

Online Resource 1

Supplementary Tables

Table S1. Predefined Physiological Thresholds for Artefact Removal

	Acceptable range
PPI	0.05 to 50
HR, bpm	30 to 160
SpO ₂ , %	50 to 100
SBP, mmHg	50 to 250
DBP, mmHg	25 to 150
MAP, mmHg	25 to 150
EtCO ₂ , mmHg	1 to 80
PPV, %	0 to 50
SVV, %	0 to 50
CVP, mmHg	0 to 40
SVI, ml.m ²	5 to 120
PCCI, l.min ⁻¹ .m ⁻²	0.5 to 12

Values outside the specified range were replaced with missing values. **Abbreviations:** CVP, central venous pressure; DBP, diastolic blood pressure; EtCO₂, end-tidal carbon dioxide; HR, heart rate; MAP, mean arterial pressure; PCCI, pulse contour cardiac index; PPI, peripheral perfusion index; PPV, pulse pressure variation; SBP, systolic blood pressure; SpO₂, peripheral oxygen saturation; SVI, stroke volume index; SVV, stroke volume variation.

Table S2. Training and Test Set Characteristics

	Train set	Test set
Patients, n	108	28
Timepoints, n	33928	8418
Low CI prevalence, %	14.7	18.5
Age, yr	58.8	62.1
Male sex, %	55.9	35.1
HR, bpm	75	76
SBP, mmHg	104	107
DBP, mmHg	57	58
PPV, %	9	11
PPI	2.9	2.9
SpO ₂ , %	100	100
EtCO ₂ , mmHg	35	34
PCCI, l.min ⁻¹ .m ⁻²	2.8	2.7

Continuous variables are presented as medians. The dataset was split by patient-level random allocation. Differences in sex distribution and outcome prevalence reflect expected sampling variability given the small test set (n=28 patients). **Abbreviations:** CI, cardiac index; DBP, diastolic blood pressure; EtCO₂, end-tidal carbon dioxide; HR, heart rate; PCCI, pulse contour cardiac index; PPI, peripheral perfusion index; PPV, pulse pressure variation; SBP, systolic blood pressure; SpO₂, peripheral oxygen saturation.

Table S3. SHAP Feature Importance Rankings on Training and Test Sets

	Train set		Test set	
	SHAP	Rank	SHAP	Rank
HR	0.9	1	0.9	1
DBP	0.67	2	0.65	2
PPV	0.54	3	0.55	4
SBP	0.53	4	0.59	3
Age	0.48	5	0.41	5
BMI	0.36	6	0.35	6
EtCO ₂	0.21	7	0.16	8
BSA	0.2	8	0.22	7
Gender	0.12	9	0.12	10
PPI	0.11	10	0.12	9
SpO ₂	0.08	11	0.07	11
ASA	0.07	12	0.04	12

Features ranked by mean absolute SHAP value. **Abbreviations:** ASA, American Society of Anesthesiologists; SHAP, SHapley Additive exPlanations; BMI, body mass index; BSA, body surface area; DBP, diastolic blood pressure; EtCO₂, end-tidal carbon dioxide; HR, heart rate; PPI, peripheral perfusion index; PPV, pulse pressure variation; SBP, systolic blood pressure; SpO₂, peripheral oxygen saturation.

Table S4. VIF for Selected Features

	VIF
HR	1.66
DBP	2.91
PPV	1.55
SBP	2.86
Age	1.23

Abbreviations: VIF, variance inflation factor; DBP, diastolic blood pressure; HR, heart rate; PPV, pulse pressure variation; SBP, systolic blood pressure.

Table S5. GLMM Coefficients, Odds Ratios, and LCI Score Derivation

	OR (95% confidence interval)	<i>p</i> -value	GLMM coefficient	Rounded coefficient	Score weight (×10)
Intercept	—	—	1.6074	-4.4	-44
Constant	—	—	—	—	+101
Final intercept	—	—	—	—	57
HR	0.88 (0.87, 0.88)	<0.001	-0.132	-0.1	-1
DBP	1.22 (1.21, 1.23)	<0.001	0.2006	0.2	2
PPV	1.1 (1.09, 1.11)	<0.001	0.0996	0.1	1
SBP	0.9 (0.89, 0.90)	<0.001	-0.1065	-0.1	-1
Age	1.05 (1.01, 1.10)	0.012	0.0515	0.05	0.5

Odds ratios correspond to a one-unit increase in each variable on the original measurement scale, derived from the GLMM with patient-level random intercept fitted on the training set. GLMM coefficients were fitted on standardised data, then back-transformed to the original measurement scale. Coefficients were rounded to one decimal place for haemodynamic variables and two decimal places for age. The intercept was re-optimised on the training set to maximise AUROC after rounding, then multiplied by ten. A constant of +101 was added to the scaled intercept to shift scores into a positive range (final intercept: $-44 + 101 = 57$); this linear transformation does not affect discriminative performance. Coefficient rounding did not alter discriminative performance (AUROC 0.84 for both). **Abbreviations:** AUROC, area under the receiver operating characteristic curve; CI, confidence interval; DBP, diastolic blood pressure; GLMM, generalised linear mixed model; HR, heart rate; LCI, low cardiac index; OR, odds ratio; PPV, pulse pressure variation; SBP, systolic blood pressure.

Table S6. Discriminative Performance of the LCI Score Compared with Individual Haemodynamic Parameters

Predictor	AUROC
LCI score	0.84
HR	0.7
Shock index	0.64
PPV	0.63
DBP	0.57
SBP	0.55
MAP	0.51

AUROC for predicting low CI ($\text{PCCI} < 2.2 \text{ l.min}^{-1}.\text{m}^{-2}$) on the test set (28 patients, 8,418 timepoints). Individual haemodynamic parameters and the shock index were evaluated as standalone predictors. **Abbreviations:** AUROC, area under the receiver operating characteristic curve; CI, cardiac index; DBP, diastolic blood pressure; HR, heart rate; LCI, low cardiac index; MAP, mean arterial pressure; PCCI, pulse contour cardiac index; PPV, pulse pressure variation; SBP, systolic blood pressure.

Table S7. Sensitivity Analysis Excluding Liver Transplant Patients

	Full test set	Excluding liver transplant
Patients, n	28	25
Timepoints, n	8,418	7,326
Prevalence (%)	18.5	18.9
AUROC	0.84	0.87
Sensitivity	0.92	0.97
Specificity	0.53	0.49
Negative predictive value	0.97	0.99
Positive predictive value	0.31	0.31

Performance of the LCI score on the test set. Formula and threshold (≥ 30) derived from the training set were applied without modification. Of 38 liver transplant patients in the analysis cohort, three were in the test set.

Abbreviations: AUROC, area under the receiver operating characteristic curve; LCI, low cardiac index.