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Simulating a self-inflicted facial gunshot wound with moulage to improve perceived realism, immersion, and learning in simulation-based airway management training

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ABSTRACT

Moulage is used to create mock wounds and injuries for clinical education and training. We developed a moulage technique to simulate a facial gunshot wound for use in simulation-based training. We removed sections of a manikin's face and used moulage materials to mock various aspects of the wound. The manikin was used in a simulated scenario that teaches clinicians how to manage a complicated airway. The moulage was evaluated with a self-report questionnaire that assessed participants' perceptions of the realism of the wound, the degree to which the wound contributed to their scenario immersion, and the degree to which the wound enhanced their learning experience on a 5-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Participants' average response to each item was significantly higher than the neutral midpoint, and the median response was 'strongly agree'. Our work suggests that the simulated facial gunshot wound contributed to perceived scenario immersion and enhancement of the learning experience, supporting existing literature that suggests moulage is a valuable tool in healthcare simulation. Future work could investigate the effect of moulage using objective measures and explore the potential to use extended reality technology in conjunction with moulage to improve immersion even further.

INTRODUCTION

Moulage is a commonly used tool to mock wounds or injuries in simulation-based education and training[1–7] that provides visual and tactile cues for the learner[8 9] and increases participant engagement.[10] We describe a moulage technique to simulate a self-inflicted facial gunshot wound to highlight the complications in airway management associated with facial trauma. We anticipate that clinicians who learn and practice the skills needed to deal with this kind of rare life-threatening injury in a simulated setting will be better prepared to face the complicated and confronting nature of the situation in a real-life setting, resulting in higher-quality patient care.

Moulage is thought to enhance the realism and authenticity of clinical simulations, potentially resulting in an improved learning experience.[8] Moulage can reduce or eliminate the reliance on verbal cues to guide participants, placing them in a better position to independently determine how the clinical presentation dictates the direction of care.[4] However, a recent systematic review on the effectiveness of moulage on participant engagement was inconclusive due to limited research,[9] but the few studies that do explore its usefulness suggest that it is more beneficial than traditional methods.[11–14]

Since it would be difficult to objectively assess participants' emotional reactions to the simulated facial gunshot wound, we assessed their subjective perceptions of the realism of the wound, the degree to which the wound contributed to the immersiveness of the scenario, and the degree to which the wound enhanced their learning experience.

MANIKIN AND MOULAGE PREPARATION

We used a discontinued Laerdal ALS Simulator manikin ($A23 000) that is no longer under warranty but annually serviced by the technical team within our simulation centre who are certified by Laerdal to provide warranty service and repair work. We also used a face skin and airway (approximately $A1050) and <$A100 in moulage materials. The wound was based on an image of a real facial gunshot wound from a difficult anaesthesia presentation. The following procedure took approximately 3 hours:

1. The lower section of the manikin's floor-of-mouth was ground out with a Dremel drill and burr tip, and moulaged with charcoal dust and a base layer of Black Fuse FX silicone paint to simulate powder burn, demonstrating the impact of the bullet entry wound. The bottom lip to mid-mental region and the right side of the upper lip and maxilla, including the right nostril for the exit wound, were removed (figure 1A).
2. Small incisions were made to the nares and sections of teeth were fractured with a hammer (figure 1B).
3. Fuse FX F-series silicone paints were applied to the wound area to differentiate blood and tissue (figure 1C).
4. A silicone flap was created with Smooth-On Dragon Skin mixed with Blood Silc Pig and attached from the inside of the right cheek to the outside of the face to simulate muscle tissue and exposed oral cavity from the fragmented bullet exit (figure 1D).

Initially, the manikin was informally evaluated by 15 simulation and clinical specialists to assess difficult airway suitability, the realistic nature of

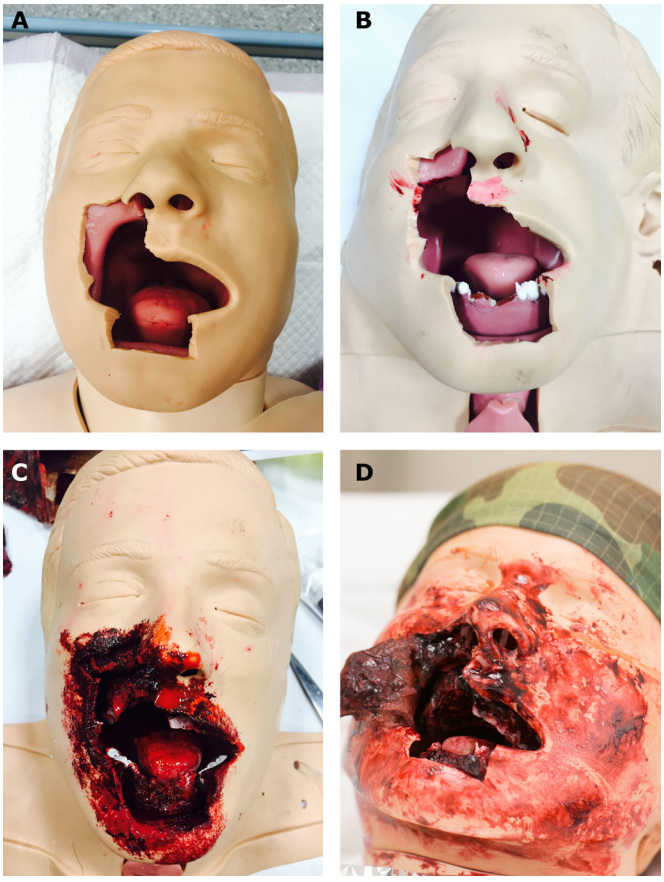

Figure 1 Manikin head with: (A) parts of mouth and jaw removed; (B) incisions made to nose and sections of teeth removed; (C) silicone blood and tissue added; and (D) the finalised moulage.

the injury, whether it had the potential to evoke an emotional response and affect decision making with airway management, and whether it contributed to the learning objectives of the scenario.

FORMAL EVALUATION OF THE SIMULATED FACIAL GUNSHOT WOUND

Participants

Data were collected from 75 healthcare professionals (97% medical, 1% nursing/midwifery, 1% undisclosed) who participated in one of two simulation-based courses (*Anaesthetic Crisis Resource Management* or *Advanced Cardiac Life Support*) at the Clinical Skills Development Service in Brisbane, Australia between June 2018 and February 2019. 67% of participants had 1–5 years of clinical experience, 19% had >5 years, 13% were new graduates, and 1% did not disclose their experience.

Procedure and materials

Three items were embedded within the standard electronic post-course questionnaire to assess participants' perceptions of the simulated facial gunshot wound: 'the appearance of the manikin's facial gunshot wound was realistic'; 'the appearance of the manikin's facial gunshot wound contributed to the immersiveness of the scenario'; and 'the appearance of the manikin's facial gunshot wound enhanced my learning experience'. Responses were collected on a 5-point Likert scale ranging from 'strongly disagree' to 'strongly agree', with 'neutral' as the mid-point.

Simulated scenario

The 15 min scenario begins with a call from the retrieval team detailing the patient's injuries, vital sign levels, and estimated arrival time. The participants then allocate roles and formulate a plan. The patient (manikin) arrives conscious but in respiratory distress. Shortly, he becomes unresponsive and hypoxic, forcing the participants to obtain a definitive airway via endotracheal intubation. During their attempts, the patient develops pulseless electrical activity due to hypovolaemia and the participants resuscitate him. The scenario ends when the patient is stabilised and resuscitation attempts are satisfactory.

Results

Table 1 presents descriptive statistics for each item. We conducted a series of one-sample t-tests using R (statistical software package, V.3.4.3) to determine whether responses were significantly higher or lower than the scale's mid-point—'neutral'—or the second-highest response on the scale—'somewhat agree'. Participants' average responses to all items were significantly higher than 'neutral', $ps < 0.001$ and 'somewhat agree', $ps < 0.001$.

DISCUSSION

Participants' perceptions of the simulated facial gunshot wound were overwhelmingly positive, with at least 93% of responses being either 'strongly agree' or 'somewhat agree' for the three evaluation items. The average response to each item was also significantly higher than 'somewhat agree'. This suggests that the simulated facial gunshot wound is perceived to be a valuable component of the scenario it is used in.

Table 1 Distribution of participant responses and means, medians, and standard deviations for each item assessing the facial gunshot wound (with the percentage of total respondents presented in parentheses)

	Distribution of responses							
	1 - Strongly disagree	2 - Somewhat disagree	3 - Neutral	4 - Somewhat agree	5 - Strongly agree	M	Mdn	SD
The appearance of the manikin's facial gunshot wound was realistic	0 (0%)	0 (0%)	1 (1.4%)	25 (33.8%)	48 (64.9%)	4.64	5	0.51
The appearance of the manikin's facial gunshot wound contributed to the immersiveness of the scenario	0 (0%)	0 (0%)	1 (1.3%)	13 (17.3%)	61 (81.3%)	4.80	5	0.43
The appearance of the manikin's facial gunshot wound enhanced my learning experience	0 (0%)	1 (1.3%)	4 (5.3%)	21 (28.0%)	49 (65.3%)	4.57	5	0.66

M, mean; Mdn, median; SD, Standard Deviation

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Anecdotal feedback from the simulation staff, who consistently observe that participants are taken aback when they first see the manikin, display caution and apprehension when examining and manipulating the airway, and exhibit marked panic when managing the compromised airway, corroborates the results. We believe the moulage provides appropriate clinical and physical cues to allow participants to assess the patient's condition and plan their care accordingly.[4] If the simulated scenario was conducted with no moulage, then staff would need to constantly disrupt the flow of the scenario to provide verbal cues and guidance for participants, reducing scenario immersion and increasing the potential for inconsistencies across training sessions and/or accidental errors in the information provided.

Moulage is widely believed to enhance the realism and authenticity of clinical simulations (and consequently improve the quality of learning); however, limited empirical evidence exists to support or refute this notion.[9] Our work suggests that moulage improves the perceived realism and immersion of simulated scenarios and enhances their perception of the learning experience, thus supporting existing evidence that moulage is a useful simulation tool.[6 12 13]

It is important to note that significantly altering a manikin will likely void the warranty. The expertise of staff at our centre allowed us to simulate the wound on a discontinued manikin that is no longer under warranty but still able to be annually serviced. The face skin and airway were sourced from a prior service exchange, but an alternative option could be to ask the manikin service/repair agent to donate used materials (that may have slight cosmetic damage).

Limitations and future directions

First, the convenient self-report format of our evaluation required participants to have insight into their own perceptions, of which they may have little,[15] and was prone to inaccurate responding due to biases such as social desirability.[16] Also, participants were recruited from a convenience sample who may not have encountered a real facial gunshot wound and therefore lack the experience to judge the realism of the simulated wound. Future work should use objective measures in place of, or in conjunction with, subjective measures to evaluate their moulage,[9] such as the recently developed Immersion Score Rating Instrument.[17] However, objective measures require substantially more resources, such as video recording equipment and additional personnel.

Second, our evaluation required minimal resources because we collected data during courses that already used the manikin. However, a lack of control or comparison group means that we cannot quantify the benefit of the moulage over no moulage. Future studies should evaluate the impact of moulage on participants' simulation experience and learning with controlled comparison studies.[10]

Third, some aspects of the wound were unable to be simulated, such as bubbling of the blood, which could be important for learning. Future research could explore ways to simulate aspects of a wound that are not possible with moulage on its own. Extended reality methods are increasingly being used for simulation-based training in healthcare[18] and could be used in conjunction with moulage to increase the authenticity of simulated scenarios.[19]

CONCLUSIONS

We demonstrated a novel method for simulating a facial gunshot wound using moulage techniques for use in simulation-based training, which was regarded as a realistic representation of a wound that contributed to participants' perceived scenario immersion and learning experience. We anticipate that providing a more authentic environment for clinicians to learn and practice the skills required to deal with a life-threatening facial gunshot wound will better prepare them for the confronting and complex nature of similar injuries in clinical settings. There are various avenues for future work in this area to further investigate the effectiveness of moulage in simulation-based training.

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Contributors CS: created the questionnaire items specific to the simulated facial gunshot wound, collected, analysed and interpreted the data, and drafted the manuscript. DH, DA, MA and CK: designed and developed the simulated facial gunshot wound, as well as the immersive simulated scenario. All authors read and approved the final manuscript.

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