PIPADOR REVISION

MRCOG Part 1 Revision Notes

Ultrasound Doppler

MEDICAL PHYSICS • LECTURE 506

VISUAL EXAMINATION REVISION NOTES

2026 Edition

506

MRCOG PART 1 REVISION NOTES | MEDICAL PHYSICS

Ultrasound Doppler

Doppler physics, modes, aliasing, indices and obstetric/gynaecological applications

$\Delta f = 2f_o v \cos\theta / c$	$\theta < 60°$	PRF/2	PI
Doppler equation	For velocity measurement	Nyquist limit (aliasing)	Main obstetric index

■ KEY FACTS: Learning objectives

- Define the Doppler effect, Doppler shift, angle of insonation, pulse repetition frequency and aliasing.
- Explain continuous-wave, pulsed-wave, colour and power Doppler, and the Doppler indices (S/D, RI, PI).
- Describe obstetric and gynaecological Doppler applications (umbilical, middle cerebral, ductus venosus and uterine arteries) and safety.

506.1 Key definitions

Term	Definition
Doppler effect	Change in the frequency of a wave reflected from a moving object — higher if moving towards the transducer, lower if moving away
Doppler shift (Δf)	Difference between transmitted and received frequency — proportional to the velocity of red blood cells
Angle of insonation (θ)	Angle between the ultrasound beam and the direction of blood flow
Pulse repetition frequency (PRF)	Number of pulses transmitted per second in pulsed Doppler
Nyquist limit	Maximum measurable Doppler shift = PRF ÷ 2
Aliasing	Wrap-around of high velocities to the opposite side of the baseline when Δf exceeds the Nyquist limit
Sample volume (range gate)	Region from which pulsed Doppler signals are analysed

■ IN PLAIN ENGLISH: Doppler

Like the falling pitch of a passing ambulance siren, sound bouncing off moving blood cells changes frequency. The size of that change tells us **how fast the blood is moving** and in which direction — so we can assess placental resistance and fetal circulation.

506.2 The Doppler equation

■ KEY EQUATIONS

$\Delta f = (2 \times f_o \times v \times \cos\theta) \div c$

f_o = transmitted frequency; v = blood velocity; θ = angle of insonation; c = 1,540 m/s

Therefore $v = (\Delta f \times c) \div (2 \times f_o \times \cos\theta)$

cos 0° = 1 (maximum shift); cos 60° = 0.5; cos 90° = 0 (no shift detected)

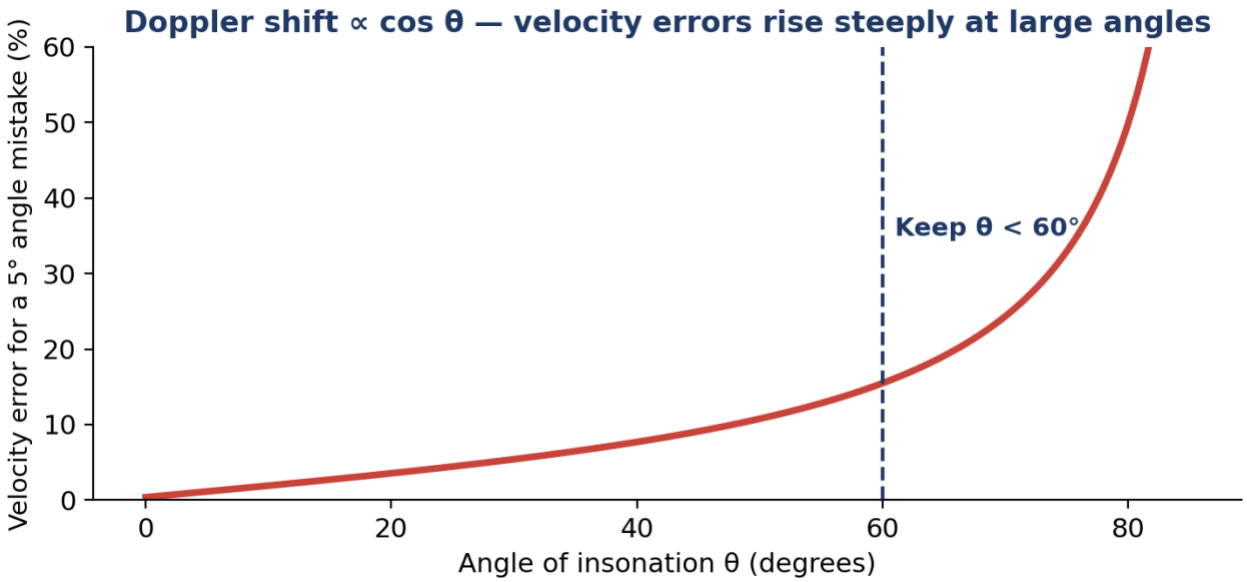


Figure 506.1 — Effect of angle on velocity accuracy

- **Velocity measurements** (e.g. MCA peak systolic velocity) require angle correction and angles as close to 0° as possible (MCA PSV measured at ≈ 0°)
  - Errors increase steeply above 60°.
- **Ratios/indices** (PI, RI, S/D) are largely **angle-independent** because the angle term cancels — a major advantage in obstetric practice.

506.3 Doppler modes and aliasing

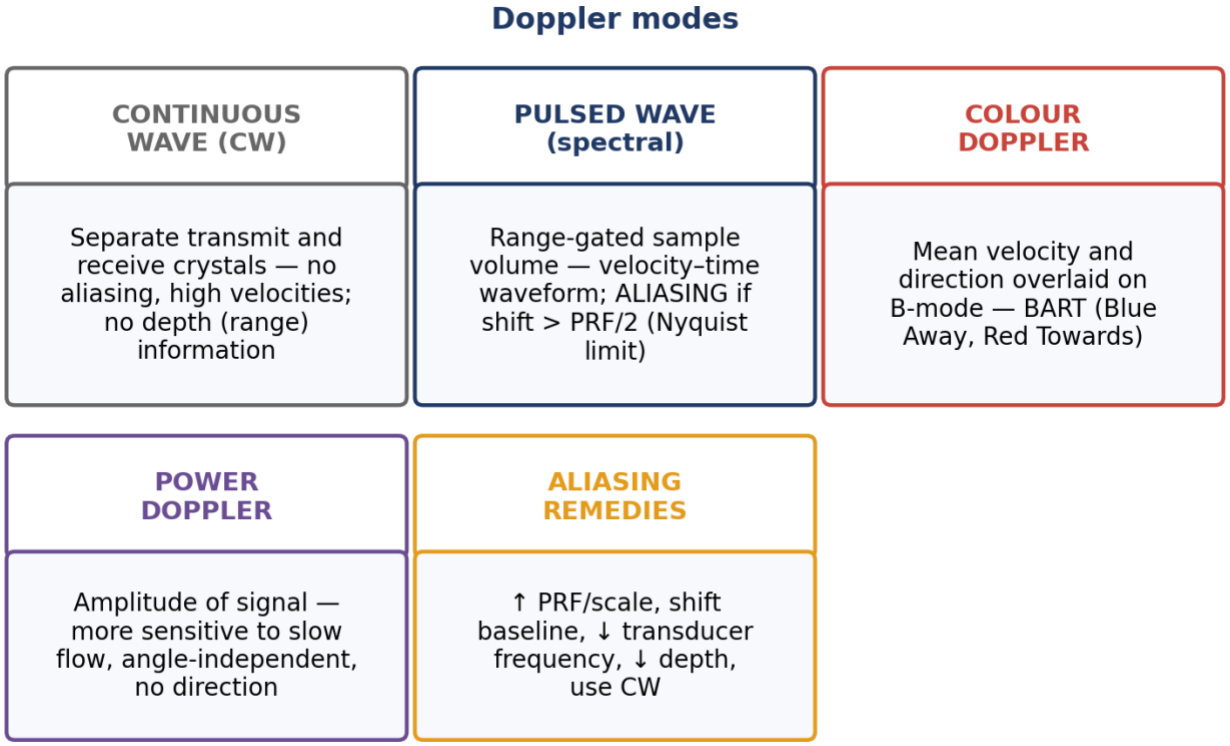


Figure 506.2 — Doppler modes

Topic	Details
Spectral display	• Velocity (y) vs time (x) • Brightness = number of cells at that velocity

Topic	Details
	• Flow towards above baseline
Duplex scanning	B-mode image + pulsed Doppler sample volume to target a specific vessel
Colour Doppler settings	Colour box size (smaller = higher frame rate), scale/PRF, gain, wall filter (removes low-frequency noise — too high hides diastolic flow)
Aliasing	• Occurs with high velocities • Deep vessels (low maximum PRF) and high transmitted frequencies — correct by raising PRF/scale, moving baseline • Lower frequency probe, CW
Wall (high-pass) filter	Set low in obstetrics (e.g. 50–100 Hz) so absent end-diastolic flow is not falsely reported

506.4 Indices and obstetric vessels

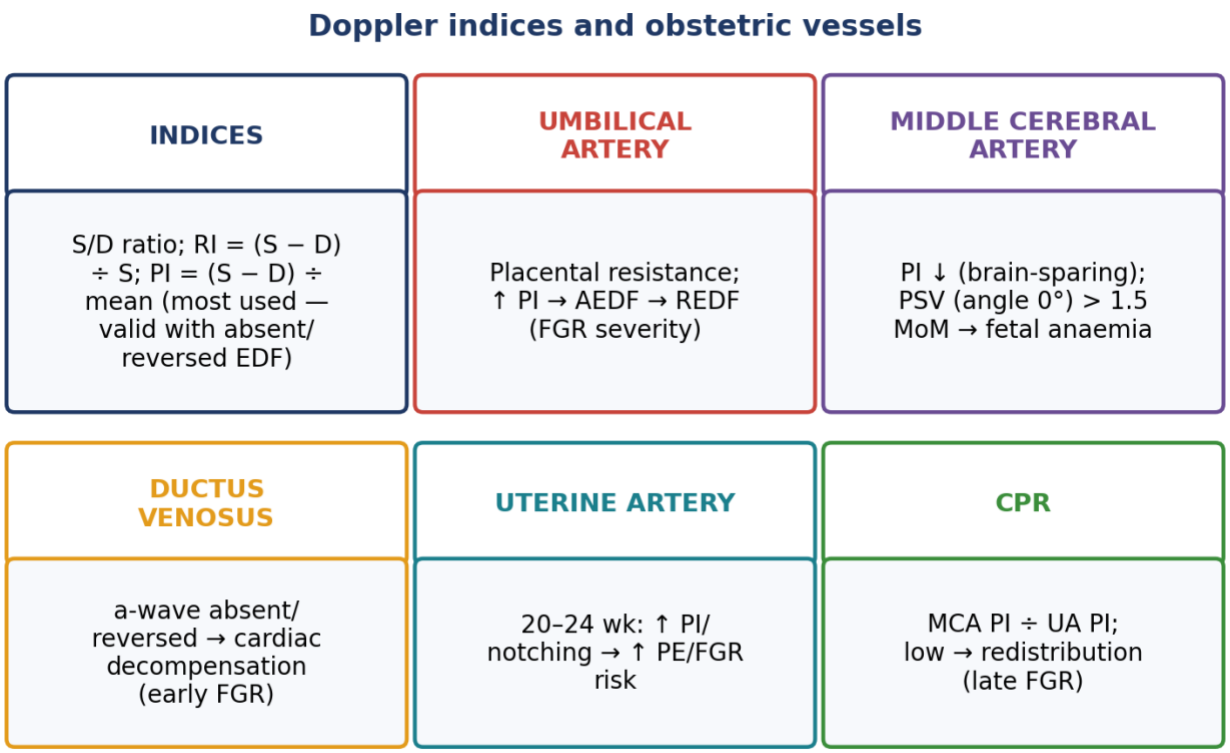


Figure 506.3 — Doppler indices and obstetric vessels

■ KEY EQUATIONS

Systolic/diastolic ratio = S ÷ D

Resistance index (RI) = (S − D) ÷ S

Pulsatility index (PI) = (S − D) ÷ mean velocity (time-averaged maximum)

Cerebroplacental ratio (CPR) = MCA PI ÷ UA PI

Vessel	Clinical meaning
Umbilical artery (UA)	• Reflects placental vascular resistance • PI falls with gestation • ↑ PI → AEDF → REDF with progressive villous vascular obliteration (FGR)

Vessel	Clinical meaning
	• UA Doppler surveillance reduces perinatal death in high-risk pregnancies
Middle cerebral artery (MCA)	• Low PI = cerebral vasodilatation ('brain-sparing') in hypoxia • PSV > 1.5 MoM predicts moderate–severe fetal anaemia (alloimmunisation, parvovirus, TAPS) — replaces amniocentesis ΔOD450
Ductus venosus (DV)	• Reflects right heart function • Absent/reversed a-wave → impending decompensation in early FGR (TRUFFLE) • First-trimester aneuploidy/cardiac marker
Uterine arteries	Assessed at 11–14 or 20–24 weeks — ↑ PI/notching → placental dysfunction, ↑ PE/FGR risk
Umbilical vein	Pulsations → severe compromise/heart failure
Gynaecology	Ovarian torsion (absent flow suggestive but flow may persist), ovarian mass vascularity (IOTA colour score), RPOC/AVM, ectopic 'ring of fire'

506.5 Safety

- Pulsed and colour Doppler deposit more energy than B-mode — check the **thermal index** (aim TI ≤ 0.7–1.0) and minimise dwell time, especially in the 1st trimester and over fetal bone/brain.
- Use Doppler only when clinically indicated (BMUS); ALARA.

■ COMMON PITFALLS

Large insonation angles for velocity measurements (MCA PSV).

Wall filter set too high → false AEDF.

Measuring UA close to the placenta vs fetal insertion inconsistently (PI varies along the cord — free loop standard).

Interpreting Doppler during fetal breathing movements (waveform variability).

506.6 Must-know summary

■ EXAM TIP

- $\Delta f = 2f_o v \cos\theta \div c$; keep $\theta < 60°$ (≈ 0° for MCA PSV); indices (PI, RI, S/D) are angle-independent.
- CW (no aliasing, no depth), PW (range-gated, aliasing above PRF/2), colour (direction — BART), power (sensitive, no direction).
- UA PI (placenta) → AEDF/REDF; MCA PI (brain-sparing) and PSV > 1.5 MoM (anaemia); DV a-wave; uterine artery PI (PE/FGR risk).
- Doppler has higher TI — use only when indicated, especially early pregnancy.

■ MNEMONIC / MEMORY AID

Colour Doppler — 'BART': Blue Away, Red Towards.