Military Medical Student Experiences during a Prolonged Casualty Care Simulation

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Introduction

Prolonged Casualty Care (PCC) (previously prolonged field care [PFC]) refers to patient care over a prolonged time in an austere environment where evacuation is not possible.[1, 2] Prolonged Casualty Care education is driven by the United States Military Joint Trauma System's Prolonged Casualty Care (PCC) guidelines, which are a 'consolidated list of casualty-centric knowledge, skills, and best practices intended to serve as the DoD baseline clinical practice guidance to guide casualty management over a prolonged amount of time in austere, remote, or expeditionary settings, and/or during long-distance movements'.[3, 4]

Specialised training in PCC is critical for military medical students, as the concepts and skills required for effective PCC apply to a variety of unexpected scenarios.[2, 5, 6] For example, in future military conflicts, there is an anticipated reliance on PCC with delayed medical evacuation times secondary to large areas of operations and challenges operating in semi- and non-permissive environments.[6]

One education modality for teaching PCC is simulation, which has been shown to develop medical student skills, confidence, decision-making abilities and professional identity.[7] During simulation training, medical students are immersed in a realistic environment where they practice their medical skills in a safe learning space.[8] Students feel free to learn from their mistakes without the concern of harming the patient, while simultaneously receiving constant guidance and feedback from experienced faculty members.[8, 9] Furthermore, simulation training has proven valuable for identifying gaps in student skills where further education may be needed.[10]

This simulation was conducted at a military medical school in the United States and is the only known PCC simulation in undergraduate military medical education. Operation Gunpowder is a two-day military medical simulation held at a National Guard Training Center at Fort Indiantown Gap, PA. The practicum reviews Tactical Casualty Combat Care (TCCC) and then exposes learners to the necessary concepts and practices of delivering PCC, including performing Forward Resuscitative Care (FRC), Forward Resuscitative Surgical Care (FRSC), and Patient Movement (PM) while providing En-Route Care (see Appendix A for course objectives).

During the simulation, the third-year medical students in our study underwent a small-team, mobile and tactical deployment with limited resources in an austere environment. They received hands-on experience with simulated patients and cutsuits as they transported their patients by vehicle and simulated aircraft, working as a team to move the patients safely from one stage of care to the next. The simulation was run by a team of interdisciplinary faculty, including physicians, physician assistants, certified nurse anaesthetists, medics and corpsmen, all with significant operational experience. Throughout the simulation, as little notionalisation as possible is utilised. For example, medication bottles were pre-labelled, and students were required to calculate, draw up and administer medication to a simulated patient. Additionally, students were required to assemble the correct equipment to set up a Walking Blood Bank (WBB).

Deeply rooted in the PCC principles published in the recent JTS PCC Clinical Practice Guideline (CPG), Operation Gunpowder took students from the Casualty Collection Point (CCP) to the Role 4 hospital in five phases: 1) CCP/Tactical Field Care; 2) Role 1/PCC; 3) Ground CASEVAC/En-Route Care; 4) Role 2/FRSC; 5) Air Evacuation En-Route Care (see Table 1).

Rationale

Past studies have explored the impact of simulation on undergraduate medical student learning as a whole.[7, 8] In addition, past research has advocated for using simulation to teach PCC to emergency medicine residents.[2] However, no research has focused specifically on how simulation helps undergraduate military medical students learn how to conduct PCC,

Table 1. Five phases of Operation Gunpowder PCC simulation

Phase 1- Casualty Collection Point (CCP) /Tactical Field Care	Students began the scenario at the CCP where they encountered a patient with traumatic wounds secondary to an explosion. Students were required to perform Tactical Combat Casualty Care (TCCC). Working as a team, students transferred their patient to a safe location and established a Role 1.
Phase 2- Role 1/ Prolonged Casualty Care (PCC)	As Gunpowder's focus is PCC, most of the practicum was spent in Phase 2. At the safe house, the students encountered a second patient who was critical. In this phase, the students performed comprehensive histories and physical examinations, completed additional life-saving procedures, and recorded and trended vital signs while creating nursing care plans. The students were also given access to teleconsultation, where additional faculty (intensivists) were integrated. During this phase, the students were also responsible for implementing teamwork/rest cycles.
Phase 3- Ground CASEVAC/ En-Route Care	Patients were transported via ground CASEVAC, where the students were required to prepare and transport their casualties safely.
Phase 4- Role 2/ Forward Resuscitative Care & Forward Resuscitative Surgical Care	The students arrived at a Role 2 facility where they were exposed to the concepts and practices of Forward Resuscitative Care and Forward Surgical Care. They practised operating ventilators and learned the role of surgeons and anaesthesiologists in stabilising patients for transport to definitive treatment.
Phase 5- Air CASEVAC En-Route Care	The students transported their patients into a simulated V-22 Osprey helicopter (a box truck) while they performed En-Route Care. On arrival, the students transferred their patients to the receiving medical team.

a vital training area for future deployments.[2, 11] To fill this research gap, this qualitative study aimed to explore the experiences of third-year military medical students during Operation Gunpowder.

Materials and methods

Design

Our research team used a qualitative phenomenological design to explore the experiences of third-year medical students attending Operation Gunpowder during Spring 2022.[12] A total of 163 students attended Operation Gunpowder in Spring 2022. We emailed all the attendees, asking them to volunteer for our study. Of the 163 students, 35 volunteered to participate in the study. We asked each volunteer participant the same questions from the interview protocol. There are no rules or calculations regarding sample size in qualitative research design.[13] Rather, after reviewing the interview transcripts, we determined that no additional follow-up data collection or participant recruitment was needed because saturation had been reached. Phenomenology explores the essence of the participants' experiences during a particular phenomenon, which in this case is Operation Gunpowder, to gain an in-depth understanding of these experiences.[12, 14] Qualitative research design provides in-depth insight into one particular case that can be applied to other cases in a variety of other settings.[15] Therefore, in this study, our insight into the students' learning experiences at Operation Gunpowder can be extrapolated to other military medical education and training venues.

Data collection

To investigate students' learning experiences at Operation Gunpowder, we interviewed the participants before the start of Operation Gunpowder and at the conclusion of Operation Gunpowder. Each student was interviewed twice using open-ended questions (see Appendix B for the Interview Guide). The interviews occurred within two days of each other. The Institutional Review Board approved this study at the authors' medical school.

Data analysis

Our research team closely followed the steps of phenomenological data analysis to analyse our data.[16] We first transcribed the interviews using an automated transcription service. Next, each research team member individually coded the deidentified data, noting statements throughout the interview transcripts that directly illustrated the students' learning experiences at Operation Gunpowder. Next, we met as a research team to discuss the codes, categorise these codes, and organise these categories into themes. After engaging in discussion, we agreed on how to define each theme. Any disagreements or differences in viewpoints between team members about this organisation and categorisation process were resolved through open discussion until we reached a consensus among team members about the study results. We took detailed notes during these meetings to document this consensus process.[17] To report our findings in the results section of this manuscript, we used a composite description of the themes, with illustrative quotes as supportive

evidence to articulate the essence of the participants' common experiences.

Strategies to increase the trustworthiness of our results

We used several strategies to increase the credibility of our study's results. First, we interviewed each participant twice to gain an in-depth understanding of their experiences, otherwise known as prolonged engagement.[18] We also used member checking, in which we emailed the interview transcripts back to the participants after the second interview so they could edit or add any necessary information from both interviews.[19] Finally, we used a research team to analyse the data, bringing multiple perspectives to the data analysis process.[20] Our research team independently coded the data and then collectively agreed on the emerging themes, which served as the study's results. Our research team also discussed our biases and how we were bracketing these biases throughout the data analysis process.[21] For example, as faculty members and medical students at the university conducting the simulation, we were inherently inclined to assume its value for student learning. However, as directed by the professional qualitative research design literature, we openly discussed this bias and collectively worked to ensure it was not influencing our interpretation of the participants' experiences.[21]

Results

The following themes emerged from our data regarding the students' learning during Operation Gunpowder. The students 1) benefited from hands-on learning, 2) learned how to navigate the unpredictable and stressful nature of the operational environment, and 3) developed leadership skills and abilities.

Benefited from hands-on learning

The participants first described Operation Gunpowder's experiential learning environment, comparing the hands-on environment to the traditional classroom. One student differentiated between the two teaching modalities. *Actually applying a tourniquet, actually trying to do a cric, actually doing those things. It takes a skill that you're not just going to get from watching videos and from listening to lectures. (P 26). Another student compared the depth of each learning approach. There's just so much more that we can learn in the field. You don't learn until you're 'doing'. It's not like I don't have the knowledge, it's just I don't know how it's applied, what it looks like. (P18).*

The students also commented on the hands-on learning environment at Operation Gunpowder. *Nothing replaces actually getting out there and doing it and being down your knees, and slipping in with blood in your hands, and trying to get an actual IV in. Trying to get tourniquets on, trying to do a cric or put in a chest tube. (P22).* Another participant described how practising their skills in a simulated operational environment provided them with more realistic learning aligned with their future operational landscapes. *Anyone can read a book and read a definition and then spit it back out. But yeah, running up on a patient and sliding down that hill that's wet and then putting on a tourniquet… that's different. (P1).*

Navigated the operational environment

As a result of their hands-on experiences at Gunpowder, the students described the lessons they learned from practising PCC in an unpredictable and stressful operational environment. First, they learned how to navigate the unknown. For example, one participant recalled that *on route to a checkpoint, we got a casualty and we had to stop and treat them. We weren't expecting it at all. We weren't ready and had to improvise. (P29).* Another described a change in mindset. She learned to constantly think about *contingency planning, you're MacGyvering things and coming up with creative solutions in the moment. I feel like that's not something I've been pushed to do at other points in my medical training so far, so I think that it was definitely a very steep and good learning curve. (P10).*

Next, the students learned how to handle the stress of providing PCC in the operational environment, especially when transporting patients. *We moved the patient four times and the IV fell out. Everything is loud, everything is cold, your patient is like, losing heat, getting worse if you don't pay attention to every single thing that's going on. So it just gives you a bigger picture of what's going on and how you have to look at every little piece. (P32).* Another student credited the stressful environment with facilitating his professional growth and development. *I think it was good to create a stressful environment because… it shows your gaps or weaknesses and better do that in a training environment versus a real deal experience. (P5).*

In addition to learning how to navigate unpredictable and stressful circumstances, the students navigated a resource-limited environment common to the operational environments they will practice medicine on future deployments. One described the importance of innovation while practising PCC in

an operational environment with limited resources. *You've got to get creative, using whatever resources you do have, trying to make it work. (P5).* Another student emphasised the importance of innovation and creativity for problem solving.

> *The amount of supplies was always a problem, you know, by the time you get to prolonged field care, you're like, 'Oh, s— I'm out of blood, I'm out of crystalloid alright, we've used all our tourniquets'....We needed to put a catheter in someone, a Foley catheter, we didn't have one. We had the tubing for it, but we had to figure out how to improvise a bag for it out of an old IV bag we had used and emptied....and realized like, Oh, okay, there's so many different things I can do to think outside the box and accomplish my mission right now. (P22).*

Because of the resource-constrained environment at Operation Gunpowder, the students gained a newfound understanding of telemedicine's value in helping them treat their patients in an austere, resource-limited environment. For most, Operation Gunpowder was the first time they used telemedicine, and they found comfort in it. *I thought it was soothing. It was like, even just like having her on the phone, like made me feel better. Like, it was like, there's another pair of eyes on this who's like not in this. (P2).* Another student's increased comfort level increased her confidence in practising PCC in an operational environment. *It was really neat that you could not know something and still get help, which would increase my confidence level in going out just because you're not alone. (P26).*

One student described the benefits of using telemedicine to gain an additional perspective about how to treat a patient. *One of our patients had signs of elevated intracranial pressure and we didn't have hypertonic saline or supplies needed to treat that. We did a telemedicine consult who was able to help us dose Keppra that we had in our packs and weren't thinking about using. (P20).* After practising telemedicine at Operation Gunpowder, the students extended the benefits of telemedicine to their future work in the field. *I think that it has revolutionised the ability to care for soldiers because if you're in the field and in an austere environment, we've got like a TBI patient, we can consult. Or, if we've got an X-ray in the field, and we don't know what's going on, we can consult radiology (P7).*

Developed leadership skills and abilities

In the complex operational environment, the students described how Operation Gunpowder helped them to better understand the complexities of leadership in the operational environment. One student discussed the need to see the big picture as a leader. *Transitioning from just being a doctor and focusing on one patient, like taking a step back, looking at the entire situation and thinking about more than just the patient. (P11).* When serving as a team leader for the first time, another student realised the need to intentionally take a step back so that she could see the big picture.

> *It was really hard to find that right balance, being involved enough to know what was going on with each of our team's patients, but also staying far back enough to not get bogged down. Like bogged down and then miss something that was happening, but trusting my teammates, "Okay, they've got this. I just need to supervise, and fill in where it is needed, or help redirect", even though that's difficult as a med student 'cause you're like, "I should be there doing the hands-on stuff that we are being trained to do." (P31)*

In addition to gaining insight into the leadership role during PCC, the students recognised the importance of the followership role for successful team dynamics. One described the importance of *always being willing to just take a step back, be the follower when you're needed and then be the leader when it's time. (P13).* Another explained the benefits of the follower role for enhancing team dynamics. *Sometimes it makes sense to be a follower...Seeing my fellow med students think through the process and following their lead, and following their instruction...and trusting them. (P27).*

As a result of these leadership and followership experiences, the students realised their potential as leaders. One described how he was *out of my comfort zone, but it absolutely increased my confidence. I am definitely more confident in my leadership ability. I felt myself being more vocal and willing to take that role. (P4).* Another described how his confidence in his leadership abilities increased after stepping into a leadership role at Gunpowder. *Gunpowder made me aware that I'm not always the most comfortable stepping up into a leadership position, but also helped me to recognize it's not usually as bad as you think it's going to be. (P21).*

Discussion

Students' perceptions are essential for determining the value of a learning environment.[22-25] The students in our study described their experiences at a high-fidelity simulation, Operation Gunpowder. Overall, they discussed how the simulation-based learning experience increased their medical skills, ability to

navigate the operational environment's unpredictable stressors and conceptualisation of leadership.

PCC is an important focus area for research and training to effectively prepare military physicians for future combat operations in far-forward, resource-limited environments.[1, 2] As best practices and models for PCC continue to be researched and developed, both medical education and military leadership need to know how to effectively teach these best practices to medical students and military medical officers in the field so that they are ready and able to care for patients in the evolving landscapes of the operational environment.

The results of our study likewise align with the past studies in the medical education literature that prove the benefits of simulation-based education for student learning.[7, 26] We extended these results to a simulated PCC scenario as our students described the value of a high-fidelity simulation for learning PCC. To expand on this initial study, we plan to gather quantitative data measuring the impact of Operation Gunpowder on students' skill performance using a pretest–post-test design.

Telemedicine is another important area of future research and training for military physicians conducting PCC in austere and resource-limited environments.[6] The students in our study expounded on telemedicine's benefits for future use in the field. As technology develops and the potential to use telemedicine in the field increases significantly,[27] it is crucial for military medical educators to continue to develop best practices like Operation Gunpowder for training future military physicians to effectively use and maximise the benefits of telemedicine in the operational environment.

Limitations

This study's results were limited to one cohort of students from one university. In addition, we only explored the experiences of 35 students. Future large-scale quantitative research might examine the learning experiences of all 163 students participating in Operation Gunpowder and determine the impact of the simulation on their learning and performance.

Conclusion

The participants in our study described how the high-fidelity simulation challenged their existing medical knowledge and skills helped them identify areas for future professional development. The third-year medical students also described how Operation Gunpowder developed leadership abilities necessary for their roles as military medical officers.

Disclaimer

The opinions and assertions expressed herein are those of the authors and do not reflect the official policy or position of the US Army, the US Navy, the Uniformed Services University of the Health Sciences, or the Department of Defense.

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Appendix A. Course Objectives

By the conclusion of MFP 201: Operation Gunpowder, students will be able to do the following:

Military Medical Leadership:

1. Demonstrate a high standard of professionalism
2. Contextually discriminate effective and ineffective leadership behaviours in a small-team and squad-level environments
3. Using Troop Leading Procedures, effectively lead a small medical team in an isolated, austere, and resource-constrained environment
4. Demonstrate Leader-Follower Framework principles of leadership on a squad level

Military Medical Practice:

1. Describe medical support challenges within special operations and other far-forward small units
2. Create Prolonged Casualty Care and En-Route Care contingency plans
3. Demonstrate appropriate casualty preparation for air and ground evacuation in a simulated situation
4. Outline unique En-Route Care considerations regarding the environment and Patient Movement
5. Perform equipment class-VIII inventory in order to support Prolonged Casualty Care

Military Field Medicine:

1. Demonstrate Tactical Combat Casualty Care knowledge and skills consistent with current guidelines, with simulated combat casualties in a field setting
2. Participate in the performance of critical care resuscitation skills, including hemorrhage control, vascular access, and airway management, with simulated medical and trauma patients in a Prolonged Casualty Care scenario
3. Demonstrate the ability to recognize and manage a patient in hemorrhagic shock
4. Demonstrate the ability to recognize and manage a patient in septic shock
5. Demonstrate the ability to recognize and manage a patient in respiratory failure
6. Demonstrate critical care best practices, including resuscitation, pain management, and nursing skills with simulated patients in a Prolonged Casualty Care scenario
7. Defend the collection and use of fresh whole blood for patient resuscitation in a field environment
8. As a team, execute appropriate telemedicine consultation to optimize care of patients in a Prolonged Casualty Care scenario
9. Outline Forward Resuscitative Surgical Care capabilities of a Role-2 Light Maneuver unit or team
10. Explain the concepts, principles, and intended outcomes of damage control resuscitation and damage control surgery
11. Recommend appropriate transitions of patient care, including verbal hand-off and written documentation to another provider

Appendix B. Interview guide

Interview 1:

What are your expectations for Operation Gunpowder?

Do you feel prepared for Operation Gunpowder?

What goals have you set for yourself?

What do you think you will learn at Operation Gunpowder?

How would you describe Tactical Field Care?

How would you describe Prolonged Casualty Care?

How would you describe Forward Resuscitative Care and Forward Resuscitative Surgical Care?

How would you describe En-Route Care?

How will you utilize prolonged field care in the future?

Why is Prolonged Casualty Care important?

How will you utilize telemedicine in your future work as a MMO?

How would you describe the role of the Military Medical Officer (MMO)?

How confident do you feel in your readiness for your first deployment, on a scale of 1-10?

Interview 2:

What was the most memorable part of Operation Gunpowder?

What goals did you accomplish?

How did Gunpowder affect your medical skills?

How did Gunpowder affect your leadership abilities?

How would you describe Tactical Field Care?

How would you describe Prolonged Casualty Care?

How would you describe Forward Resuscitative Care and Forward Resuscitative Surgical Care?

How would you describe En-Route Care?

How will you utilize prolonged field care in the future?

Why is Prolonged Casualty Care important?

How will you utilize telemedicine in your future work as a MMO?

How would you describe the role of the Military Medical Officer (MMO)?

How confident do you feel in your readiness for your first deployment, on a scale of 1-10?