

Ultrasound Quantification of Flow Dynamics During Peripheral Intravenous Catheter Flushing: A Simulation-Based Study

Jiaxin Deng, Brian Deegan, Michael Liddelow, Barry Doyle, Ánie Kelly, Leo Quinlan, Orlaith Hernon, Andrew J. Simpkin, Caitriona Duggan, Peter J. Carr

Background

Flushing is standard practice to maintain catheter patency and clear intraluminal residue.¹ The pulsatile technique is widely recommended, yet real-world flushing behavior has not been quantitatively characterized.^{2,3}

Objectives

- Describe and quantify flow dynamics during PIVC flushing using Doppler ultrasound in a vascular simulation model.
- Examine differences in flow dynamics by vessel diameter, catheter gauge, and flushing technique.

Methods:



Figure of Simulation model.

Ultrasound & Participants

Philips EPIQ Elite, XL14-3 transducer.
PW Doppler: 1.5–2.0 mm sample volume at catheter tip, angle correction $\leq 60^\circ$.
Healthcare practitioners with vascular access devices management experience.

Statistical Analysis

Pulsatile: Linear mixed-effects models (LMM).

Continuous: Mann–Whitney U tests.

Significance significance: $p < 0.05$.

Data extraction

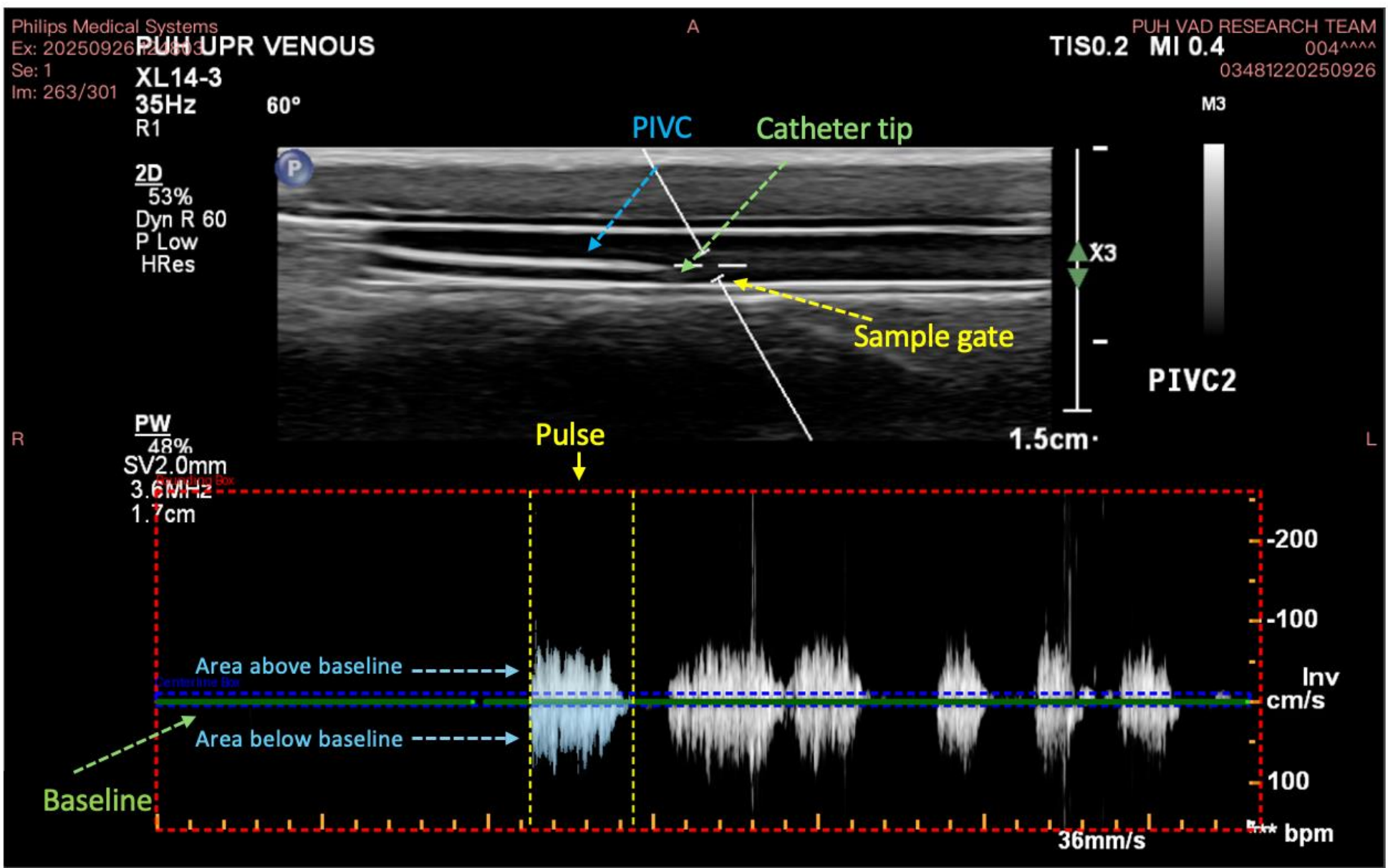


Figure of Data extraction and definition of pulses & episodes

Results

42 healthcare practitioners
37 participants—pulsatile flushing—104 episodes—1331 pulses
5 participants—continuous flushing—31 episodes

Findings

1. Pulsatile Flushing Generates Different Flow Dynamics Across Participants

3-36 Pulses Per episode	3.19-30.36 Seconds Episode duration	5-259.80 cm/s Peak velocity	2.11 – 235.74 cm/s Mean velocity
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Parameter	Mean $\pm$ SD	Range
Peak velocity (cm/s)	42.46 $\pm$ 27.28	5.00 – 269.80
Pulse mean velocity (cm/s)	32.84 $\pm$ 27.69	2.11 – 235.74
Pulses per episode	12.75 $\pm$ 7.10	3 – 36
Episode duration (s)	9.32 $\pm$ 4.90	3.19 – 30.36

ImageJ (point-based extraction)

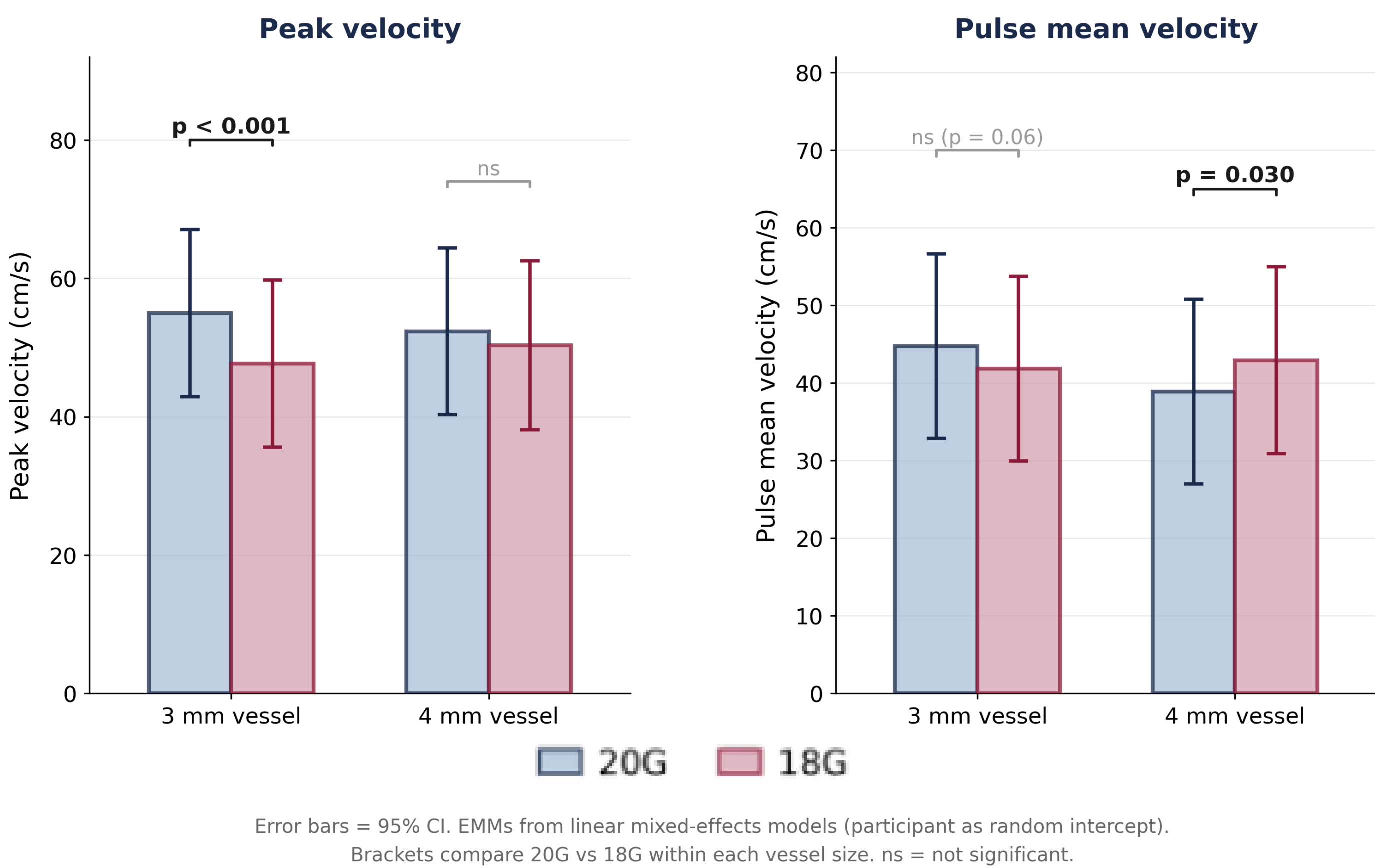
Python (area-based extraction):

Automated Doppler envelope detection $\rightarrow$ spectral area (above/below baseline)

Calibration

Pixel $\rightarrow$ cm/s and seconds using Doppler scale

2. Gauge Effect Reversal By Vessel Size in Pulsatile Flushing



3. Continuous Flushing Shows Comparatively Stable Flow dynamics

3.61-9.75
Seconds
Episode duration

19.76-110.94
cm/s
Peak velocity

11.92 – 65.93
cm/s
Mean velocity

No significant differences between catheter gauges or vessel diameters (all $p > 0.05$).

Conclusion

Substantial inter-participant variability in PIVC flushing flow dynamics is further influenced by catheter gauge and vessel diameter.

Reference

- Goossens GA. Flushing and Locking of Venous Catheters: Available Evidence and Evidence Deficit. *Nurs Res Pract*. 2015;985686.
- 2021 Infusion Therapy Standards of Practice Updates. *J Infus Nurs*. 2021;44:189–190.
- Deng J, et al. Flushing peripheral intravenous catheters: A scoping review. *PLoS One*. 2025;20(8):e0330125.