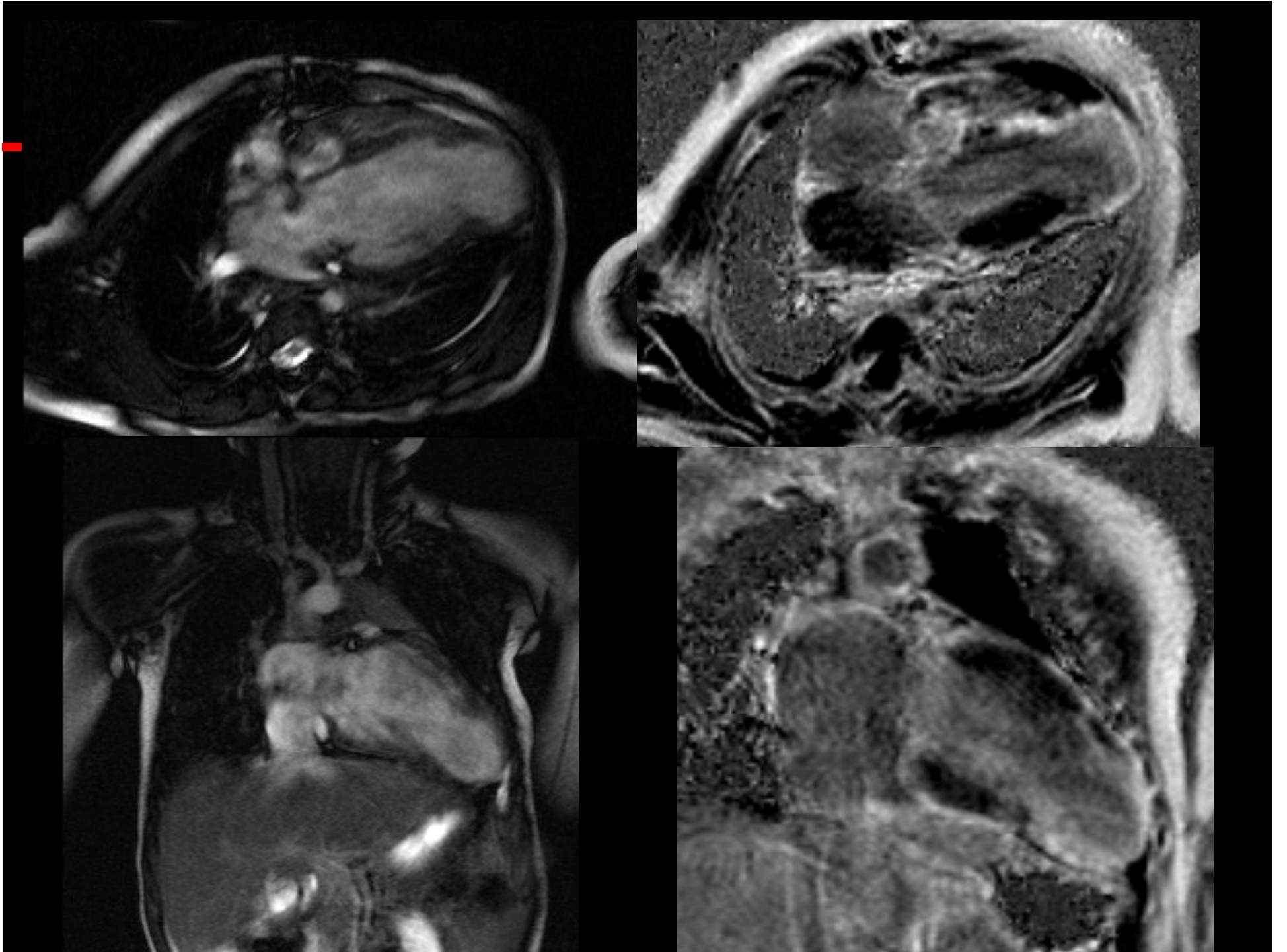


# Delayed enhancement

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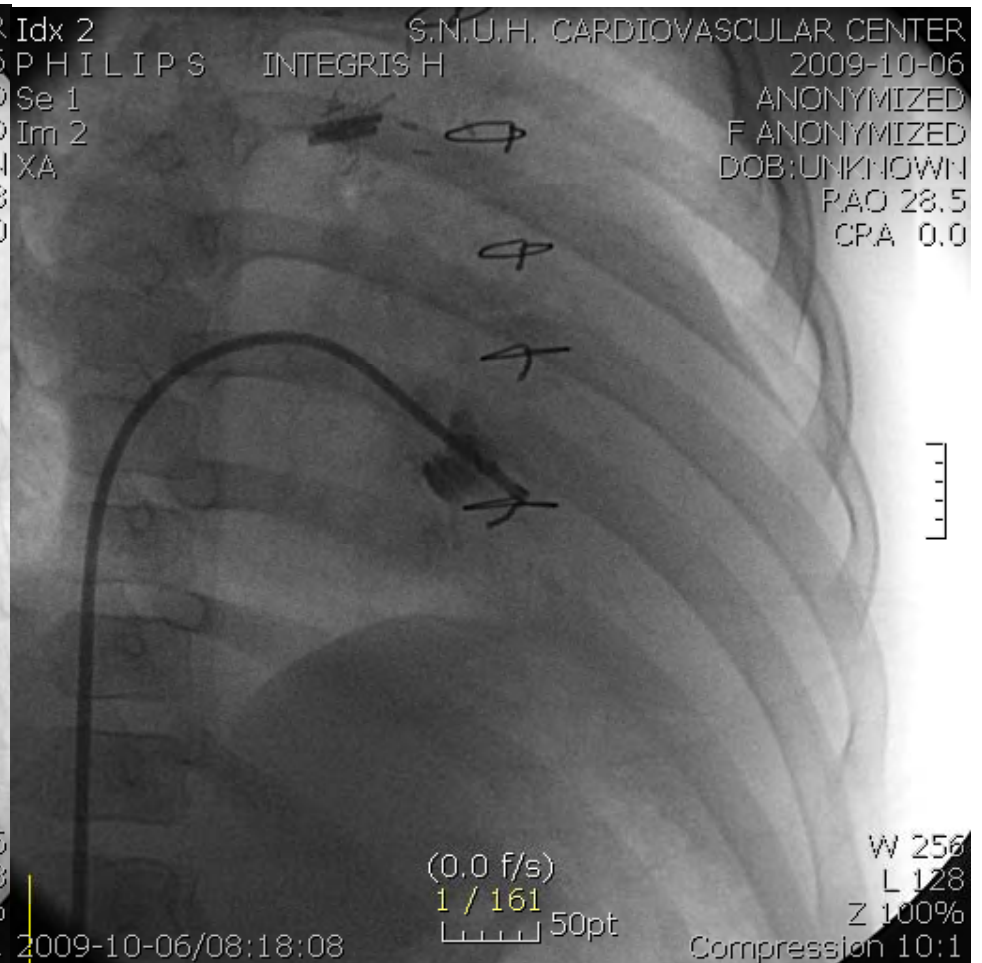
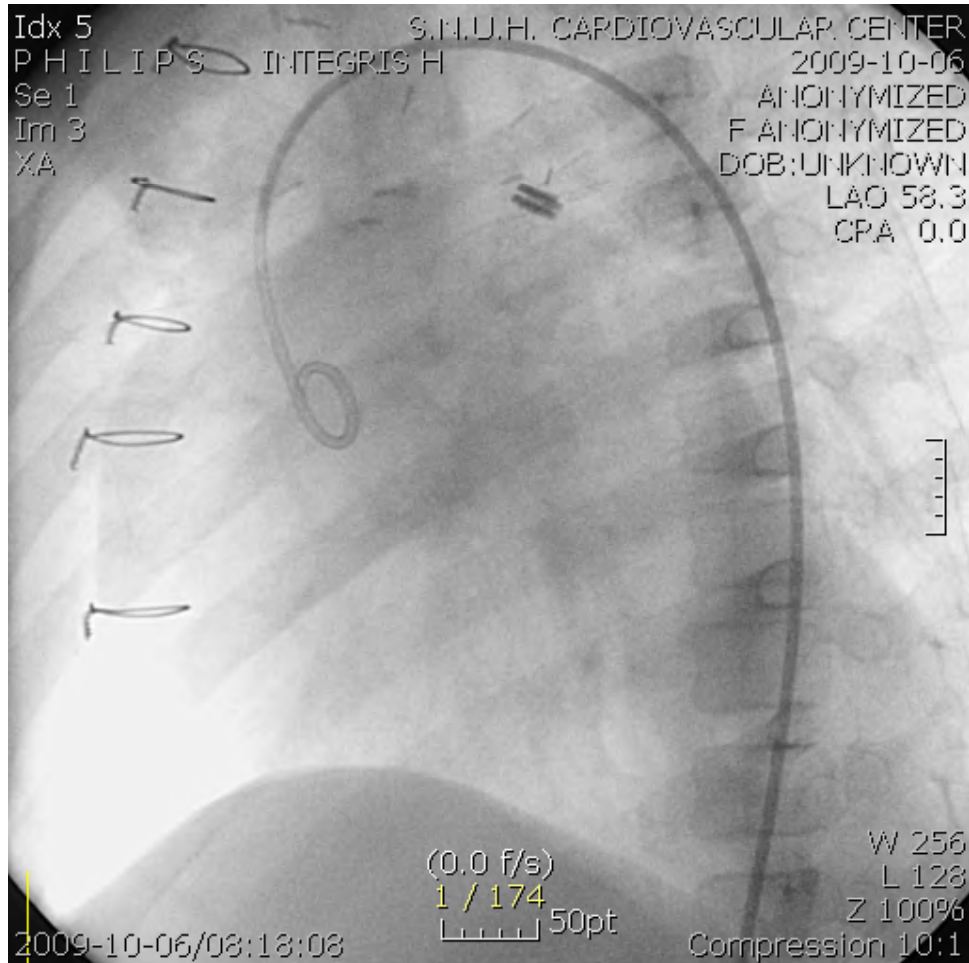






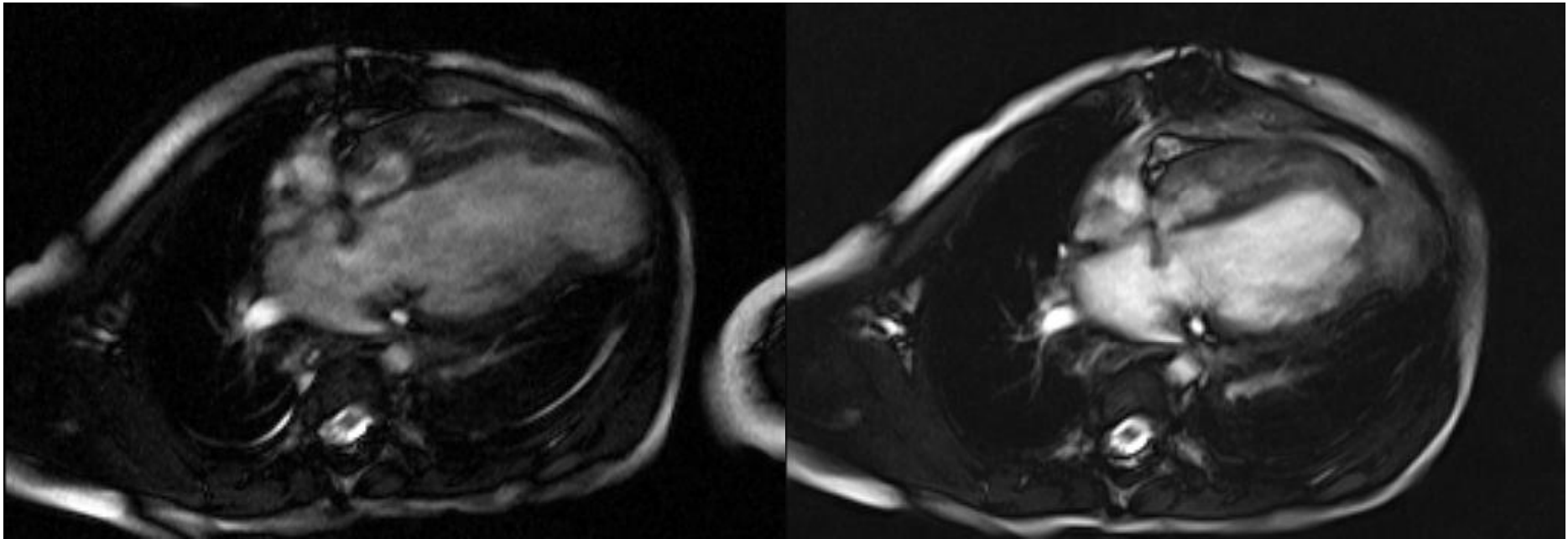
# PA IVS RVDCC

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# Dor procedure pre and post op

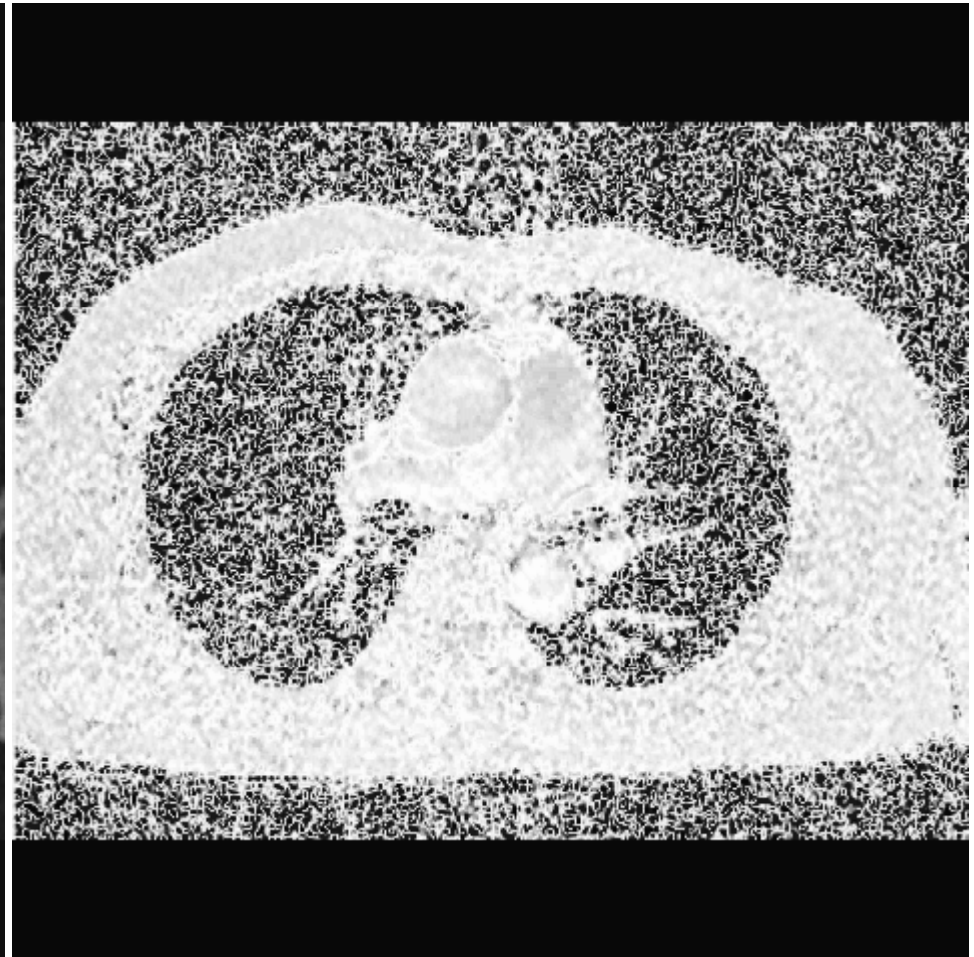
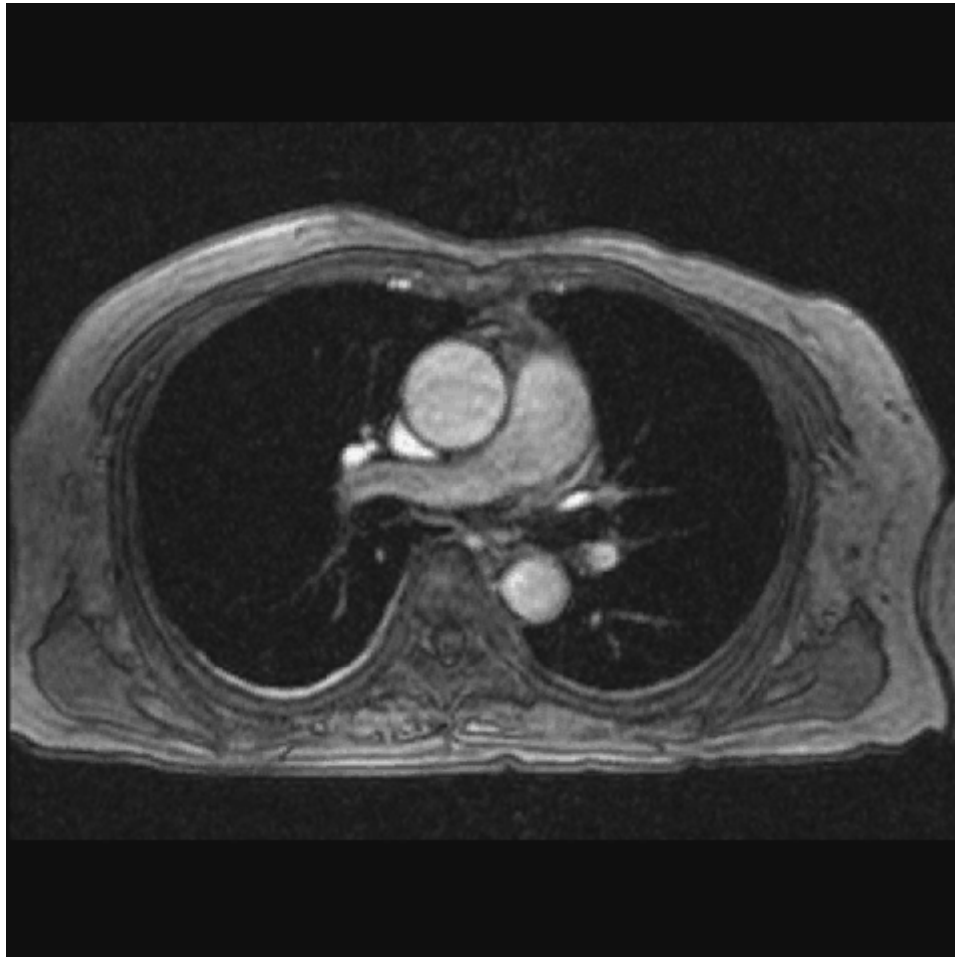
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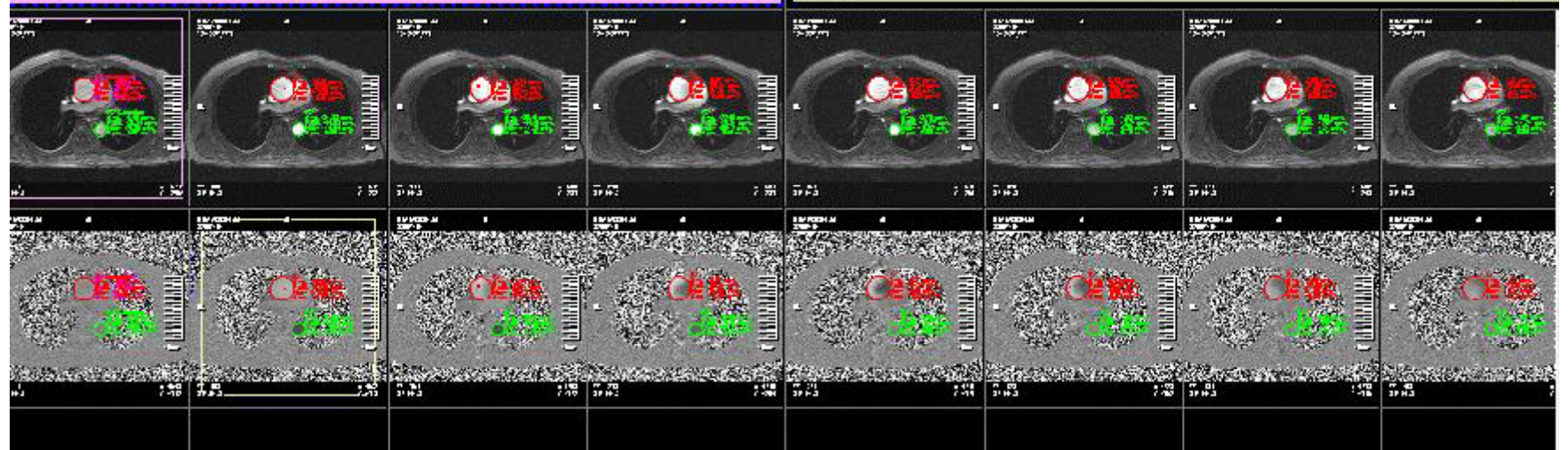
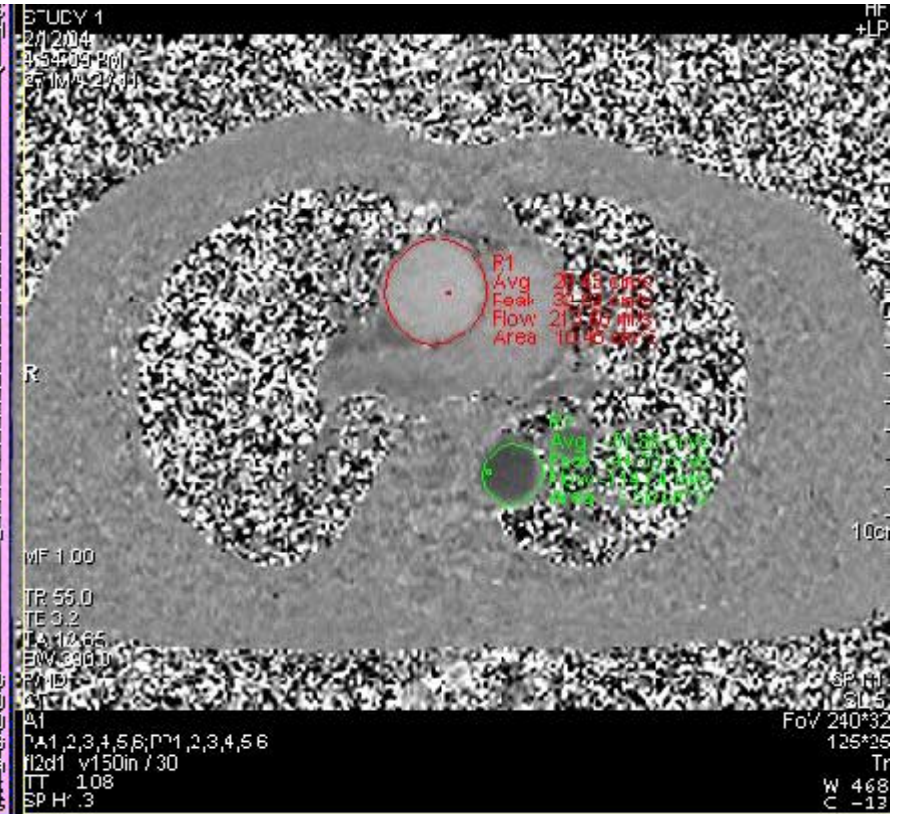
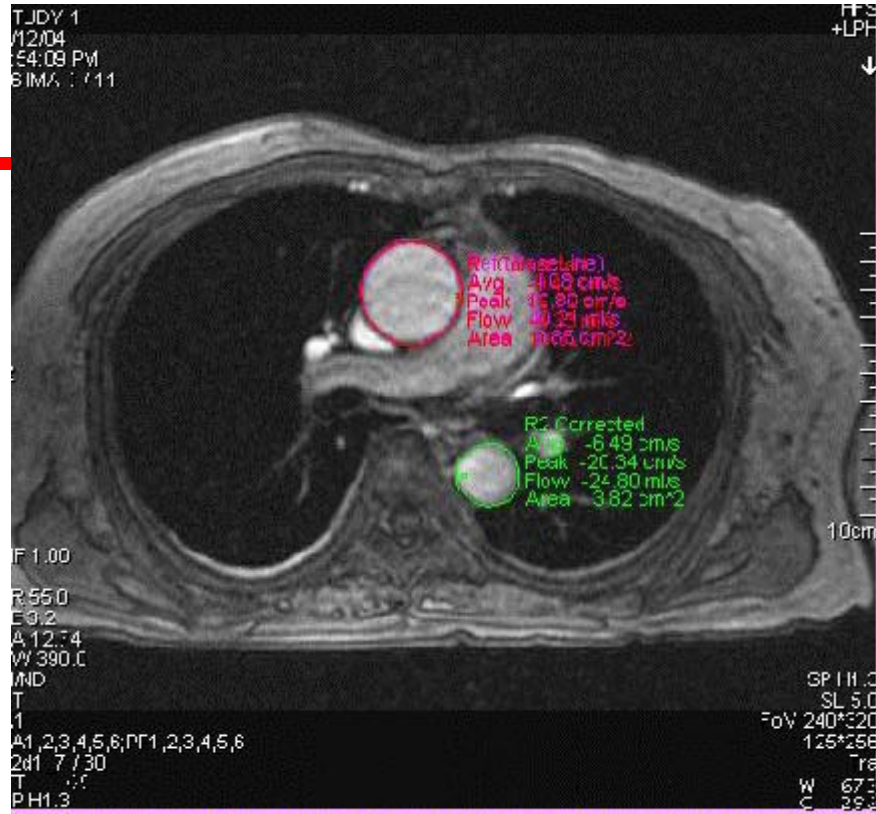


# Flow Quant Analysis

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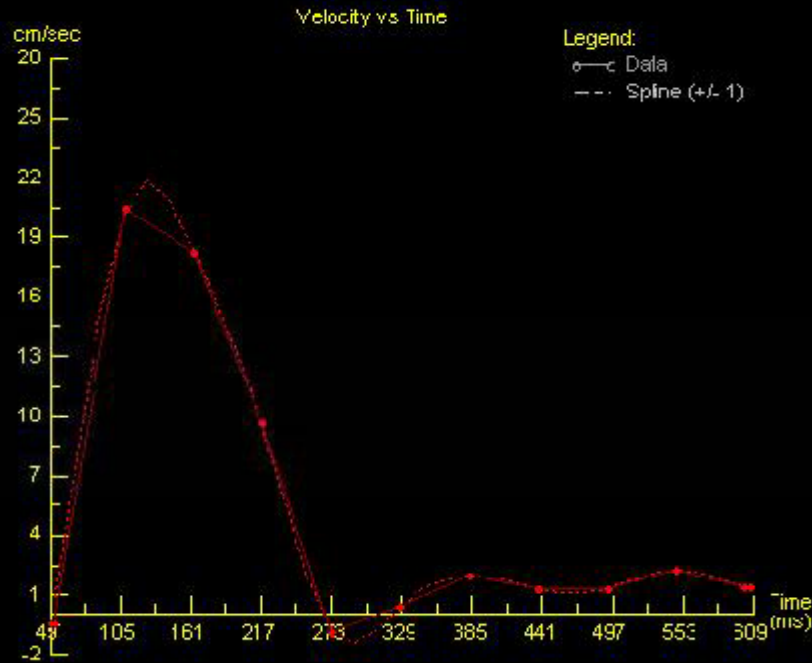
VENC – velocity encoding cine





### Mean Velocity Graph

Patient Name: KIM MOON JA  
 Patient ID: 32697191 Examination Date: 2/12/04  
 Patient Height: 153.00 cm. Patient Weight: 50.00 kg. R to F Interval: 744 ms.

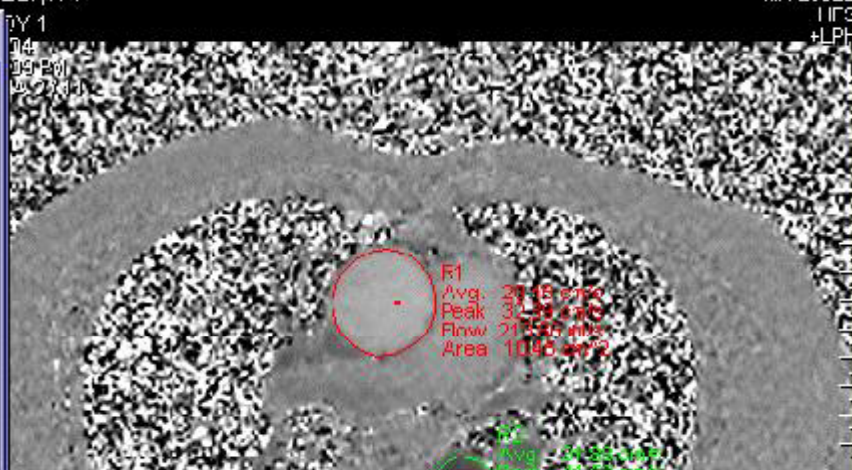


Slice Position: SP H1.3 Venc Adjustment -150 : 150 Baseline Corrected

Include All Graphs with Save

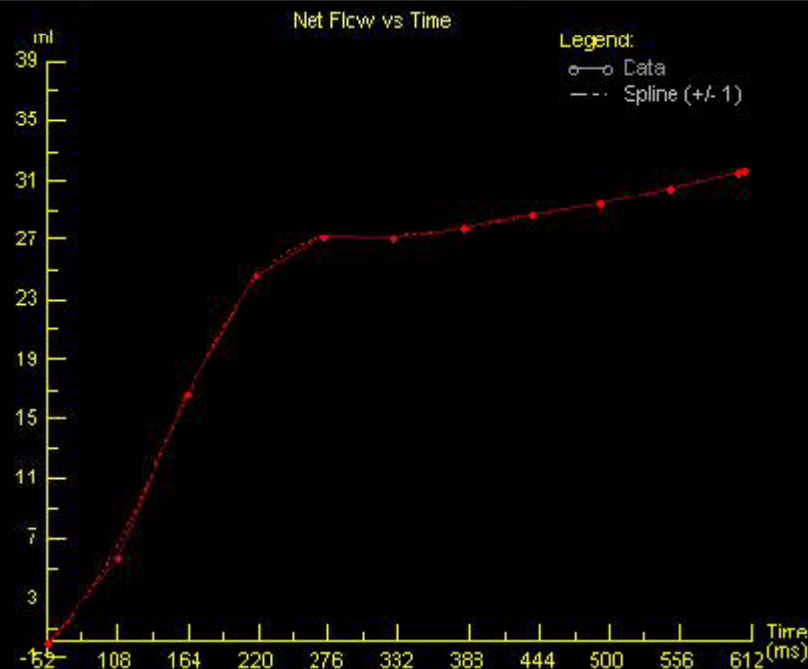
Close Window

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### Net Flow Graph

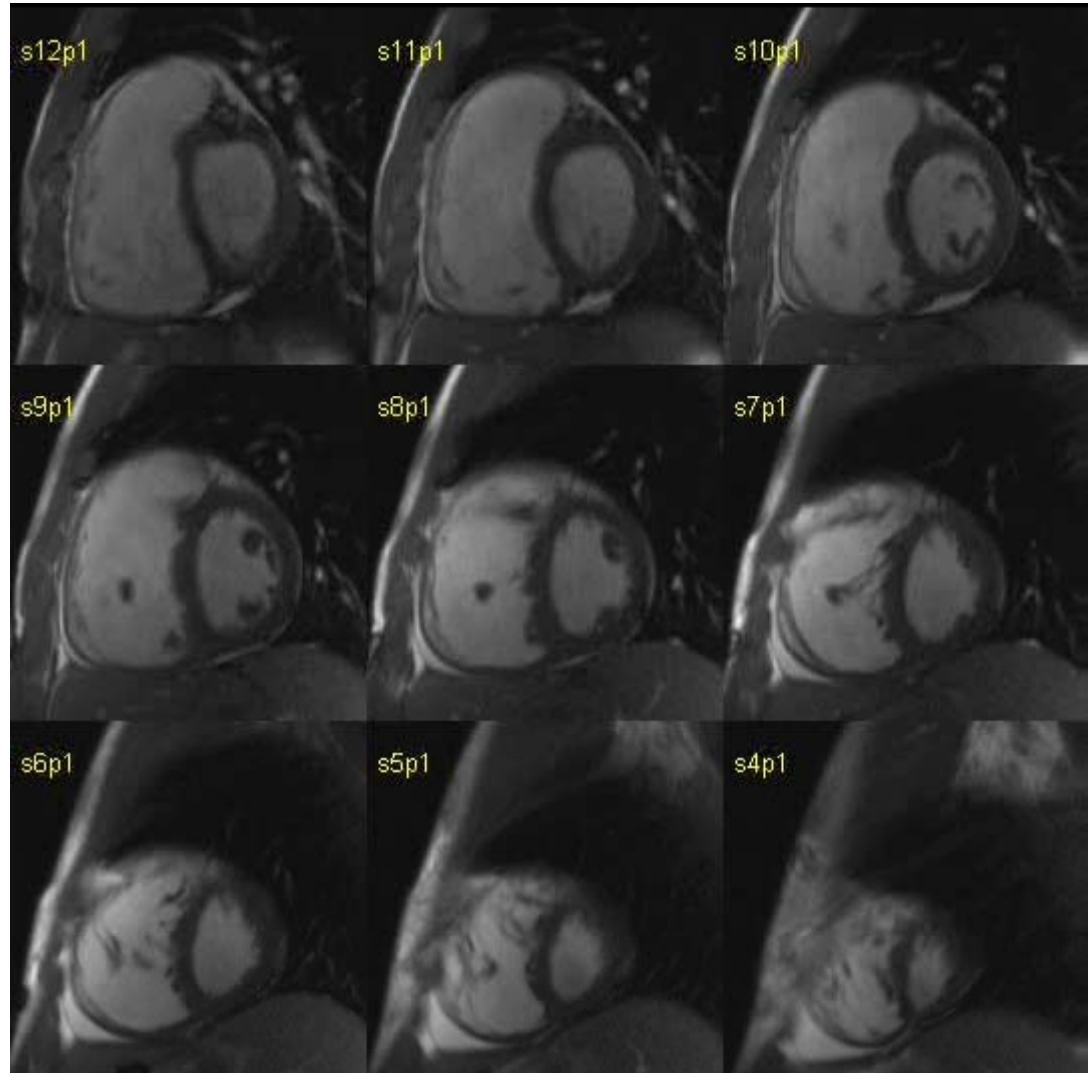
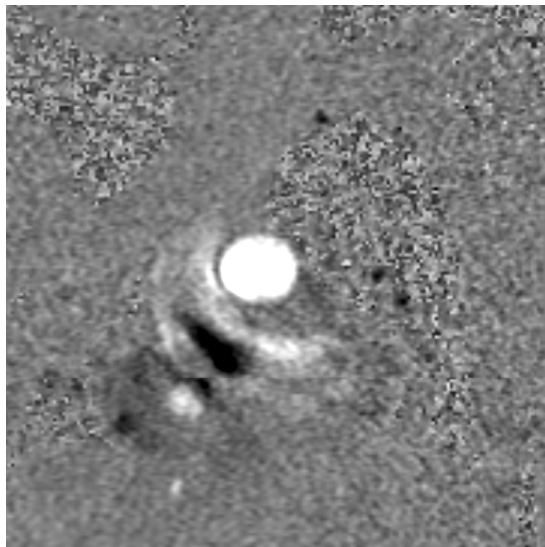
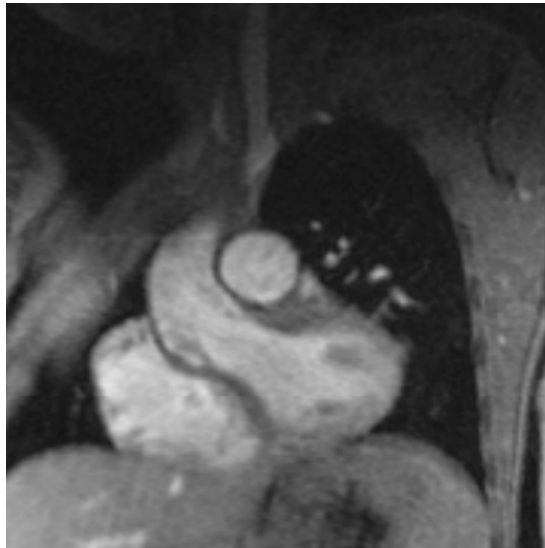
Patient Name: KIM MOON JA  
 Patient ID: 32697191 Examination Date: 2/12/04  
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Slice Position: SP H1.3 Venc Adjustment -150 : 150 Baseline Corrected

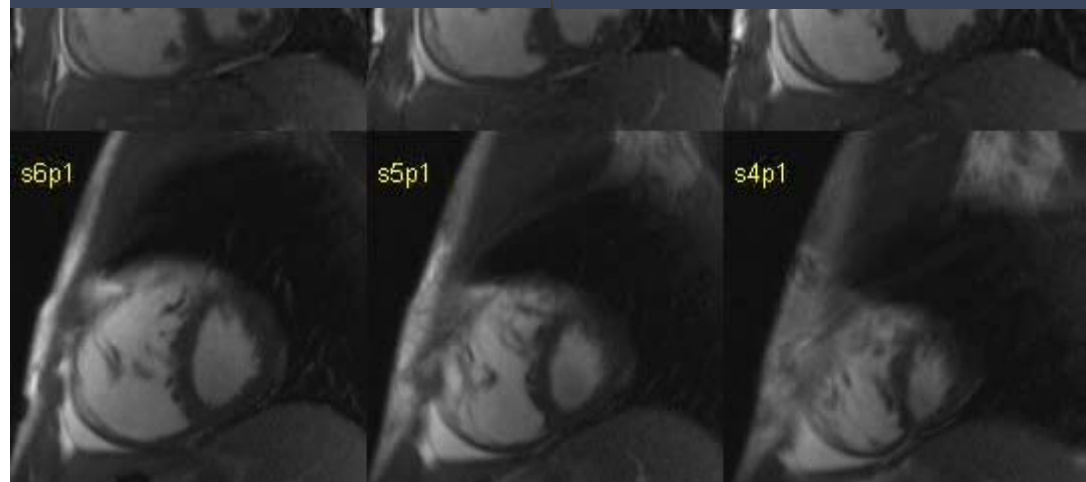
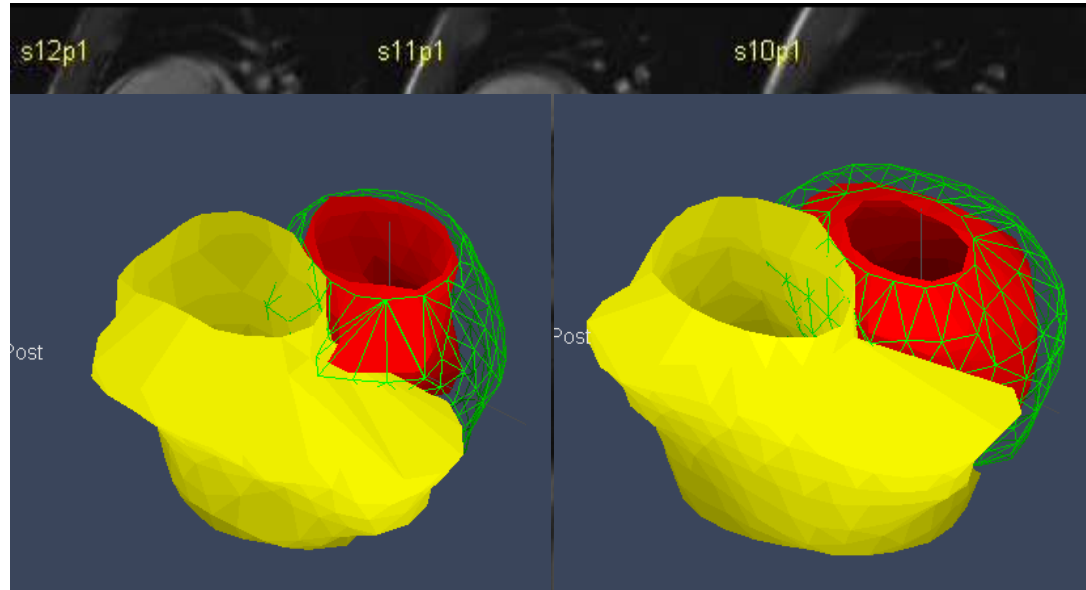
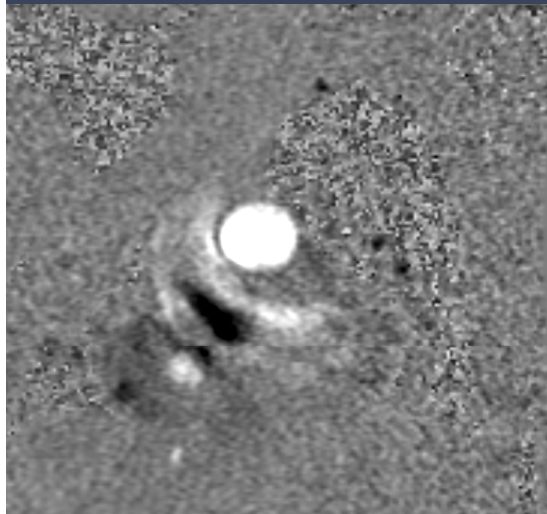
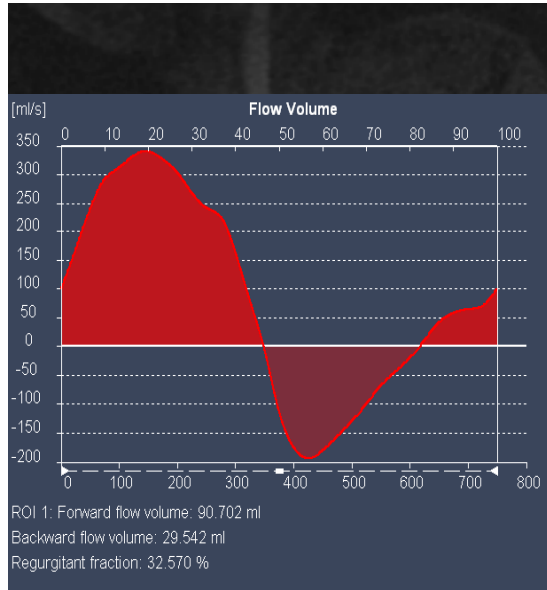
# Functional analysis with MRI

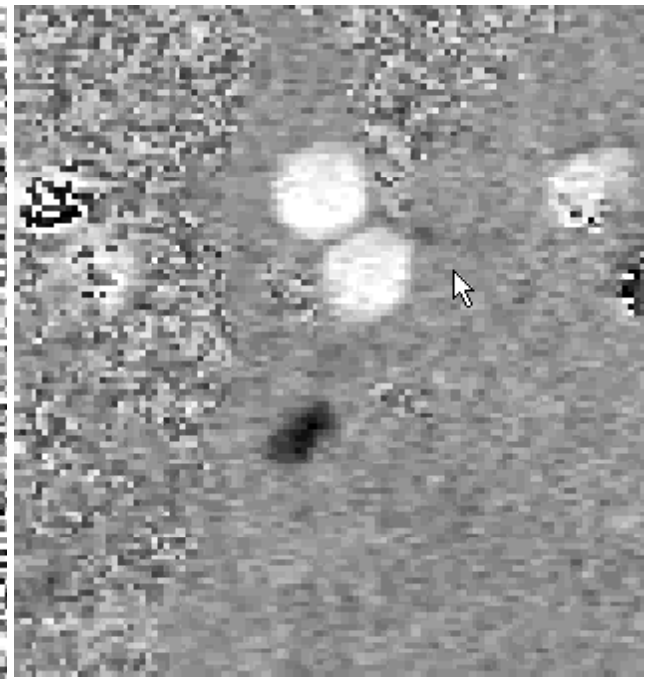
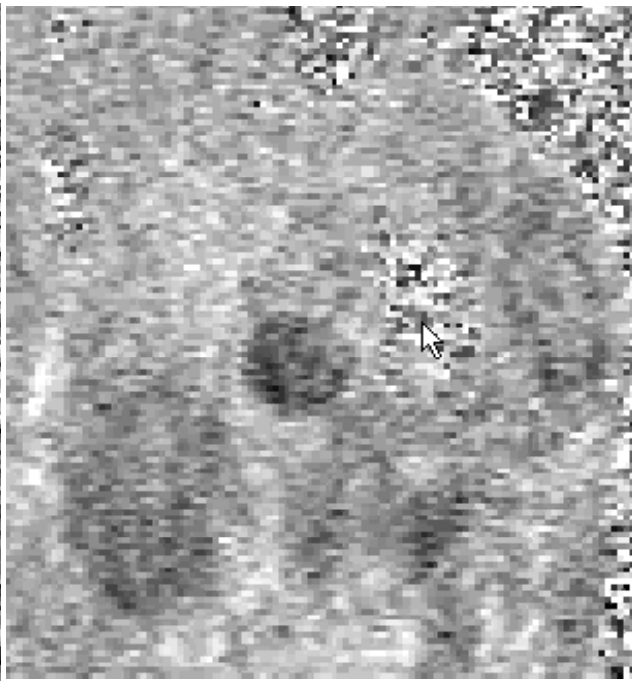
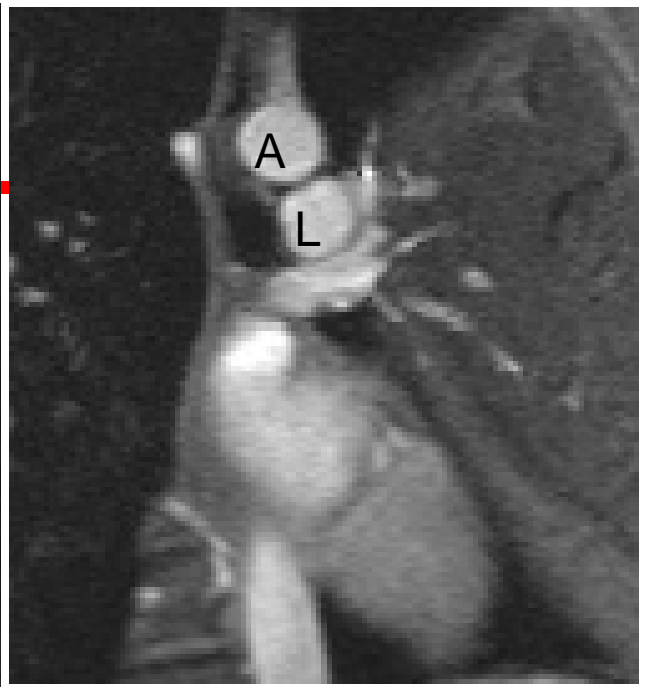
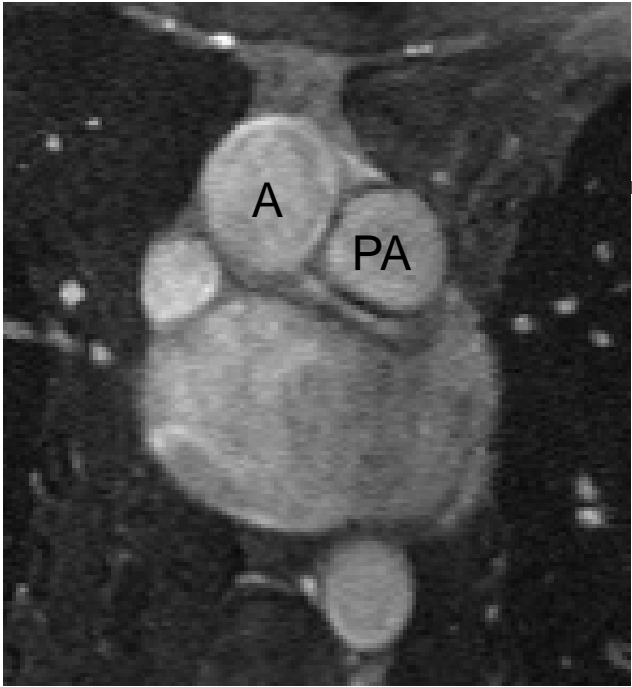
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# Functional analysis with MRI

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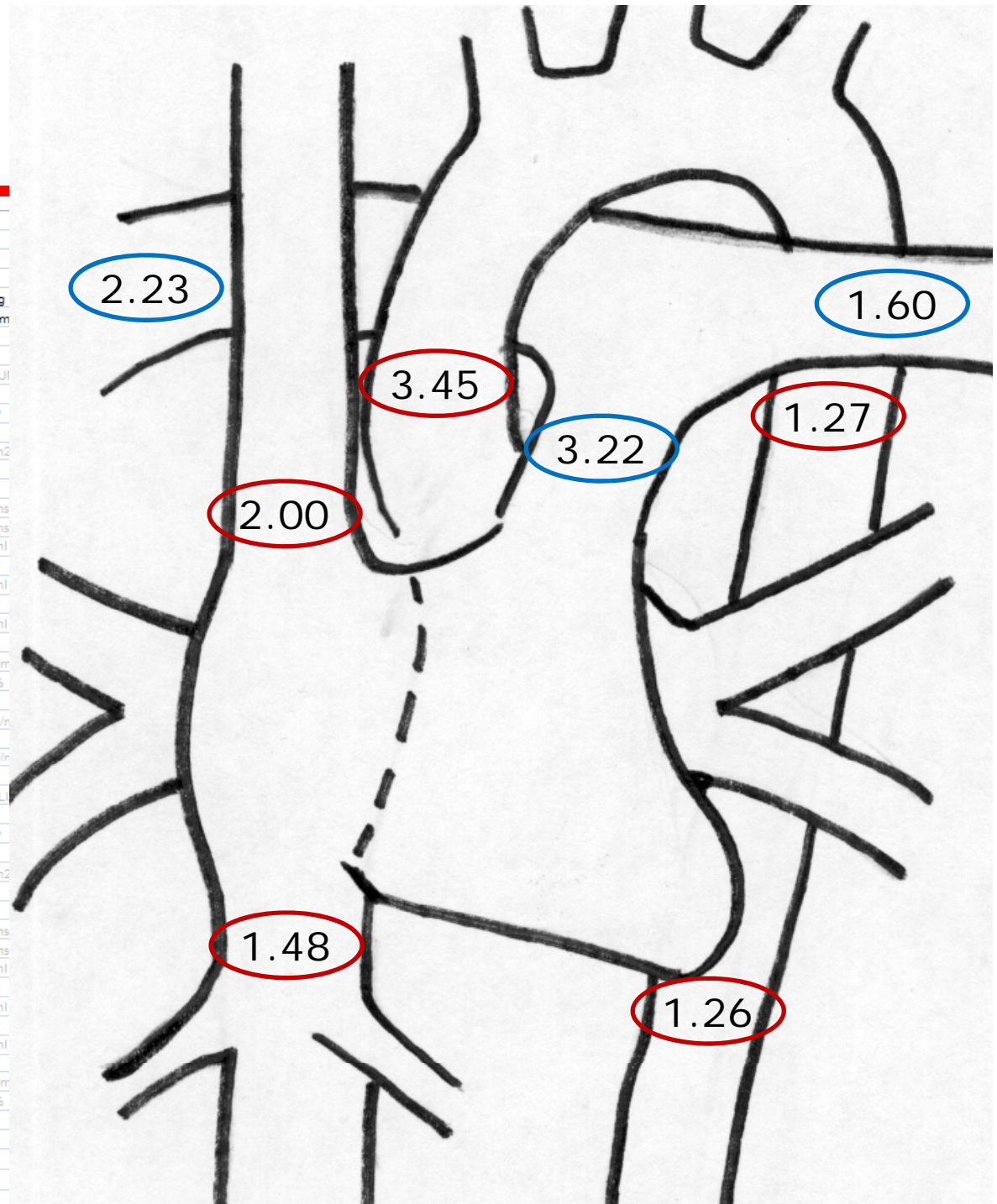






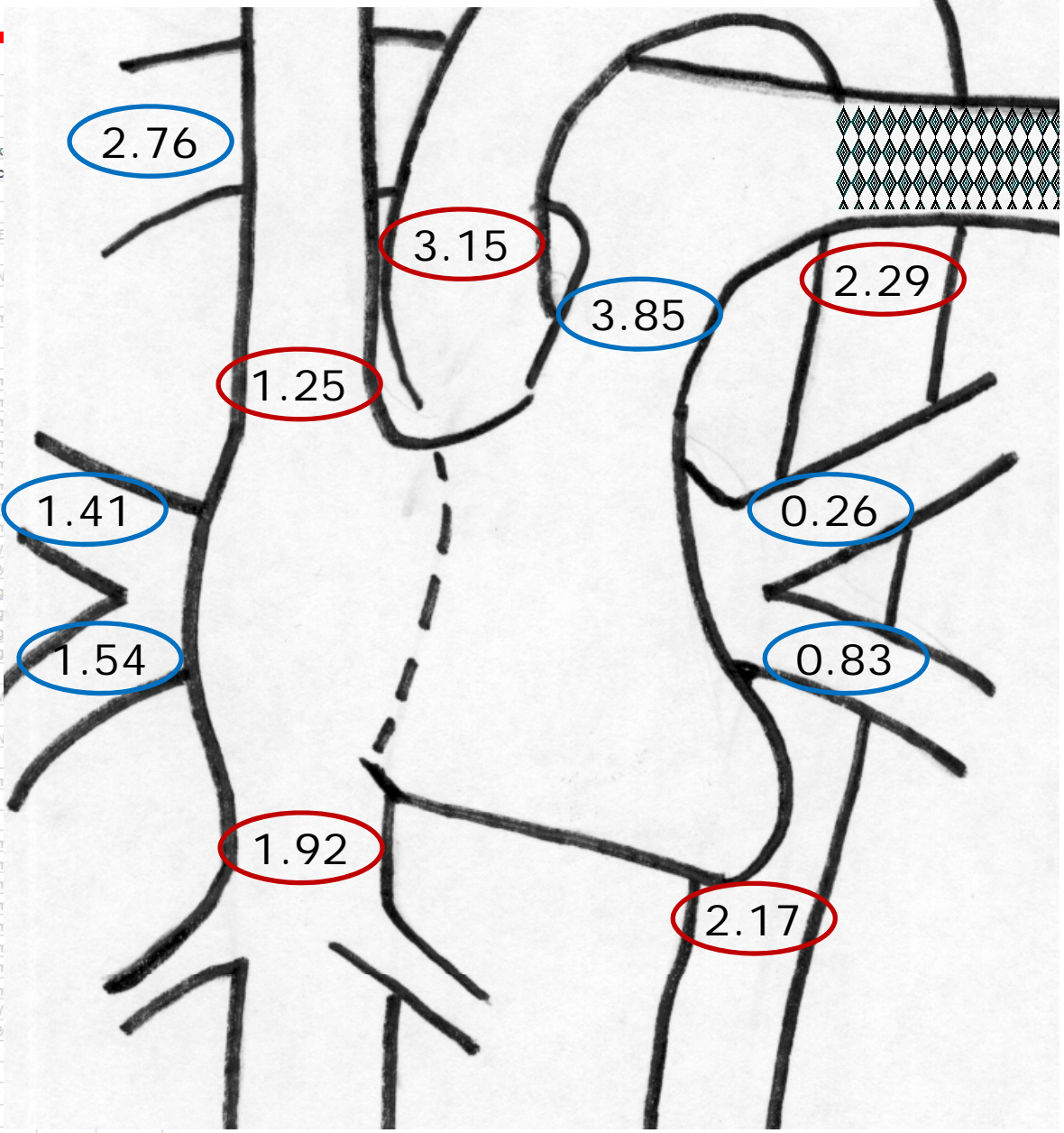
# Normal

1									Patient name:	BENIL
2	Weight	14.3							Patient ID:	2E+06
3	Height	105.0							Patient gender:	M
4	BSA(m <sup>2</sup> )	0.65	BSA(cal)	0.65					Birth date:	#####
5	Heart rate	105							Patient weight:	14.3 kg
6									Patient height:	105 cm
7										
8	Flow									
9		indexed peak	For/BS	Rev/BS	l/min	RF	ratio		LEFT VENTRICULAR VOLU	
10	AAO	3.45	3.45	0.00	2.24				Parameter	ue
11	DAO	1.27			0.82				Method:	axis/3D*
12	SVC	2.00			1.3				Body Surface Ar	0.65 m <sup>2</sup>
13	D+S	3.27			2.12				ED phase numb	20
14	dD+S	3.26			2.12				ES phase numb	10
15	dDAO	1.26			0.82				ED phase time:	539.60 ms
16	IVC	1.48			0.96				ES phase time:	255.6 ms
17	RPA	2.23	2.23	0.00	1.45	58			ED volume:	37.62 ml
18	LPA	1.60	1.60	0.00	1.04	42			ED volume/BSA:	57.9 2
19	R+L	3.83	3.83	0.00	2.49	0.0			ES volume:	13.07 ml
20	MPA	3.22	3.22	0.00	2.09				ES volume/BSA:	20.11 2
21	asinus	0.00	0.00	0.00					Stroke volume:	24.55 ml
22	AoV	0.00	0.00	0.00					Stroke volume/B	37.78 2
23	LVOT	0.00	0.00	0.00					Cardiac output:	2.59 l/m
24	RUPL	0.00							Ejection fraction:	65.26 %
25	RLPV	0.00							LV mass ED:	24.71 g
26	LUPV	0.00							LV mass ED/BSA:	38.03 g/m <sup>2</sup>
27	LLPV	0.00							LV mass ES:	23.01 g
28	RPV	0.00			0.00	###			LV mass ES/BSA:	35.42 g/m <sup>2</sup>
29	LPV	0.00			0.00	###				
30	PV	0.00			0.00					
31	azugos	0.00							RIGHT VENTRICULAR VOLU	
32	azugos2	0.00							Parameter	ue
33	coA	0.00							Method:	axis/3D*
34	QpQs a	1.17							Body Surface Ar	0.65 m <sup>2</sup>
35	QpQs v	0.00							ED phase numb	20
36	EA w MV	3.20	normal		2.08				ES phase numb	10
37	EA w TV	3.11	rev		2.02				ED phase time:	539.60 ms
38	LV								ES phase time:	255.6 ms
39	LV mass ED/BSA:	38	[46 - 84]						ED volume:	39.48 ml
40	ED volume/BSA:	58	[52 - 112]						ED volume/BSA:	60.73 2
41	ES volume/BSA:	20							ES volume:	18.67 ml
42	Stroke volume/BSA:	38							ES volume/BSA:	28.73 2
43	Ejection fraction:	65	[55 - 74]						Stroke volume:	20.79 ml
44	Cardiac index	3.98							Stroke volume/B	32.2
45	RV								Cardiac output:	2.2 l/m
46	ED volume/BSA:	61	[58 - 115]						Ejection fraction:	52.69 %
47	ES volume/BSA:	29							RV mass ED:	
48	Stroke volume/BSA:	32							RV mass ES:	
49	Ejection fraction:	53	[47 - 63]							
50	Cardiac output:	2.2								
51	RV cardiac index	3.38								
52										



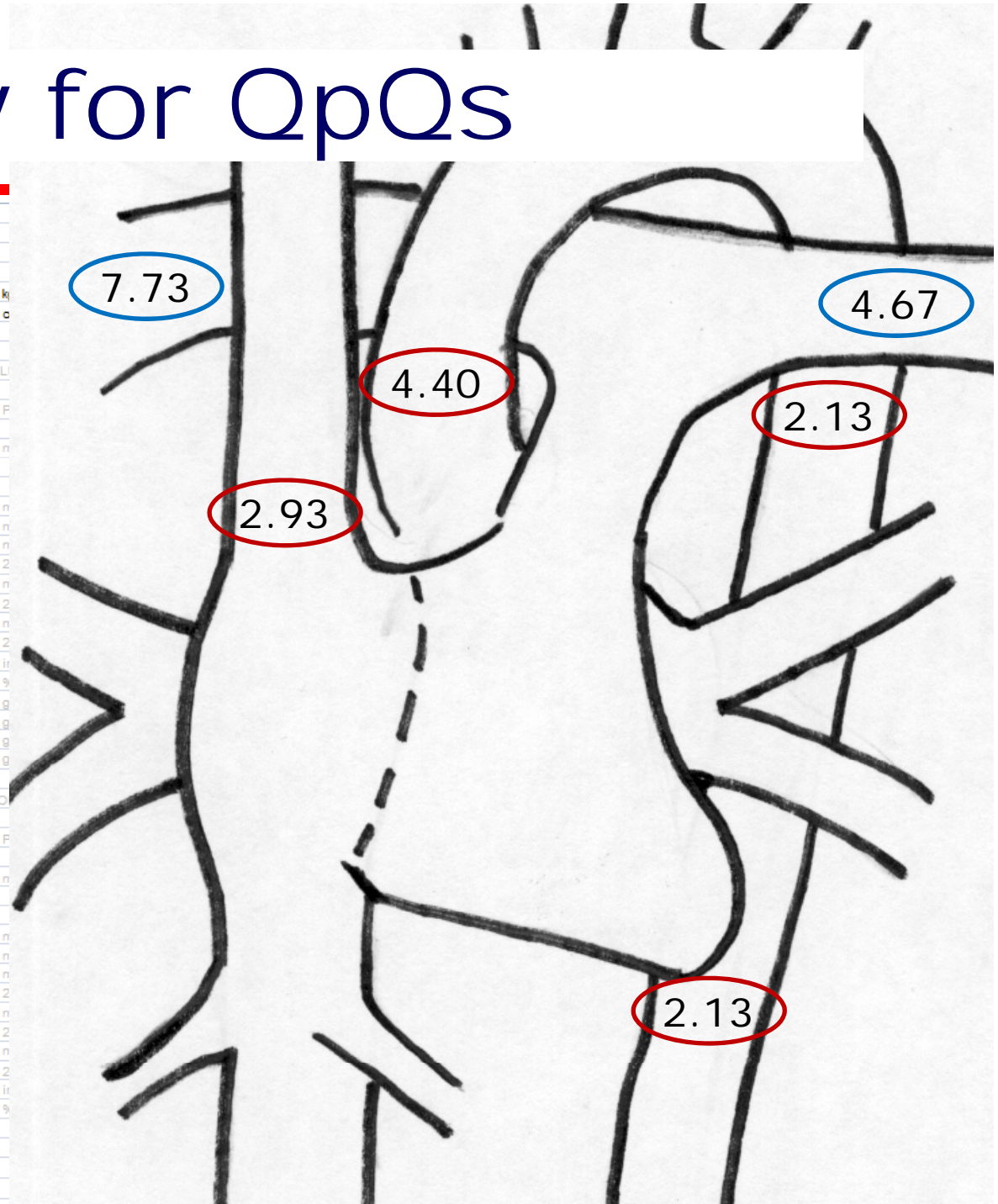
# Post TOF: LPA stent and PR

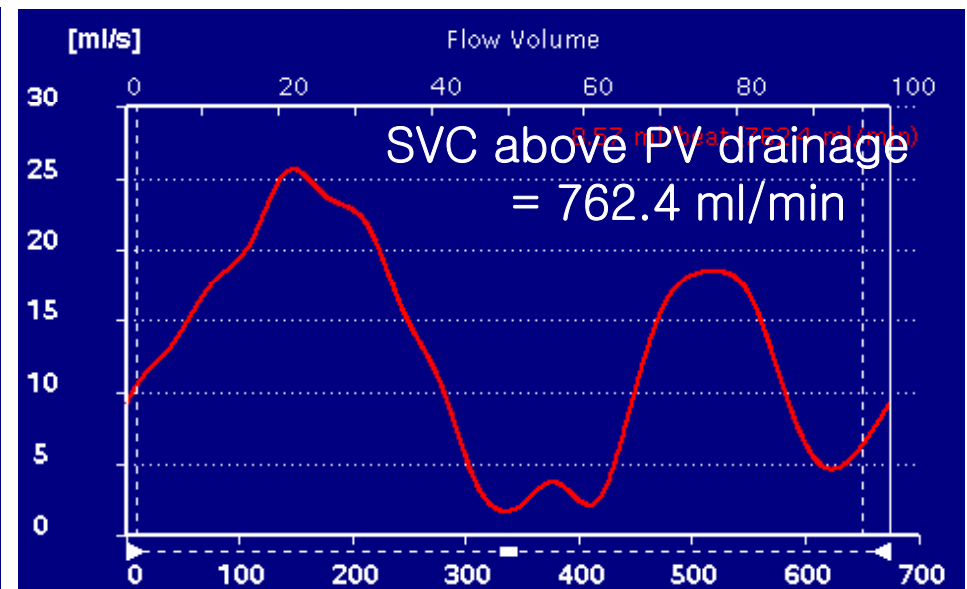
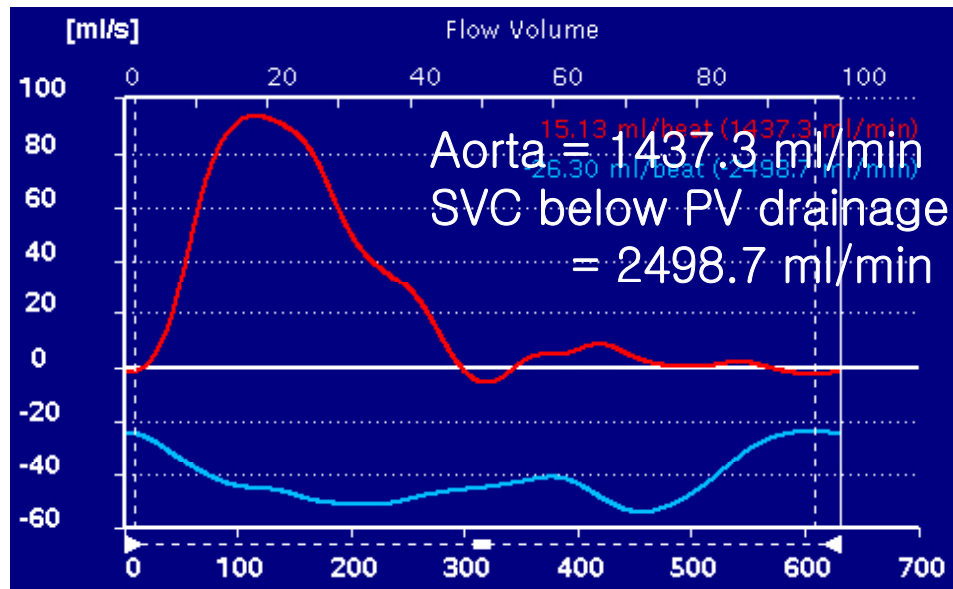
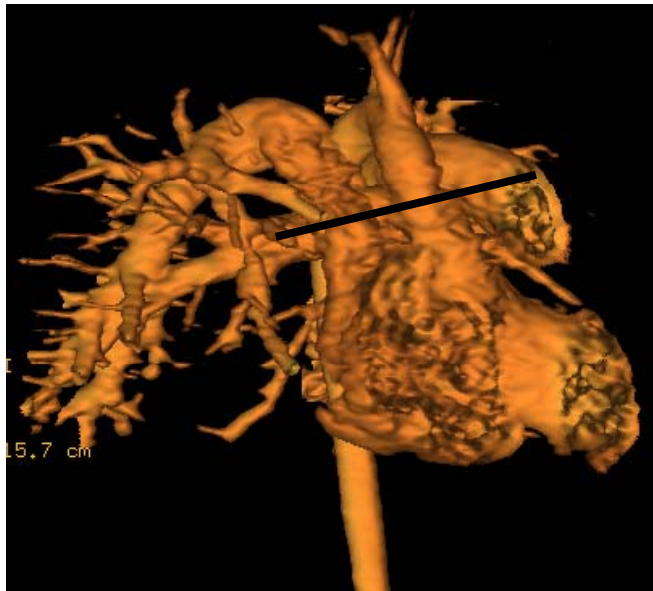
1									Patient name:	CARLS
2	Weight	70.5							Patient ID:	2E+06
3	Height	170.0							Patient gender:	M
4	BSA(qMass)	1.82	BSA(cal)	1.82					Birth date:	#####
5	Heart rate	88							Patient weight:	70.5 k
6									Patient height:	170 c
7										
8	<b>Flow</b>									
9		indexed peak	For/BS	Rev/BS	l/min	RF	ratio		LEFT VENTRICULAR VOLUME	
10	AAO	3.15	3.15	0.00	5.73				Parameter	lue
11	DAO	2.29			4.17				Method:	-axis/30°
12	SVC	1.25			2.27				Body Surface Area	1.82 n
13	D+S	3.54			6.44				ED phase number:	20
14	dD+S	3.42			6.22				ES phase number:	7
15	dDAO	2.17			3.95				ED phase time:	650.75 n
16	IVC	1.92			3.49				ES phase time:	205.5 n
17	RPA	2.76	4.69	1.93	5.02	41.2	72		ED volume:	126.17 n
18	LPA	1.09	1.09	0.00	1.98		28		ED volume/BSA:	69.51 n
19	R+L	3.85	5.78	1.93	7.00	33.4			ES volume:	50.26 n
20	MPA	3.85	6.41	2.56	7.00	40.0			ES volume/BSA:	27.69 n
21	asinus	0.00	0.00	0.00					Stroke volume:	75.91 n
22	AoV	0.00	0.00	0.00					Stroke volume/BSA:	41.82 n
23	LVOT	0.00	0.00	0.00					Cardiac output:	6.65 l/min
24	RUPL	1.41			2.56				Ejection fraction:	60.17 %
25	RLPV	1.54			2.81				LV mass ED:	90.47 g
26	LUPV	0.26			0.48				LV mass ED/BSA:	49.84 g
27	LLPV	0.83			1.51				LV mass ES:	97.53 g
28	RPV	2.95			5.37		73		LV mass ES/BSA:	53.73 g
29	LPV	1.09			1.99		27			
30	PV	4.04			7.36					
31	azugos	0.00							RIGHT VENTRICULAR VOLUME	
32	azugos2	0.00							Parameter	lue
33	SVC-azygo	0.00							Method:	-axis/30°
34	QpQs a	1.13							Body Surface Area	1.82 n
35	QpQs v	1.28							ED phase number:	20
36	EA w MV	3.21	normal		5.84				ES phase number:	7
37	EA w TV	2.96	delay 20-30 ms		5.39				ED phase time:	650.75 n
38	LV								ES phase time:	205.5 n
39	LV mass ED/BSA:	50	[46 - 84]						ED volume:	285.04 n
40	ED volume/BSA:	69	[52 - 112]						ED volume/BSA:	157.03 n
41	ES volume/BSA:	28							ES volume:	166.5 n
42	Stroke volume/BSA	42							ES volume/BSA:	91.73 n
43	Ejection fraction:	60	[55 - 74]						Stroke volume:	118.54 n
44	Cardiac index	3.65							Stroke volume/BSA:	65.3 n
45	RV								Cardiac output:	10.38 l/min
46	ED volume/BSA:	157	[58 - 115]						Ejection fraction:	41.59 %
47	ES volume/BSA:	91							RV mass ED:	-
48	Stroke volume/BSA	65							RV mass ES:	-
49	Ejection fraction:	42	[47 - 63]							
50	Cardiac output:	10.38								
51	RV cardiac index	5.70								



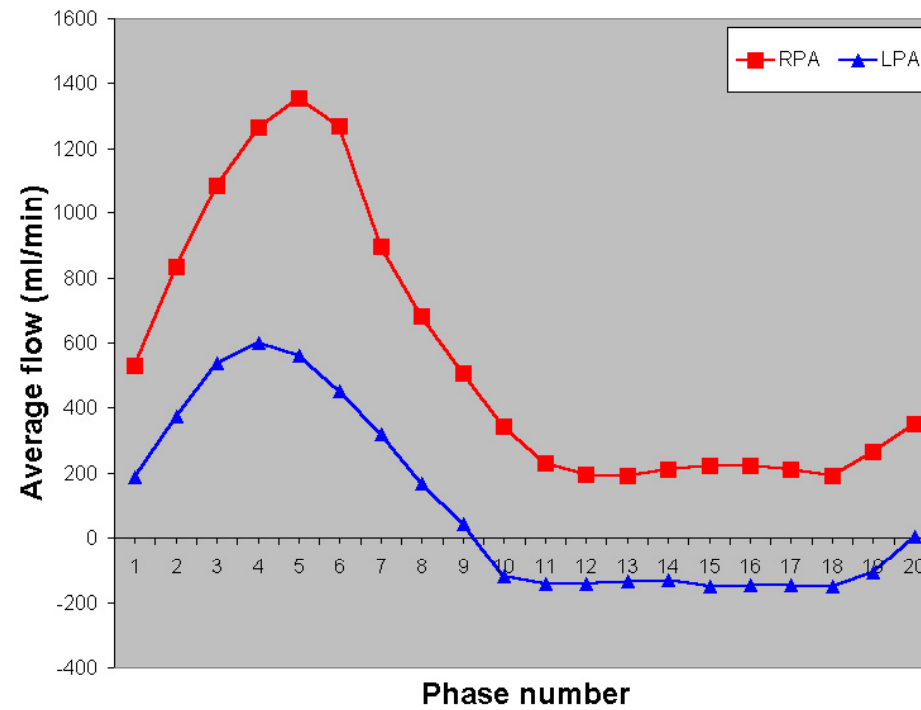
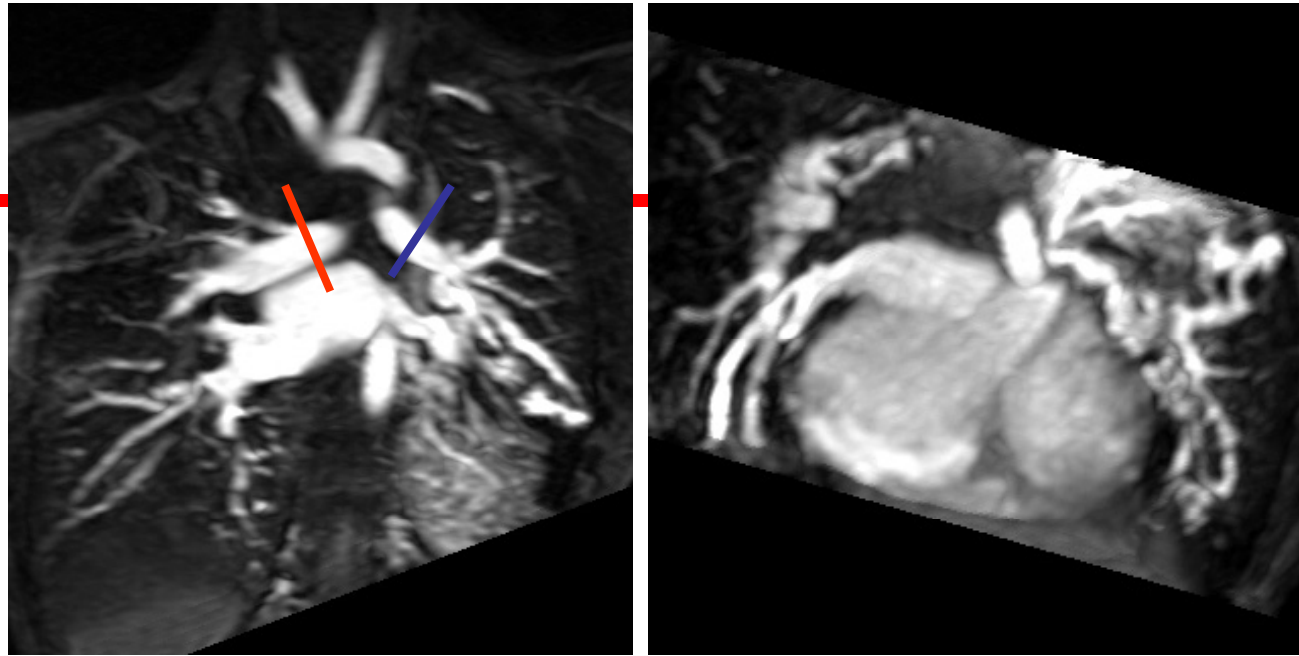
# Brief study for QpQs

1							Patient name:	
2	Weight	18.2					Patient ID:	
3	Height	112.0					Patient gender:	
4	BSA(m <sup>2</sup> /Mass)	0.75	BSA(cal)	0.75			Birth date:	
5	Heart rate	#DIV/0!					Patient weight:	kg
6							Patient height:	cm
7								
8	Flow							
9		indexed peak	For/BS	Rev/BS	l/min	RF	ratio	LEFT VENTRICULAR VOL
10	AAO	4.40	4.40	0.00	3.3			
11	DAO	2.13			1.6			Parameter
12	SVC	2.93			2.2			Method:
13	D+S	5.07			3.80			Body Surface Ar 0.75
14	dD+S	5.07			3.80			ED phase number:
15	dDAO	2.13			1.6			ES phase number:
16	IVC	0.00						ED phase time:
17	RPA	7.73	7.73	0.00	5.8	62		ES phase time:
18	LPA	4.67	4.67	0.00	3.5	38		ED volume:
19	R+L	12.40	12.40	0.00	9.30	0.0		ED volume/BSA:
20	MPA	0.00	0.00	0.00				ES volume:
21	asinus	0.00	0.00	0.00				ES volume/BSA:
22	AoV	0.00	0.00	0.00				Stroke volume:
23	LVOT	0.00	0.00	0.00				Stroke volume/BSA:
24	RUPL	0.00						Cardiac output:
25	RLPV	0.00						Ejection fraction:
26	LUPV	0.00						LV mass ED:
27	LLPV	0.00						LV mass ED/BSA:
28	RPV	0.00		0.00		###		LV mass ES:
29	LPV	0.00		0.00		###		LV mass ES/BSA:
30	PV	0.00		0.00				
31	azugos	0.00						RIGHT VENTRICULAR VO
32	azugos2	0.00						
33	coA	0.00						Parameter
34	QpQs a	2.45						Method:
35	QpQs v	0.00						Body Surface Area:
36	EA w MV	0.00						ED phase number:
37	EA w TV	0.00						ES phase number:
38	LV							ED phase time:
39	LV mass ED/BSA:	0	[46 - 84]					ES phase time:
40	ED volume/BSA:	0	[52 - 112]					ED volume:
41	ES volume/BSA:	0						ED volume/BSA:
42	Stroke volume/BSA:	0						ES volume:
43	Ejection fraction:	0	[55 - 74]					ES volume/BSA:
44	Cardiac index	0.00						Stroke volume:
45	RV							Stroke volume/BSA:
46	ED volume/BSA:	0	[58 - 115]					Cardiac output:
47	ES volume/BSA:	0						Ejection fraction:
48	Stroke volume/BSA:	0						RV mass ED:
49	Ejection fraction:	0	[47 - 63]					RV mass ES:
50	Cardiac output:	0						
51	RV cardiac index	0.00						
52								



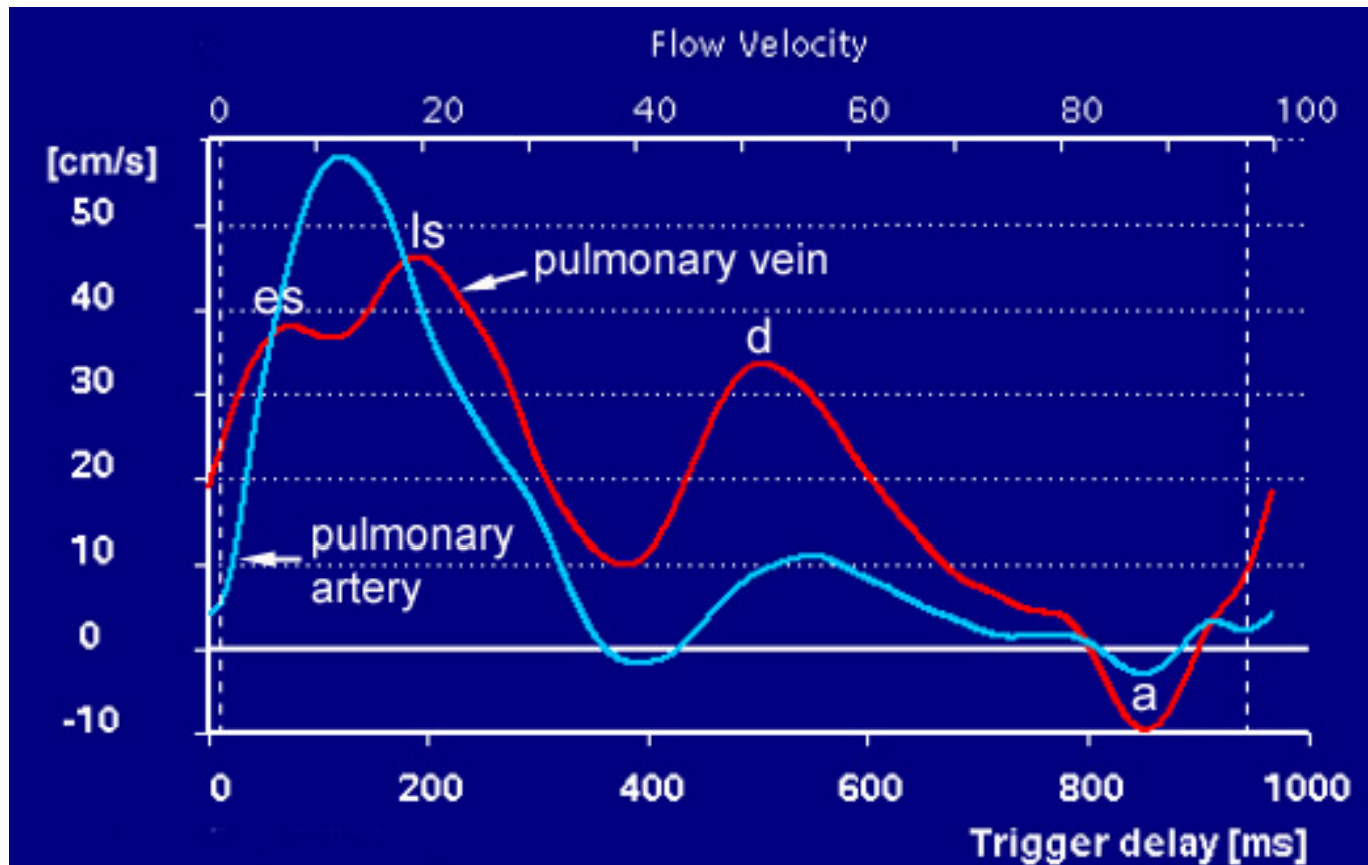


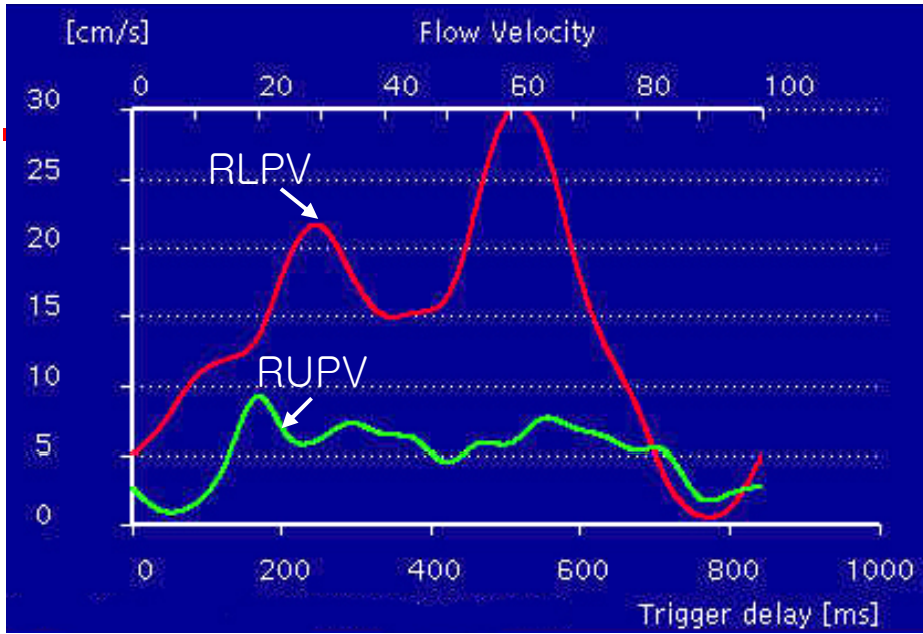
Estimated volume of anomalous PV drainage  
= 1728.6 ml/min

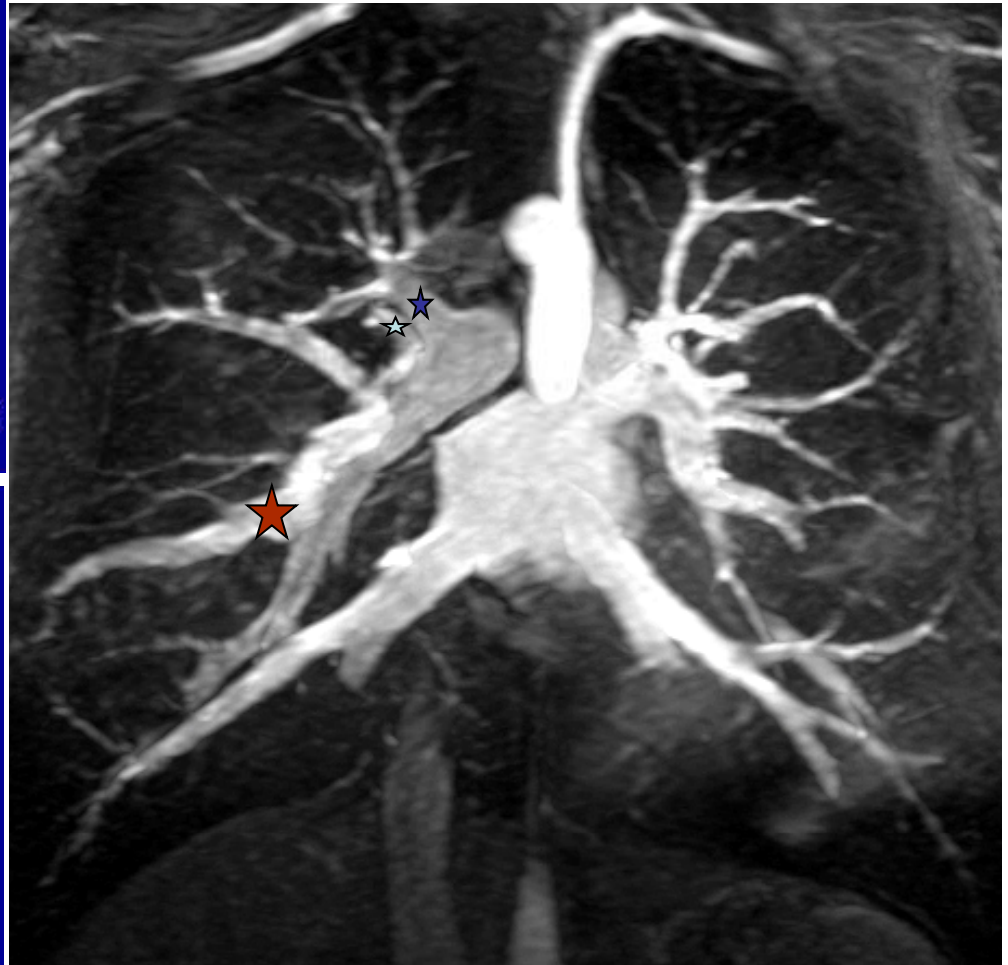
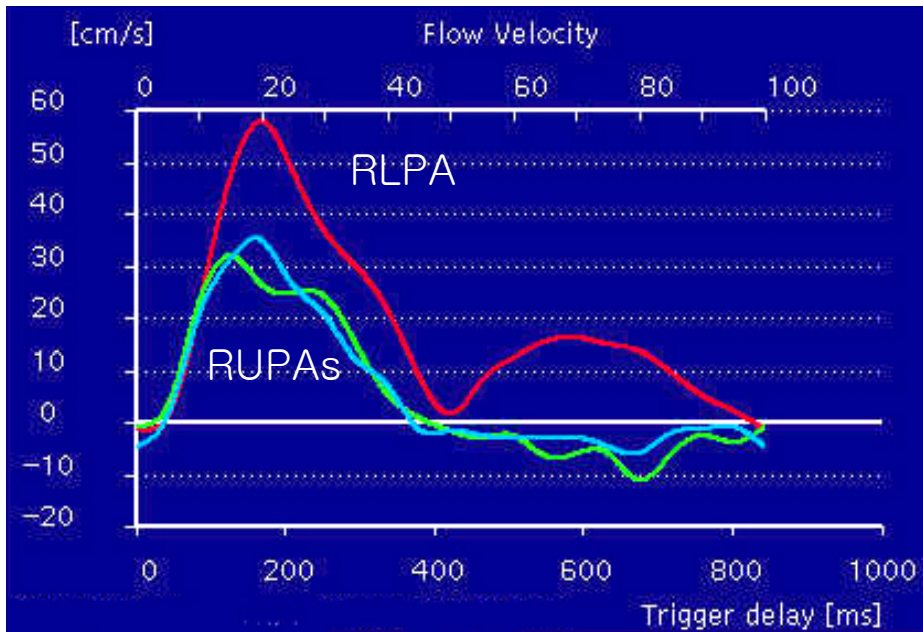
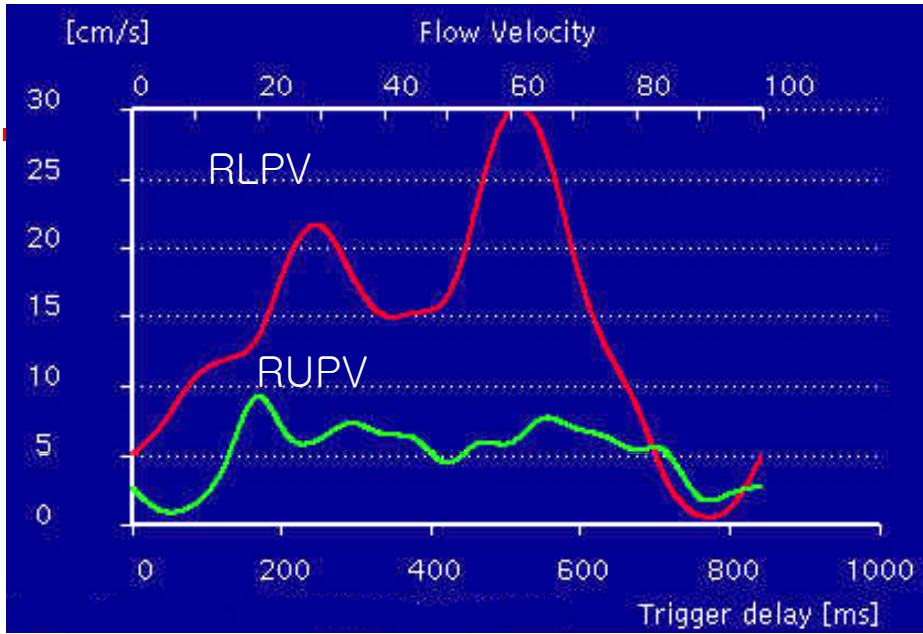


# Normal flow pattern of PA and PV

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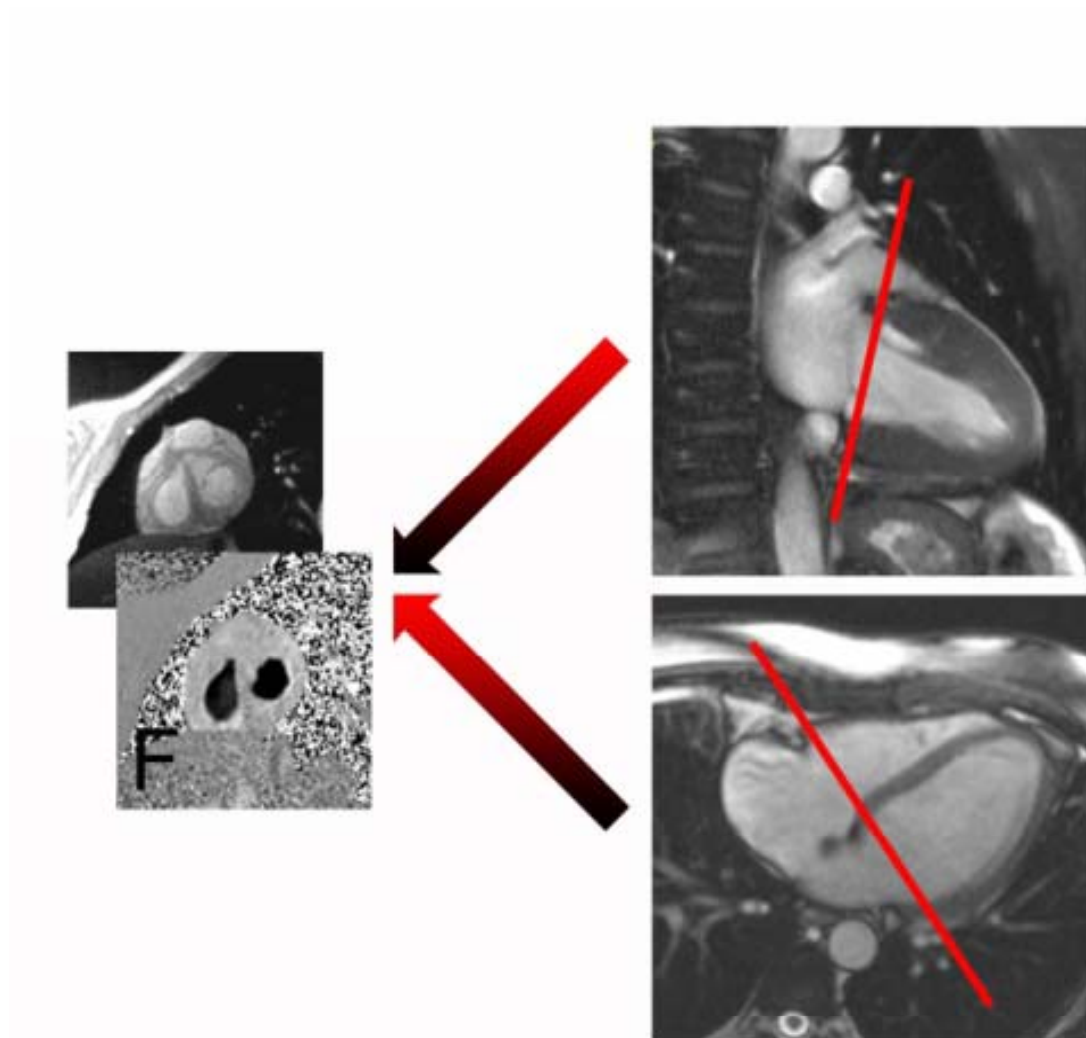


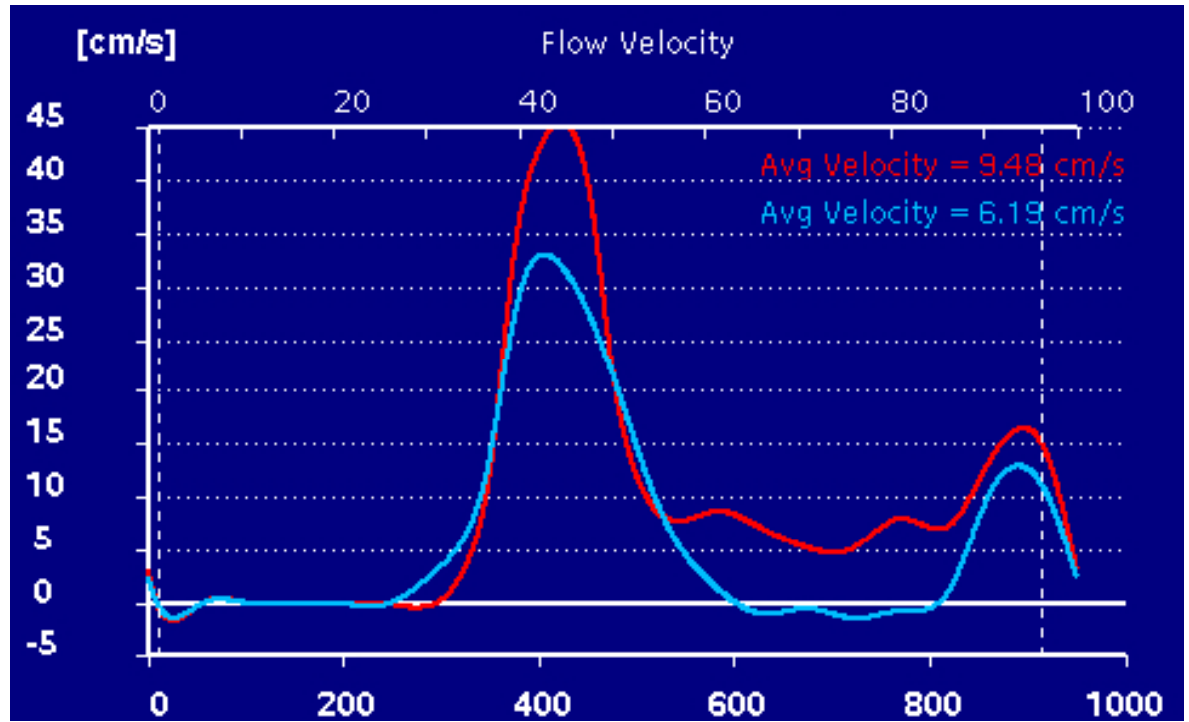
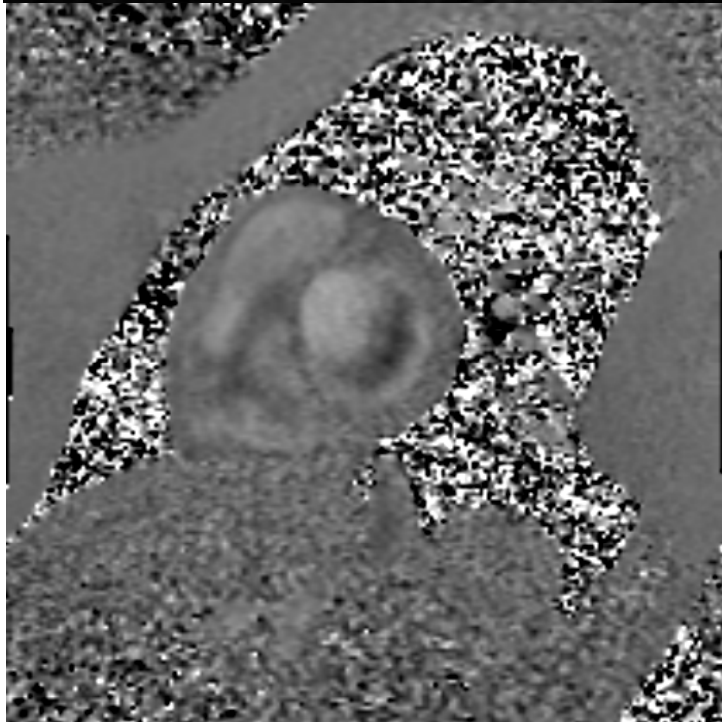
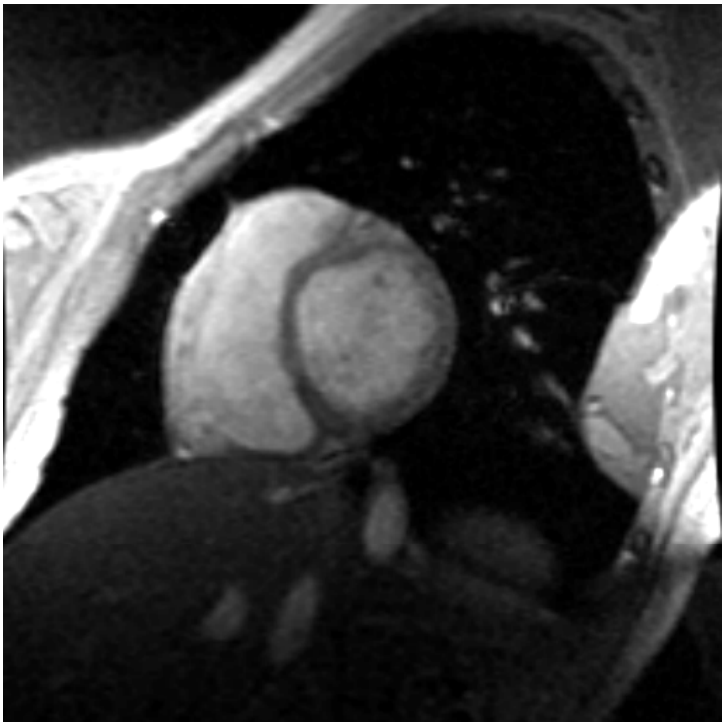


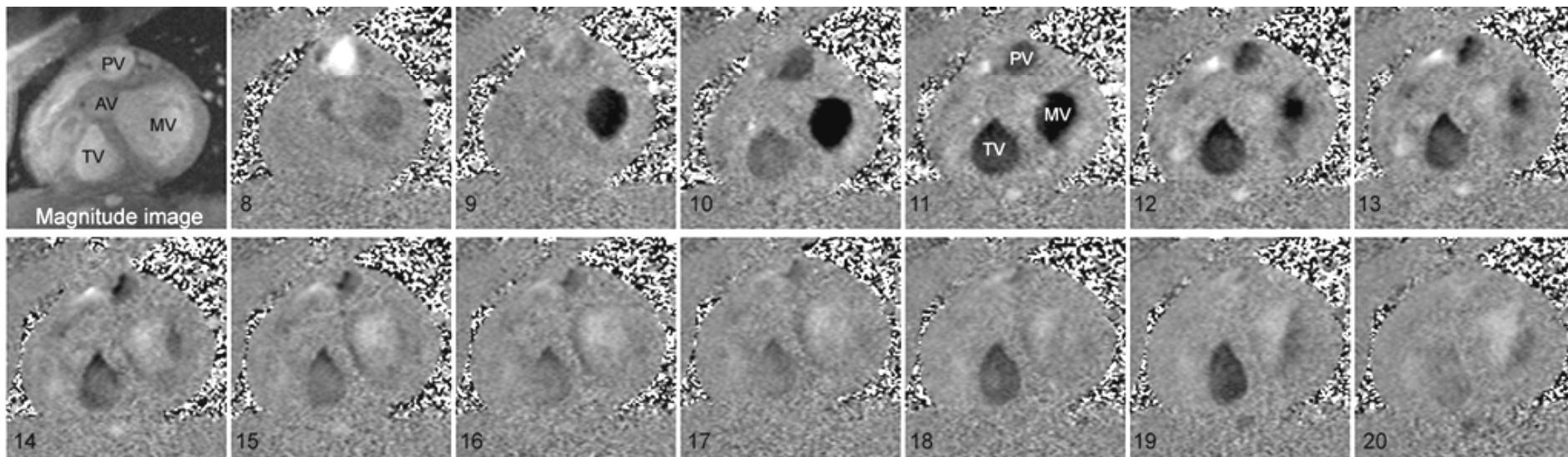
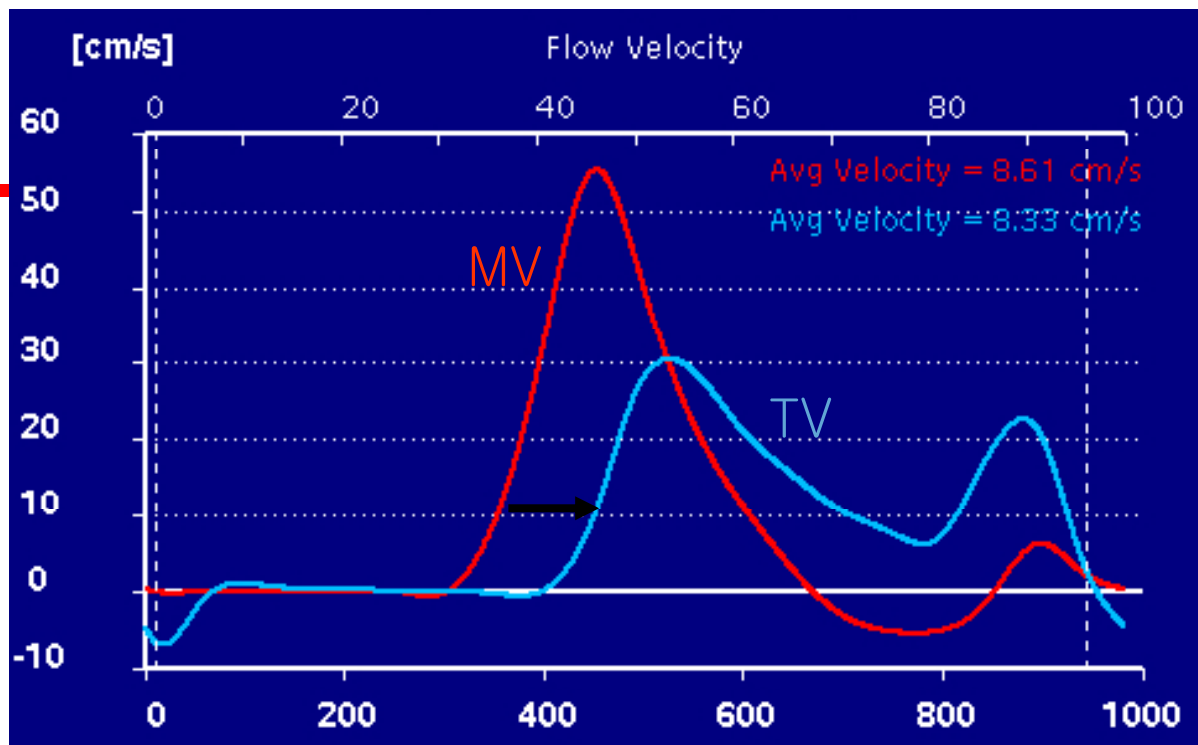


# Flowmetry at AV valve

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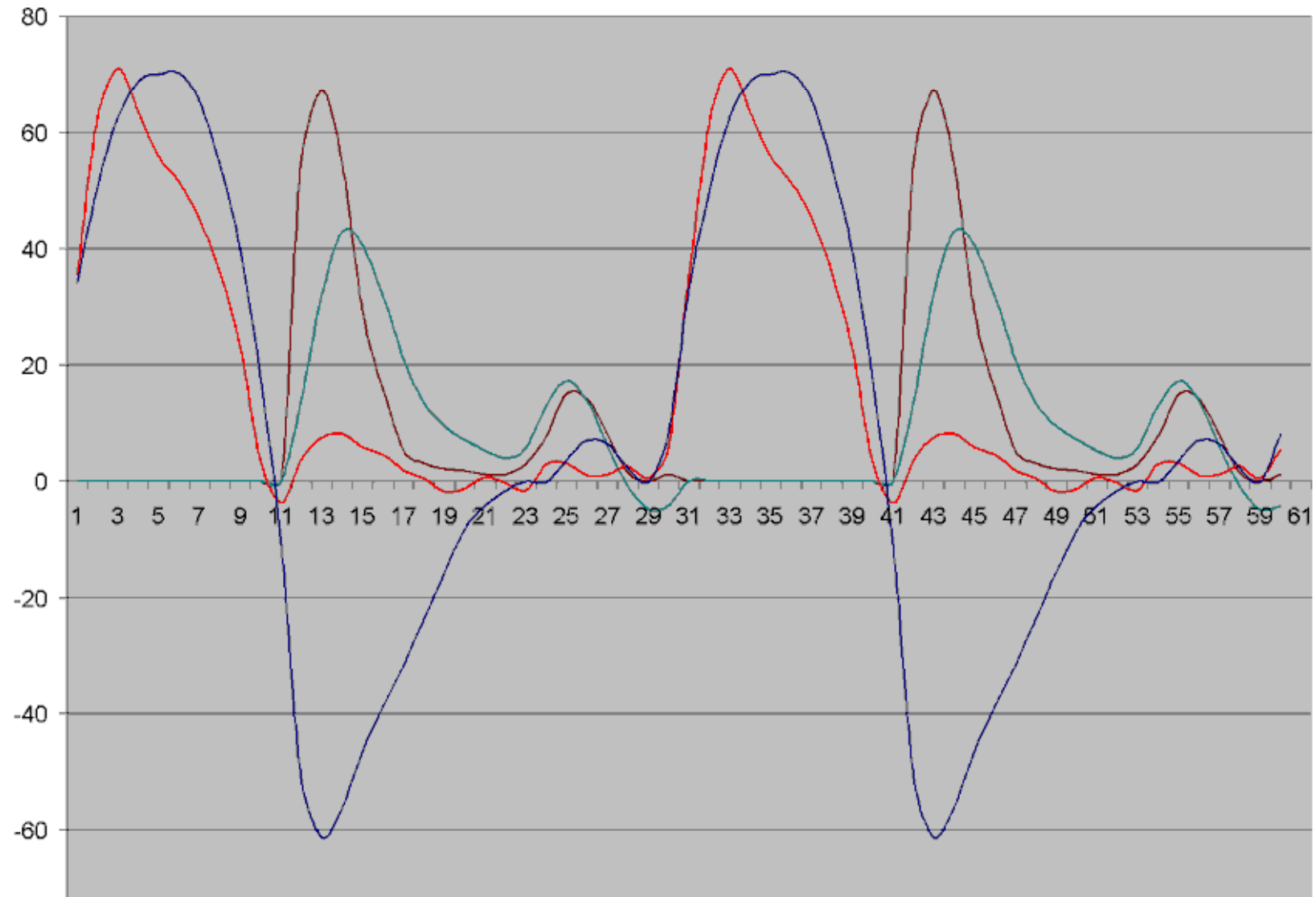






# Post OP TOF

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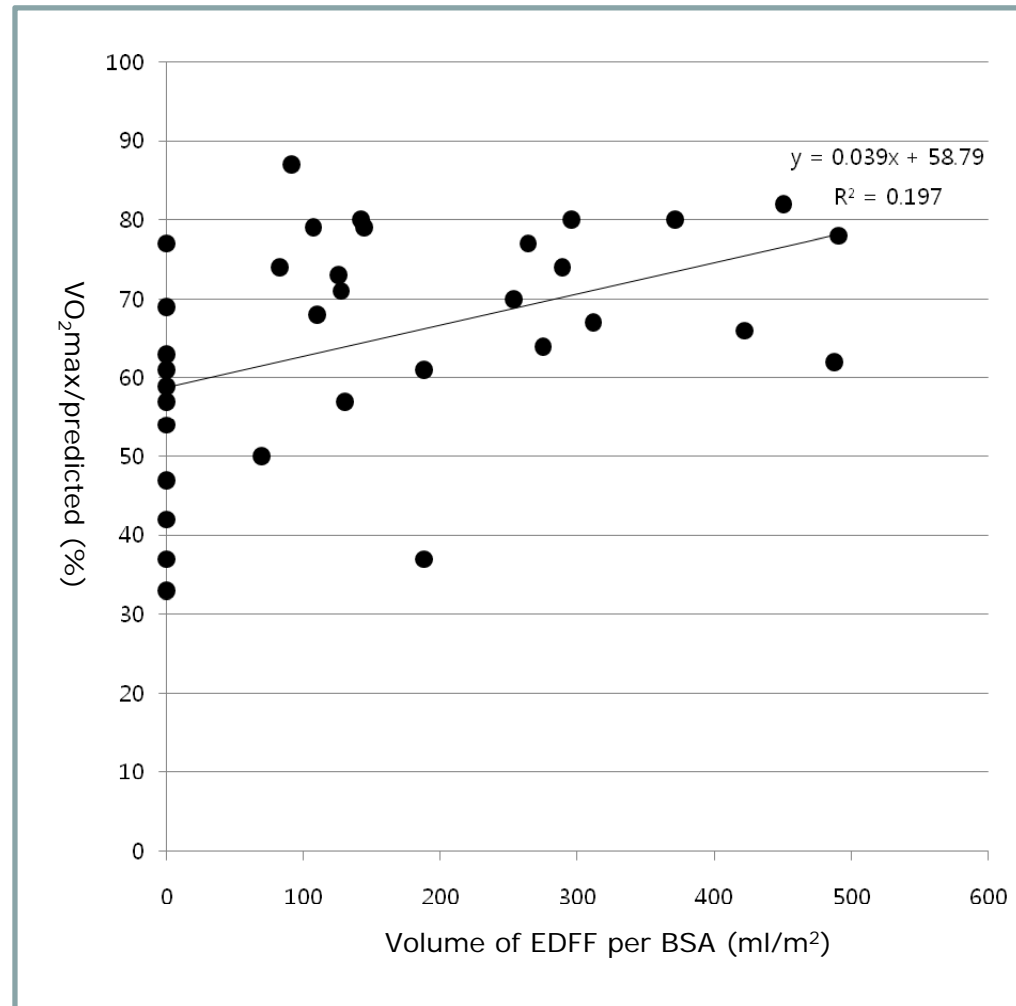
# EDFF in Repaired TOF

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- End diastolic forward flow(EDFF) is thought to be a sign of restriction to RV filling
- Reports have been equivocal on long-term clinical state or exercise tolerance in repaired TOF patients
- Gatzoulis MA, Redington AN, et al. *Circulation* 1995;91:1775–1781.
  - patients with EDFF had
    - shorter PR duration
    - less cardiomegaly
    - better exercise capacity
  - protective effect of restriction to RV filling
- Berg J, Helbing WA, et al. *Radiology*: Volume 243;1:212–219
  - patients with EDFF had
    - more severe PR
    - worse exercise capacity

# Relation of $\text{VO}_2\text{max}$ to EDFF

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# Applications of VENC

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- Valvular regurgitation
- Blood flow distribution
- Shunt amount ,  $Q_p/Q_s$
- Stroke volume, cardiac output
- Diastolic function of the ventricles
- Collateral blood flow
  - Coarctation of aorta
  - After BCPC, Fontan operation
  - Pulmonary vein obstruction
- Pulmonary hypertension

# Cardiac MRI for CHD

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- Cine
  - Ventricle function and volume
- MR angiography
  - Good vascular anatomy study
- Delayed enhancement of myocardium
  - Infarct or damaged myocardium
- Perfusion
  - Rest and stress
  - Coronary artery flow reserve
- Flow-metry
  - Flow volume and flow wave form analysis



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Thank You !