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Defining, divining, and defeating recurrent cardiac arrest

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Recurrent cardiac arrest (or rearrest) is common, affecting up to half of patients initially resuscitated after out-of-hospital cardiac arrest (OHCA).[1-4] Rearrest is associated with poor outcomes, including higher mortality and unfavorable neurological function compared to those without rearrest. A number of factors, including demographics, tracheal intubation prior to return of spontaneous circulation (ROSC), and epinephrine administration, have been retrospectively associated with the risk of rearrest, but no interventions have consistently reduced its incidence.[3-9] Further, timely identification of rearrest, especially in the prehospital setting, can be difficult, and few tools exist for its prediction. Altogether, rearrest is a vexing problem: adversely impacting outcomes and eluding both prediction and prevention.

In this issue of Resuscitation, Suchko and colleagues describe rearrest in a large, national database encompassing approximately 53,000 OHCA cases from over 1700 emergency medical services (EMS) agencies in the United States.[10] The investigators observed that 30% of patients experienced rearrest and identified a number of risk factors which potentially represent surrogates of ischemia severity. Unwitnessed arrest, lack of bystander CPR, and longer response and resuscitation intervals were associated with rearrest. These findings provide additional motivation to support the links in the chain, highlighting that positive predictors of return of spontaneous circulation (ROSC) are subsequently inversely related to the risk of rearrest. The research also observed that a greater risk of rearrest was inversely associated with survival at the EMS agency level, at least among agencies that treated ≥ 30 cardiac arrest patients during the study period and had outcome data available.

This study has several strengths. The topic is clinically important. The study's database is large and geographically diverse, derived from multiple US EMS agencies, likely with varied patient characteristics and practice patterns. The study design uses standard definitions to derive the cohort, primary outcome, and potential risk factors. The finding

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Declaration of competing interest

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that ischemia surrogates predict rearrest helps inform our understanding how these clinical characteristics influence the resuscitation course and mediate survival outcomes.

The investigation also has limitations. Missingness of covariates and outcomes challenged the inferential analysis of rearrest risk factors and rearrest-survival relationship, highlighting the concern that cases missing predictors or outcome may somehow be different, and hence limit generalizability. Additionally, the study observes an association between rearrest and survival at the EMS agency level; the study however could not determine whether this association is mediated by individual patient factors or by differences in agency-level practices. None of the agency-level practices that the authors hypothesized might explain this association, including scene time and field termination rate, were associated with rearrest, underscoring the difficulty explaining this relationship.

Another challenge to this research topic more generally is defining and timestamping rearrest and conversely ROSC. Suchko and colleagues use an operational definition for rearrest, including any of the following documented after notation of ROSC: 1) chest compressions, 2) defibrillation, 3) adrenaline administration in 1 mg aliquots, or 4) a non-perfusing rhythm upon hospital arrival. ROSC is also challenging to define in the prehospital setting, and typically requires both a cardiac rhythm capable of perfusion and manual palpation of a pulse, the latter of which is error-prone.[11,12] However, the physiological timing of rearrest and ROSC may occur well before clinical recognition and corresponding actions. Time-sensitive identification is important if we are to robustly predict rearrest especially using time-dependent, dynamic measures, ultimately with the goal to intervene and prevent rearrest.

In the case of ventricular fibrillation, the physiological moment of rearrest is immediately visible on standard cardiac monitors; several defibrillator and cardiac monitor manufactures already include alarms for ventricular fibrillation. With non-shockable cardiac rhythms however, which represent 75% of rearrests in this cohort, tools for identifying the physiological timing of rearrest in the prehospital setting are limited. Clinicians who care for patients in highly-monitored settings, such as the intensive care unit or operating theatre, may leverage invasive monitoring such as the arterial blood pressure tracing or even direct measures of cardiac output to more accurately identify rearrest. Such invasive monitoring is rarely available in the prehospital setting.

Ultimately the goal is not just to identify but also to accurately predict rearrest as a means to intervene ideally with patient-specific therapy to sustain spontaneous circulation, a compelling strategy to improve survival. The use of clinical characteristics such as response and low-flow intervals may be useful in an actionable strategy, though ideally identification and prediction are informed by real-time, automated, dynamic measures which can alert professional rescuers to impending rearrest and potentially even guide intervention. The defibrillator is a ubiquitous and essential tool for professional rescuer resuscitation and often continuously measures multiple bio-signals (ECG, capnogram, transthoracic impedance, pulse oximetry), providing a platform to consider if these bio-signals maybe used alone or in conjunction with clinical characteristics to alert or forewarn rescuers of rearrest (or ROSC). For example, a stepwise decline in the amplitude of capnogram waveform, a surrogate marker for cardiac output, is associated with impending rearrest and may provide advance warning to healthcare providers.[13] In addition to the defibrillator, novel, non-invasive approaches that monitor cardiac output, carotid blood flow, and brain oxygenation may also have a role in rearrest identification and prediction.[14-17] Methods of artificial intelligence may be well-suited to integrate this collection of time-dependent information to identify and predict pulse or loss of pulse and help guide treatment. The need then is to couple a library of real-time bio-signals with accurately time-stamped clinical status and robust quantitative methods.[14-17]

The study by Suchko and colleagues highlights the common and adverse role of rearrest as well as the potential to predict who is at risk following ROSC. The ability to act on this understanding and prevent rearrest may depend on whether existing and new technology can achieve robust prediction that triggers operationally-feasible and clinically-effective changes in care. The opportunity is before us.

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