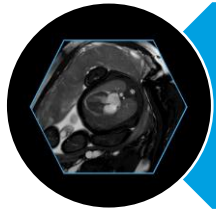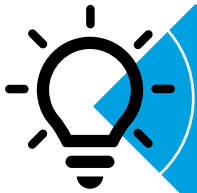# Section 3 - How to adapt sequences and optimize images

3.1 BFFE Cine Setup

3.2 Flow quantification

3.3 Tips & tricks and Challenges

3.4 Common pitfalls and artifacts

Flow quantification

1. Cardiac Flow Quantification (Qflow)
Different techniques are used to quantify blood flow throughout the cardiac cycle in different heart phases.

Aim: Evaluation of Blood flow in the heart & great vessels, valvular regurgitation and complex flow pattern (CHD). Sequences that can be used: *2D QFlow & 4D Flow*.

### 1.1 2D QFlow Setup

➢ **Planning**
Pediatric cardiac scans associated with CHD often require Qflow scan to support the diagnosis. There are many anatomy variations in CHD therefore a correct planning of the sequences is important:

- Choose the appropriate imaging plane <u>perpendicular to the direction of flow</u>.
- Consider <u>orthogonal acquisition</u> to define the peak velocity.
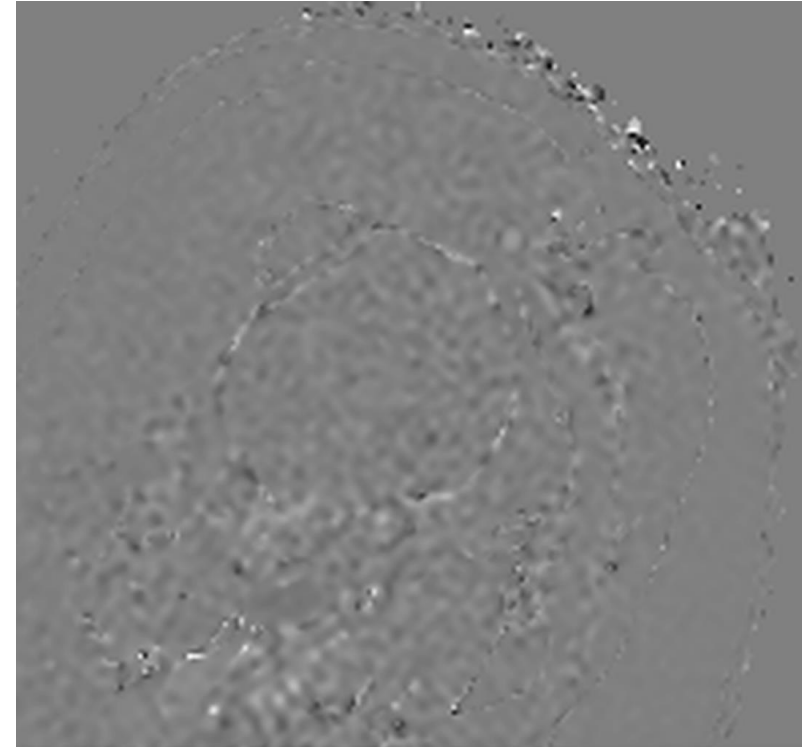- Set required <u>direction of flow (Qflow directions</u>).

Magnitude (FFE/M)

phase (PCA/P)

velocity →

← anatomy
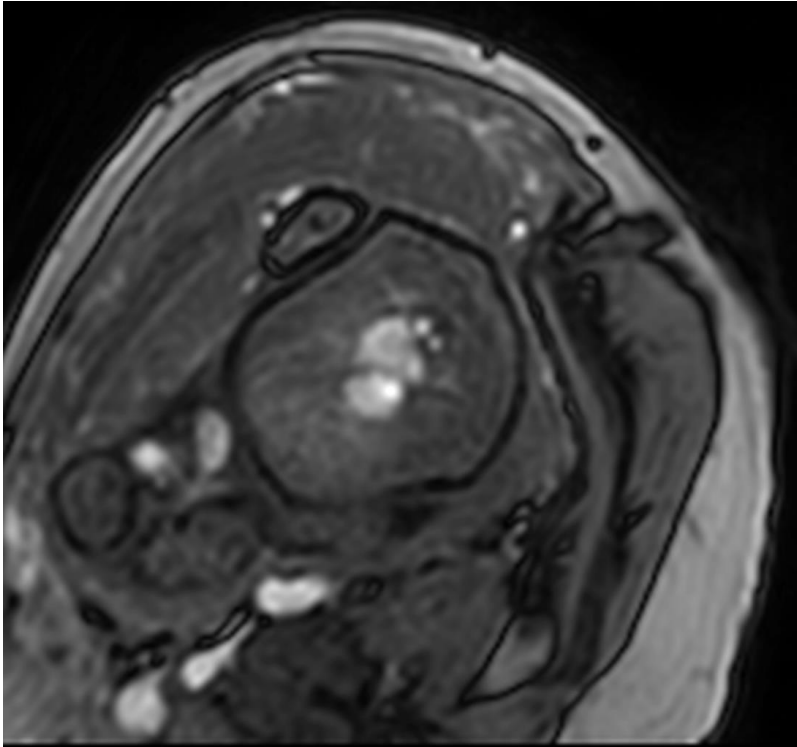
Limitations

- Often difficult to plan
- ❖ Only 1 flow direction (⊥ On slice)

➢ **Velocity Enconding (VENC) Settings**

Important steps:
1. Choose appropriate VENC.
2. Depending on which region will be measured. Use normal value VENC as a starting point.

<u>Adult</u> settings:
- Normal aortic flow: 150cm/s
- Normal pulmonary flow: 100cm/s
- Adjust in pathological situations (severe valve stenosis > 400cm/s)

Normal reference VENC values for <u>Pediatric</u> scanning:

Settings	VENC(cm/s)
As-Ao	150
De-Ao	250
SVC	70
IVC	100
mPA	200
Rt-PA	200
Lt-PA	200
Rt-PV	150
Lt-PV	150

Note: Normal reference VENC values for pediatric scanning.

➢ *Sequences:*

2D Qflow Breath hold(BH) – Gold standard
- *Cardiac synchronization = Retrospective*
- *Temporal Resolution = At least 16 heart phases to cover the entire RR interval*
- *Modulus Image and Phase contrast image*

2D Qflow Free Breathing(FB)
- Used when it is not possible to hold the breath
- Use Multiple NSA/Average/NEX to average motion

➢ *2D Qflow MRI Sequences Parameters*

| Parameters |
|---|
| **TE** = 2.9 ms |
| **TR** = 4.6 ms, |
| **FOV** = 280x230 mm, |
| **FA** = 10° |
| **slice thickness** = 5 mm |
| **Acquired voxel size** = 2.5 × 2.5× 5 mm |
| **Reconstructed voxel size** = 1.17 × 1.17 × 5 mm |
| **Cardiac phases** = 35, |
| **VENC factor** = 120 cm/s |
| **NSA** = 1. |

> *Challenges of 2D QFlow sequences*

Check VENC settings
- Too low: flow aliasing artefacts
- Too high: underestimating velocity (grey flow)
- Correct direction of flow (Right-Left, Foot-Head)
- Flow assessment: perpendicular to the vessel

| Venc too low = 100 + Aliasing | Venc ok = 200 + darknest signal | Venc too high = 300 + gray signal |
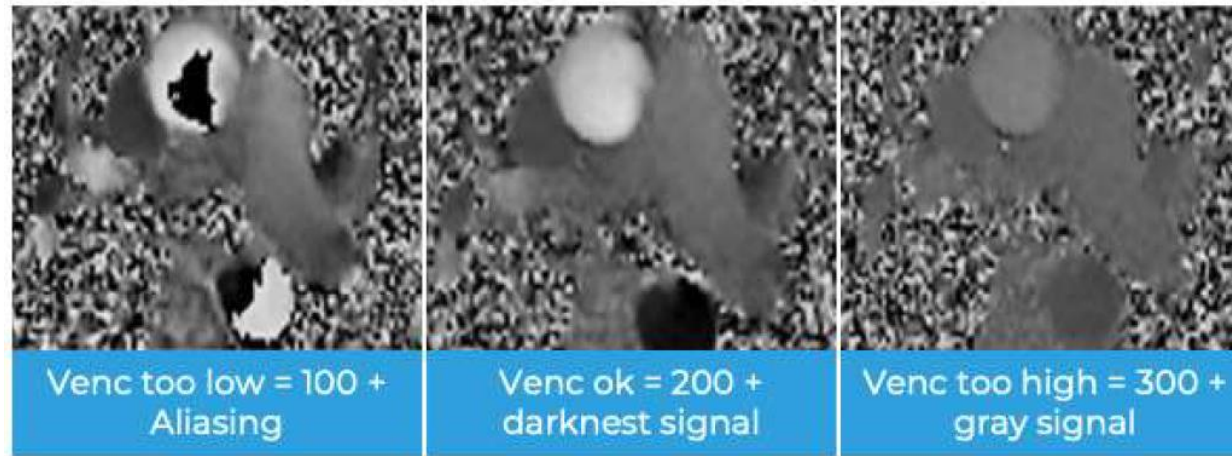
Avoid underestimation of velocities. Check adequate temporal resolution (phases)
- Free-breathing acquisition: 30 phases
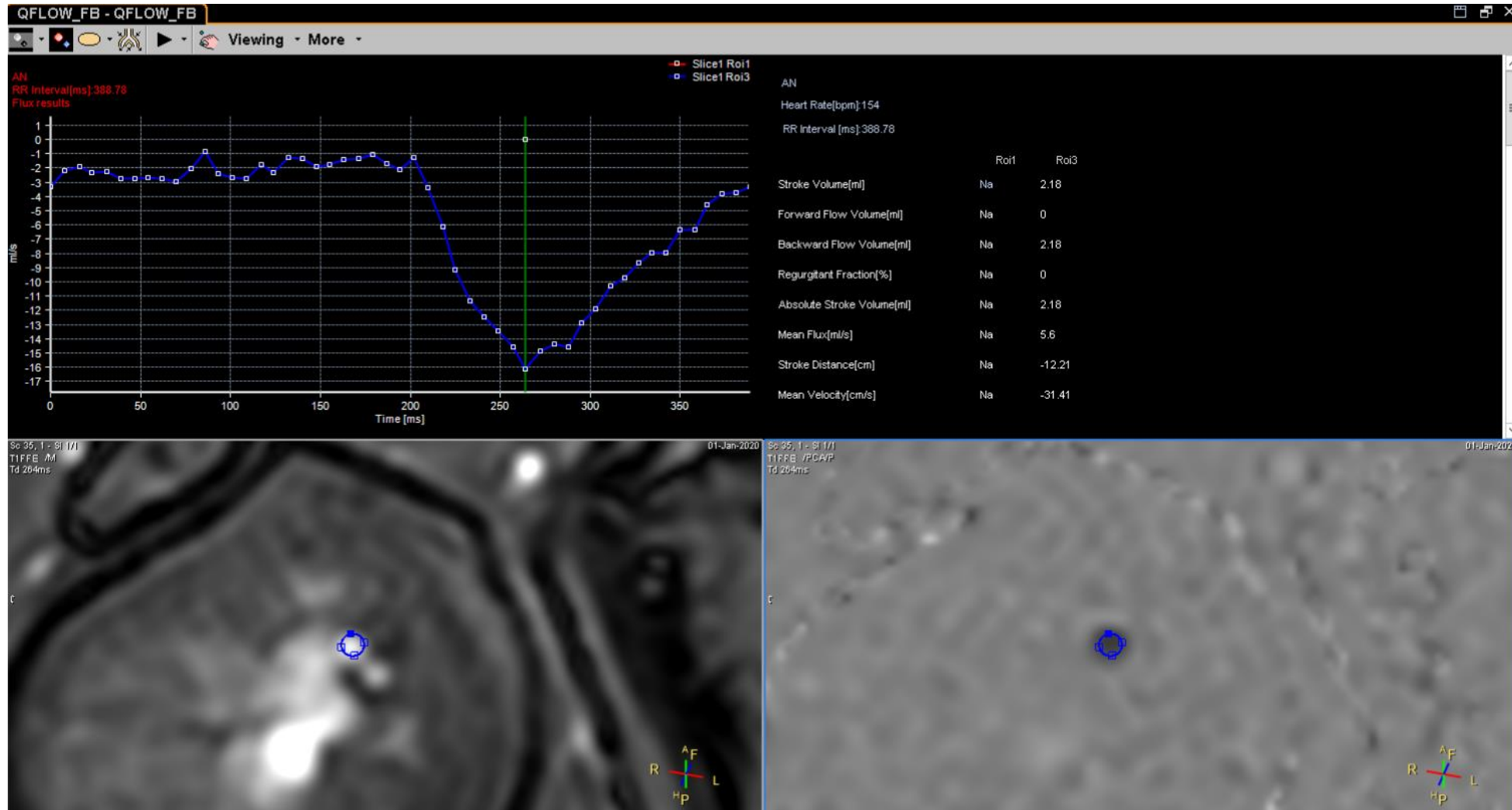- Breath-hold acquisition: 20-25 phases

Rotate FOV
- Orthogonal to the direction of flow

2D QFlow Analysis

Flow quantification

1. Cardiac Flow Quantification (Qflow)
Different techniques are used to quantify blood flow throughout the cardiac cycle in different heart phases.

Aim: Evaluation of Blood flow in the heart & great vessels, valvular regurgitation and complex flow pattern (CHD). Sequences that can be used: *2D QFlow & 4D Flow.*

1.2 4D Flow Setup
It is called 4D flow because the acquisition is:
3D sequences + triggering (retrospective) = 3D time-resolved = 4D

Advantage over 2D

- Very easy to plan
- Flow in all direction
- 3D coverage

Challendes - Imaging

- Long scan time (▸ 2min)
- Big amount of data
- Motion sensitivity
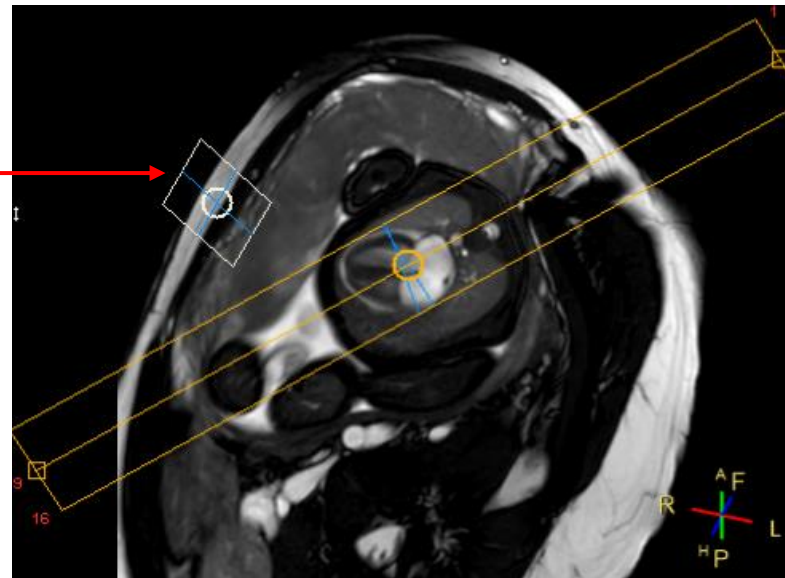
➤ *Consideration 4D flow sequences*

Planning
- 4D flow MRI sequence is usually acquired over the entire fetal cardiac cycle in **parasagittal orientation and parallel to the aortic arch,** with full volumetric coverage of the fetal great thoracic vessels (see *Section 2 - How to plan sequences*).

MRI Motion artifacts (Respiratory) and possible solution
- The pregnant women were advised to breathe shallowly to minimize motion artefacts during the scan. If available on your MRI system we can compensate the respiration using the Navigator (see image below).

Note: placed 2/3 of the Navigator package in the belly and 1/3 outside, in order to avoid mother's breath artefacts

Manual parameters adjustment

- Run your D4 flow sequence from your cardiac protocols considering slight cariations of the scan protocols, particularly in **FOV, spatial and temporal resolution.**

➢ *4D flow MRI Sequences Parameters:*

Parameters	Default & Average
TE	1.8–2.0 ms
TR = 2.9–4.0 ms	2.9–4.0 ms
FOV = 300 × 300	300 × 300
Acquired spatial resolution = 1.8 × 1.8 × 2	1.8 × 1.8 × 2mm3 to 2.5 × 2.5 × 2.5 mm3
Reconstructed voxel size	1.0 × 1.0 ×1.0mm3 to 1.25 × 1.25 × 1. 1.25 mm3
Number of slices	20–28 (depending on individual fetal anatomy)
Flip angle	5°
NSA	1–2
VENC in all three dimensions	120–200 cm/s
CS-Sense	4 to 6
Scan time	2:30 ± 1:25 min

4D flow images