

Knobology and Image Acquisition: How to Improve Images

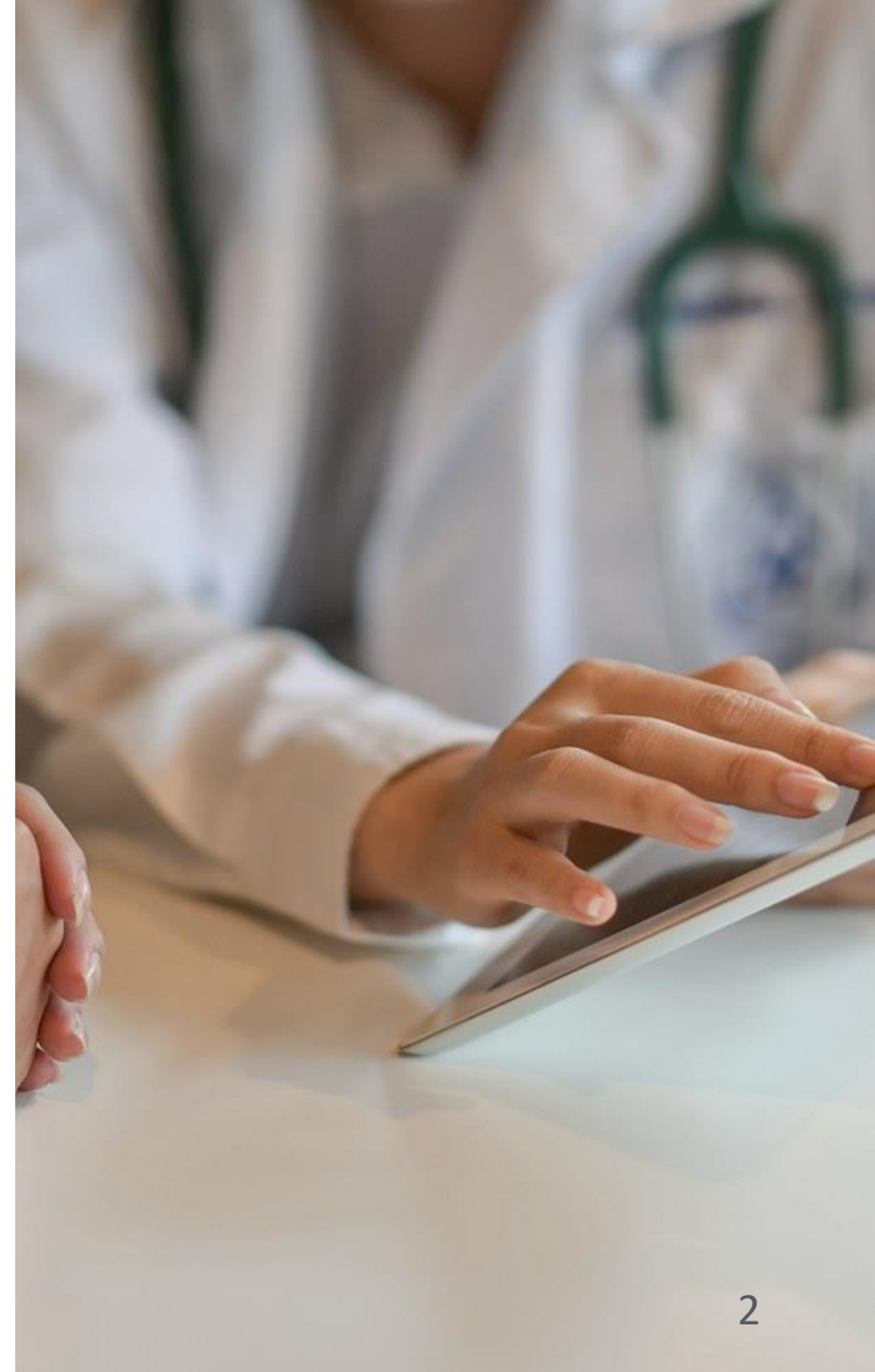
Diagnose first, then turn the knob. A systematic approach for sonographers, fellows, and MFM physicians.

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Disclosure

George Kennedy Antillon, RDMS, RDCS, RVT has no relevant financial relationships with ineligible companies to disclose.



Learning Objectives

1

Select probe, frequency, depth and sector width for the target

Predict what each choice costs in resolution, penetration and frame rate.

2

Separate acquisition from display processing

Explain what package settings and processing change, and what they cannot recover.

3

Apply: diagnose, change with a purpose, reassess

Troubleshoot B-mode, color and spectral Doppler, including MFM pitfalls such as wall filter and output.



The Framework: Diagnose, Acquire, Refine, Know Your Limits

1

DIAGNOSE

What is limiting the image?

- Spatial: axial, lateral, elevational
- Contrast
- Temporal (frame rate)
- Penetration

2

ACQUIRE

Change what is collected

- Probe
- Frequency and harmonics
- Depth
- Sector width
- Focus

3

REFINE

Change how it is displayed

- Gain and TGC
- Dynamic range
- Persistence
- Compounding and smoothing

4

KNOW YOUR LIMITS

Is the machine actually the problem?

- Window and patient position
- Scanning technique
- Ergonomics

Change with a purpose → reassess.

Processing can make an image look better. It cannot recover information that was never acquired.

Name the limitation before you touch a control

Limitation	What governs it	First controls	What it costs
Axial	Pulse length (frequency)	Higher frequency; harmonics	Penetration
Lateral	Beam width at the target	Focus on the target; narrow the sector; higher frequency	Frame rate; penetration
Elevational	Slice thickness (probe design, focus)	Center the target at the focus; change window or probe	Few controls: mostly geometry
Contrast	Gray-scale separation of tissues	Harmonics; dynamic range; TGC and gain; compounding	Edge detail; speckle texture
Temporal	Frame rate	Less depth; narrower sector; fewer focal zones; lower persistence	Coverage; lateral detail

Every control buys one kind of resolution and spends another.

Choose the probe and frequency for the target

Three questions before any control

- 1 How deep is the target?
- 2 How much detail does the question need?
- 3 What's my window, and how much do I need to see?

Frequency is the trade

Higher

Superficial or early-gestation targets, endovaginal. Best detail, shallowest reach.

Balanced

Standard anatomy survey, curvilinear probe. Most routine work lives here.

Lower

Deep targets, high maternal BMI, late gestation. Best reach, coarser detail.

Don't maximize frequency. Optimize it: the highest that still reaches the target.

Depth: End the Image Just Below the Target

What to do

Set depth so the target sits mid-image with a little tissue below it.

What you gain

Higher frame rate, and sometimes room for a higher frequency.

Cost: cut too far and you lose landmarks below the target.



17.2 cm: more tissue than the target needs. 60 Hz.



10.7 cm: depth matched to the target. 81 Hz.

Same fetus, same preset, same 30° sector. Less depth gave 21 more frames per second.

Sector width: Spend Scan Lines on the Target

What to do

Start wide to find the anatomy, then narrow once you have it.

What you gain

The same scan lines cover less tissue: better line density and frame rate.

Cost: lost context. Widen again when the question is about relationships.



Wide, 90°: orient and survey. 35 Hz.



Narrow, 30°: target the structure. 81 Hz.

Package settings: One Button, Several Trades

	You gain		You pay
Penetration mode	Deeper visualization	↔	Less fine detail
Harmonics	Better contrast, less clutter	↔	Less penetration
Frequency	Detail	↔	Penetration
Zoom (ROI)	Detail in the region	↔	Narrower field of view
Heavier processing	Smoother appearance	↔	Fine detail lost

Names aren't standardized. Don't memorize the button; know what the mode does to your image.

Better looking is not more information



Smoothing and speckle reduction change how an image looks, not what was acquired.

Too little processing

Noise and clutter hide real structures.

Too much processing

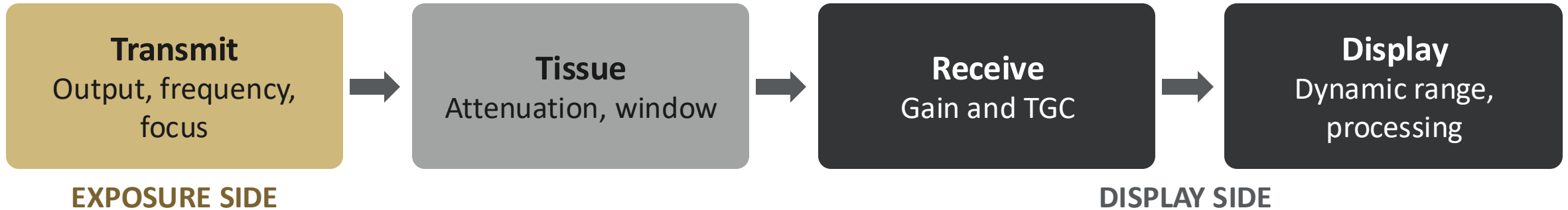
Subtle borders and textures are smoothed away.

Too much persistence

Frame averaging cleans a static image but blurs a beating heart.

Processing should refine a good acquisition, not rescue a poor one.

Better images can cost more exposure



Gain and TGC

- Amplify returning echoes
- Change brightness, not exposure
- Easy to try, easy to overuse

Output power

- Adds energy to the patient
- Can recover penetration; raises TI and MI
- Presets change it: read TI and MI on screen
- Early gestation: Doppler only when indicated, TI low (ALARA)

When the image still isn't right, ask why



Acquisition?

Probe, frequency, depth, sector width, focus



Window?

Patient position, scan approach, maternal habitus, fetal position



Display?

Gain, TGC, dynamic range, processing



Technique?

Probe pressure, stability, fatigue, ergonomics

**Change with a purpose.
Then reassess.**

Hard window or high BMI?

Reposition the patient, move the window, wait for fetal position, and lower the frequency before reaching for gain or pressure. If detail is still poor, consider a speed-of-sound adjustment.

A hidden assumption: Speed of Sound

1540 m/s

What the machine assumes in every tissue

vs

1450–1490 m/s

Fat and fluid-filled tissue run slower

Assumed speed is wrong

The system uses 1540 m/s even when the path is slower tissue.



Focus lands off target

Echo timing and focusing are calculated from the wrong speed.



Lateral detail blurs

The image looks soft, and gain cannot bring it back.

Most likely to matter: high BMI and thick subcutaneous fat.

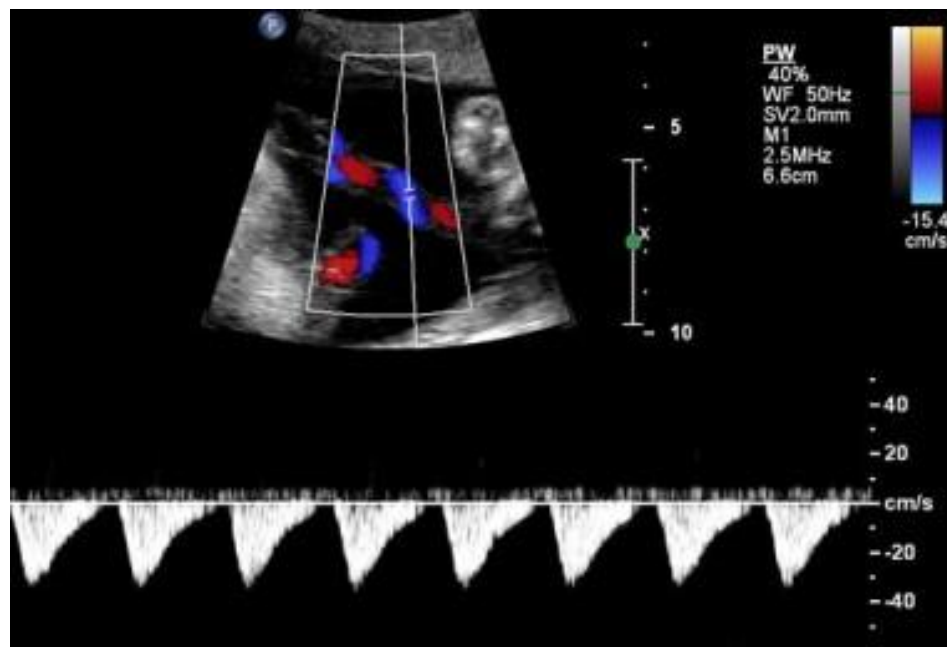
Many systems offer a speed-of-sound adjustment (GE calls it OTI). Displayed geometry depends on the speed used.

Color Doppler: Fix Acquisition Before Gain

- 1 Scale / PRF** Match to expected velocity. Too high hides slow flow; too low aliases.
- 2 Color box** As small as practical. A large box costs frame rate.
- 3 Wall filter** Low enough to keep the slow flow you need to see.
- 4 Angle** Steer or reposition so the beam is not perpendicular to flow.
- 5 Gain** Last. Raise until noise appears, then back off.

Optimize for true flow, not maximum color.

Spectral Doppler: Optimize for Accuracy



Size the waveform to the question; keep the background clean.

Gate

Sit on the vessel and size it to the vessel.

Angle

Keep it low (60 degrees or less).

Scale / baseline

Size the waveform to fill the display without clipping.

Sweep speed

Faster to resolve timing; slower to show several cycles.

Gain

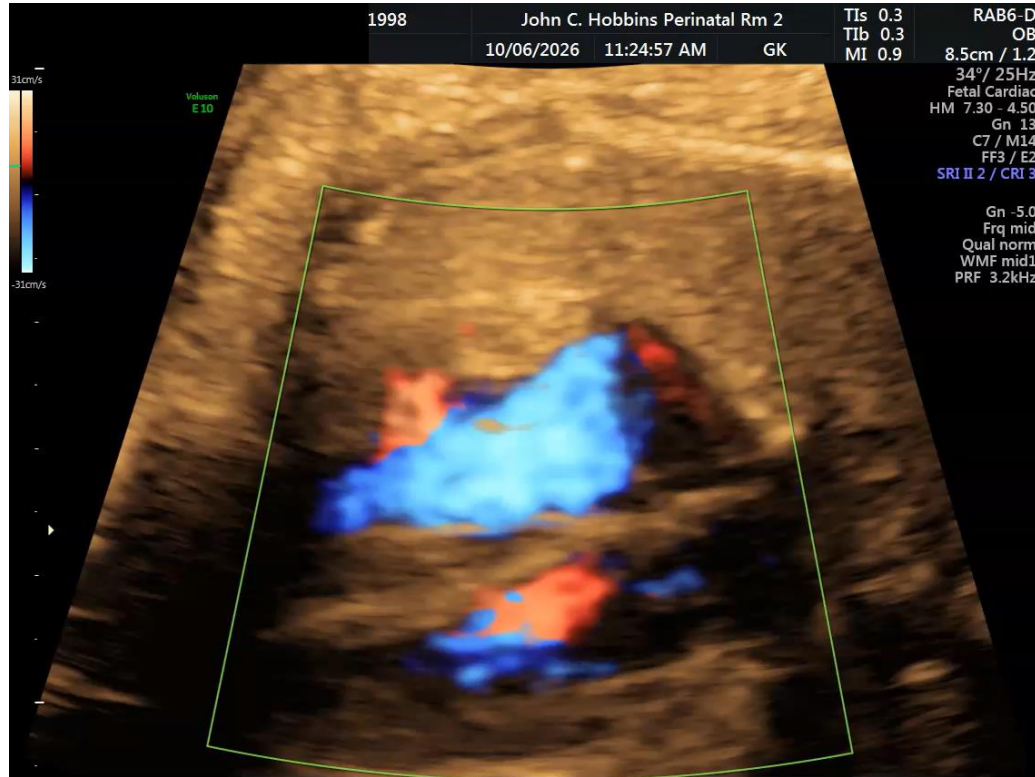
Define the envelope, not the background.

Wall filter

As low as the noise allows.

Before calling absent end-diastolic flow, check the wall filter, scale and gain. An aggressive filter can erase slow diastolic flow.

Fetal heart: Frame Rate First, Then Detail



Match the settings to the diagnostic question.

1

Narrow the sector

Once the heart is localized. Temporal resolution is the priority.

2

Cut depth and focal zones

Fewer, shallower scan lines per frame. Keep persistence low.

3

Zoom at acquisition

Use write or HD zoom for valve detail, not magnified stored pixels.

4

Color: box, scale, then gain

Small box, PRF matched to cardiac velocities, gain last.

Four ways experts compensate instead of fix



Make it brighter

instead of fixing acquisition



Make it smoother

instead of recovering information



Push harder

instead of changing the window or your posture

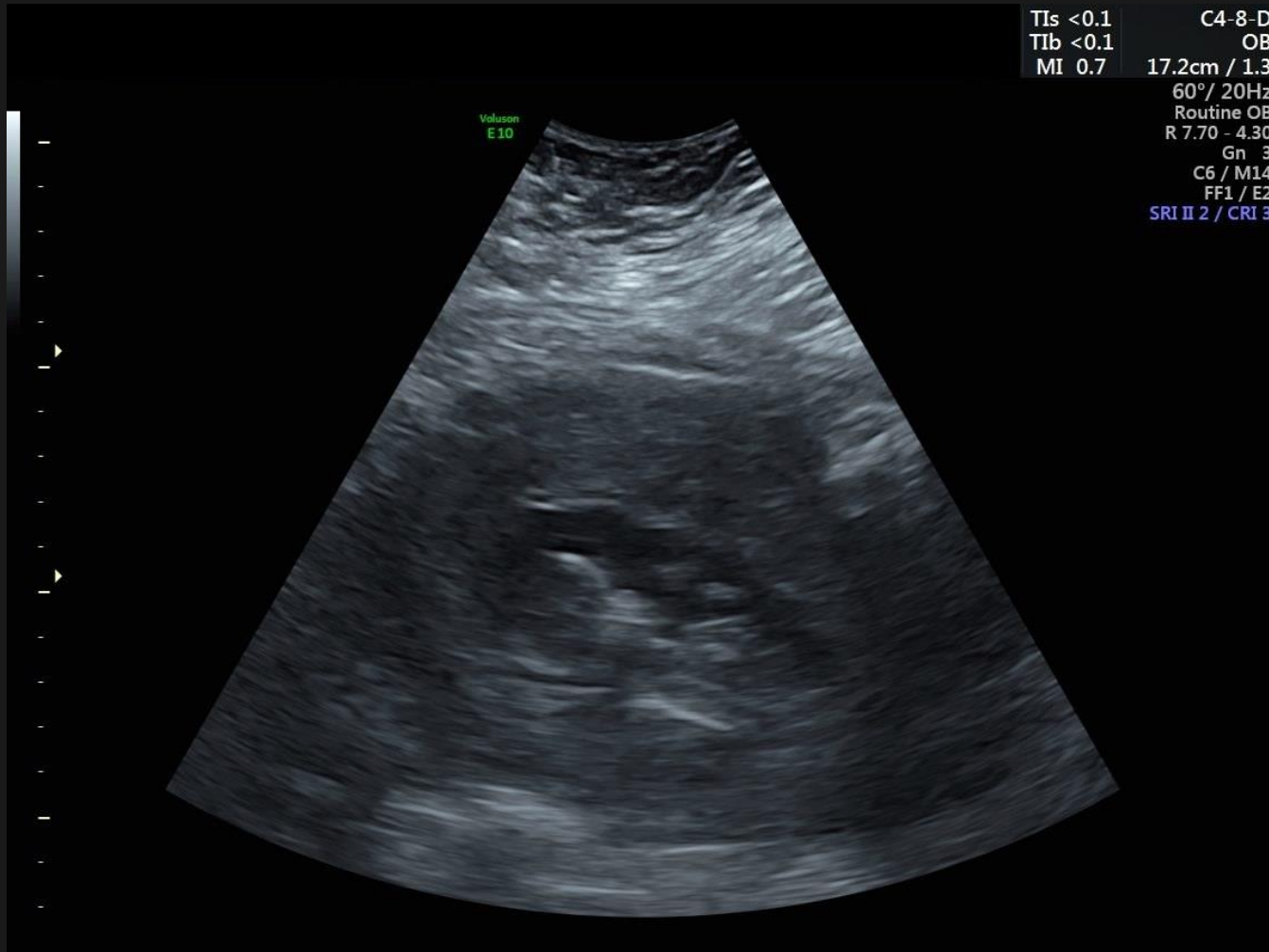


Change things at random

instead of changing with a purpose and reassessing

Expertise means adapting technique, not lowering expectations.

Case 1: Early-Gestation Profile



Before you touch a control

What is limiting this image?

Depth

Sector

Frequency

Gain

Window

Preset

What would you change first?

1 Diagnose

2 Acquire

3 Refine

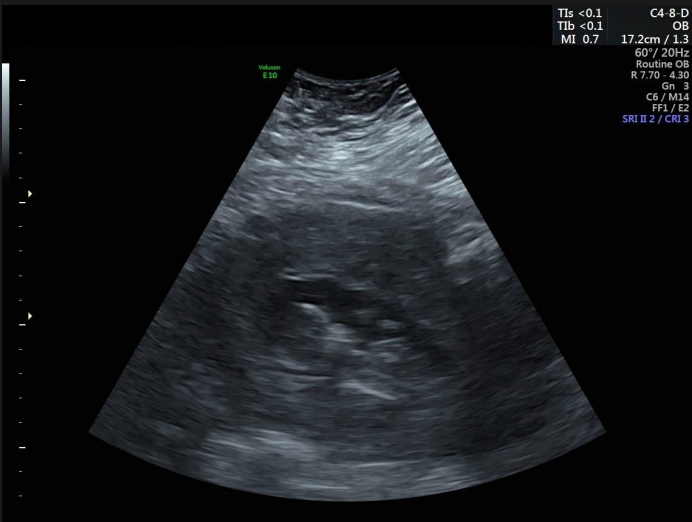
4 Know Your Limits



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Case 1: What Changed, and What It Cost

BEFORE



AFTER



What changed

Less depth, a narrower sector, the NT preset, and a new scan window. Frame rate doubled and the target fills the image. The window change isn't shown on the screen.

Read from the screen	Before	After
Preset	Routine OB	NT
Depth / sector	17.2 cm / 60°	11.3 cm / 31°
Frame rate	20 Hz	42 Hz
Scan window	First view	Changed

Cost: less context. Widen again for relationships.

Case 2: Intracranial Anatomy



Before you touch a control

What is limiting this image?

Depth

Sector

Frequency

Gain

Window

Preset

What would you change first?

1 Diagnose

2 Acquire

3 Refine

4 Know Your Limits



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Case 2: What Changed, and What It Cost

BEFORE



AFTER



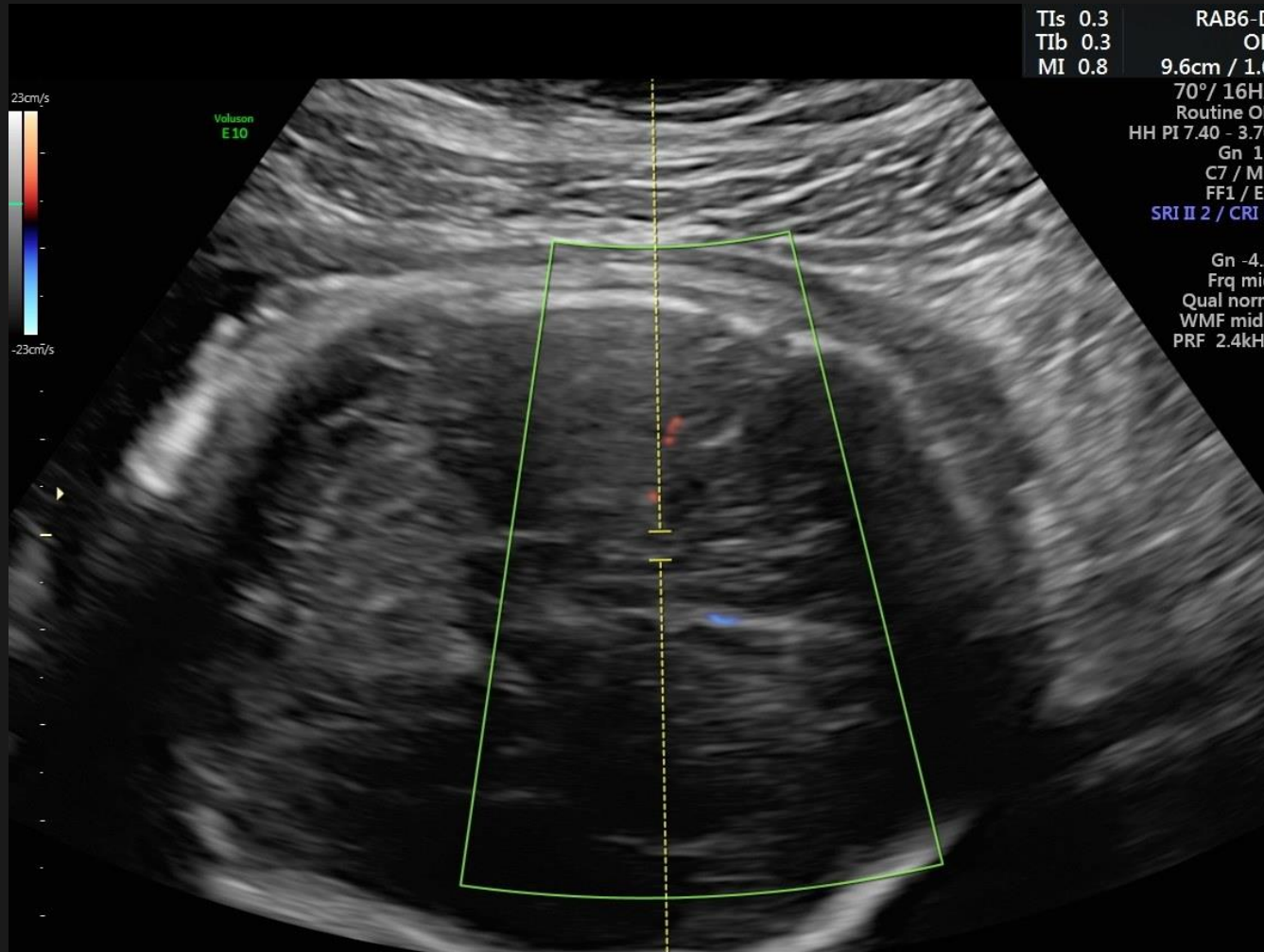
What changed

A technology chosen for the question: lower-frequency band, more gain, different processing = more intracranial information.

Read from the screen	Before	After
Preset band	HI M 7.9-4.6	Augment 7.5-3.1
Gain	2	5
Frame rate	34 Hz	22 Hz
MI	0.8	1.2

Cost: frame rate 34 to 22 Hz; MI 0.8 to 1.2.

Case 3: Fix the Doppler



Before you touch a control

What is limiting this image?

Depth

Sector

Frequency

Gain

Window

Preset

What would you change first?

1 Diagnose

2 Acquire

3 Refine

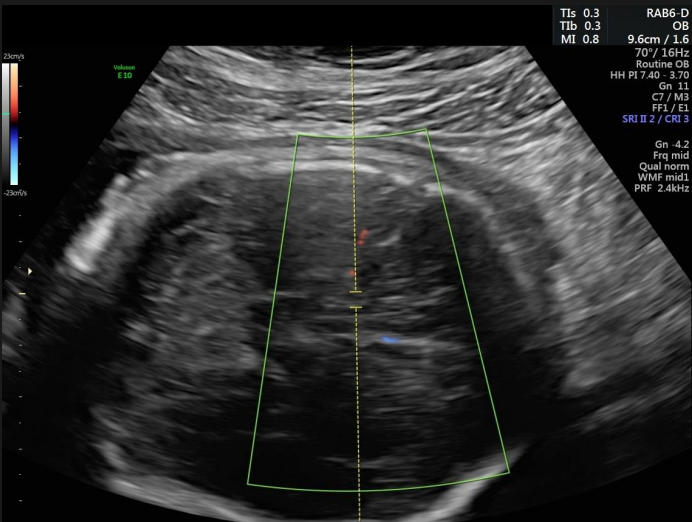
4 Know Your Limits



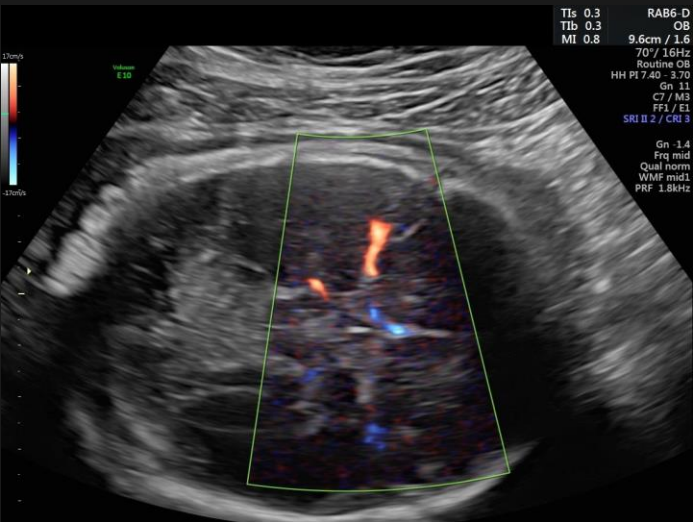
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Case 3: What Changed, and What It Cost

BEFORE



AFTER



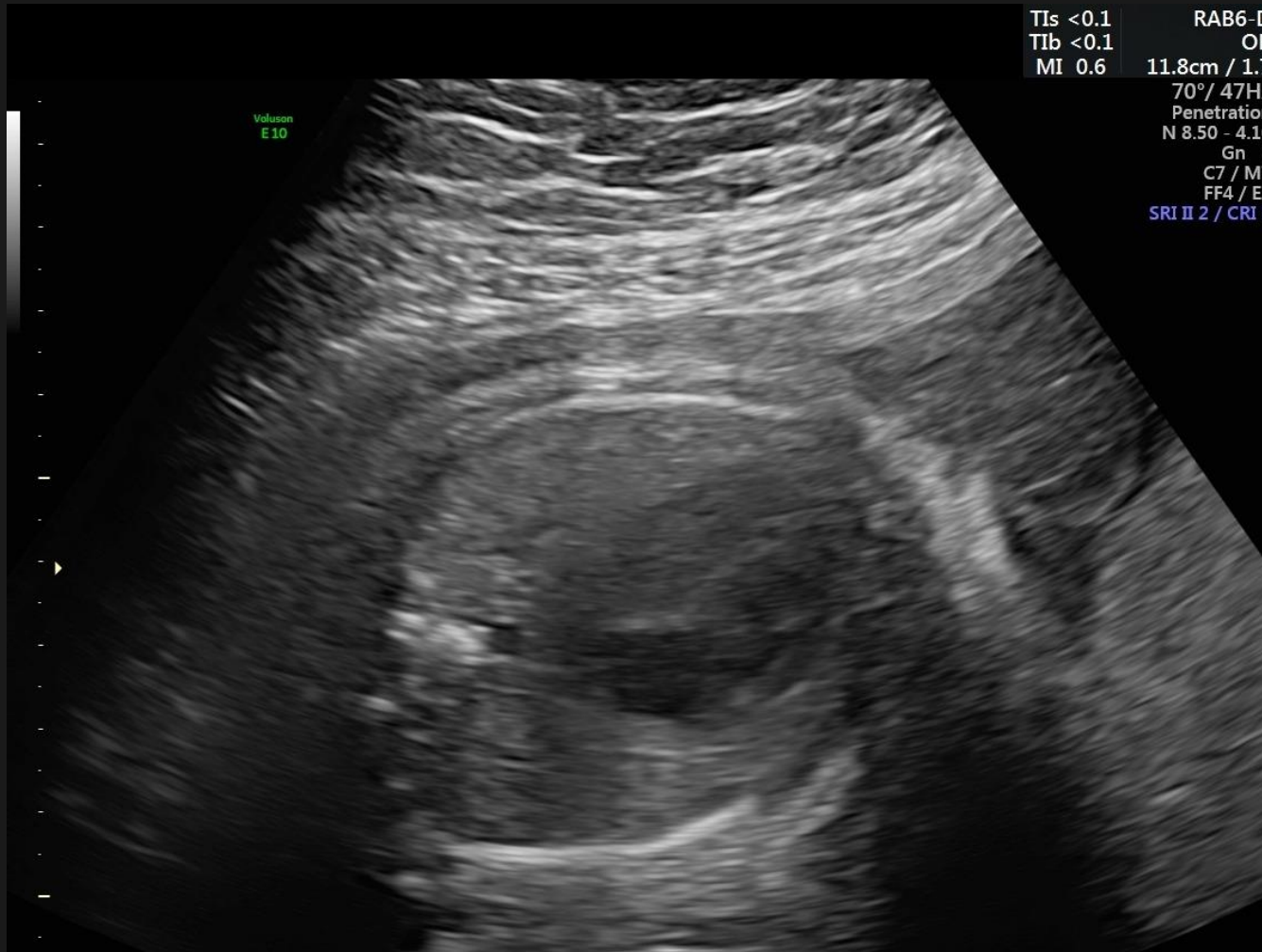
What changed

Flow was there. The scale was too high.
Lower the PRF first, then add a little gain.

Read from the screen	Before	After
Color PRF	2.4 kHz	1.8 kHz
Color gain	-4.2	-1.4
Wall filter	mid1	mid1 (same)
Frame rate	16 Hz	16 Hz (same)

Cost: go too low and you invite aliasing
and color noise.

Case 4: Fetal Heart



Before you touch a control

What is limiting this image?

Depth

Sector

Frequency

Gain

Window

Preset

What would you change first?

1 Diagnose

2 Acquire

3 Refine

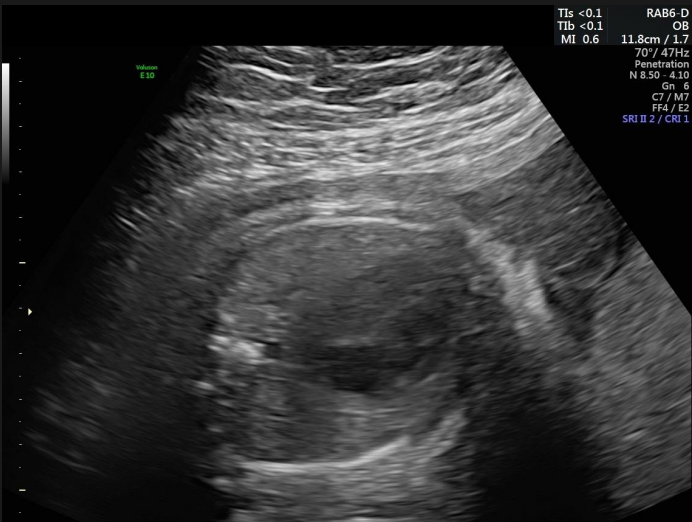
4 Know Your Limits



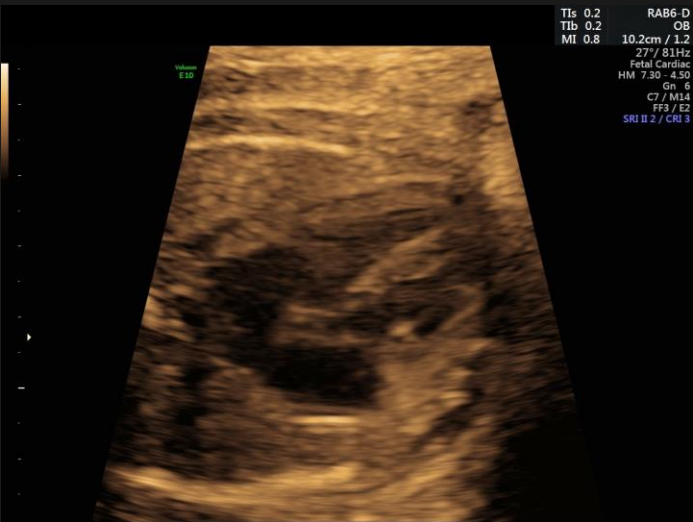
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Case 4: What Changed, and What It Cost

BEFORE



AFTER



What changed

Fetal cardiac preset, also a narrower sector (70° to 27°), a little less depth, and the Gain stayed at 6 on both images.

Read from the screen	Before	After
Preset	Penetration	Fetal Cardiac
Sector / depth	70° / 11.8 cm	27° / 10.2 cm
Frame rate	47 Hz	81 Hz
MI	0.6	0.8

Cost: MI 0.6 to 0.8, and less surrounding context.

Three things to take back to the scan room

1

Acquire first

Probe, frequency, depth, sector width, focus. Then gain.

2

Every setting is a trade

Resolution, penetration, frame rate, and exposure. Read the cost off the screen.

3

Change with a purpose

Name the limitation, make the change that addresses it, and look again.

Don't ask, "What knob should I turn?" Ask:

What information am I missing?

Why am I missing it?

What is the least costly change that will recover it?



Resources

Practice guidelines

- AIUM practice parameters: obstetric ultrasound; fetal echocardiography
- ISUOG practice guidelines: mid-trimester scan; Doppler in obstetrics; fetal cardiac screening

Safety and output

- AIUM statements on ALARA, thermal index and mechanical index
- ISUOG safety statements on Doppler in early pregnancy

Ergonomics

- SDMS industry standards for preventing work-related musculoskeletal disorders in sonography
- soundergonomics.com | healthysonographer.com

Professional bodies

- AIUM.org | SDMS.org | ARDMS.org

Questions

Diagnose · Acquire · Refine · Know Your Limits

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