



Clinical paper

Predicting neurologically intact survival after in-hospital cardiac arrest-external validation of the Good Outcome Following Attempted Resuscitation score



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ABSTRACT

Background: A do-not-attempt-resuscitation order is issued when it is against the wishes of the patient that cardiopulmonary resuscitation is performed, or when the chance of good quality survival is minimal. Therefore it is essential for physicians to make an objective prearrest prediction of the outcome after an in-hospital cardiac arrest (IHCA). Our aim was external validation of the Good Outcome Following Attempted Resuscitation (GO-FAR) score in a population based setting.

Methods: The study was based on a retrospective cohort of adult IHCA in Stockholm County 2013–2014 identified through the Swedish Cardiopulmonary Resuscitation Registry. This registry provided patient and event characteristics and neurological outcome at discharge. Neurologically intact survival is defined as Cerebral Performance Category score (CPC) 1 at discharge. Data for the GO-FAR variables was obtained from manual review of electronic patient records. Model performance was evaluated by measure of discrimination with the area under the receiver operating curve (AUROC) and calibration with assessment of the calibration plot.

Results: The cohort included 717 patients with neurologically intact survival at discharge of 22%. In complete case analysis (523 cases) AUROC was 0.82 (95% CI 0.78–0.86) indicating good discrimination. The calibration plot showed that the GO-FAR score systematically underestimates the probability of neurologically intact survival.

Conclusion: The GO-FAR score has satisfactory discrimination, but assessment of the calibration shows that neurologically intact survival is systematically underestimated. Therefore, only with caution should it without model update be taken into clinical practice in settings similar to ours.

Introduction

The estimated incidence of cardiac arrests in-hospital where resuscitation is attempted (IHCA) is 1–5 events per 1000 hospital admissions, with survival to hospital discharge in the range of 15–30% [1–5]. However, most patients suffering cardiac arrest (CA) in hospital do not undergo cardiopulmonary resuscitation (CPR), and the rate of CPR attempts varies from 5 to 31% [1,6–9]. A do-not-attempt-resuscitation (DNAR) order may be issued when it is against the expressed

wishes of the patient to receive CPR, or when CPR is considered medically futile; that is when the chances of good quality survival are minimal [10].

Previous studies have shown that it is difficult for medical personnel to accurately predict good outcome after CA [11], that medical personnel have difficulty accurately predicting patient wishes regarding CPR preference [12] and that prognostic information influences patient wishes regarding CPR preferences [13,14]. Therefore it is essential for clinicians to make an objective prearrest prediction of outcome for

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Table 1
The GO-FAR model variables according to original publication [17].

GO-FAR variable	Definition ^a	Score
Neurologically intact or minimal deficits at admission	CPC 1	-15
Major trauma	Evidence of multisystem injury or single system injury associated with shock or altered mental status during the current hospitalization	10
Acute stroke	Documented diagnosis of an intracranial or intraventricular hemorrhage or thrombosis during the current admission	8
Metastatic or hematologic cancer	Any solid tissue malignancy with evidence of metastasis or any blood-borne malignancy	7
Septicemia	Documented bloodstream infection in which antibiotic therapy has not yet been started or is still ongoing	7
Medical non-cardiac diagnosis		7
Hepatic insufficiency	Evidence of hepatic insufficiency within 24 h of the event, defined by total bilirubin > 34 $\mu\text{mol/l}$ and (AST > 2 times the upper limit of normal or cirrhosis)	6
Admission from skilled nursing facility		6
Hypotension or hypoperfusion	Any evidence of hypotension within 4 h of the event, defined as any of the following: SBP < 90 or MAP < 60 mmHg; vasopressor or inotropic requirement after volume expansion (except for dopamine \leq 3 $\mu\text{g/kg/min}$); or intra-aortic balloon pump	5
Renal insufficiency/dialysis	Requiring ongoing dialysis or extracorporeal filtration therapies, or serum creatinine > 2 mg/dL within 24 h of the event	4
Respiratory insufficiency	Evidence of acute or chronic respiratory insufficiency within 4 h of the event, defined as any of the following: Pao ₂ /Fio ₂ ratio < 300, Pao ₂ < 60 mmHg, or Sao ₂ < 90% (without preexisting cyanotic heart disease); PaCO ₂ , ETco ₂ , or Tcco ₂ > 50 mmHg; spontaneous respiratory rate > 40/min or < 5/min; requirement for noninvasive ventilation, or negative pressure ventilation; or requirement for ventilation via invasive airway	4
Pneumonia	Documented diagnosis of active pneumonia, in which antibiotic therapy has not yet been started or is still ongoing	1
Age, y		
70–74		2
75–79		5
80–84		6
\geq 85		11

Abbreviations: CPC, Cerebral Performance Category; AST, aspartate aminotransferase; SBP, systolic blood pressure; MAP, mean arterial pressure; Pao₂, arterial partial pressure of oxygen; Fio₂, fraction of inspired oxygen; Sao₂, arterial oxygen saturation; PaCO₂, arterial partial pressure of carbon dioxide; ETco₂, end-tidal carbon dioxide pressure; Tcco₂, transcutaneous carbon dioxide pressure.

^a Adapted from the American Heart Association.

IHCAs. It is of special importance to identify patients with a very low likelihood of good outcome where a DNAR order may be indicated. However, previously developed prediction tools for survival after IHCA have not performed well in validation [15,16] and clinician's decision making is limited to clinical judgement.

The Good Outcome Following Attempted Resuscitation (GO-FAR) score [17] was developed in 2013 and external validation has so far been limited to one single site study [18]. A validated and clinically applicable prearrest prediction tool would substantially contribute to daily clinical practice in discussing DNAR orders. Therefore we performed a population based external validation study based on a retrospective cohort of IHCAs in Stockholm County, Sweden.

Methods

Study design and population

This validation cohort included index episodes of IHCA in adults in Stockholm County (2.3 million inhabitants) 2013–2014 identified through the Swedish Cardiopulmonary Resuscitation Registry (SCRR). This registry is a national quality registry funded by the Swedish Association of Local Authorities and Regions that reports IHCAs from 93% of Swedish hospitals with their own resuscitation team according to the Utstein style since 2005. Completeness of case findings in SCRR has been estimated to be 85% [19]. Details of the register have been published elsewhere [9]. We included 6 out of 7 hospitals in Stockholm County, the one that was excluded (Norrtälje Hospital) was due to lack of access to the electronic patient record. Norrtälje Hospital is the smallest hospital in the county and contributes the smallest number of IHCA to the registry [19]. An IHCA was defined as an admitted patient who is unresponsive with apnea, where CPR and/or defibrillations have been initiated and the CA is included in the SCRR. The registry provides CA event characteristics, national registration numbers and Cerebral Performance Category (CPC) score [20] at discharge from hospital. The study was approved by the regional Ethical Review Board in Stockholm, Sweden (2013/1959-31/4;2014/2064-32;2015/2157-32). All IHCA

survivors were asked for informed consent and agreed to participate in SCRR and on-going studies based upon it. The proportion of survivors who do not wish to participate in SCRR is extremely low (less than 10 patients have asked for withdrawal from the register). Further, by accepting care at hospitals in Stockholm County, patients are informed about how to find information about ongoing studies including withdrawal of participation.

The GO-FAR score

The GO-FAR model was developed using a cohort of 51240 index episodes of IHCA in adults from 366 hospitals participating in the Get With The Guidelines-Resuscitation (GWTG) registry [21] 2007–2009. It is a summed score consisting of 13 prearrest variables with values ranging from –15 to 11 points (pts) (Table 1) and is intended to predict the likelihood of neurologically intact survival defined as a CPC score of 1 (alert, able to work and lead a normal life, may have minor psychological or neurologic deficits) [20]. The likelihood of neurologically intact survival is categorized into risk groups: very low (< 1%) \geq 24 pts; low (< 3%) 14–23 pts; average (3–15%) –5 to 13 pts; above average (> 15%) –15 to –6 pts. In this study, data for the GO-FAR variables was obtained from manual review of electronic patient records. The review was performed by an Internal and Emergency Medicine consultant (EP) and two junior physicians (SB, SeG), blinded to the outcome. All uncertainties were reviewed by the consultant and in case of residual uncertainty settled by consensus with a second Internal and Emergency medicine consultant (TD). The original definitions of the GO-FAR variables (Table 1) remain unchanged with the following exceptions:

- Neurologically intact at admission defined as CPC 1 was replaced by Glasgow Coma Scale (GCS) 15 (opens eyes spontaneously, oriented, converses normally, obeys commands) [22] on admission in order not to introduce information bias. The CPC score on admission is submitted to SCRR only for patients alive at discharge or 30 days but is otherwise not used clinically, and is not noted in electronic patient

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