Prospective Comparison of Standard Technique, Doppler Ultrasonography, and Waveform Analysis of Pressure Transduction for Confirming Correct Intraosseous Catheter Placement

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Background

- Intraosseous (IO) catheters allow rapid administration of medications to critically ill patients when intravenous access is not feasible.
- Improperly placed IO catheters can cause delay in care for patients and complications such as limb necrosis, abscess formation, and osteomyelitis
- We hypothesized that a novel method using waveform analysis of a transduced IO catheter (M3) would be superior to the standard of care technique (M1) and Doppler ultrasound technique of verification (M2).

Methods

- **Study design:** Single center prospective, reviewer-blinded study
- **Setting:** University Hospital, Newark NJ
- **Population:** Patients ≥ 18 years old with an IO catheter placed for clinical purpose
- **Study period:** July 2019 to February 2021
- **Method:** All IO catheters underwent the three confirmatory techniques within a 24hr period. The data captured for M2 and M3 were stored in a secure database and were reviewed by two blinded reviewers to assess if the IO catheter was correctly placed.
- **Criteria for correct placement**
  - Standard technique (M1): stability of catheter, ability to aspirate blood or marrow, ability to flush without extravasation
  - Doppler ultrasonography (M2): doppler signal only in the IO space
  - Waveform analysis arterial pressure transduction (M3): visualization of pulsatile waveform by pressure transduction of the IO catheter

Fig. 1

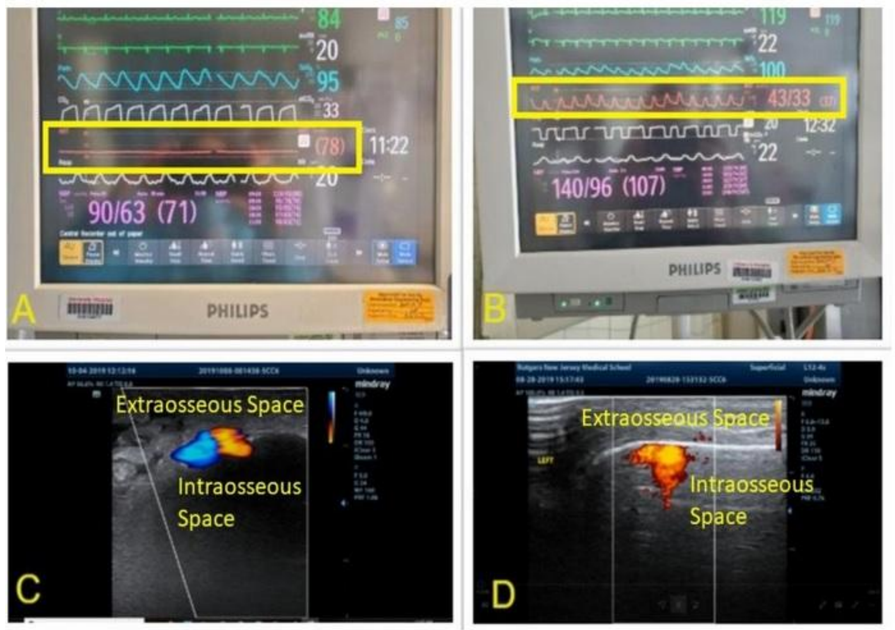

Fig. 1A: Incorrect IO catheter placement by pressure transduction with *flatline* waveform

Fig. 1B: Correct IO catheter placement by pressure transduction with *pulsatile* waveform

Fig. 1C: Incorrect IO catheter placement by ultrasound doppler method with *extraosseous* doppler signal

Fig. 1D: Correct IO catheter placement by ultrasound doppler method with *intraosseous* doppler signal

Results

IO catheters - total no.	42
Subjects - total no.	34
Male sex - no./total no. (%)	13/24 (38.2%)
Median age (SD)	53.8 ± 15.4
Median BMI (IQR)	26.6 ± (22.1-33.1)
Site of IO placement Proximal tibia (%) Humeral head (%)	 39 (92.9%) 3 (7.1%)
IO size Blue 25mm 15-gauge (%) Yellow 45mm 15-gauge (%)	 34 (81.0%) 8 (19.0%)
Number of IO catheter placements 1 (%) 2 (%) 3 (%)	 27 (79.4%) 6 (17.6%) 1 (8.8%)
Indications for IO placement Cardiac arrest (%) Shock (%) Medications for respiratory failure (%) Neurological diseases (%)	 15 (35.7%) 16 (38.0%) 8 (19.0%) 3 (7.0%)
Required CVC placement within 24hrs - no./total no. (%)	27/42 (64.3%)
Median APACHEII score (IQR)	28
Complications	0

Fig. 2

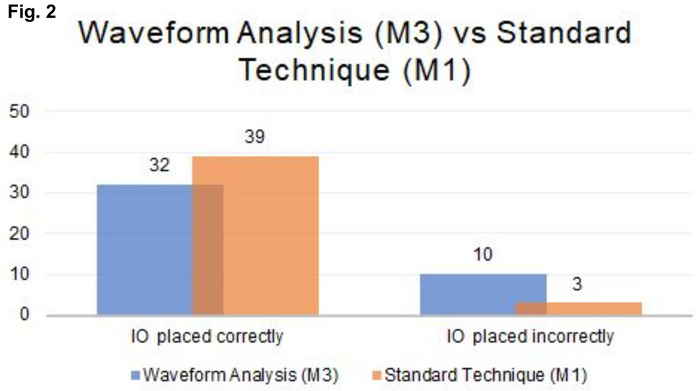

Fig. 2: Compared to method 3, method 1 misclassified 7/10 (70%) of incorrectly placed IO catheters (McNemar p<0.01).Interrater agreement between the two blinded reviewers for M3 was substantial (κ 0.77, p <0.001).

Fig. 3

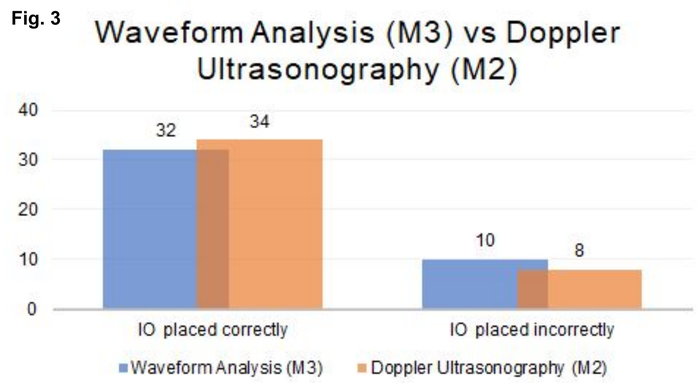

Fig. 3: M3 and M2 performed similarly (McNemar p=0.71). Interrater agreement between the two blinded reviewers for M2 was moderate (κ 0.58, p <0.001)

Conclusion

Waveform analysis via pressure transduction (M3) is superior to the standard of care method (M1) of confirming placement of IO catheters.