

Cumulative sum (CUSUM) analysis: A novel tool to assess learning of ultrasound-guided vascular access procedures among pediatric anesthesiology trainees

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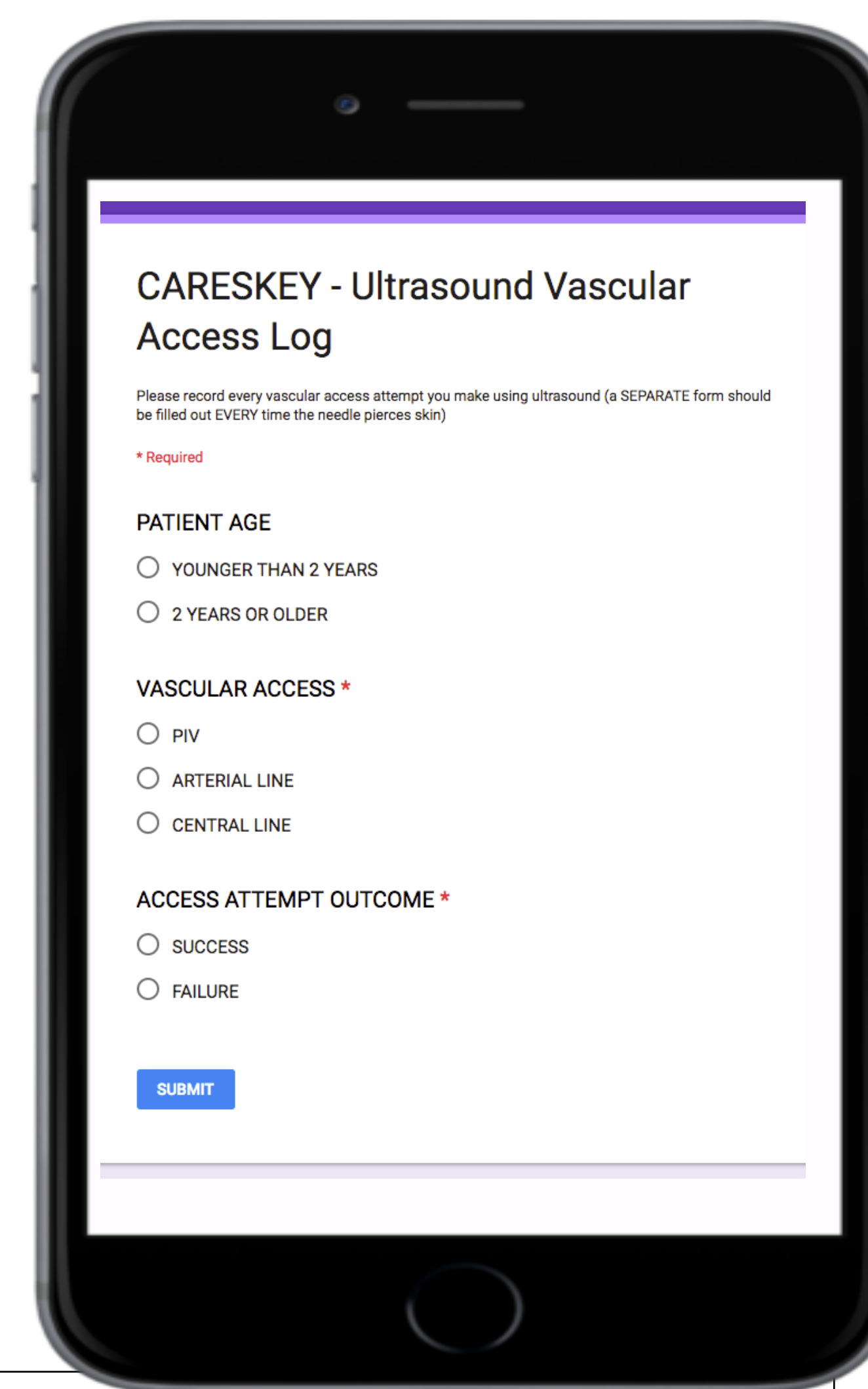


Background

- Vascular access is a critical but often challenging component in providing safe anesthetic care to pediatric patients
- Ultrasound (US) guidance is increasingly utilized in cases of particularly difficult access
- Hypothesis: proficiency in US-guided establishment of vascular access among learners should improve over time
- Mastery of skill should be expected after a certain number of attempts
- CUSUM analysis is a statistical model that quantifies an individual's progress over time as they learn a new procedural skill
- CUSUM gauges skill mastery with objective data

Methods

- Anesthesia fellows self-report their each US-guided PIV, A-line and C-line attempt
- Submissions via web-based application on CCHMC-issued smartphones
- Each needle poke through the skin is counted as an attempt
- Individual CUSUM plots were created for each fellow based on procedure type
- Acceptable and unacceptable failure rates (Fig 2) were established prior to data collection based on experiences from senior faculty in our department
- Skill mastery is defined when the graphical trend falls below the CUSUM value representative of an acceptable failure rate



Screenshot of web-based app for self-reported individual attempts at ultrasound guided PIV, A-line and central line placement. Each pediatric anesthesia fellow has this app pre-downloaded on their CCHMC-issued smartphone.

CUSUM Results: Evidence (or not!) of skill mastery

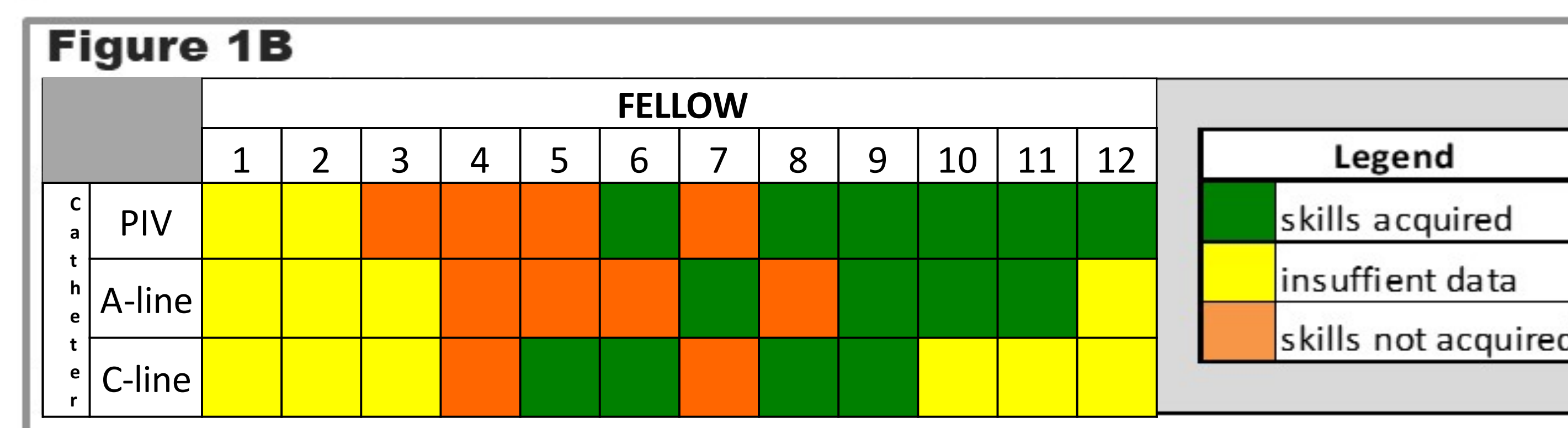
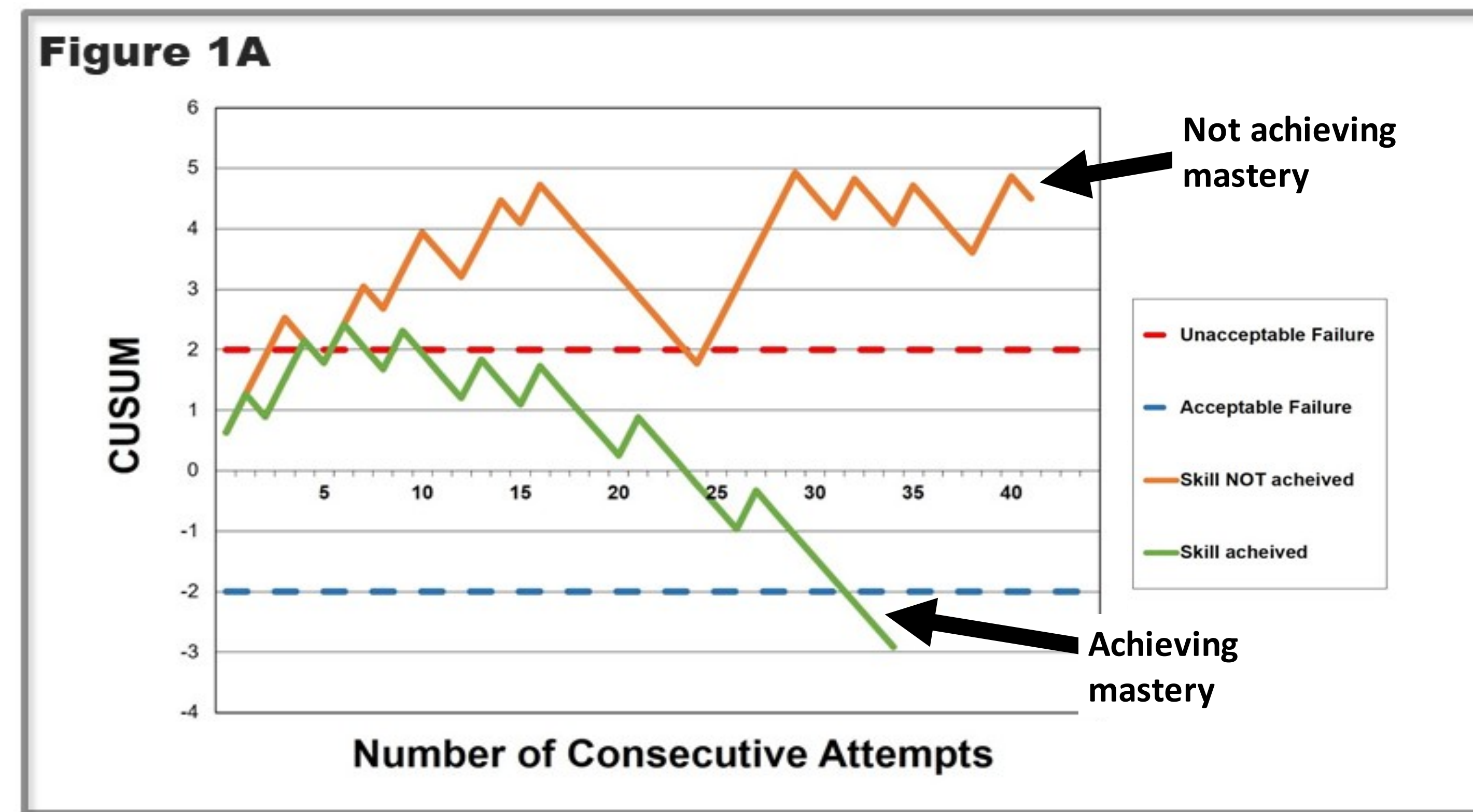


Figure 1A. Representative CUSUM plots for two learners performing a procedure. CUSUM values of -2 and +2 represent the acceptable and unacceptable failure rates. **B:** Once a learner's curve crosses and is sustained above or below the unacceptable or acceptable CUSUM values respectively, the learner is identified as "skills acquired" or "skills not acquired." If a sustained trend is not established, there is "insufficient data" to categorize the learner.

Figure 1B. Skill acquisition plot for all pediatric anesthesia fellows indicating various ultrasound-guided procedures.

Figure 2

Failure rates defined:

Acceptable failure rate ($\leq 20\%$) - How often an "expert" would miss an IV/A-line/C-line
"an expert would be successful in 4 out of 5 attempts"

Unacceptable failure rate ($\geq 50\%$) - How often a "novice" would miss an IV/A-line/C-line
"a novice's success rate would be only as good as a coin flip, 50/50"

Discussion

- Data suggest that US-guided PIV placement might be a more difficult skill to master than central and arterial lines
- Limitations of the CUSUM methodology include the need for self-reporting and large number of attempts required to prove statistical significance
- Further data are needed to better define acceptable failure rates among learners, and to understand reasons for variance in number of trials leading to skill acquisition
- CUSUM may be a useful tool for hospital and departmental credentialing criteria
- This methodology may be generalizable to other procedural skills in anesthesia and other medical specialties

Limitations

- Participation rates vary among fellows
- Potential for selection bias (participants more likely to report successes)
- Brief time frame to collect data
- CUSUM does not offer insight into *why* some achieve mastery and others do not
- Acceptable and unacceptable failure rates are arbitrary

Conclusions

CUSUM analysis is a useful evaluation tool for competence in US-guided vascular access procedures among learners of pediatric anesthesia

References

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