

IPEM UNIRSIG Advisory Note:

**Potential ambiguity in Transcranial Doppler (TCD) mean velocity and
Pulsatility Index (PI) labelling on imaging ultrasound systems**

Group/Committee: Ultrasound & Non-Ionising Radiation Special Interest Group
(UNIRSIG)

Committee Members: Adam Studd, Charlotte Groves, Jason Britton, Katie Marshall, Shijie
Liang

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Background

The Ultrasound and Non-Ionising Radiation Special Interest Group (UNIRSIG) has been made aware that, on some imaging ultrasound systems (including Philips Affiniti and EPIQ systems), users may encounter more than one “mean” velocity and Pulsatility Index (PI) option within the Transcranial Doppler (TCD) package under similar or easily misinterpreted labels.

This advisory note highlights a potential source of ambiguity in displayed TCD mean velocity and PI values and recommends practical checks for services using these measurements.

Definition of the Pulsatility Index

The PI is commonly expressed using the Gosling formulation:

$$PI = (\text{maximum velocity} - \text{minimum velocity}) / \text{mean velocity}$$

In the original Gosling formulation, the maximum and minimum velocities are derived from the outer spectral envelope over the cardiac cycle from the Doppler waveform. In much of the TCD literature, mean velocity refers to the time-averaged mean of the traced spectral envelope over one or more complete cardiac cycles. This corresponds to the methodology originally described by Aaslid et al.¹, although terminology varies between manufacturers and clinical applications.

Sources of discrepancy

There are two separate issues, either one of which can cause the displayed PI to differ from a PI calculated from the traced outer spectral envelope over the cardiac cycle:

1. The first issue is the definition of mean velocity. Most TCD workflows use an envelope-derived time-averaged velocity based on a traced spectral outline over the cardiac cycle. This has historically been the most widely used approach in the TCD literature and corresponds to the methodology originally described by Aaslid et al.¹ In contrast, some TCD references describe mean velocity from Peak Systolic Velocity (PSV) and End Diastolic Velocity (EDV) only, using $(PSV + 2 \times EDV)/3$, particularly where envelope tracing is unavailable or unreliable.^{2,3} These measures are not mathematically equivalent and should not be assumed to be interchangeable. The difference may increase when distal resistance is raised and diastolic flow is reduced.
2. The second issue is the definition of the “minimum” velocity. The original Gosling PI concept is based on the maximum (Vmax) and minimum (Vmin) velocities over the cardiac cycle divided by the mean velocity (Vmean), i.e. $PI = (V_{max} - V_{min})/V_{mean}$.⁴ Some systems assume that EDV is equivalent to Vmin. However, in high-resistance waveforms Vmin is not necessarily equal to EDV, so substituting EDV for the true minimum velocity can underestimate PI.

In the examples described by Deane et al.⁵, “Mean(TCD)” is a PSV/EDV-derived estimate rather than an envelope-traced time-averaged value. “PI(TCD)” uses this PSV/EDV-derived mean and substitutes EDV for the true minimum velocity over the cardiac cycle. It therefore gives a different value from the trace-derived Gosling PI shown elsewhere on the same device and from PI values reported on systems that use the trace-derived calculation.

Available evidence and clinical significance

Available quantitative evidence is limited. In the example shown in Figure 1, PI(TCD) is 1.66 compared with a trace-derived Gosling PI of 2.07, approximately 20% lower. In the high-resistance example reported by Deane et al.,⁵ the corresponding PI values are 1.95 and 5.61, while the PSV/EDV-derived mean is approximately 43 cm/s compared with an envelope-derived mean of 21 cm/s. The magnitude and direction of the discrepancy depend on waveform shape and may be greatest when diastolic flow is reduced, absent, or reversed.

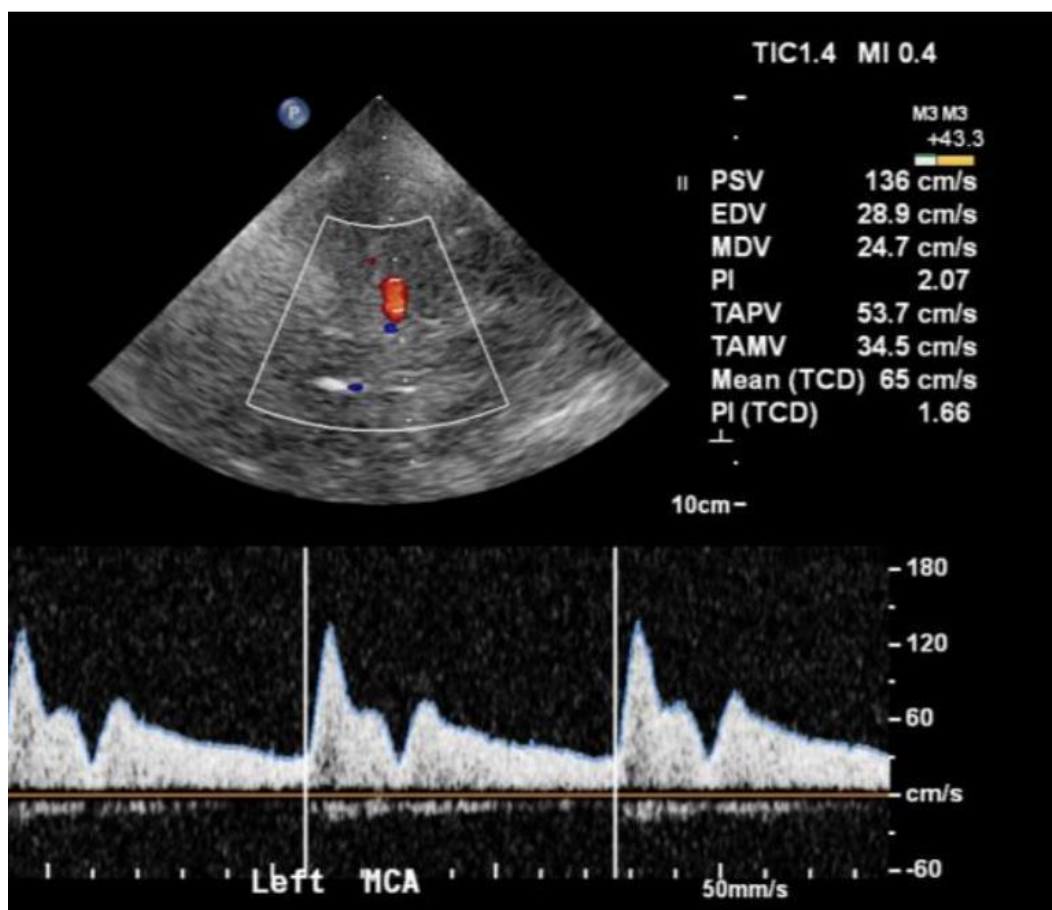


Figure 1: Clinical example showing a marked difference between the conventional Gosling PI = 2.07 and the PI(TCD) = 1.66, where PI(TCD) is calculated using EDV in place of the true minimum velocity (V_{min}) and a PSV/EDV-derived mean ($Mean(TCD) = (PSV + 2 \times EDV)/3$) rather than an envelope-derived time-averaged mean. Taken from Deane et al.⁵

It is not known how commonly this discrepancy occurs across installed systems, and it may vary with scanner model, software version, measurement package and local preset. The clinical significance will depend on the application, but differences may affect longitudinal trending, comparison with published reference ranges or thresholds, cross-platform comparison, and multicentre research, particularly when values lie close to a clinical decision threshold or the waveform is abnormal.

Relevant professional-society guidance, including the AIUM Practice Parameter for Transcranial Doppler Ultrasound and the American Society of Neuroimaging practice standards, supports standardised acquisition and documentation.^{6,7} These are performance standards rather than specifications for manufacturer-specific labels or calculations, so services still need to verify the method used by their scanner, measurement package, and preset.

Recommendations

UNIRSIG recommends that services explicitly define, in local protocols and reporting templates, which mean velocity and PI outputs are to be used for TCD. This should include the on-screen label, whether the value is envelope-derived or PSV/EDV-derived, and whether PI uses the true cycle minimum velocity or EDV. Values used for trending, thresholds, audit or research should not be assumed comparable across systems unless the underlying definitions match.

UNIRSIG also recommends that researchers explicitly state the calculation method used for TCD mean velocity and PI. Where an envelope-derived time-averaged value is intended, this should be stated clearly. Package-specific outputs such as PI(TCD) should be used only when their calculation method is explicitly stated and justified, as they may not be comparable with trace-derived Gosling PI reported in the wider literature or across vendors.

References

1. Aaslid R, Markwalder TM, Nornes H. Noninvasive transcranial Doppler ultrasound recording of flow velocity in basal cerebral arteries. *J Neurosurg.* 1982;57(6):769-74.
<https://doi.org/10.3171/jns.1982.57.6.0769>
2. Byrd SM. An overview of transcranial color flow imaging: a technique comparison. *Ultrasound Q.* 1995;13(4):197-210.
3. Naqvi J, Yap KH, Ahmad G, Ghosh J. Transcranial Doppler ultrasound: a review of the physical principles and major applications in critical care. *Int J Vasc Med.* 2013;2013:629378.
<https://doi.org/10.1155/2013/629378>
4. Gosling RG, King DH. Arterial assessment by Doppler-shift ultrasound. *Proc R Soc Med.* 1974;67(6 Pt 1):447-9. <https://doi.org/10.1177/00359157740676P113>
5. Deane C, Fernandes F, Chung E. Pulsatility Index (PI) in transcranial Doppler (TCD) measurements: problems of consistency [poster]. British Medical Ultrasound Society Annual Scientific Meeting; 2024. Available from:
https://www.bmus.org/media/resources/files/48_Colin_Deane.pdf [Accessed 4 March 2026].
6. American Institute of Ultrasound in Medicine. AIUM Practice Parameter for the Performance of Transcranial Doppler Ultrasound. *J Ultrasound Med.* 2023;42(9):E36-44.
<https://doi.org/10.1002/jum.16234>
7. Alexandrov AV, Sloan MA, Wong LKS, Douville C, Razumovsky AY, Koroshetz WJ, et al. Practice standards for transcranial Doppler ultrasound: Part I—test performance. *J Neuroimaging.* 2007;17(1):11-8. <https://doi.org/10.1111/j.1552-6569.2006.00088.x>