Python-based data extraction and visualisation of beat-to-beat arterial waveforms: A tool for clinical learning

Gabriel Palti[1*], Kate Lachowyz[1], Zachary Starr[1], Shadman Aziz[1], James Price[1], Paul Rees[1], Ed Barnard[1]

1. Department of Research, Audit, Innovation, and Development (RAID), East Anglian Air Ambulance, Norwich, UK

East Anglian Air Ambulance

Research, Audit, Innovation & Development Group

Improving patient outcomes

Introduction

Retrospective review of high-resolution clinical data is essential for improving patient outcomes through clinician learning. Beat-to-beat haemodynamic data offer unique insight into physiological responses and the effects of clinical interventions, enabling clinicians to interrogate each blood pressure cycle to evaluate practice and optimise care. However, **current monitoring systems**, such as the Zoll X-series, **display waveforms at low resolution without beat-to-beat metrics, limiting real-time clinical interpretation**. At present, no published method enables extraction and visualisation of waveform data in a form suitable for meaningful review. This project **aimed to develop and validate** a practical, Python-based **technique for extracting beat-to-beat arterial blood pressure data into an interactive, analysable format** for clinician use, research, and export.

Methods

Waveform data **were converted into a long-format structure with millisecond-level timestamps**, with the resulting visualisations **enabling detailed inspection of individual beats and temporal trends**. Extracted data were benchmarked against 30-second and two-minute averages, and waveform morphology was assessed for clinical relevance and fidelity.

Results

The developed method **successfully extracted and visualised millisecond-level arterial waveforms** from Zoll X-series outputs. Clinicians could **interrogate beat-to-beat trends, identify artefacts and anomalies**, and explore haemodynamic responses **not visible in averaged datasets**. The interactive **interface allowed zooming, panning, and export** to .csv format for further analysis.

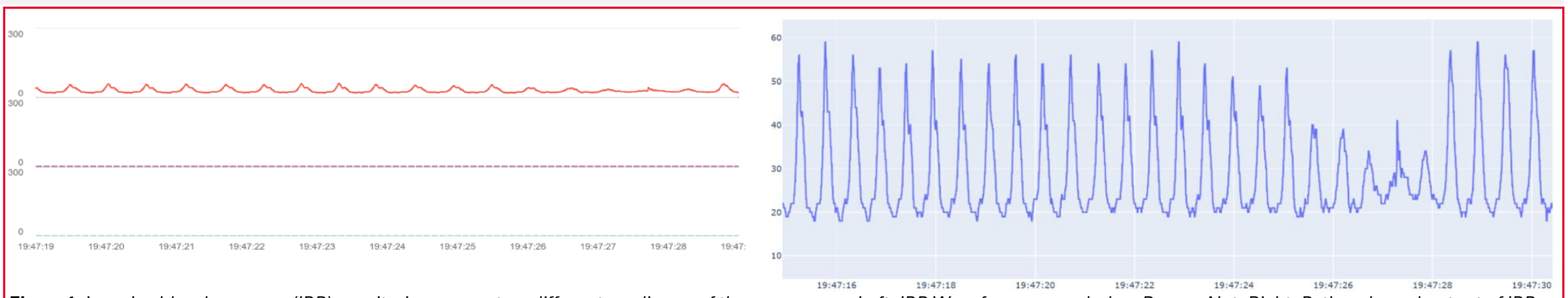

Figure1: *invasive blood pressure (IBP) monitoring across two different mediums, of the same case. Left: IBP Waveforms recorded on RescueNet. Right: Python-based output of IBP waveform.*

Conclusion

This approach provides a novel, practical solution to access and interpret high-resolution arterial data, enhancing opportunities for clinical learning, performance evaluation, and research into haemodynamic response during prehospital interventions. The structured data format also presents opportunities for machine learning and AI-driven analysis of haemodynamic patterns.

* Contact: Gabriel Palti gabriel.palti@eaaa.org.uk