

Introduction

- Accurate invasive arterial pressure monitoring is essential for hemodynamic assessment in critically ill patients.
- Arterial line insufficiency, including waveform distortion and impaired catheter function, remains a frequent and underrecognized problem in cardiovascular ICUs (CV-ICUs).
- Despite its clinical relevance, systematic education regarding the mechanisms, recognition, and prevention of arterial line insufficiency is limited.
- We aimed to describe the patterns of arterial line insufficiency observed in postoperative CV-ICU patients and to discuss their educational implications, with particular attention to catheter-related factors.

Methods

- This was a component-level analysis of a double-blinded randomized controlled trial comparing the rate of arterial line insufficiency between polyethylene and polyurethane catheters.¹⁾

PARTICIPANTS: Adult cardiovascular ICU patients undergoing elective surgery and admitted to the ICU.

INTERVENTION: Polyethylene catheter.

COMPARISON: Polyurethane catheter.

OUTCOME: Arterial line insufficiency.

- Arterial line insufficiency was defined by one or more of the following 4 criteria:

i. Flattened or overdamped blood pressure waveform

ii. Sluggish free backflow of blood taking more than 2 seconds when the stopcock of the pressure tube was opened to the atmosphere

iii. Inability to draw blood from the arterial line

iv. Inability to flush the catheter
- Outcome was compared at 4 time points: ICU admission, first noon, 24 hours, and 48 hours after admission.
- Observed insufficiency patterns were categorized into predefined components and analyzed to identify dominant failure modes relevant to bedside assessment and device selection.

Characteristics of Study Participants

Characteristic	Polyethylene Group	Polyurethane Group	Overall	Missing (%)
<i>n</i>	69	63	132	
Age, yr	74 (66–77)	72 (63–77)	73 (64–77)	0.0
Sex, female/male	25/44 (36.2/63.8)	14/49 (22.2/77.8)	39/93 (29.5/70.5)	0.0
Height, cm	164 (155–171)	164 (158–172)	164 (157–172)	0.0
Weight, kg	60 (51–70)	63 (56–72)	61 (54–71)	0.0
Body mass index, kg/m ²	22.6 (20.3–25.4)	23.4 (21.2–25.6)	24.0 (20.6–25.5)	0.0
Hypertension	53 (76.8)	52 (82.5)	105 (79.5)	0.0
Diabetes	11 (15.9)	10 (15.9)	21 (15.9)	0.0
Hyperlipidemia	27 (39.1)	28 (44.4)	55 (41.7)	0.0
Current smoker	7 (10.1)	4 (6.3)	11 (8.3)	0.0
Past smoker	8 (11.6)	12 (19.0)	20 (15.2)	0.0
Peripheral vascular disease	1 (1.4)	1 (1.6)	2 (1.5)	0.0
Preoperative creatinine, mg/dL	0.95 (0.74–1.19)	0.94 (0.80–1.08)	0.94 (0.78–1.11)	0.0
Acute Physiology and Chronic Health Evaluation-II score	20 (14–24)	21 (14–24)	21 (14–24)	0.8
Sequential Organ Failure Assessment score	8 (5–10)	7 (6–9)	8 (5–9)	0.8

Occurrence Rate of Each Outcome Component

Evaluation Time	Outcome Component	Polyethylene Group	Polyurethane Group
At ICU admission	Flattened or overdamped blood pressure waveform	0 (0.0)	3 (4.8)
	Sluggish free backflow of blood taking > 2 s	1 (1.4)	1 (1.6)
	Inability to draw blood from the arterial line	0 (0.0)	0 (0.0)
	Inability to flush the catheter	0 (0.0)	0 (0.0)
First noon after admission	Flattened or overdamped blood pressure waveform	3 (4.3)	17 (27.0)
	Sluggish free backflow of blood taking > 2 s	2 (2.9)	4 (6.3)
	Inability to draw blood from the arterial line	0 (0.0)	3 (4.8)
	Inability to flush the catheter	0 (0.0)	2 (3.2)
24 hr after admission	Flattened or overdamped blood pressure waveform	2 (2.0)	13 (20.6)
	Sluggish free backflow of blood taking > 2 s	1 (1.4)	2 (3.2)
	Inability to draw blood from the arterial line	0 (0.0)	3 (4.8)
	Inability to flush the catheter	0 (0.0)	3 (4.8)
48 hr after admission	Flattened or overdamped blood pressure waveform	2 (3.8)	8 (19.0)
	Sluggish free backflow of blood taking > 2 s	1 (1.9)	1 (2.4)
	Inability to draw blood from the arterial line	0 (0.0)	2 (4.8)
	Inability to flush the catheter	0 (0.0)	2 (4.8)

Results

- Among cases with arterial line insufficiency, waveform abnormalities (flattening or overdamping) accounted for the majority of events (approximately 80–90%), whereas complete functional failure (inability to aspirate or flush) was rare.
- The incidence of insufficiency was highest at the first noon after ICU admission and declined thereafter, suggesting that many events were transient, possibly reflecting reversible factors such as temporary kinking or dynamic changes in catheter function.
- The distribution of failure modes suggests that catheter-related factors, including material properties such as flexibility and resistance to kinking or luminal obstruction, play a key role in waveform integrity.
- These findings indicate that arterial line malfunction is multifactorial and not solely attributable to patient-related or technical insertion factors.

Conclusions

- Arterial line insufficiency is predominantly driven by waveform abnormalities and often occurs early after ICU admission, highlighting the importance of systematic early assessment.
- Understanding catheter-related factors, including material-dependent behavior, may facilitate earlier recognition and more effective troubleshooting at the bedside.
- Incorporating failure mode–based education into ICU training programs may support informed arterial catheter selection and improve the reliability of invasive blood pressure monitoring in critically ill cardiovascular patients.

References

1) Minami K, Kazawa M, Shimatani T, Morinaga M, Shimokawa A, Maeda T, Takeuchi M. Comparison of the Incidence of Arterial Pressure Line Insufficiency Between Polyethylene and Polyurethane Catheters in the ICU: A Randomized Study. Crit Care Med. 2025 Oct 1;53(10):e1973-e1981. doi: 10.1097/CCM.0000000000006794. Epub 2025 Jul 16. PMID: 40668064.