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Introduction

The emergence of COVID-19 resulted in major challenges to our global health systems. In response to requests from leadership at our institution the anesthesia department developed clinical protocols to care for COVID-19 patients with a very short window for design and deployment. Frequently new guidelines developed represent "work as imagined" and may not reflect work as done. Rapid workflow changes could put staff at risk for errors and exposure. In situ simulation could provide staff with opportunities to fill gaps in education, practice protocols, reduce cognitive load and help mitigate errors. Simulation-based clinical systems tests (SbCSTs) have been useful to detect gaps and latent safety threats (LSTs) in other clinical applications.

Purpose:
We hypothesized that a rapidly deployed in situ simulation-based clinical system test (SbCST) could help identify latent safety threats (LSTs) in the newly developed protocols for COVID-19 patients in the operating room.

Methods

This study had two main objectives :
1. Use an SbCST approach hybridized with rapid-cycle deliberate practice concepts to identify latent safety threats (LSTs) together with recommendations for mitigation.
2. Evaluate this approach for feasibility and utility based on staff evaluations with immediate and follow-up assessments.

The study took place in a tertiary care children's hospital OR (similar layout to the negative pressure OR's) and was approved by the IRB as non-human subject research. Our aim was to conduct COVID-19 SbCSTs combined with training. SbCST scenarios were designed to be conducted over 60-minute time period. We used Laerdal mannequins, and portable tablet-monitors (SimMon). Prior to arriving participants were instructed to review the COVID protocol and watch the training video that had been developed. After pre-briefing the participant began as the assistant for the first scenario and then participated as the airway manager for the next scenario. Each scenario employed "tipping points" in care to emulate workflow changes.

Scenario Details and Expected Actions

Scenario Triggers	Expected Actions
Pre-briefing-6mo old COVID positive with retropharyngeal abscess presenting for I&D	* Staff Demonstrates ability to don proper PPE * Staff assigns lead and assistant roles * Staff reviews COVID checklist and completes set up
Patient in room and ready for induction	* Staff limits use of positive pressure with low O2 flows * In scenario patient now does not have a functional IV-how does participant handle situation with uncooperative patient that is crying
Intubation	* Staff demonstrates knowledge of checklist * After intubation notifies staff outside of room to start 21 min timer
Need for circuit disconnection	* Demonstrates need to clamp ETT if paralyzed or leave filter on if spontaneously ventilating prior to disconnecting circuit
Extubation	* Follows checklist to prepare for and extubate patient
Transfer of care	* Demonstrates understanding of hand off process to PACU staff in room or transport intubated back to PICU

Methods Cont.

Short debriefs reviewed guidelines such as PPE, and gathered staff input, and then staff repeated the simulation to consolidate learning. After completion of the simulation each participant completed a brief web-based survey to evaluate the SbCST for knowledge gained (novice to expert), feasibility, acceptability and suggestions for improvement. Three trained simulation staff observed each scenario and took notes on a standardized observation form designed for systems testing in four categories: Isolation Measures, Equipment, Job Aid and Communication.
Members of the department then completed a follow up survey 4 months later to evaluate their level of comfort in caring for COVID patients while utilizing the new protocol whether or not they participated in the simulation. The group that participated in the simulation was then compared to the group that did not complete the simulation but utilized the work products (video, checklist, job aid).

Results

A total of 14 anesthesia staff completed the training. **For Objective 1. LSTs and staff recommendations**: A total of 17 unique LSTs were identified. (See table below) A resolution was found for all LSTs.

LST Category	Frequency	LST Description	Resolution
Isolation measure	2/14 pilot	Uncooperative patient increases aerosol risk	Sedation prior to separation
Isolation measure	2/14 pilot	PICU unaware of ETT clamping procedure	Education provided
Isolation measure	2/14 pilot	Discomfort with donning/doffing PPE	Workflow posters placed in ante room of negative pressure OR's
Isolation measure	14/14 (100%)	PPE poster doesn't include required OR attire-caps, shoe covers	Add reminder to include these steps on OR posters
Isolation measure	11/14 (79%)	Unsure where to dispose of contaminated airway equipment	Clarified on job aid/checklist
Isolation measure	14/14 (100%)	Air handler requires 21 min-staff forget to communicate with staff outside OR	Added to job aid
Job aid/checklist	14/14 (100%)	Forgetting to turn O2 flows off/on prior to and post intubation	Added to job aid
Job aid/checklist	14/14 (100%)	COVID checklist too cumbersome (40 steps)	Intubation/extubation job aid created

LST Category	Frequency	LST Description	Resolution
Isolation measure	9/14 (64%)	Contamination of personal stethoscope	Disposable stethoscope added to COVID cart
Isolation measure	14/14 (100%)	Primary provider and assistant had difficulty coordinating roles	Clarified on Checklist and added to job aid
Equipment & Technology	1/14 (0.07%)	Inadvertent extubation from increased weight from clamp while taping tube	Leave circuit attached while taping to avoid clamping
Job aid/checklist	10/14 (71%)	Cuff should be inflated prior to ventilation to minimize aerosol	Added to job aid and clarified on checklist
Job aid/checklist	14/14 (100%)	Lack of communication around patient transfers	OR nursing staff developed standard work
Job aid/checklist	14/14 (100%)	Staff unaware of critical patient transfer procedures	Established guidelines with PICU leadership
Equipment	1/14 (0.07%)	Ventilator circuit cap not tight	Educated to check cap prior to start of case
Communication	14/14 (100%)	Lack of closed loop verification of air handler timer started	Reminders placed on job aids
Communication	11/14 (79%)	OR staff outside unsure when it was safe to enter	Sign outside door with entry time written

Objective 2: Post training Evaluation.
In all, 12 participants filled out the post debriefing survey. All participants strongly agreed it was worth their time. 92% strongly agreed and 8% somewhat agreed that this was an acceptable way to improve system readiness and staff knowledge. Similarly, 92% strongly agreed and 8% somewhat agreed that this was an effective way to test changes and provide feedback. All of the participants strongly agreed that the debriefing process allowed them to share their ideas for improvement.

Results - 4 Month Post-Training Evaluation

Survey item	Did not participated in sim						Participated in sim						Overall				
	N	Mean	Median	SD	Min	Max	N	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
Process was easy to follow	12	4.42	4	0.52	4	5	14	4.64	5	0.50	4	5	4.54	5	0.51	4	5
Process was logical	12	4.5	4.5	0.52	4	5	14	4.71	5	0.47	4	5	4.62	5	0.50	4	5
Process helps protect staff	12	4.75	5	0.45	4	5	14	4.79	5	0.43	4	5	4.77	5	0.43	4	5
Process helps protect patients	12	4.5	5	0.67	3	5	14	4.36	5	0.84	3	5	4.42	5	0.76	3	5
Process helps prevent mistakes	12	4.58	5	0.67	3	5	14	4.29	4.5	0.83	3	5	4.42	5	0.76	3	5
Survey item	Did not manage COVID patient						Managed COVID patient						Overall				
	N	Mean	Median	SD	Min	Max	N	Mean	Median	SD	Min	Max	Mean	Median	SD	Min	Max
Long checklist helps manage airway	10	4.80	5	0.42	4	5	16	4.63	5	0.81	2	5	4.69	5	0.68	2	5
Job aid helps manage airway	9	4.78	5	0.44	4	5	16	4.75	5	0.45	4	5	4.76	5	0.44	4	5
Video helps manage airway	9	4.78	5	0.44	4	5	16	4.06	4	1.06	1	5	4.32	5	0.95	1	5
Covid cart helps manage airway	8	4.88	5	0.35	4	5	16	4.63	5	0.50	4	5	4.71	5	0.46	4	5

Discussion

We found that in situ simulation is a good way to prepare for disease outbreaks and test the development of new protocols. It allowed for the practice of care team dynamics within the actual clinical environment. It also enabled us to identify and address unexpected problems that were not obvious during the formulation of the protocols. Based on the staff perceptions from the post debriefing surveys this method was highly rated and worth the time it took. The simulation participants reported higher levels of expertise in utilizing the COVID protocol for cases in the OR compared to those who did not participate in the simulation. Self-rated knowledge in using PPE did not seem to differ between those who did and did not participate in the simulation session.

Conclusion

In situ simulation of our COVID-19 protocols allowed us to identify and address problems not foreseen during the planning stages and led to many downstream changes to the protocol. It improved participant compliance and increased their confidence with the new process.

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