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## Letter to the Editor

# Reply to Wallner B et al. Prognostication of outcome for hypothermic avalanche victims in cardiac arrest



To the Editor,

We thank Wallner B et al. for commenting on the ERC 2021 guidelines.<sup>1,2</sup> They present three hypothetical arrested avalanche patients and caution the use of the HOPE score.<sup>3,4</sup> We would like to explain why the HOPE score is currently the best method to determine chances of survival in arrested hypothermic avalanche victims.

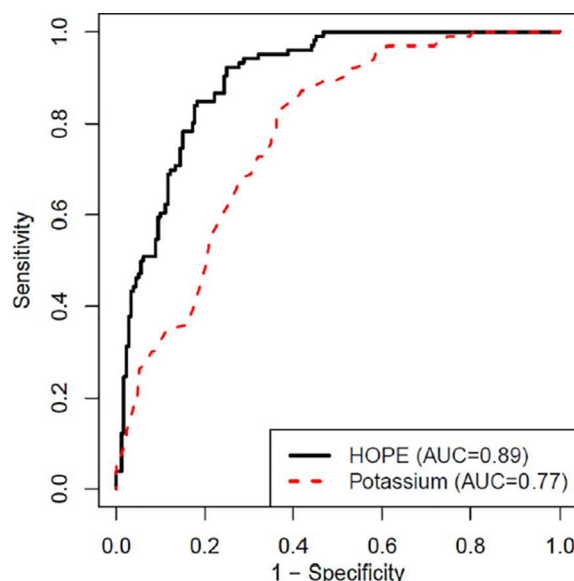
Firstly, the HOPE score is based on a study including 286 patients with 106 survivors from published articles ( $n = 237$ ) and consecutive cases of four hospitals ( $n = 49$ ).<sup>3</sup> Out of nine potential parameters, related with survival in prior studies, six could be correlated with survival in a multivariate analysis: age, sex, core temperature at admission, serum potassium, mechanism of cooling, and cardiopulmonary resuscitation duration. In the HOPE score calculation, the mechanism of cooling and cardiac arrest can be either selected as being 'asphyctic' or 'non-asphyctic'. Patients arrested in an avalanche should by default be included as having suffered 'asphyctic' cooling, because most avalanche victims asphyxiate. The website '[www.hypothermiascore.org](http://www.hypothermiascore.org)' where the score can be calculated mentions this. The corresponding area under the receiver operating characteristic (ROC) curve was 0.895 (95% CI: 0.859–0.931) compared to 0.774 (95% CI: 0.720–0.828) when based on serum potassium level alone (Fig. 1), confirming the superiority of the HOPE score compared to the dichotomous triage based on potassium alone, to predict outcome of hypothermic cardiac arrest patients rewarmed with ECLS.<sup>3</sup>

Secondly, the HOPE score has been externally validated with a follow-up study ( $n = 122$ , 51 survivors<sup>3</sup>, confirming the good discrimination (area under the ROC curve was 0.825 (95% CI = [0.753–0.897])), and excellent calibration of the HOPE score.

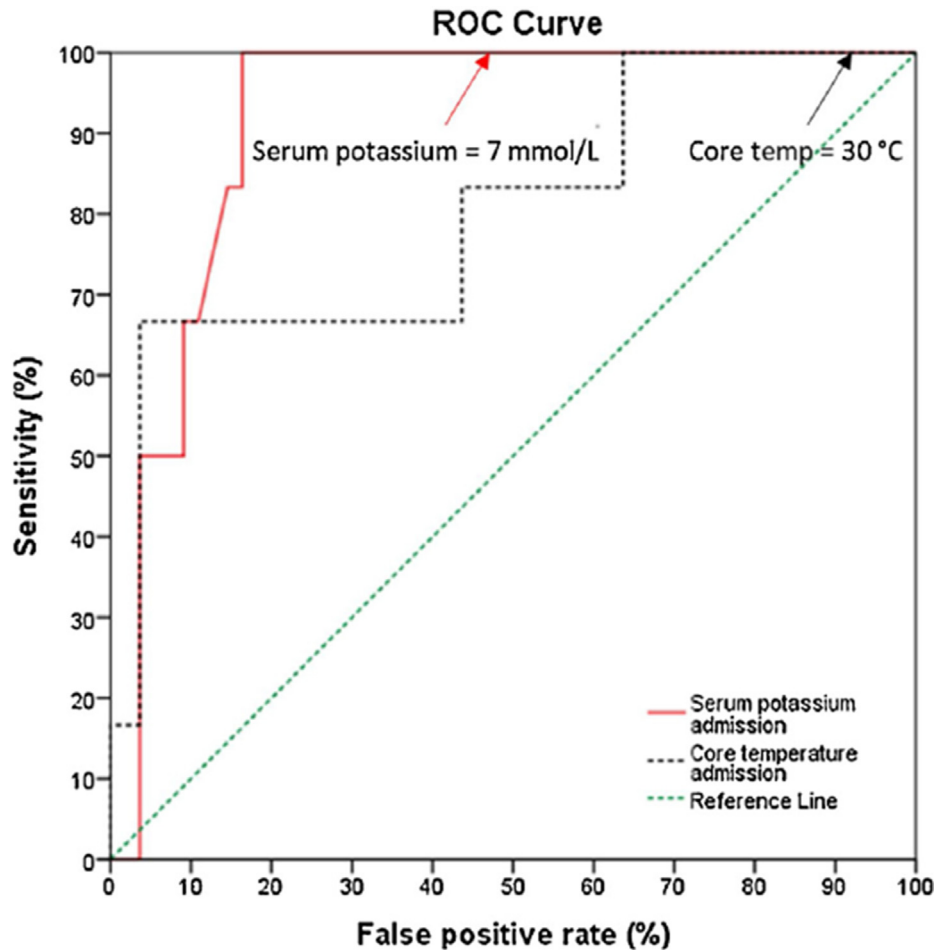
Thirdly, prior to the introduction of HOPE, prognostication of arrested hypothermic avalanche victims was performed with potassium and hypothermia, which was suggested in 1990 based on a case series ( $n = 9$ ).<sup>5</sup> The potassium triage was revised based on case reports and case series, it was never validated, and criticized because of too many non-survivors after ECLS rewarming. The first study to assess potassium triage and hypothermia in a systematic way was published in 2019 ( $n = 103$ , 6 survivors).<sup>6</sup> The cut-offs of 7 mmol/L for serum potassium and 30 °C for core temperature achieved the lowest over-triage rate (47%) (Fig. 2), and the highest

positive predictive value (19%), with a sensitivity of 100% for survivors in the population of avalanche victims in cardiac arrest. The discrimination for survival is lower with potassium and hypothermia as compared to the HOPE score (Fig. 1).<sup>3,4,6</sup> In contrast to the HOPE score, the sample size is smaller and the triage with potassium and hypothermia has never been externally validated.

We agree with the authors that for avalanche victims both proposed triage systems may not be optimal. The most relevant limitation in outcome prediction in arrested hypothermic avalanche patients is the low number of survivors. Only very few patients survived ECLS rewarming after hypothermic cardiac arrest.<sup>3,4,6</sup>



**Fig. 1 – Hypothermia Outcome Prediction after ECLS (HOPE) receiver operating characteristic curve of the survival probabilities estimated from our 286 patients using Hypothermia Outcome Prediction after ECLS (HOPE) model or potassium (right panel). AUC = area under the curve.**



**Fig. 2 – Receiver operating curve (ROC) for rewarmed avalanche victims (n = 61) with respect to serum potassium levels (red) and core temperature (black dotted). Areas under the curve for serum potassium AUC = 0.92 (95% confidence interval 0.85–0.99, p = 0.001) and for core temperature AUC = 0.80 (95% confidence interval 0.60–1.00, p = 0.015). When considering a serum potassium level of 7 mmol/L and core temperature of 30 °C as cut-offs, rate of over-triage (False positive rate = 1-specificity) is 47%. The respective cut-off values are marked by arrows, showing that the respective cut-offs were chosen conservatively, for safety reasons.**

Therefore, all prediction models are limited in their predictive value, they better predict non-survivors than survivors. The three hypothetical avalanche patient cases presented by the authors show that the ideal triage system for avalanche victims in cardiac arrest is still under debate and needs further improvement. If the sub-population of avalanche victims differs significantly from the population of the evaluated patients, HOPE would still need to be validated for this sub-population. As soon as more data of survivors are available the prediction models will be refined.

Lastly, it will remain to the discretion of the clinician to consider whether to rewarm an arrested hypothermic avalanche patient based on the medical history, clinical picture, additionally to any prediction tool such as the proposed HOPE score.

### Declaration of Competing Interest

CL, HB and MF report no COI.

MP, VR and PP have been involved with derivation and validation of the HOPE score.

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