Prone cardiopulmonary resuscitation: an intensive care unit case series

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Background: Critically ill patients frequently receive mechanical ventilation in the prone position. If hypoxic respiratory failure progresses, pulseless events requiring emergent cardiopulmonary resuscitation may occur. Administering cardiopulmonary resuscitation in the prone position provides an opportunity to initiate chest compressions quickly, eliminating delays in resuscitative efforts.

Case Description: Three cases of patients with extended hospital stays who received prone cardiopulmonary resuscitation for pulseless electrical activity arrests while in the Medical Intensive Care Unit are reviewed. All three patients achieved return of spontaneous circulation for a period of time during their resuscitative efforts. Additionally, patients obtained either adequate end-tidal carbon dioxide levels or appropriate arterial line waveforms demonstrating administration of adequate compressions with prone cardiopulmonary resuscitation. Ultimately all three patients did not survive, but this is most likely attributable to their underlying conditions and severity of disease rather than the adequacy of prone cardiopulmonary resuscitation.

Conclusions: Although there is a paucity of literature, prone cardiopulmonary resuscitation provides an opportunity to eliminate delays and initiate immediate resuscitative efforts in critically ill patients who experience a pulseless event while in the prone position. Current guidance from the American Heart Association recommends initiating cardiopulmonary resuscitation in the prone position if an advanced airway is present and it is unsafe to move the patient into the supine position. Defibrillator pads should be placed in the anterior-posterior position and compressions should be administered with hands over the T7/10 vertebral bodies. The administration of high-quality cardiopulmonary resuscitation should be guided by the monitoring of end-tidal carbon dioxide or via arterial lines. While more quality literature is needed to fully establish clinical outcomes, prone cardiopulmonary resuscitation should be implemented within the intensive care unit to eliminate resuscitative delays in patients who have a pulseless event while in the prone position.

Keywords: Cardiopulmonary resuscitation (CPR); prone; critically ill; intensive care unit (ICU); case series

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Introduction

Mechanical ventilation in the prone position is administered to patients experiencing severe hypoxia due to either moderate-to-severe acute respiratory distress syndrome (ARDS) or coronavirus disease 2019 (COVID-19) respiratory failure. While prone ventilation has become relatively common in the intensive care unit (ICU), patients may still deteriorate and their clinical course

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may culminate in a pulseless event. These events require emergent cardiopulmonary resuscitation (CPR) which may be delayed by the patient's position and the requirement to don appropriate personal protective equipment (PPE). In order to avoid an extended delay, administration of CPR in the prone position (prone CPR) should be considered. Currently there is a paucity of data supporting prone CPR and current guidelines only briefly describe it (1-5). Due to the lack of details provided, a literature review was conducted and a prone CPR process was developed at an 852-bed, non-teaching, tertiary-referral medical center. In accordance with the CARE reporting checklist (available at https://jeccm.amegroups.com/article/view/10.21037/jeccm-22-26/rc), we present the first three patients who received prone CPR in the Medical ICU.

Case presentation

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was not obtained from the patients due to the Institutional Review Board at Lakeland Regional Health granting an exemption (No. IRB00002126).

Case #1

The patient was a middle-aged female with a past medical history of metastatic pancreatic cancer and pulmonary embolism who was admitted to the hospital with ascites requiring paracentesis. Through her admission she was diagnosed with erosive gastritis, pancytopenia, and supraventricular tachycardia requiring transfer to a telemetry unit. On hospital day #8, the patient developed pulseless electrical activity (PEA) arrest, was intubated, and received CPR for 13 minutes (epinephrine ×3) until return of spontaneous circulation (ROSC) was achieved. She again developed PEA en route to the ICU and received CPR for an additional 6 minutes (epinephrine ×2) until ROSC was achieved again.

Upon admission to the ICU, the patient received targeted temperature management, continuous renal replacement therapy, and multiple vasopressors for ongoing hypotension. She developed severe ARDS requiring deep sedation, neuromuscular blockade, and prone therapy. On ICU day #5 (hospital day #12), the patient developed PEA arrest again, this time in the prone position. She received prone CPR for 4 minutes (epinephrine ×2) until ROSC was achieved. During the code event, the patient had continuous end-tidal carbon dioxide ($EtCO_2$) monitoring in place and obtained levels of 8, 15, and 24 mmHg during CPR. A few minutes later, she developed PEA again and received an additional 8 minutes of CPR (epinephrine ×3). The patient obtained $EtCO_2$ of 16, 15, 28, and 20 mmHg during CPR. The patient was pronounced dead at the conclusion of the code.

Case #2

The patient was a middle-aged male with a past medical history of gout who was admitted to the hospital with COVID-19 respiratory failure. During his hospitalization his respiratory function deteriorated and he was transferred to the ICU and intubated on hospital day #10. Following intubation, the patient developed severe ARDS requiring deep sedation, neuromuscular blockade, and prone therapy.

On ICU day #15 (hospital day #24), the patient developed PEA arrest while in the prone position and CPR was initiated. He received 4 minutes of prone CPR (epinephrine ×2) until ROSC was achieved. He developed PEA again over an hour later (14 minutes of CPR and epinephrine ×5) and for a third time an hour after the second code (20 minutes of CPR and epinephrine ×7). During the last two code events, the patient had a continuous $EtCO_2$ monitoring in place and obtained levels ranging from 18 to 33 mmHg. Ultimately the patient was pronounced dead at the conclusion of the third code.

Case #3

The patient was a middle-aged male with a history of HIV and hypertension who was admitted to the hospital with pneumonia suspicious for COVID-19. The patient tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), experienced worsening respiratory failure requiring non-invasive ventilation, and ultimately transferred to the ICU on hospital day #12 for intubation. Upon intubation the patient developed severe ARDS, received deep sedation, neuromuscular blockade, and prone therapy was initiated the following day.

On ICU day #5 (hospital day #16), the patient experienced three different PEA arrests while in the prone position lasting 7, 4, and 5 minutes (received prone CPR and epinephrine ×2, ×3, and ×2, respectively). He obtained ROSC for 44 minutes following the first code and 20 minutes following the second code. The patient had an arterial line which the intensivist used to monitor for the presence of a pulse between code events and the quality of CPR during the code. The patient was pronounced dead at the conclusion of the third code.

Discussion

CPR performed in the prone position is not only possible, but effective. Each patient in the case series obtained adequate $EtCO_2$ levels (≥15 mmHg) or acceptable arterial line readings and experienced ROSC with maintenance of a pulse during their resuscitative efforts. Ultimately all three patients did not survive, but this is most likely attributable to their underlying conditions and severity of disease rather than the adequacy of prone CPR. The ability to provide CPR in the prone position undoubtedly allowed the team to begin resuscitative efforts much sooner than if they were required to place the patient in the supine position. A recent letter-to-the-editor highlighted the potential benefits of prone CPR and encouraged its implementation, especially in light of the ongoing COVID-19 pandemic (6).

Prone CPR is not a new concept and is routinely credited to McNeil in 1989 (7). Most supporting literature is limited to neurosurgical patients who experience an emergency in the operating room (8-10). Although prone CPR is relatively unknown amongst ICU clinicians, its effectiveness was demonstrated in a small study conducted at Columbia Presbyterian Medical Center (11). Patients who failed CPR for 30 minutes received an additional 15 minutes of standard CPR and then crossed over to receive 15 minutes of prone CPR (termed reverse CPR in the study). Patients demonstrated a statistically significant improvement in systolic blood pressure (48 *vs.* 72 mmHg) and mean arterial pressure (32 *vs.* 46 mmHg) with standard CPR *vs.* prone CPR, respectively. This was one of the first studies to demonstrate the effectiveness of prone CPR.

The American Heart Association (AHA) has intermittently addressed prone CPR in their CPR and emergency cardiovascular care guidelines. The 2010 guidelines mention patients may receive CPR in the prone position if they are unable to be placed in the supine position, whereas the 2015 and 2020 updates provide no additional information (1-3). In light of the recent pandemic, the AHA published interim guidance for patients with known or suspected COVID-19 in 2020 and 2021 which offered the most detailed recommendation concerning prone CPR. They recommend to perform prone CPR in patients with an advanced airway if it is unsafe to move the patient into the supine position or if deemed necessary to provide optimal care. Patients receiving prone CPR should have the defibrillator pads placed in the anterior-posterior position and compressions with hands over the T7/10 vertebral bodies (4,5).

At our institution, patients may receive prone CPR if they are in the prone position with an advanced airway at the time of a pulseless event. When resuscitative efforts are initiated, a CPR board with a sandbag is positioned under the patient's chest to provide adequate counter pressure while defibrillator pads are placed in the anterior-posterior positions. Compressions are administered with hands over the T7/10 vertebral bodies (just above the lower end of the scapula) at the same rate and depth as standard CPR (100–120 compressions per minute at a depth of 2–2.4 inches). Traditional advanced cardiovascular life support (ACLS) protocols including administration of high-quality CPR, defibrillation of shockable rhythms, and medication administration are followed. $EtCO_2$ monitoring is highly encouraged to demonstrate the quality of CPR being administered. Patients may be transitioned to the supine position at the discretion of the physician or if prone CPR is ineffective, airway issues arise, or additional procedures are needed to be completed. Patients without an advanced airway should not receive prone CPR and placement into the supine position is required prior to resuscitation initiation.

The administration of high-quality CPR and early defibrillation continue to be cornerstones of cardiac arrest treatment (2). Prone CPR provides an opportunity to avoid delays and initiate immediate resuscitative efforts in pulseless patients. Although more quality literature is needed to fully establish clinical outcomes, prone CPR should continue to be considered in all ventilated prone patients, especially during the COVID-19 pandemic.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://jeccm.amegroups.com/article/view/10.21037/jeccm-22-26/rc

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://jeccm.amegroups.com/article/view/10.21037/jeccm-22-26/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was not obtained from the patients due to the Institutional Review Board at Lakeland Regional Health granting an exemption (No. IRB00002126).

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