Relevance of Simulation Practices for Improving the Internalization of Cardiopulmonary Arrest Management Protocols

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ABSTRACT

Objective:

Effective training in cardiopulmonary arrest (CPA) management is crucial for future healthcare professionals, as timely actions impact survival. Despite standardized AHA protocols, their practical internalization remains difficult. Simulation-based medical education (SBME), particularly with structured debriefing like the PEARLS model, has become essential for developing competencies in safe environments. The objective of this study was to evaluate the relevance of deliberate simulation practices (zones 1 and 2) in improving theoretical understanding and CPA protocol adherence among medical students.

Methods:

A quasi-experimental pre-post study was conducted at the Clinical Simulation Laboratory (LaSiC), Faculty of Medical Sciences, University of Buenos Aires. Ten teams of final-year medical students participated voluntarily in a 30-hour simulation workshop over five weeks. The program included asynchronous theoretical content and in-person sessions: basic skills training (Zone 1) and eight high-fidelity scenarios (Zone 2) emphasizing teamwork. After each scenario, a structured debriefing based on the PEARLS model was conducted, fostering self-assessment, facilitation, and feedback. Internalization was measured via an anonymous pre-post questionnaire.

Results:

Correct questionnaire responses improved significantly, from a pre-test average of 66.24% to 83.3% in the post-test. Some scenarios showed increases of up to 56.3%, indicating effective protocol incorporation. Deliberate practices across simulation zones supported the development of individual and team competencies. The PEARLS model was key for reflection and consolidation. Despite limitations (no control group, indirect measurement), findings suggest a strong association between the intervention and improved outcomes

Conclusion:

A simulation workshop using deliberate practices and structured debriefing (PEARLS model) is an effective strategy to enhance CPA protocol internalization and develop essential technical and non-technical skills in medical students

Keywords: Simulation, Deliberate Practice, Structured Debriefing

INTRODUCTION

Effective clinical training in emergency medical management is a fundamental pillar in the education of future healthcare professionals. Within this domain, cardiopulmonary arrest (CPA) represents one of the most critical situations, where timely and appropriate intervention is a key determinant in patient survival rates [1]. American Heart Association (AHA) guidelines emphasize the relevance of a rapid and protocolized response, including early administration of drugs like epinephrine in non-shockable rhythms or early defibrillation in

shockable rhythms [2]. Despite the existence of standardized protocols, their effective internalization and the practical training of healthcare professionals for their correct application remain a significant challenge. In this context, simulation-based medical education (SBME) emerges as a high-impact pedagogical strategy, allowing students to experience realistic scenarios and develop essential skills in a safe and controlled environment [3, 4]. SBME has proven to be a robust tool for teaching and evaluating complex clinical skills [5, 6].

A crucial component of clinical simulation is debriefing, a reflective analysis session following the experience that facilitates knowledge integration and performance improvement [7, 8]. Structured debriefing models, such as PEARLS (Promoting Excellence And Reflective Learning in Simulation) [9], enhance self-assessment, focused facilitation, and direct feedback—essential elements for meaningful learning and protocol consolidation [10, 11]. This study aimed to evaluate the relevance of deliberate practices applied in a "Simulation Workshop" on basic and advanced CPR to improve the internalization of theoretical content and the action protocol for CPA. Through a structured approach that combined theory with deliberate practices followed by instructor-guided structured debriefing, we sought to determine the impact of these experiences on students' ability to apply theoretical knowledge in practical situations, thereby strengthening their confidence and competence in managing critical situations.

Objective

General Objective: To determine the effectiveness of a clinical simulation workshop integrating deliberate practices and structured debriefing (PEARLS model) to improve medical students' performance in the internalization and rapid application of the CPA management protocol.

Specific Objective: To quantitatively compare the percentage of correct responses in a pre-post questionnaire, evaluating the internalization of theoretical content and the action protocol in CPA scenarios, following participation in simulation practices in zones 1 and 2.

MATERIALS AND METHODS

Study Design: A formative intervention study with a quasi-experimental pre-post (pre-test/post-test) design was conducted at the Clinical Simulation Laboratory (LaSiC) of the Free Chair of Training in Simulated Emergencies and Catastrophes, Faculty of Medical Sciences, University of Buenos Aires.

Population and Sample: The target population included final-year medical students (Annual Rotating Internship). Participation in the workshop was voluntary, forming a total of 10 student teams.

Formative Intervention: The "Simulation Workshop" A 30-hour training program was designed and implemented, structured into two complementary stages over five consecutive weeks:

Asynchronous Stage (Theoretical): Prior to the in-person component, students accessed audiovisual material in the "Simulation Workshop" virtual classroom on the Faculty of Medical Sciences' virtual campus. This material included six asynchronous video classes on basic and advanced CPR, basic and advanced airway management, effective resuscitation team dynamics, and acid-base status. Additionally, two tutorials on automated external defibrillator use and advanced airway management setup were provided. Access to these resources was enabled after completing an anonymous expectations survey, 10 days before the start of in-person practical sessions.

In-person Stage: Students attended the simulation laboratory for 30 practical hours, distributed weekly.

Week 1 (4 hours): Training in fundamental technical skills (basic CPR, airway management, AED use, bag-valve-mask-reservoir device use) using low-fidelity part-task trainers. This phase corresponds to Simulation Zone 1 [12], focused on acquiring individual skills. Guided simulations with initial feedback from instructors were conducted.

Weeks 2 to 5 (26 hours): Students progressed to solving eight high-fidelity clinical scenarios of increasing difficulty, categorized as Simulation Zone 2 [12], emphasizing teamwork and acute situation management. Students, organized into groups of 10, assumed specific roles (Airway Management, Compressions, Drug Administration, Monitor/Defibrillator, Recorder, Leader, Coach) and were required to evaluate, diagnose, and treat the patient in CPA. Each scenario lasted 10-15 minutes, with no direct instructor intervention during the scenario run.

After each case, a structured debriefing was conducted, lasting approximately 20-30 minutes. This debriefing was guided by a facilitating instructor and was based on the PEARLS (Promoting Excellence And Reflective Learning in Simulation) model [9], which integrates self-assessment, focused facilitation, and direct feedback. The main phases and guiding questions included:

Reaction Phase: "How did you feel after the simulation?" (to establish psychological safety).

Description Phase: "Can you briefly summarize what happened?" (to establish a common understanding of the facts).

Analysis Phase:

Self-assessment: "What do you think you did well?" "What would you do differently?"

Focused Facilitation: "What were you thinking at that moment?" "Why did you make that decision?" (to explore clinical reasoning).

Direct Feedback and/or Teaching: The facilitator provided specific information or explanations about key concepts ("I noticed that... best practice would be...").

Summary Phase: "What are the key takeaways?" "How will you apply this in your next simulated case?" (to consolidate learning and promote transfer to practice).

Data Collection and Variables: A pre-post questionnaire was administered at the beginning and end of the in-person training via a Google Form. The questionnaire, anonymous in nature, requested participants to create an alias to allow individual tracking of their responses and evaluation of changes. The instrument consisted of 5 emergency clinical situations (2 in public spaces, 2 in hospitals, 1 in a sanatorium) where participants had to select the most appropriate initial decision from options ranging from inability to resolve the situation to optimal conduct. The main variable was the overall percentage of correct responses on this questionnaire, serving as an indicator of the internalization of theoretical content and the action protocol. (see Table 1).

Table 1. Equivalent cases to solve in the pre- and post-test

PRE-TEST	POST-TEST
1) Summer, Sunday, your day off, it's very hot, and you're relaxing by the pool at the club. Suddenly, you hear a woman desperately screaming for help: "Help, please, someone help me, my husband is drowning." How would you order the victim assistance protocol based on the following options? Indicate the order in which you would perform each action. You may consider not carrying out some of the proposed options. **Options:** • I jump into the pool to rescue her (do not perform this action) • I look for something to protect my hands to assist her. (2) • I shout for someone to call 107 to request an ambulance. (3) • I shout to the lifeguard to get the AED. (4) • I wait for the lifeguard to take her out of	**1)** Sarmiento Park, summer, swimming season has started. You're in the solarium, when suddenly you hear a woman desperately shouting for help for her sister: "Help, please, someone help me, my sister is drowning, she can't swim." You approach and see a woman in the pool who is unable to swim and gradually sinks under the water. How would you order the victim assistance protocol based on the following options? Indicate the order in which you would perform each action. You may consider not carrying out some of the proposed options. **Options:** • I jump into the pool to rescue her (do not perform this action) • I look for something to protect my hands to assist her. (2) • I shout for someone to call

the pool so I can approach to assess her. (1)	107 to request an ambulance. (3) • I shout to the lifeguard to get the AED. (4) • I wait for the lifeguard to take her out of the pool so I can approach to assess her. (1)
2) It's Monday, you're on your way to the hospital. While waiting for the subway on the platform, someone suddenly collapses next to you. You quickly check that the scene is safe, put on gloves and a face mask, and approach the person. You assess their consciousness and, upon checking the pulse, you find they are in cardiac arrest. There's a lot of noise around, so you shout to a man in a burgundy jacket next to you to call 107 and request an ambulance.	**2)** You're on vacation, waiting in the pre-boarding area of Aeroparque J. Newbery for your flight. Suddenly, a person collapses next to you. You quickly check that the scene is safe, put on gloves and a face mask, and approach the person. When you assess consciousness and pulse, you find the person is unresponsive and in cardiac arrest. There's a lot of noise around, so you shout to an airport worker in uniform to call 107 and request an ambulance.
3) You're on duty at the hospital and Lautaro comes in. He is a bit anxious, sweaty, and having difficulty breathing. You ask him the reason for his visit. He says that about half an hour ago, while riding the train, he suddenly began to feel intense, oppressive chest pain. Lautaro is 54 years old. He has smoked 20 cigarettes a day for the last 20 years. He has a history of type 2 diabetes and hypertension. On physical exam: BP: 180/90, HR 120 bpm, RR 18.	**3)** You're on call at the Sanatorio de Las Flores in Buenos Aires. Josefa Suárez, 73 years old with a history of hypertension, arrives. She is a smoker and diabetic, on treatment with metformin and enalapril. She reports sudden onset of typical precordial chest pain, without radiation, accompanied by sweating and shortness of breath. On physical exam: BP: 170/80, HR 110 bpm, RR 20.
4) You're on duty at the hospital. The trauma nurse calls to ask you to evaluate the patient in bed 104, Carlos Rodríguez, 44 years old, who has difficulty breathing. You go to the trauma unit. Carlos was hit by a car and is now on post-op day 3 after femoral fracture surgery with plates and screws. On physical exam, he is unconscious and has no carotid pulse.	**4)** You're on call at a clinic in Buenos Aires. The nurse from the Gynecology Department calls asking you to evaluate the patient in bed 14, Camila Fernández, 54 years old, who is on post-op day 3 after a Wertheim-Meigs procedure for cervical cancer. On physical exam, the patient is unconscious and has no carotid pulse.
5) A patient arrives at the emergency room of a Buenos Aires clinic in bed 2 of the shock room. It's Patricio Orlando, 65 years old, with sudden epigastric pain after eating. On physical exam: BP: 140/80, HR 100 bpm, RR 20. A 12-lead ECG shows an inferior wall myocardial infarction. While awaiting lab results (CBC, chemistry, cardiac enzymes), 500 mg of chewable aspirin is administered. He is monitored, with a peripheral IV running normal saline and a non-rebreather mask delivering O2 at 15 L/min. You're called to continue evaluation. Suddenly, he develops ventricular tachycardia on the monitor and has no carotid pulse.	**5)** Graciela Díaz, 85 years old, arrives at the hospital by ambulance with sudden post-prandial abdominal pain of 30 minutes duration, intensity 8/10. On admission: BP: 160/90, HR 98 bpm, RR 18. A 12-lead ECG shows an inferior wall myocardial infarction. You're on call at the hospital's shock room. Graciela is in bed 8 under observation, awaiting cardiac evaluation. Lab tests (CBC, chemistry, cardiac enzymes) are pending. She received 500 mg of chewable aspirin and is currently monitored, with a peripheral IV running normal saline and a non-rebreather mask delivering O2 at 15 L/min. While you're re-evaluating her, she develops ventricular tachycardia on the monitor and has no carotid pulse.

RESULTS

The analysis focused on comparing the percentage of correct responses obtained in the questionnaire administered before (pre-test) and after (post-test) the training. (see image 1). In the pre-test, for three of the five scenarios presented, 87.8% or more of the participants correctly answered the initial conduct, and less than

2% reported not knowing how to manage the situation. However, in two specific scenarios (questions three and five), the percentage of correct responses was considerably lower (38.5% and 18.4%, respectively), and in one of these, (question five) 7% indicated they did not know how to proceed.

After the formative intervention, the post-test revealed a substantial improvement in most scenarios. In 4 of the 5 scenarios presented, the percentage of correct responses increased between 3.3% and 56.3%. Only in one scenario was a decrease in the percentage of correct responses observed, falling from 95.9% to 78.5%.

The overall average of correct responses in the pre-test was 66.24%, while in the post-test it reached 83.3%.

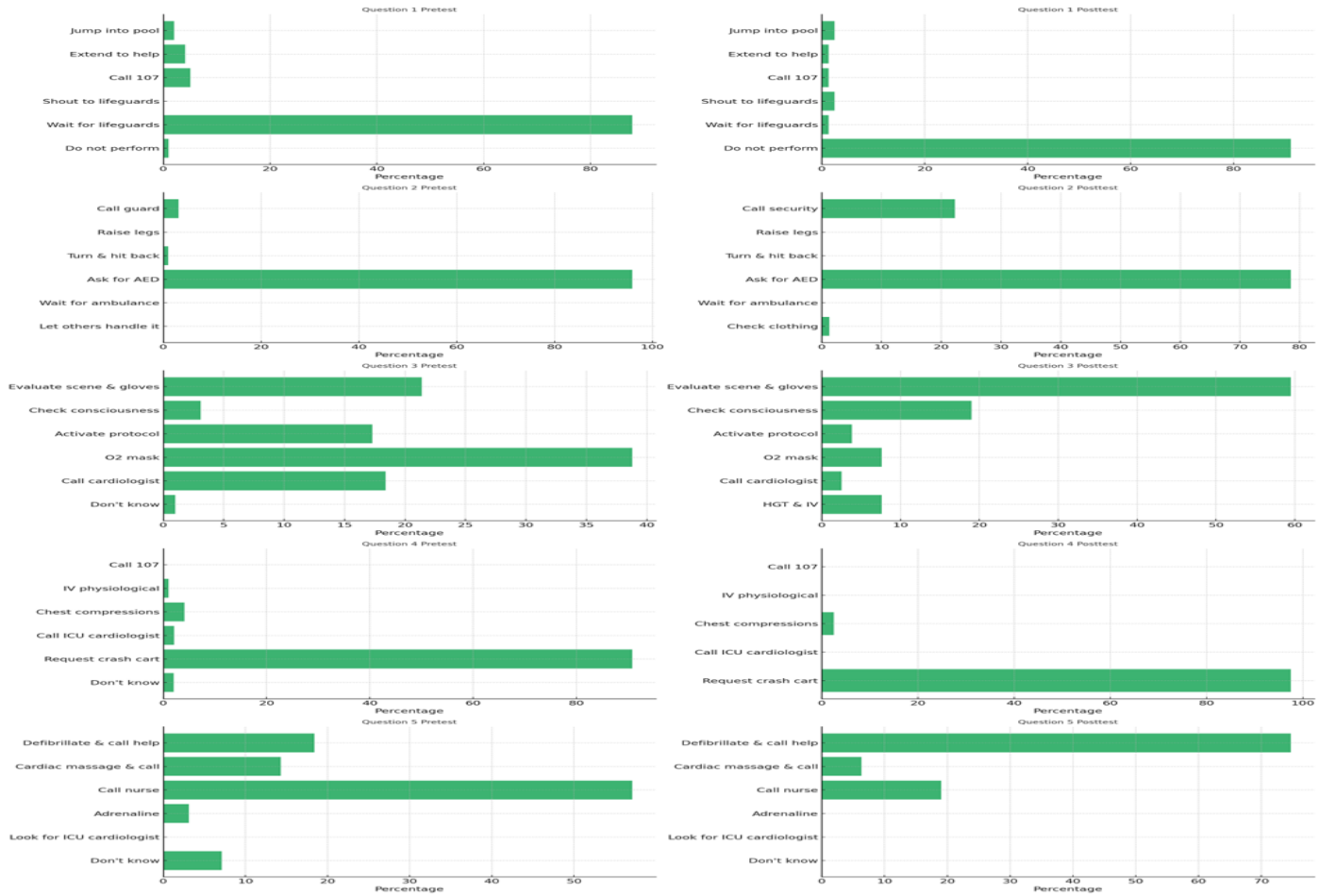

Image 1. Graphical representation of results

DISCUSSION

These quantitative results demonstrate that clinical simulation practices during the workshop had a significant impact on the internalization of theoretical content and the CPA action protocol by medical students. The generalized improvement in post-workshop evaluations indicates that students effectively incorporated the action protocol for managing medical emergency situations, demonstrating an advance in their performance

This study provides strong evidence regarding the relevance and effectiveness of clinical simulation practices, specifically in the "Simulation Workshop" format with deliberate practices in zones 1 and 2 and structured debriefing, for improving the internalization of the CPA management protocol in medical students. The average increase of 17.06% in correct responses on the post-test questionnaire is a robust indicator of the acquisition and consolidation of knowledge and understanding of the protocols. The observed improvement can be attributed to the nature of experiential learning facilitated by simulation [13]. By recreating high-fidelity scenarios for deliberate practices, students can apply and test their knowledge in a safe and controlled environment, which allows for the development of technical and non-technical skills [14, 15]. Practices in simulation zones (Zone 1 for basic skills and Zone 2 for team scenarios) [12] allowed for a logical pedagogical

progression, first consolidating individual skills and then integrating them into the context of a complex resuscitation team.

The structured debriefing based on the PEARLS model played a fundamental role in this process. As Raemer et al. [16] and Kessels & van der Vleuten [17] point out, debriefing is the most critical component of simulation for learning, as it fosters reflection on performance, identification of strengths and areas for improvement, and conceptualization of the experience. Self-assessment, focused facilitation, and direct feedback, inherent to PEARLS, allowed students to transform practical experience into applicable knowledge and strengthen the internalization of the protocol. The qualitative improvement in aspects such as team dynamics and communication, evidenced during the debriefings, underscores the importance of this component in developing essential non-technical competencies in emergencies [18].

Limitations Of The Study

While the results are promising, this study has some limitations. Being a quasi-experimental design without a control group, the entirety of the improvement cannot be attributed exclusively to the intervention. Furthermore, the measurement of internalization was conducted through a questionnaire, which primarily evaluates declarative knowledge and understanding of the protocol, and not necessarily its direct application in real clinical situations outside the simulated environment. However, the literature suggests a positive correlation between simulation performance and clinical competence [8, 19]. Future research could benefit from including a control group, long-term evaluation of skill retention and protocol internalization, and the use of observational performance evaluation tools in simulated scenarios for a more direct measurement of practical application.

CONCLUSIONS

The results of this study strongly support the relevance of simulation practices for improving the internalization of the CPA management protocol in patients. The implementation of a "Simulation Workshop" integrating deliberate practices in Zone 1 and Zone 2, complemented by structured debriefing based on the PEARLS model, proved to be a highly effective educational strategy. Clinical simulation, by providing a practical and realistic experience in a safe environment, allows students not only to acquire and consolidate crucial technical and cognitive skills for CPA management but also to develop non-technical competencies such as teamwork, effective communication, and rapid and accurate decision-making. The systematic feedback offered during debriefing is fundamental to this process, enabling reflection, identification of areas for improvement, and consolidation of learning.

In summary, clinical simulation is positioned as an indispensable educational strategy in the training of healthcare professionals. Its application enhances students' preparation and competencies to face medical emergency situations more safely and effectively, which has a direct potential impact on the quality of patient care and survival in critical events like CPA.

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