Automated Identification and Validation to Detect Physiologically Implausible Pulsatile BP Artifacts

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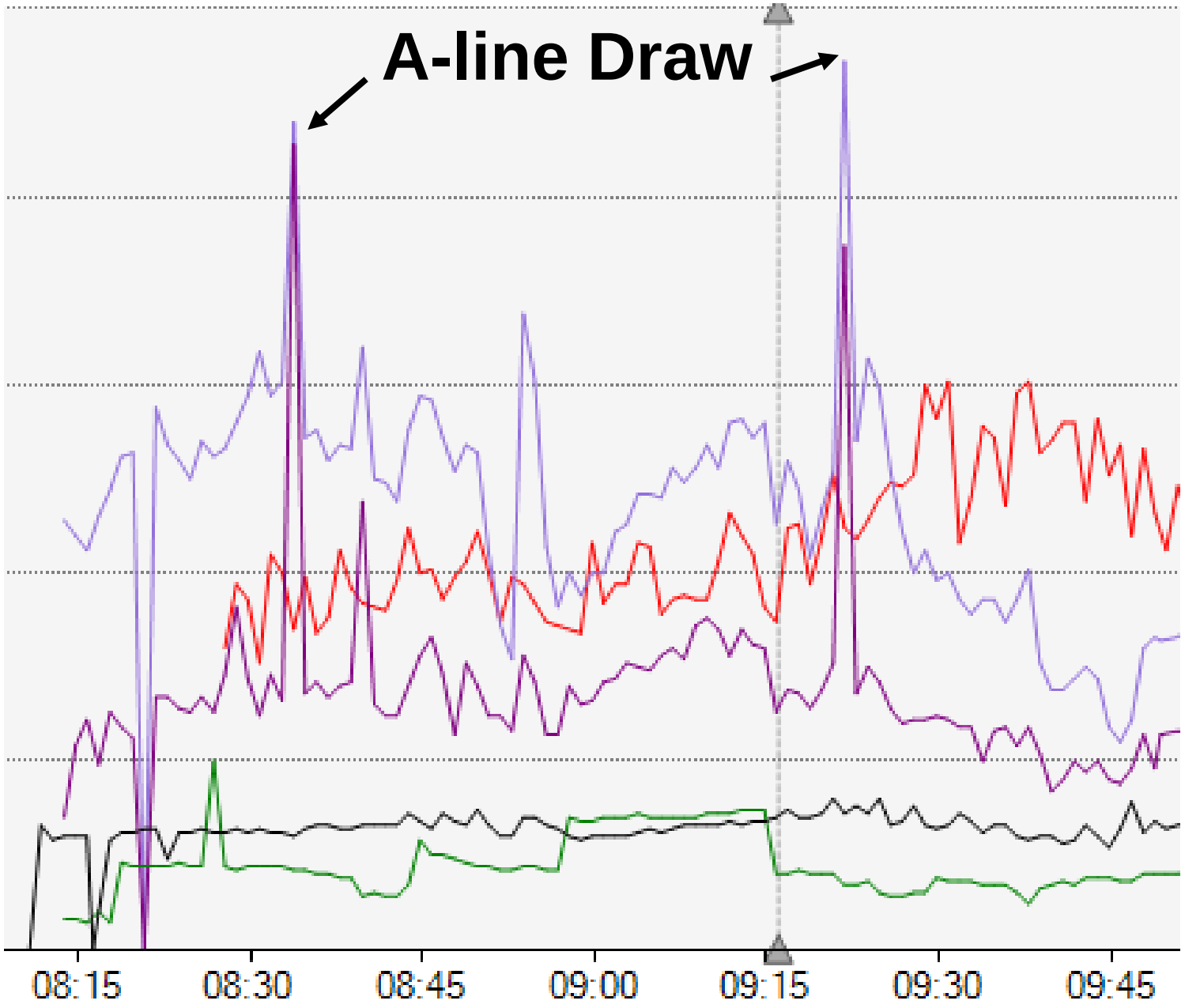
MULTICENTER PERIOPERATIVE OUTCOMES GROUP


A-line Draw
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08:30
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09:00
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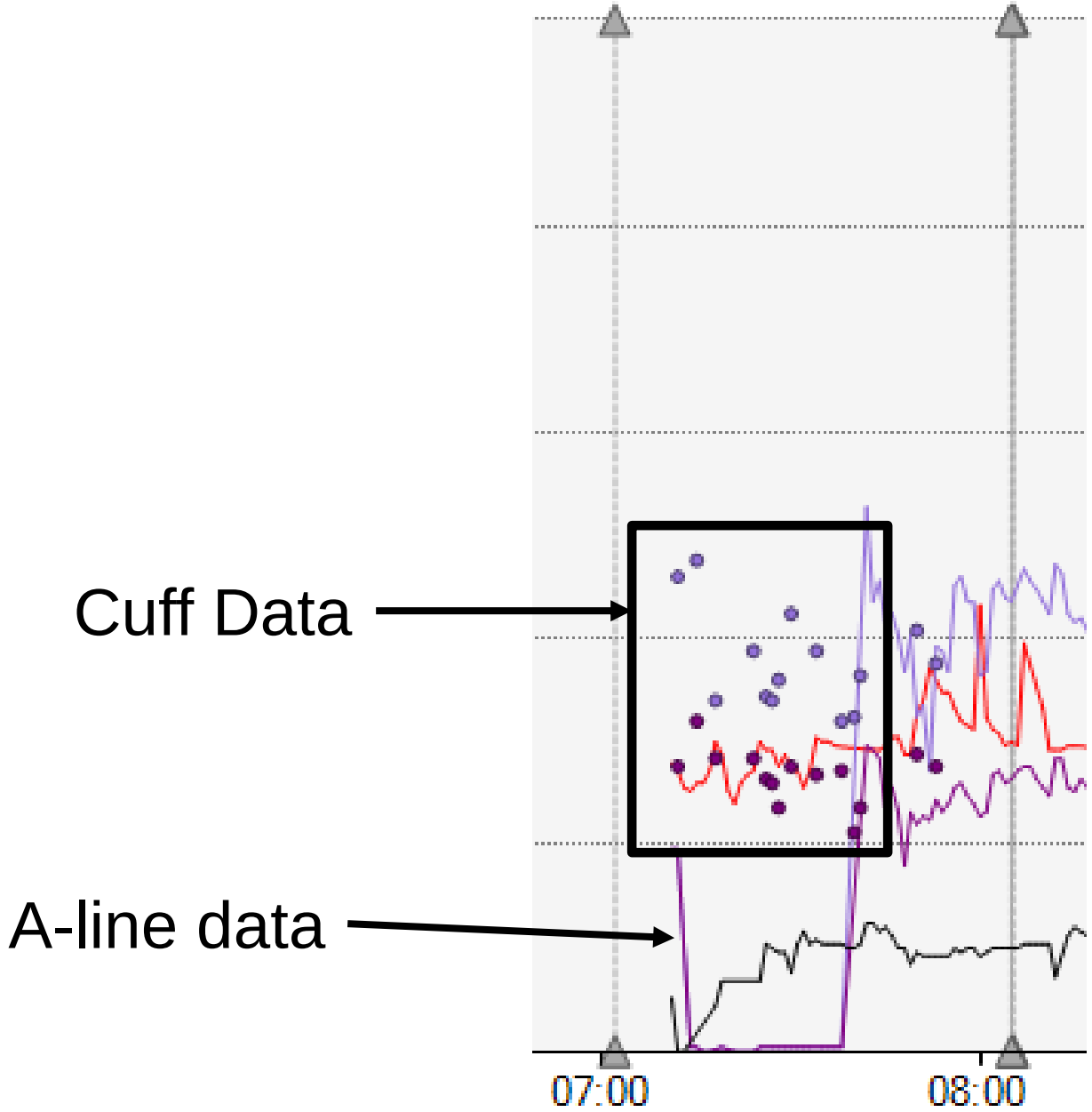
Cuff Data
A-line data
07:00
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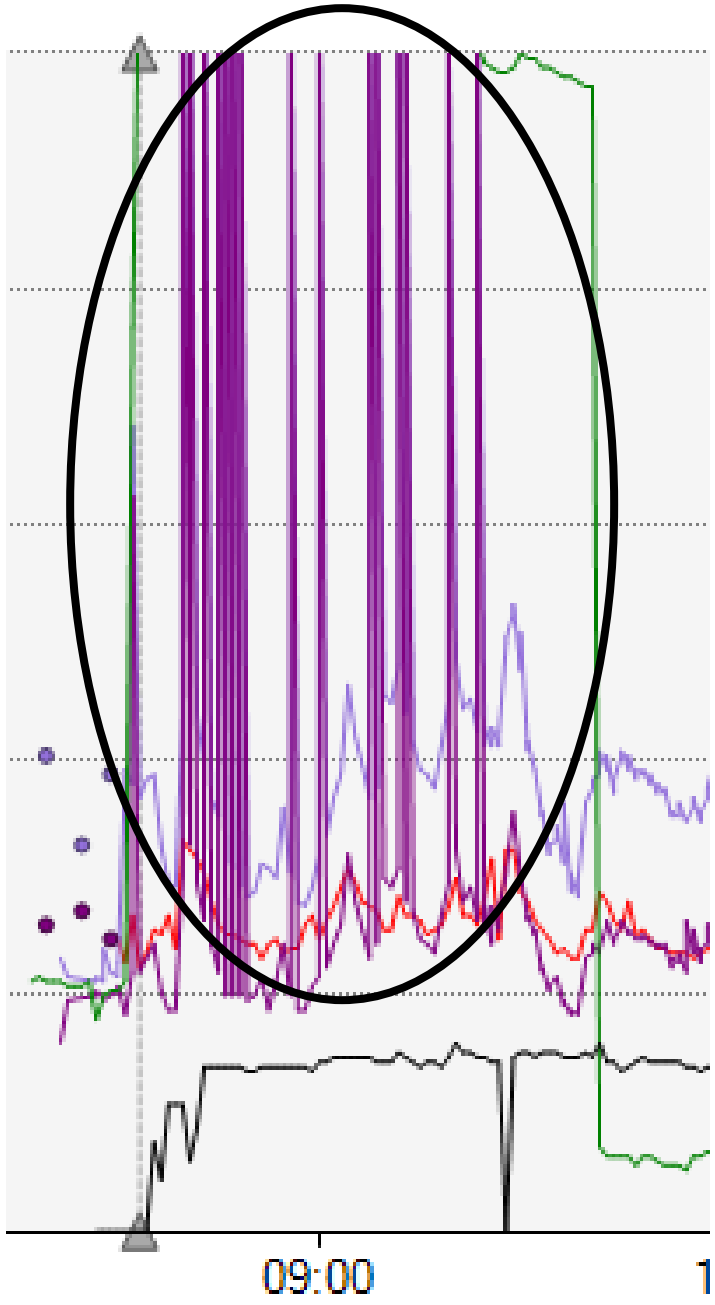
09:00
1

Two Peer-Reviewed Studies Investigating Incidence of BP Artifacts

- Both prospective observation trials to determine BP artifact incidences
- Completed in Utrecht
- Pediatric patient population
- Kool et al. (2012)
  - NIBP artifact incidence 2.3% (95% CI 1.8-2.9)
  - Invasive BP artifact incidence 14% (95% CI 12-15)
- Hoorweg et al. (2017)
  - NIBP artifact incidence 5.0% (95% CI 4.0-6.0)
  - Invasive BP artifact incidence 7.3% (95% CI 5.9-8.8)

BP Reduction Algorithms in Previously Published Literature

Author	Patient Population	BP Reduction Algorithm
Sun et al.	• Adult • Non-cardiac • LOS ≥ 1 day • A-line monitoring cases	• Change of MAP in either direction ≥ 50% between measurements • No MAP recordings for ≤ 2 minutes
Oprea et al.	• Adult • Non-cardiac • GA • NIBP and Invasive BP monitoring	• MAP < 30 mmHg or MAP > 250 mmHg
Salmasi et al.	• Adult • Non-cardiac • IP only • NIBP and Invasive BP monitoring	• BP documented as artifact by clinician • SBP ≥ 300 mmHg or SBP ≤ 20 mmHg • SBP ≤ DBP + 5 mmHg • DBP ≤ 5 mmHg or DBP ≥ 225 mmHg • Abrupt SBP changes ≥ 80 mmHg within 1 minute between measurements in either direction • Abrupt SBP changes ≥ 40 mmHg within 2 minute between measurements in either direction

Observational research with no BP artifact reduction algorithms used in the last 10 years: Bijker et al 2007, 2009, 2012, Walsh et al. 2013, Hsieh et al. 2016

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Creation of BP Reduction Algorithm (BPAA) and Patient Population

- Consensus taken amongst MD's using Delphi methodology of what is a BP artifact value
- Thousands of cases were hand-reviewed to derive the current algorithm values

- Adult ASA I-IV patients with pulsatile blood flow
- Non-cardiac GA cases with a minimum of 3 hours of anesthesia monitoring
- Data were drawn from a minimum of 5 MPOG sites
- Exclusion criteria
  - Cases without valid intraoperative timestamps
  - Cases where invasive BP monitoring was used <80% of the case
  - NIBP monitoring cases with only user entered values

MPOG Blood Pressure Reduction Algorithm

Artifact Code	Rules/Logic
1	Marked as artifact in real-time by the provider (Not included in analysis)
2	SBP > 150 and PP < 30
3	SBP ≥ 100 AND SBP ≤ 150 AND PP < 15
4	SBP < 100 AND PP < 10
5	SBP > 200 AND PP < 50
6	SBP ≤ 10 OR DBP ≤ 10
7	SBP = DBP = MAP
8	MAP < 0
9	MAP ≥ 140
10	If any BP is marked as artifact #1, then all BP measurements for that time will be marked as artifact

Note: If artifact code #2-9 is marked for SBP, DBP, or MAP → All BP's for that timestamp are artifacts

Validation of BP Reduction Algorithm

- Data were divided into 4 cohorts: Invasive BP and NIBP with and without vasoactive medications used
- Manual clinician review of a random subset of cases for each cohort to identify BP artifacts
  - Clinicians blinded to artifact code that was triggered but could see artifacts documented during the case

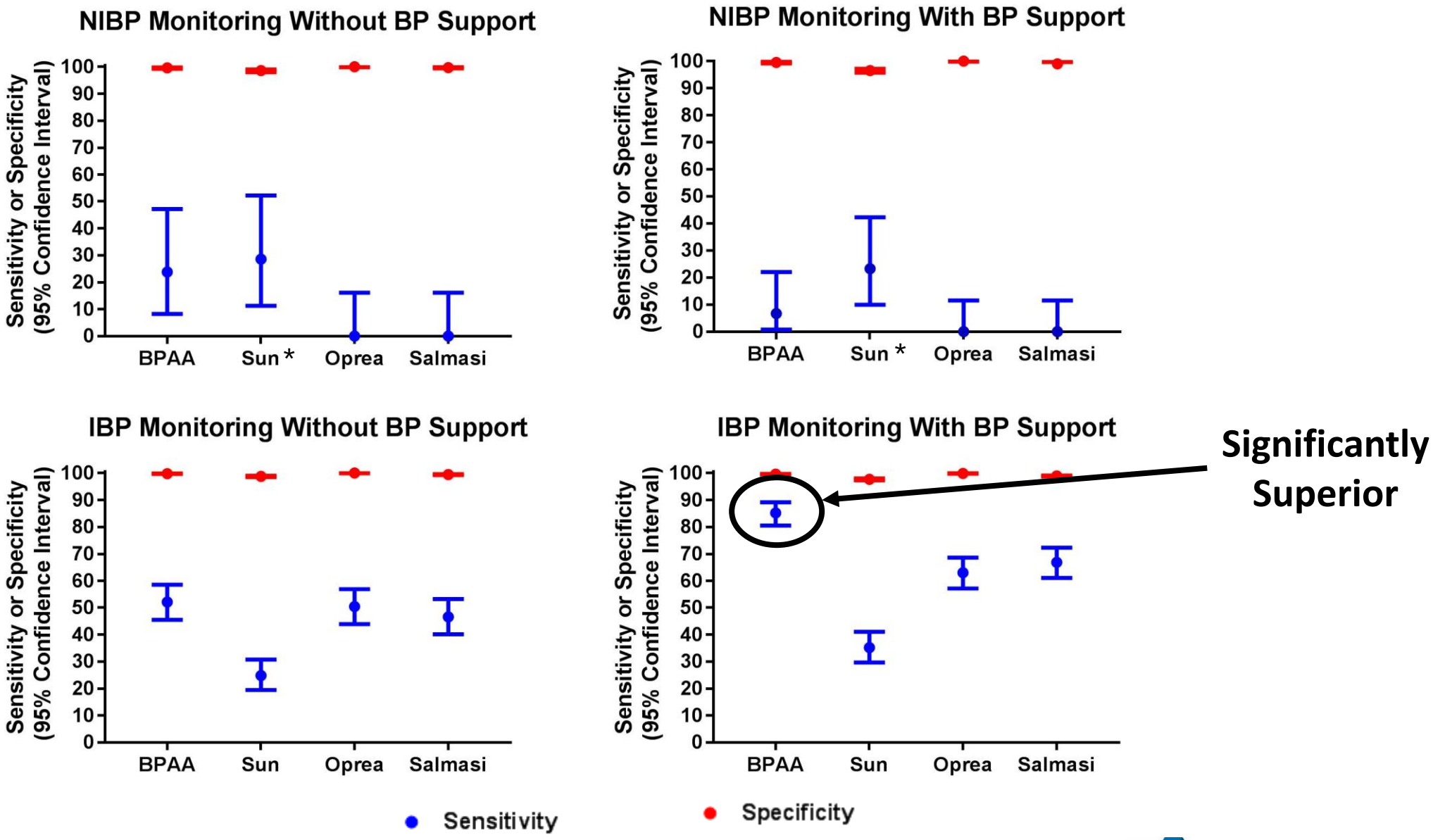
- Percentage of algorithm artifacts for each case were calculated by cohort
- Calculated sensitivity/specificity by cohort for BPAA compared to clinician review
- Compared BPAA against three observational trials BP reduction algorithms
- Interrater reliability measured using Krippendorff's alpha
  - 1.00 indicates perfect agreement

Incidence of Artifacts Triggered by Cohorts

	Incidence of artifacts	Range	Krippendorf's Alpha
NIBP Monitoring without BP support	0.43 ± 1.29	0.00 to 5.17	0.33
NIBP Monitoring with BP support	0.51 ± 1.18	0.00 to 5.61	-0.01
IBP Monitoring without BP support	1.61 ± 2.08	0.00 to 8.64	0.81
IBP Monitoring with BP support	3.02 ± 3.39	0.00 to 12.9	0.70

- Previous research demonstrated NIBP artifacts 2.3-5.0% and Invasive BP artifacts 7.3-14% using real-time clinician documentation by an independent observer
- Clinician documented artifacts were included in their calculations

Sensitivity and Specificity For Detecting MAP Artifacts Across Four Algorithms



* Original research manuscript only looked at IBP monitoring cases.

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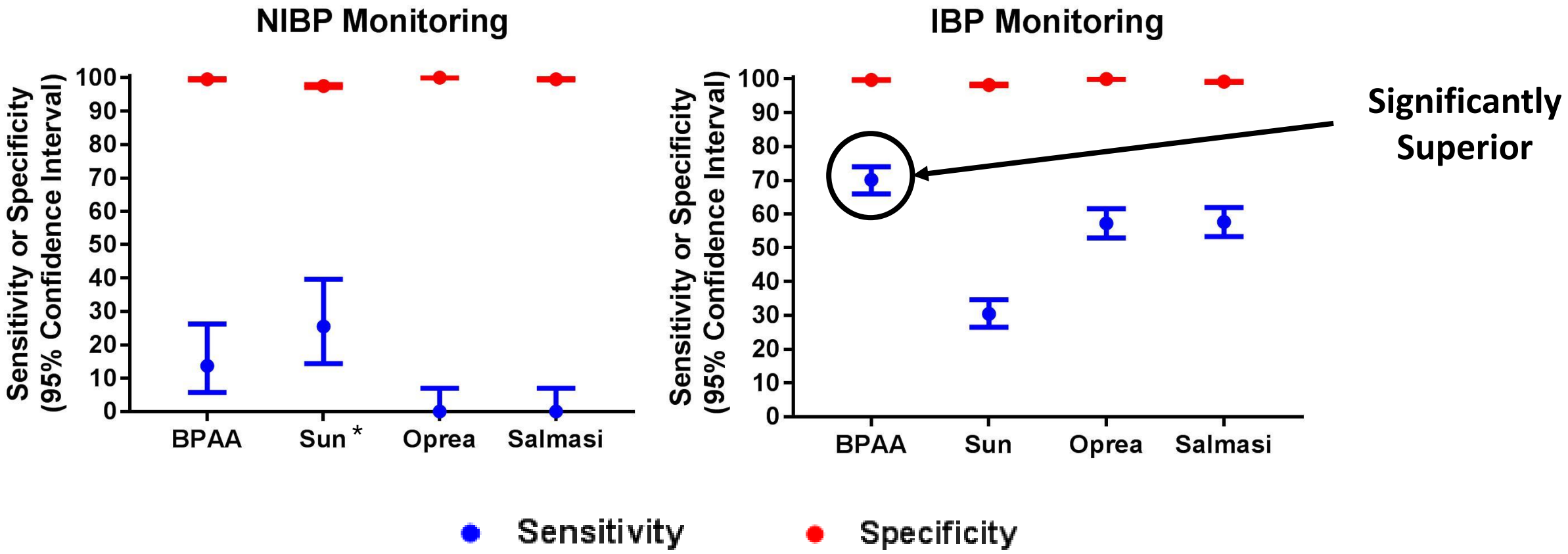

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Conclusions

- The pulsatile BP artifact reduction algorithm is *statistically superior* for invasive BP monitoring with vasoactive medications and invasive BP monitoring without stratification by vasoactive medications to previously published algorithms
- Interrater reliability was good for invasive BP monitoring
- All sensitivities across the algorithms were poor for NIBP cases. However, perhaps looking at percent change from consecutive values is advantageous
- We feel the BP artifact reduction algorithm should be used in future observational research design to allow for consistency and comparability