



## Clinical Paper

Validation of the Pittsburgh Cardiac Arrest Category illness severity score<sup>☆</sup>

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## ABSTRACT

**Background:** The purpose of this study was to validate the ability of an early post-cardiac arrest illness severity classification to predict patient outcomes.

**Methods:** The Pittsburgh Cardiac Arrest Category (PCAC) is a 4-level illness severity score that was found to be strongly predictive of outcomes in the initial derivation study. We assigned PCAC scores to consecutive in and out-of-hospital cardiac arrest subjects treated at two tertiary care centers between January 2011 and September 2013. We made assignments prospectively at Site 1 and retrospectively at Site 2. Our primary outcome was survival to hospital discharge. Inter-rater reliability of retrospective PCAC assessments was assessed. Secondary outcomes were favorable discharge disposition (home or acute rehabilitation), Cerebral Performance Category (CPC) and modified Rankin Scale (mRS) at hospital discharge. We tested the association of PCAC with each outcome using unadjusted and multivariable logistic regression.

**Results:** We included 607 cardiac arrest patients during the study (393 at Site 1 and 214 at Site 2). Site populations differed in age, arrest location, rhythm, use of hypothermia and distribution of PCAC. Inter-rater reliability of retrospective PCAC assignments was excellent ( $\kappa=0.81$ ). PCAC was associated with survival (unadjusted odds ratio (OR) for Site 1: 0.33 (95% confidence interval (CI) 0.27–0.41)) Site 2: 0.32 (95% CI 0.24–0.43) even after adjustment for other clinical variables (adjusted OR Site 1: 0.32 (95% CI 0.25–0.41) Site 2: 0.31 (95% CI 0.22–0.44)). PCAC was predictive of secondary outcomes.

**Conclusions:** Our results confirm that PCAC is strongly predictive of survival and good functional outcome after cardiac arrest.

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## 1. Introduction

Over 500,000 Americans suffer a cardiac arrest annually.<sup>1</sup> Among those with return of spontaneous circulation (ROSC) admitted to the hospital, 50–70% die before discharge. Accurate prognostication of survival, good functional outcome and

complications after ROSC can inform medical management, surrogate decision-making and resource allocation. Furthermore, a measure that controls for illness severity using early clinical characteristics would allow prospective stratification or retrospective adjustment in research that examines post-resuscitation care in this heterogeneous population. A number of illness severity scores have been developed for use after cardiac arrest, but rely on information that is not readily available to clinicians in the early hours after ROSC.<sup>2–4</sup> Further, these scores are intended for use in either in-hospital cardiac arrest (IHCA) or out-of-hospital cardiac arrest (OHCA), but not both.<sup>2–4</sup> We previously derived an illness severity scale, the Pittsburgh Cardiac Arrest Category (PCAC), that was strongly associated with survival to hospital discharge and good functional outcome in both IHCA and OHCA.<sup>5</sup> This scale was derived

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for simplicity, focus on objective physical findings, and relevance to post-arrest patients.

The present study was intended to validate the PCAC. We hypothesized that the PCAC would independently predict survival and functional outcome in two populations of patients hospitalized after cardiac arrest even after adjustment for other variables. Since neurological prognostication may lead to a “self-fulfilling prophecy” whereby care is withdrawn based on perceived prognosis,<sup>6</sup> we assigned the PCAC *prospectively* at the center where it had been derived and *retrospectively* at another center. Thus, our study was intended to prospectively validate the PCAC in a population similar to the derivation cohort while simultaneously providing external validation to avoid the possibility of bias.

## 2. Methods

The University of Pittsburgh Institutional Review Board approved this study.

### 2.1. Setting and study population

We included survivors of cardiac arrest that presented to UPMC Presbyterian (Site 1) or UPMC Mercy (Site 2) hospitals and were admitted to the intensive care unit (ICU) between January 2011 and September 2013. Site 1 is a 798-bed tertiary care center with 53,000 emergency department visits annually and is a regional referral center for post-arrest care. Subjects in the original PCAC derivation cohort were cared for exclusively at Site 1 from 2005 to 2009<sup>5</sup> and were not included in this analysis. Site 2 is a 535-bed tertiary care center with 62,000 emergency department visits annually and serves a primarily local, urban population.

At Site 1, a consulting Post-Cardiac Arrest Service (PCAS) physician consulted on most patients included in this analysis and prospectively assigned each patient’s PCAC as part of routine clinical practice. Therefore, the clinical team caring for each patient was aware of both the PCAC and anticipated prognosis. By contrast, a separate group of intensivists staffs Site 2’s ICUs without PCAS input minimizing cross contamination. PCAC was not routinely used at Site 2 to inform decision-making or family discussions about prognosis.<sup>5</sup>

We defined “cardiac arrest” as a patient receiving chest compressions by a health care provider. We defined ROSC as regaining and maintaining spontaneous circulation for  $\geq 20$  min. We excluded patients from our study if they died less than 6 h after of ROSC, since PCAC is assigned on the basis of the best neurologic exam in the first 6 h after ROSC. We included IHCA and OHCA defining emergency department arrests as OHCA.

### 2.2. Treatment during the study period

At Site 1, patients received post-arrest care consistent with our standardized practice guidelines as reported.<sup>7</sup> This included routine use of mild hypothermia with a target temperature of 33 °C maintained for 24 h. All comatose arrest survivors were treated with hypothermia, regardless of initial rhythm, except those with active, non-compressible bleeding, severe bradycardia or refractory hemodynamic instability. In both OHCA and IHCA patients, providers generally induced hypothermia with rapid intravenous infusion of 4 °C crystalloid solutions followed by maintenance with endovascular or surface cooling. We used continuous electroencephalography (EEG) to monitor comatose patients and responded to EEG findings with a standardized antiepileptic medication protocol. Additional care protocols included sedation with propofol or benzodiazepines, narcotic use to prevent shivering, and use of bolus paralytics as needed to facilitate hypothermia induction. We generally recommended maintenance of a mean arterial pressure (MAP)

goal  $\geq 80$  mmHg for cerebral perfusion. In a majority of patients, the PCAS service led care goal discussions.

At Site 2, the intensivist group used an identical induced hypothermia and sedation protocol. Intermittent EEG monitoring was used at the discretion of the treating intensivist. Care protocols recommended fluids and vasoactive medication to maintain MAP  $\geq 65$  mmHg and urine output  $\geq 0.5$  mL/kg/h.<sup>8</sup> The treating intensivist led care goal discussions without PCAS input.

### 2.3. Data collection

We collected patient demographics including age, sex, initial arrest rhythm (ventricular tachycardia or fibrillation (VT/VF), pulseless electrical activity (PEA), asystole, unknown), location of arrest (OHCA or IHCA), and Charlson Comorbidity Index. We assigned PCAC as previously described.<sup>5</sup> The PCAC is derived from the Full Outline of UnResponsiveness (FOUR)<sup>9</sup> brainstem and motor sub-scores and the Serial Organ Failure Assessment (SOFA)<sup>10</sup> cardiac and respiratory subscales (Supplemental Table 1). The four PCAC levels are<sup>5</sup>:

- (I) Awake (FOUR motor + brainstem = 8); 80% survival, 60% good outcome.
- (II) Coma (not following commands but intact brainstem responses; FOUR motor + brainstem of 4–7) and mild cardiopulmonary dysfunction (SOFA cardiac + respiratory score < 4); 60% survival, 40% good outcome.
- (III) Coma (as defined above) with moderate to severe cardiopulmonary dysfunction (SOFA cardiac + respiratory score  $\geq 4$ ); 40% survival, 20% good outcome.
- (IV) Coma with at least one absent brainstem reflex (FOUR motor + brainstem < 4); 10% survival, 5% good outcome.

We used the best neurological examination within 6 h after ROSC to assign FOUR score. Patients were examined free of sedation and neurological blockade before consideration of hypothermia. No exams clouded by drugs were considered. We used the worst SOFA score in the first 6 h after ROSC to derive PCAC scores. Our methods of assigning PCAC were identical to the derivation study.<sup>5</sup>

At Site 1, the PCAS physician prospectively assigned the PCAC. At Site 2, a single study investigator assigned PCAC based on retrospective medical record review. To assess the inter-rater reliability of retrospective PCAC assignment, three investigators independently assigned PCAC to a random sample of 32% of Site 2 patients.

### 2.4. Outcomes

Our primary outcome was survival to hospital discharge. Secondary outcomes were discharge Cerebral Performance Category (CPC), discharge modified Rankin Scale score (mRS) and discharge disposition, which we operationalized as a three-level categorical variable (home or acute inpatient rehabilitation; nursing facility or hospice; death). At both sites, we assigned neurological outcomes retrospectively based on review of physical medicine and rehabilitation, physical therapy, occupational therapy and nursing documentation.<sup>11,12</sup> We categorized cause of death as hemodynamic instability, brain death, withdrawal of care for medical reasons (other than neurological prognosis), or withdrawal for anticipated neurological prognosis. At both sites, patients are generally discharged to rehabilitation when their CPC reaches 3, so in our setting discharge CPC does not reflect patients’ ultimate recovery. Since 90% of our arrest survivors who go to acute inpatient rehabilitation ultimately are discharged home, “good functional outcome” was operationalized as discharge to home or rehabilitation.

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