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Improvements to out-of-hospital cardiac arrest and opioid overdose treatment algorithms to enhance positive outcomes

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According to the National Heart, Lung, and Blood Institute (2023),[1] out-of-hospital cardiac arrests (OHCA) claim more than 350,000 lives every year. In parallel, and considering a timeframe starting in 1999, a continuous increase in the number of deaths due to opioid overdose or poisoning (OOP) events is found [2] (Fig. 1). For example, in 2022 alone, 81,806 fatalities occurred. Although early review of 2023 data identifies the number of opioid deaths has fallen, the overall number of OOP fatalities is still alarmingly high.[3] Because of early and prompt, life-saving interventions, such as high-quality cardiopulmonary resuscitation (CPR) and the use of a defibrillator or administering the opioid antagonist, Naloxone, not every one of these events leads to a fatality.[4,5] Given the large number of aggregate occurrences and the important fact that their initial, visual presentations are similar, a crucial question immediately presents itself, *is what is being witnessed an OHCA or an OOP event?*

We present proposed revisions to existing algorithms for assessing and delivering immediate care by either the trained, lay bystander and the trained, healthcare professional to individuals experiencing an OHCA and/or OOP event. The goals of these revisions are to (1) generate discussion within the expert emergency care communities in order to improve the initial assessments and immediate steps of care for an individual experiencing an OHCA and/or OOP; and (2) positively affect outcomes by (a) differentiating between OHCA and OOP events when they are indeed separate; and (b) generating more robust, quantitative data to support decision making that will allow appropriate and targeted care for the actual emergency situation to be provided.

These revisions include incorporating the use of (1) conventional finger pulse oximeter (FPO) devices.[6] According to the American Lung Association,[7] FPOs provide data within a few seconds. The data provided are heart rate and blood oxygen saturation levels or peripheral oxygen saturation (SpO_2) values. While a degree of bias associated with FPO's SpO_2 measurements versus actual arterial hemoglobin oxygen saturation (SaO_2) values for darker-skinned individuals is acknowledged, we feel that there is a role for these devices in the out-of-hospital, emergency setting. This position is supported by the large-scale study[8] that identifies that although the SpO_2 versus SaO_2 values are statistically significant, the differences are small in magnitude, and the ability to detect a pulse at all is not different. Further discussion about FPO and their bias is addressed in the separate, Addendum section; (2) a pupillary exam using a simple light source, such as a pen-light or cell phone for unresponsive individuals when they are in poorly lit areas; and (3) Naloxone nasal spray, now available over the counter,[9] thus allowing lay rescuers to have the opioid antagonist available for immediate use.

Although only about 10% of individuals that suffer an OHCA survive, since the turn of the century, this rate has increased about 2 times.[1] This increase can be attributed to several factors, including more responsive CPR and defibrillation actions, brought about by improved lay individual awareness and training in resuscitation methods, greater requirements and expectations for resuscitation training of tangential professionals, such as professional and amateur coaching staff personnel, and improvements in treatment protocols and practices through actions of organizations such as the Resuscitation Organizations Consortium (ROC).[10] These positive trends may be expected to continue as further protocol and practice revisions and increased awareness about resuscitation measures are made and more people are trained.

Along a similar vein, a report from Wheeler, Jones, Gilbert, and Davidson [11] (more recent data is not available) permits a similar axiom to CPR for OCHA responses to be confidently drawn for OOP events, i.e., prompt use of 4-mg Naloxone nasal spray [9] that is available over the counter. For both OHCA and OOP events, early intervention with appropriate treatment is crucial and lay persons can be critical players to increasing the likelihood of positive outcomes.

With the large number of occurrences of both OHCA and OOP events, especially when treated as an aggregate, and the fact that their initial, visual presentations are similar, i.e., the individual being unresponsive and having the appearance of not breathing or exhibiting agonal breathing (these assessments are standard evaluation techniques taught in basic lifesaving training), it can be useful to rapidly differentiate the two clinical entities if it does not significantly increase the time to CPR or defibrillation for the OHCA patient. The importance in the differentiation of these two episodes is grounded in avoiding clinically adverse events that have been suggested with unnecessary CPR. Although there is general agreement and broad consensus that Naloxone has a demonstrated safety profile history and that its emergency use benefits outweigh potential risks of harm in the case of OOP events, the data is not as clear for OHCA events. For example, while studies by Panchal et al.,[12] and Olasveengen et al.,[13] suggest that "the potential harm from CPR for a patient who has been incorrectly identified as having an OHCA is low and that the benefit of providing CPR to such individuals clearly outweighs any potential risk of harm," investigations by van Veelen et al.,[14] and van Wijck,[15] report that rib fractures are a common occurrence with this resuscitation treatment.

The datasets generated during and/or analyzed during the current study are publicly available.

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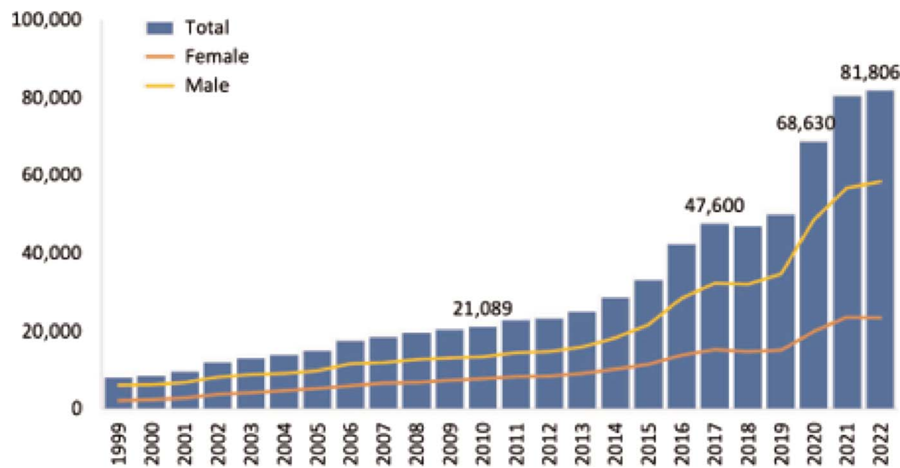

Figure 1. U.S. overdose deaths involving any opioid by sex, 1999–2022. Figure published in August 2024.[2] With the approval for figure use by National Institute on Drug Abuse.

These investigators identify that rib fractures are not sequelae-free. In addition, several studies[12,16–18] found that all rescuers, including healthcare professionals, can have difficulty manually detecting a pulse. This difficulty can be a result of challenges associated with proper placement of fingers on requisite target locations, eg. the carotid, overcoming and managing the epinephrine load during this time of heightened stress, and the fact that the according to the Centers for Disease Control and Prevention,[19] ">40% of Americans are categorized as obese." As a result of obesity, common sites used to check for a pulse, eg. carotid artery, can be made increasingly difficult to assess due to adipose deposition overlying these areas, resulting in a dampening effect.

We suggest two assessment additions to the current treatment algorithms[12] for the trained, lay bystander and the trained, healthcare professional to utilize when assessing the unresponsive and apneic or semiapneic patient in the out-of-hospital setting. These additions are (1) assessment of the victim's pupils and (2) incorporation of a FPO to supplement the detection of a pulse and provide a measurement of SpO_2 values. These additions will provide complementary, quantitative data to finger pulse and visual breathing assessments before specific resuscitation actions are initiated without significantly compromising the time to onset CPR and defibrillation in the OHCA patient.

According to Zhao et al.,[20] "when blood flow or the oxygen tension of arterial blood is reduced, the pupils dilate. When all blood flow ceases, the pupils dilate widely within an interval of 30–120 seconds and the pupillary reaction to light disappears;" as in the case of cardiac arrest. However, in the event of an OOP event, the target individual's pupils exhibit constriction with a depressed or completely absent light reflex [21]. It is acknowledged that an OOP patient who has progressed into cardiac arrest might not have dilated pupils on initial assessment. However, in this case, the resuscitation algorithm would call for CPR. As a result, for this unique patient population, CPR delivery would not be delayed.

The foundation for FPO incorporation in an assessment of a nonresponsive individual in an out-of-hospital setting is (1) the device's ease of use, being a non-invasive technique, and the fact it can operate simultaneously while other assessments are being made, eg. visual assessment of breathing and evaluation of the pupils' status; and (2) promptness in supplying important pulse and SpO_2 data. Thus, in a patient with constricted pupils who is found to have a pulse, CPR and the potential adverse effects thereof can be avoided. However, the absence of pulse detection via FPO will not delay the onset of CPR significantly or at all.

Finally, pupil assessments[20,21] and the use of FPOs are widely recognized and accepted diagnostics[6] in myriad healthcare settings. Thus, this paper's suggested additions to the current treatment algorithms[12] for the trained, lay bystander and the trained, healthcare professional when assessing the unresponsive and apneic or semiapneic patient in the out-of-hospital setting, found in Table 1, are grounded in evidence. Furthermore, the rationale of enhancing assessment algorithms for potential OHCA or OOP patients, using rapid pupillary exam and FPO data is founded on the opportunity to decrease the potential for any adverse events associated with unnecessary CPR, while not significantly increasing the time of CPR onset if required. Ultimately, initiating discussions around algorithm revisions provide the foundation to improve the initial assessment and immediate steps of care for individuals experiencing the discussed, life-threatening, out-of-hospital events, thus enhancing the likelihood of positive outcomes.

Table 1

Suggested Additions to Adult BLS Algorithm

Encourage the carry of Naloxone, 4-mg nasal spray, 2 doses and the use of a pen or cell phone light (for performing pupil assessments in poorly lit areas) and a commercial or Rx grade FPO for pulse detection and SpO_2 evaluation. Consider making the devices part of training and complementary take-home materials.
If the victim exhibits no response to the rescuer's delivered stimulus, consider immediately (1) applying FPO to provide pulse and SpO_2 data to complement visual breathing assessment; and (2) doing a pupil assessment. If pupils are constricted, consider immediately administering Naloxone.
Utilize FPO information along with the traditional breathing and pupillary assessments and any response to Naloxone, if administered, to make a data-rich, informed decision as to whether to start CPR and use AED, if appropriate and available.

AED, automated external defibrillator; BLS, basic life support; CPR, cardiopulmonary resuscitation; FPO, finger pulse oximeter.

Conflict of interest statement

The authors declare no conflict of interest.

Author contributions

Davis CR initially conceptualized and participated in organizing, writing, critiquing, reviewing, editing, and formalizing the manuscript. Schinella M and Papish M participated in organizing, writing, critiquing, reviewing, editing and formalizing the manuscript.

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Appendix 1

The authors acknowledge the limitations associated with pulse oximetry, especially based on recent studies in the technique's bias toward darker skinned individuals, eg. Asian, Black, and Hispanic versus White in SpO_2 measurements and SaO_2 values as determined by arterial blood gas (ABG) studies. In particular, SpO_2 values overestimate the actual SaO_2 values in darker skinned individuals [8].

Individuals hospitalized with respiratory disease, eg. coronavirus disease 2019, and vulnerable to being biased against SpO_2 and SaO_2 variations and therefore underdiagnosed with hypoxemia, experienced delays in proper care [22–24]. However, Wong et al.'s work [8] with nearly 90,000 hospital patient encounters found that although "there were statistically significant differences in true oxygen saturation levels between White patients compared with those in other racial and ethnic subgroups, the differences were small in magnitude." As a result, the authors are confident in proposing the use of FPO to detect the presence of a pulse and provide an SpO_2 evaluation when properly used and can provide important complementary data to visual and physical assessments in out-of-hospital emergency care delivery situations.

Appendix 2

FPOs can be placed into one of two categories [25]: (1) Prescription oximeters have been vetted by the FDA and are available only with a prescription. These devices have undergone clinical testing to confirm their accuracy and are typically used in clinical settings, although they can be prescribed for at-home use; and (2) Over-the-counter oximeters are sold directly to consumers and may use apps to estimate oxygen saturation. These products do not undergo FDA review.