The use of cumulative sum (CUSUM) analysis as a competency assessment tool for ultrasound-guided arterial line procedures in young children performed by pediatric anesthesiology trainees

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Introduction

- Invasive arterial monitoring is an important tool in the management of critically ill children and the ACGME currently requires that pediatric anesthesia fellows perform a minimum of 30 arterial cannulations over the course of a 1 year fellowship
- Neonates and small children can be challenging due the small caliber of their arteries and ultrasound-guided vascular access has become an invaluable skill for anesthesia providers (2)
- Fellowship programs may benefit from an objective assessment of procedural competency and the ability to monitor skill acquisition
- Cumulative sum (CUSUM) analysis is a statistical methodology that looks at an individual's progress over time and has been used to determine proficiency in various clinical procedures based on establishment of acceptable failure rates (1)
- Here, we describe CUSUM analysis as an assessment tool to evaluate competency in US-guided arterial line placement in a cohort of pediatric anesthesia fellows

Methods

- 30 pediatric anesthesia fellows self-reported their successful and unsuccessful consecutive attempts at US-guided arterial line placement in pediatric patients older and younger than 2 years; each needle insertion through the skin was counted as an attempt. Individual CUSUM plots were created for each fellow.
- Acceptable and unacceptable failure rates of 25% and 50% respectively were established prior to data collection
- "Competency achieved" was defined as the graphical CUSUM trend falling below two consecutive boundary lines
- "Competency not achieved" was defined as the CUSUM curve failing to cross two boundary lines
- If fewer than 17 attempts (based on power analysis) were recorded, then the fellow was determined to have insufficient number of attempts to determine competency. Frequency and percentage for competency outcomes were summarized by patient's age (<=2 and >2 years old).

Results

- Ten and two fellows failed to achieve competency in younger and older pediatric patients, respectively
- Among fellows who had a sufficient number of attempts in both age groups (n=18), more fellows failed to achieve competency in younger (n=9, 50%) than older (n = 2, 11%, p=0.0082 from McNemar test) pediatric patients

Figure 1A: US-guided Arterial Line Attempts in Patients Age Less Than 2 years - Competency Not Achieved (n=10)

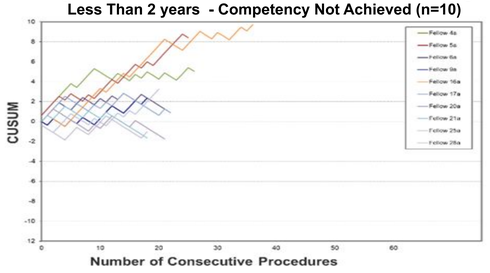

Figure 1B: US-guided Arterial Line Attempts in Patients Age Less Than 2 years - Competency Achieved (n=12)

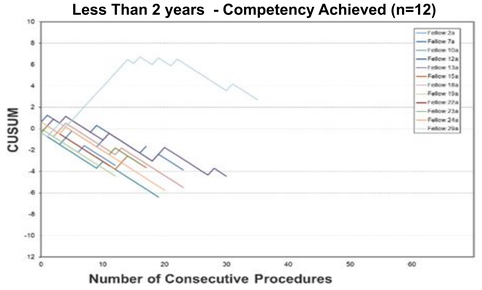

Figure 1C: US-guided Arterial Line Attempts in Patients Age 2 years and Older – Competency Achieved (n= 18)

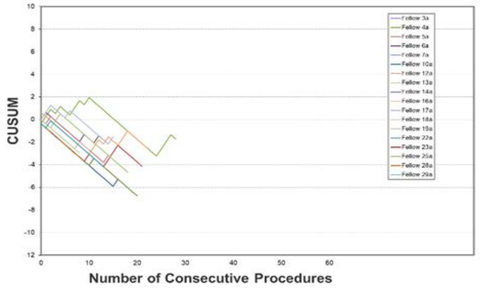

Figure 1. CUSUM plots for fellows performing US-guided arterial line placement in patients younger and older than 2 years. Each CUSUM curve represents a series of successes (downward trend) and failures (upward trend). If a fellow crosses two boundary lines from above, the observed failure rate is lower than the acceptable failure rate and competency can be declared.

Results Cont'd

- On average (median), 11 and 6 attempts were required to achieve competency in younger and older patients, respectively
- Among fellows who achieved competency in both age groups (n=9), attempts required to achieve competency is higher (mean(sd)=13.9 (7.8)) in the younger than in the older (mean(sd)=8.7(4.3), p=0.018 from paired t-test) age group
- Individual CUSUM curves for fellows achieving and not achieving competency are shown in Figure 1

Discussion

- Our data demonstrates the utility of CUSUM in determining competency for US-guided arterial line placement in pediatric patients
- We found varying skill acquisition with some learners achieving competency faster than others
- US-guided arterial line placement in children younger than two years appears to be a more challenging skill
- Limitations of the CUSUM methodology include the need for self-reporting and large number of attempts required to prove statistical significance

Conclusion

- CUSUM analysis has potential as an evaluation tool of competency in US-guided vascular access procedures among learners of pediatric anesthesia
- It may be possible to use CUSUM analysis to identify those who lag behind to provide targeted intervention measures

References

1. Getulio de Oliveira Filho. Anesth Analg. 2002. 95: 411-6
2. Anantasit, N, et al. J Ultrasound Med. 2017; 36: 2495-2501