Analyzing Rapid-Cycle Deliberate Practice vs Mastery Learning in Training Nurse Anesthetists on the Universal Anesthesia Machine Ventilator in Sierra Leone

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Abstract

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INTRODUCTION: Underserved Sub-Saharan countries have 0.1-1.4 anesthesia providers per 100,000 citizens, below the Lancet Commission’s target of 20 per 100,000 needed for safe surgery.

OBJECTIVES: To compare 2 techniques in training nurse anesthetists on the Universal Anesthesia Machine: rapid-cycle deliberate practice (RCDP) and mastery learning (ML) and determine if RCDP is superior to ML.

METHODS: A 2-week Universal Anesthesia Machine course was administered to nurse anesthetists in Sierra Leone. Total time in each scenario, number of completed checklist items, and number of times participant was stopped were recorded. Statistical significance to .05 was determined with the Mann-Whitney U Test.

RESULTS: Participants underwent baseline and post-training evaluations. Of 17 participants, 7 were randomized to the rapid-cycle deliberate practice (RCDP) group, and 10 to the control group. Participants completed 3 scenarios: general anesthesia (GA), intra-operative power failure (IPF) and postoperative pulmonary edema (PPE). For GA, mean time difference between the post and pre-test was 14 minutes for the RCDP group, and 10.4 minutes for the ML group. For IPF, mean time difference was 2.7 minutes for the RCDP group and 3.2 minutes for the ML group. For PPE, mean time difference was 0.07 min for the RCDP group and 0.1 minute for the ML group. There was no statistically significant difference in time elapsed between the RCDP and ML groups. The highest frequency problem areas were: pre-oxygenation, switching from spontaneous to mechanical ventilation, and executing appropriate treatment interventions for a postoperative emergency.

CONCLUSION: These findings suggest that while RCDP may be a useful strategy, increasing the sample size may increase the statistical power of the study to provide stronger evidence of any differences between ML and RCDP.

Introduction

- Low and middle income countries (LMICs) in Sub-Saharan Africa have a shortage of anesthesia providers.
- Only 0.1-1.4 per 100,000 citizens (Dubowitz, Detlefs, & McQueen, 2010).
- Challenging to identify knowledge/skill gaps and improve practice.

Background

- The education need
- Provider maldistribution & provider shortage
- Simulation as an education strategy
- Rapid-cycle deliberate practice as an education strategy
- Simulation-based mastery learning as an education strategy

Rapid Cycle Deliberate Practice vs Mastery Learning as educational strategies

Purpose

- To evaluate rapid-cycle deliberate practice (RCDP) vs simulation-based mastery learning (ML) in achieving proficiency & accuracy of the clinical scenarios on a new intraoperative ventilator.

Hypothesis

Compared to mastery learning (ML) participants, participants in the RCDP group would be more proficient in completing three simulations:

- general anesthesia (GA)
- postoperative pulmonary edema (PPE)
- intraoperative power failure (IPF)

Methods – Participant Selection

Participants: representation of nurse anesthetists from each of the four regions of Sierra Leone.

Inclusion Criteria: All participants must have completed a previous "Fundamentals of Anesthesia" course in Sierra Leone

Exclusion Criteria: Physicians; Healthcare providers trained outside of Sierra Leone

Methods – Design & Variables

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- Experimental pretest & posttest for 2 intervention groups (RCDP & ML)
- Variables:
  - total time spent in clinical scenario (minutes)
  - Number of steps completed on checklist
  - Number of times participant was stopped in scenario (RCDP group only)

Methods - Analysis

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- Mann-Whitney U Test to determine statistical significance between the groups
- Kappa coefficient for inter-rater reliability

Sample General Anesthesia (GA) Checklist for Data Collector

Name of Recorder:
Name of Participant:
Date:
Location:

Routine General Anesthesia Pre-Training Assessment

Time at the start:

Routine Anesthesia Case Learning Objectives

- Not placing the flow-sensor between patient and breathing circuit
- Not placing a bacterial filter in the circuit prior to the flow-sensor
- Not pre-oxygenating patient
- Not transitioning the patient to mechanical ventilation via one of the 3 methods:
    - Moves the ventilator switch (to ventilator)
    - Confirms that the ventilator settings are appropriate
    - Starting the ventilator
- Not transitioning the patient to spontaneous ventilation prior to extubation

Time at the end:

Randomization and Simulation Flow

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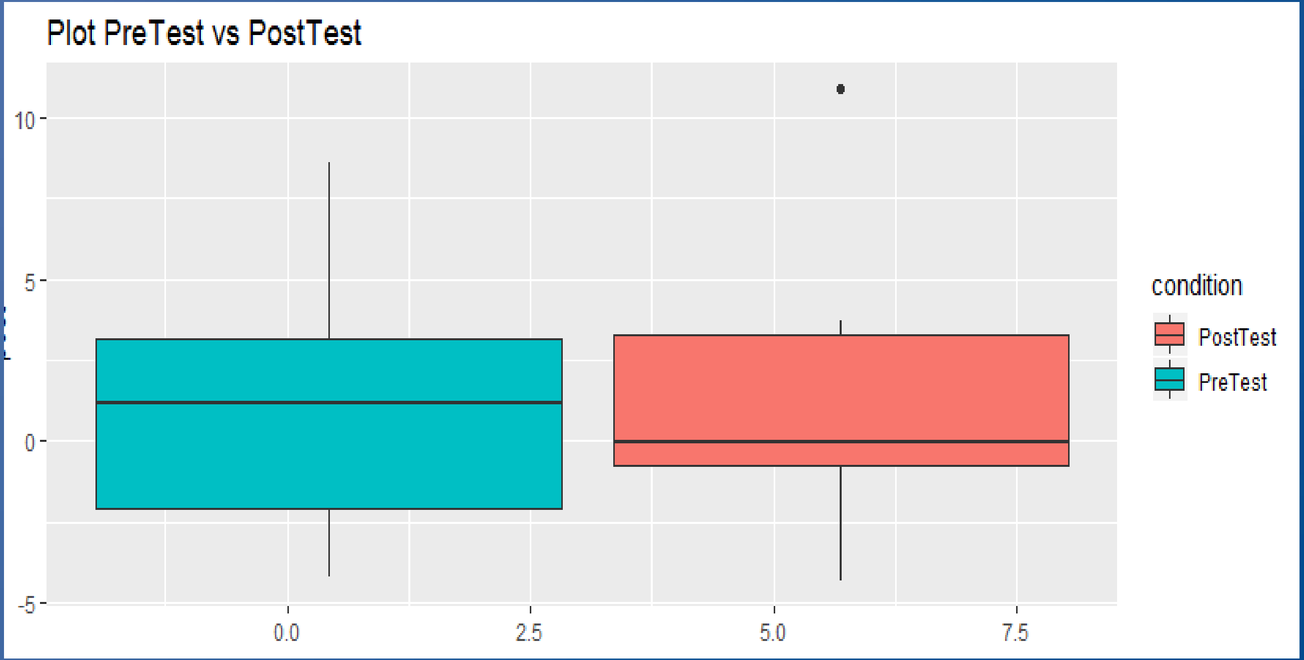
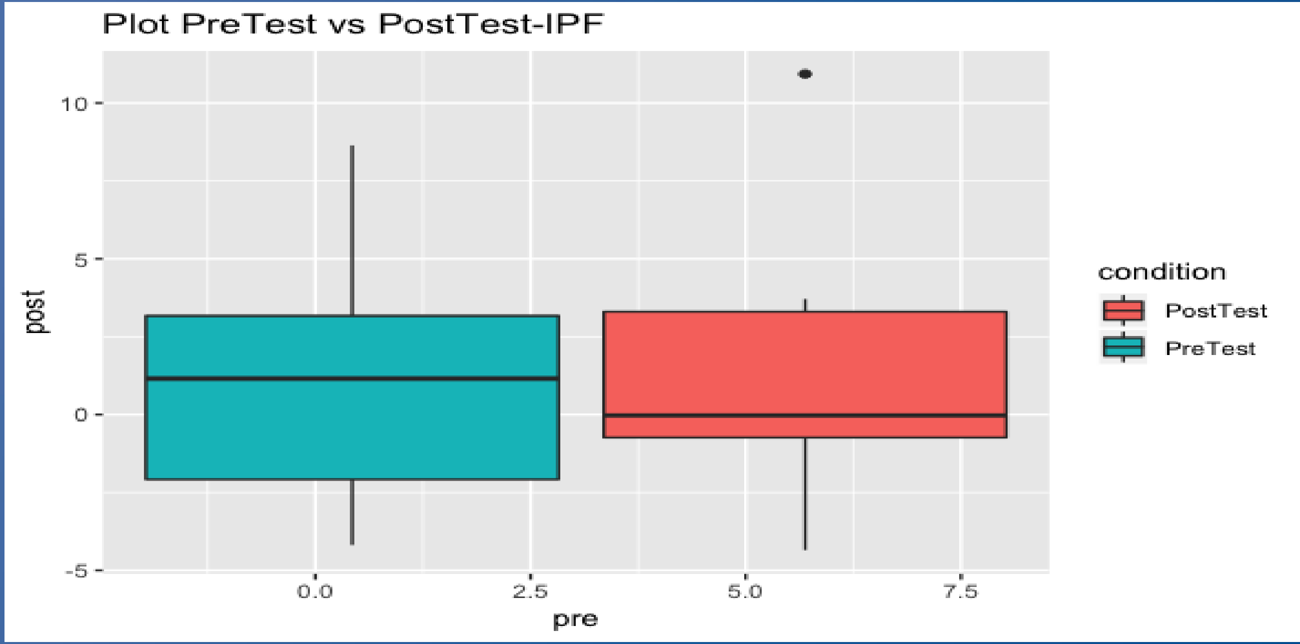
Results (Demographics)

Demographics	Number of Participants	Percentage
Gender		
Male	10	59.41%
Female	7	41.17%
Region		
North Region	6	35.3%
South Region	3	17.65%
East Region	3	17.65%
West Region	5	29.41%
Type of Hospital		
Academic Teaching Hospital	4	23.43%
Community Hospital	13	76.47%
Previous training on UAM Ventilator	0	0%
Nurse Technician	2	11.76%
Anesthetist	15	88.23%

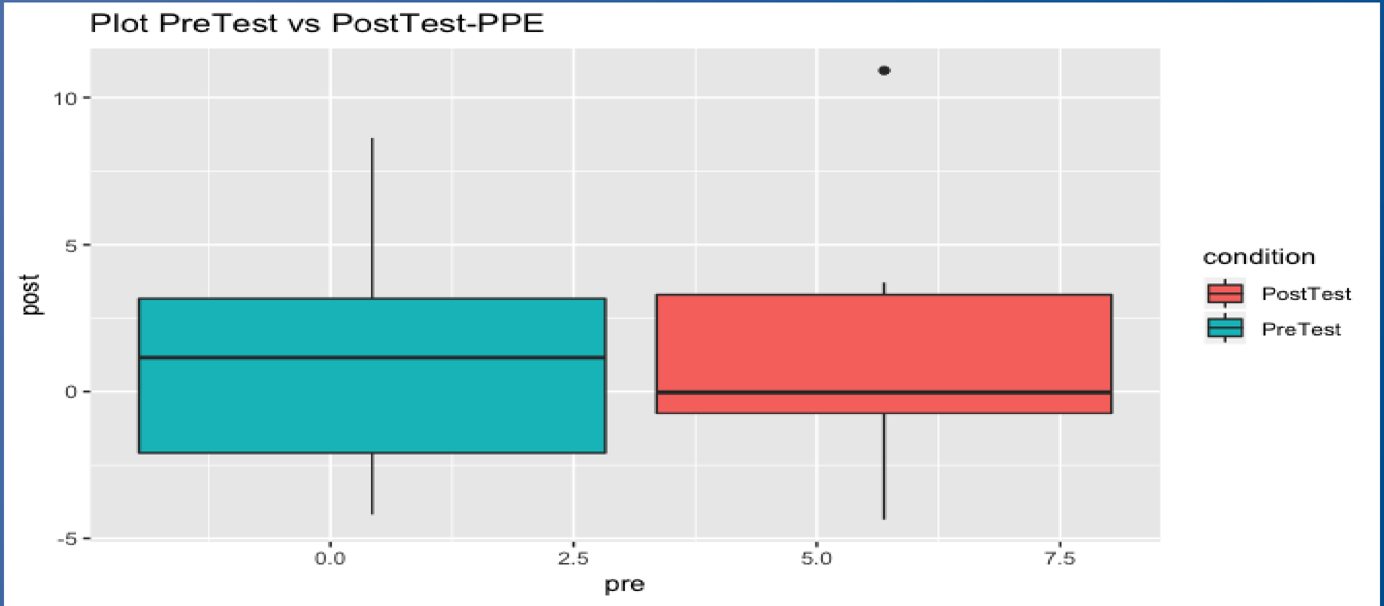
Boxplot - GA Scenario Time Differences



Boxplot - IPF Scenario Time Differences



Boxplot - PPE Scenario Time Differences



Results for proficiency and accuracy (Statistical Analysis)

Group	Mean Difference (95%CI)	P Value from Mann Whitney U tests
GA: Mastery Learning Group and RCDP Group	-3.72(-12.25, 14.07)	0.5164
IPF: Mastery Learning Group and RCDP Group	0.48 (-3.73,4.70)	0.8908
PPE: Mastery Learning Group and RCDP Group	0.03(-2.35, 2.40)	0.846

Comparison group	*Difference (95%CI)*	*P Value*
GA: Mastery Learning Group vs RCDP Group	1.80(-0.64, 4.24)	0.111
IPF:Mastery Learning Group vs RCDP Group	-0.31(-1.60,0.98)	1
PPE:Mastery Learning Group vs RCDP Group	-0.40(-1.11, 0.32)	0.39

Checklist items that correspond to life-threatening gaps in care and group performance

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Variable	Pre-Oxygenation (GA)	Switch from spontan. to mech. Ventilation (GA)	Switch from mech. to spontan. Ventilation (GA)	Identify post operative emergency (PPE)	Identify approp treatment Interventions (PPE)	Recognize breathing circuit disconnect (IPF)	Systematic approach to identifying & correcting the source of disconnect (IPF)	Recognize decreasing oxygen flow meter (IPF)	Recognize depletion of tank (IPF)
% of participants achieving checklist item (both groups)	41.2%	35.3%	35.3%	52.9%	32.4%	21.2%	21.2%	59.3%	50%
# of times stopped for checklist item (RCDP group only)	6	11	2	1	6	2	0	3	3

Interpretation

- Both strategies revealed checklist items with significant performance gaps
- Neither RCDP nor ML had a statistically significant educational advantage in training with the checklist scenarios

Implications

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- Checklist performance gaps have clinical significance in low-resource settings
- There are certain skills that benefit from RCDP in LMICs like Sierra Leone, due to opportunity for “reflection-in-action”
- Reducing performance gaps with either RCDP or ML may reduce frequency of life threatening gaps in care

Limitations

- Small sample size, especially in RCDP group
- No control group; compromise in internal validity
- No long-term follow up
- Limited recording of time-sensitive transitions, especially in PPE scenario

Future Directions

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- Identify long term benefits of RCDP over other education strategies in low-resource settings
- Address the types of skills that benefit from RCDP as a superior strategy in low resource settings.
- Investigate if RCDP has a benefit in other learning domains (knowledge-based, affective) in low resource settings

Conclusion

- Neither ML nor RCDP had a noticeable advantage in acquired proficiency and accuracy.

- Some checklist items correspond with life-threatening gaps in the performance of safe anesthesia in LMICs

- In LMICS, the limiting factor in safe surgical care may be in anesthesia care

Conclusion

- Determining the best educational strategy, training of anesthesia providers at any level can become more impactful in Sierra Leone

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Questions?