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Development and validation of a new simplified anatomic trauma mortality score

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ABSTRACT

Background: Most trauma mortality prediction scores are complex in nature. GAP (Glasgow Coma Scale, Age, Systolic blood pressure) and mGAP (mechanism, Glasgow Coma Scale, Age, Systolic blood pressure) scores are relatively simple scoring tools. However, these scores were not validated in low and middle income countries including Malaysia and its accuracies are influenced by the fluctuating physiologic parameters. This study aims to develop a relevant simplified anatomic trauma scoring system for the local trauma patients in Malaysia.

Method: A total of 3825 trauma patients from 2011 to 2016 were extracted from the Hospital Sultanah Aminah Trauma Surgery Registry. Patients were split into a development sample (n = 2683) and a validation sample (n = 1142). Univariate analysis is applied to identify significant anatomic predictors. These predictors were further analyzed using multivariable logistic regression to develop the new score and compared to existing score systems. The quality of prediction was determined regarding discrimination using sensitivity, specificity and receiver operating characteristic [ROC] curve.

Results: Existing simplified score systems (GAP & mGAP) revealed areas under the ROC curve of 0.825 and 0.806. The newly developed HeCLLiP (Head, cervical spine, lung, liver, pelvic fracture) score combines only five anatomic components: injury involving head, cervical spine, lung, liver and pelvic bone. The probabilities of mortality can be estimated by charting the total score points onto a graph chart or using the cut-off value of (>2) with a sensitivity of 79.2 and specificity of 70.6% on the validation dataset. The HeCLLiP score achieved comparable values of 0.802 for the area under the ROC curve in validation samples.

Conclusion: HeCLLiP Score is a simplified anatomic score suited to the local Malaysian population with a good predictive ability for trauma mortality.

Background

Traumatic injury is the fifth leading cause of death recorded in health care centres of Malaysia. [1] It is a significant burden in regards to manpower and loss in economy due to the high cost incurred to manage this cohort of patients. Trauma scores is an important tool for outcome prediction (mortality or functional outcome), to triage patients in a pre-hospital setting with continuous auditing for betterment of the trauma service.

Current existing trauma scores include MGAP [2], GAP [3], RTS [4], NISS [5], TRISS [6], TARN [7], ASCoT [8], PRESTO [9] or Trauma Mortality prediction model [10]. These are complex scoring system which requires training and complex mathematical formulas to calculate in exception to the GAP and MGAP scores. GAP and MGAP scores developed in 2011 and 2010, is based on physiological

Abbreviations: GCS, Glasgow Coma Scale; NISS, New Injury Severity Score; RTS, revised trauma score; TRISS, trauma and injury severity score; HR, heart rate; RR, respiratory rate; SBP, systolic blood pressure; AIS, abbreviated injury scale; MGAP, mechanism of injury, Glasgow Coma Scale, Age, Systolic Blood Pressure; GAP, Glasgow Coma Scale, Age, Systolic Blood Pressure; TARN, trauma audit and research network; ASCoT, a severity characterisation of trauma ASCoT (among) others; NTrD-TRISS, Malaysian National Trauma registry database derived TRISS; HeCLLiP, head, cervical spine, lung, liver, pelvic fracture; FAST, focussed assessment of sonography in trauma.

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parameters which are simple and easy to use. However, these models were developed and validated in high income countries. Trauma epidemiology and mortality trends is different in low-middle income countries based on CRASH-2 trial database [7]. Lack of trauma registries in these countries limits the validation of current available prognostic models [11].

Therefore, the suitability of the above-mentioned trauma scoring system may not be applicable to patients in the low-middle income countries. Furthermore, these scores utilized the physiologic parameters which may be inaccurate if data is obtained after resuscitation or recorded too early before physiologic compromise.

The new scoring system may improve the efficacy of triaging trauma patients, assist clinician with surgical resource allocation, local clinical auditing for quality of care improvement, loco-regional centre comparison, improved communication among trauma care providers and assist in counselling to family on prognosis targeting to the organ injuries sustained.

The main objective of this study is to formulate a new simplified anatomic prediction score for trauma mortality suitable for a Malaysian trauma population. Secondary objectives are to compare the formulated score with other available trauma scores and identify the better scoring system to predict trauma deaths.

Methodology

Hospital Sultanah Aminah is a tertiary government run-hospital with specialized trauma surgery services. This specialized trauma surgery service is led by a trauma surgeon(s), general surgeons, medical officers with nurses trained to handle traumatic patients. This current trauma division under the umbrella of general surgical department may contribute to a better outcome in managing trauma patients. Nevertheless, the injury pattern and patient's characteristics are similar to other general surgical unit in Malaysia [12,13]. In addition to providing trauma surgery care, the trauma coordinators has started the electronic trauma registry since its establishment in 2011. The electronic prospective trauma registry captures data from every trauma patient treated by the trauma surgery team since its inception in 2011. The data was entered by a trained trauma nurse which acts as the trauma coordinator. All discrepancies in data was reviewed and supervised by two senior trauma surgeon's prior data entry into the electronic database.

This is a retrospective analysis of the prospective Trauma Surgery Registry database. All trauma patients treated from 1 st May 2011 to 31 st April 2016 (5years) was included. The following were the inclusion criteria: a) All patients aged 13 years or older, b) All patients admitted and treated by the trauma surgery unit, c) Admission to other department in the hospital but referral made to trauma surgery team due to unstable hemodynamic status, d) Limb vascular injuries, e) Injuries to neck and torso.

The exclusion criteria include: a) Injury resulting from pathological conditions (i.e pathological fractures resulting from malignancy) and injury resulting from degenerative changes or medical illnesses. b) Hanging, drowning, burns and envenomation. c) Very late presentations or transfers or referrals from other hospitals for conditions not as a direct result of the initial trauma insult where definitive treatment had been accomplished in the hospital of origin (i.e bowel obstruction following a laparotomy performed for trauma) or sequelae of complications occurring temporally distant from the index injury.

The data of interest was retrieved from the registry anonymously. Data extracted were demographics (age and gender), mechanism of injury (blunt / penetrating), AIS grade of each organ injured, physiologic parameters (systolic blood pressure, respiratory rate, heart rate, temperature, Glasgow coma score) and injury severity scoring (revised trauma score, new injury severity score, and trauma and injury severity score).

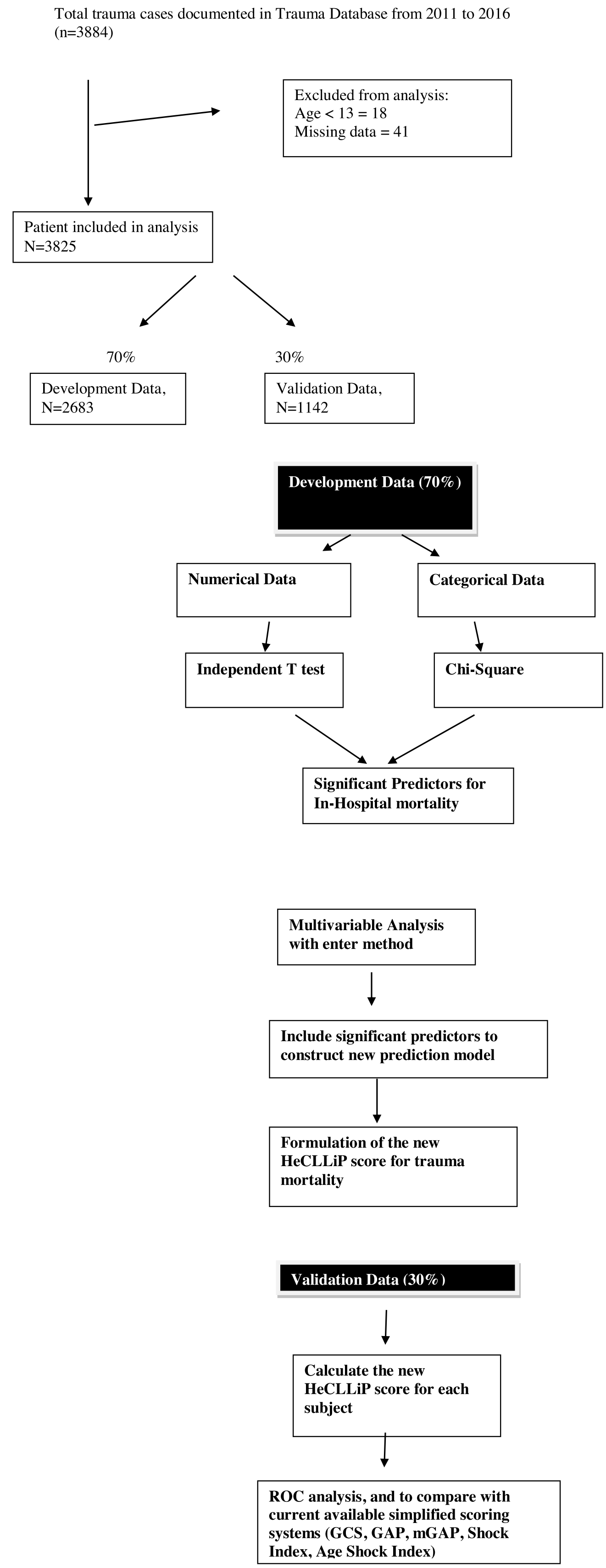

Chart 1. Overall Flow Chart of Statistical Analysis Plan.
Total trauma cases documented in Trauma Database from 2011 to 2016 (n=3884)

The organ injury grade was based on AIS 2005 which classifies the injury for each organ from grade 1 to 6. The organs recorded were head, face, neck, heart, cervical spine, lumbar spine, chest wall, lung, thoracic vascular, diaphragm, esophagus, stomach, liver, spleen, biliary, pancreas, duodenum, small bowel, colon, rectum, adrenal, kidney, ureter, bladder, urethra, uterus, pelvic fracture, fallopian tube, ovaries, vagina, vulva, testis, scrotum, penis, cervical vascular, abdominal vascular, peripheral vascular and extremities [14]. Blunt mechanism includes events involving car, heavy vehicles, motorcycle, bicycle, fall, pedestrian or assault. Penetrating injuries included were mainly involving weapons of knife, agricultural tool, industrial tools, hand gun or shotgun.

Statistical analysis plan (refer to Chart 1 for flow chart of analysis)

The data analysis was performed using SPSS version 16, Chicago, SPSS Inc with a total of 3825 patients included. Forty one patients were excluded due to missing data. The dataset was divided into two subsets: 70% (n = 2683) were used as development dataset and the remaining 30% (n = 1142) was analyzed for validation of new scoring tool (Chart 1). The independent variables included were age, gender, mechanism of injury, physiologic parameters and anatomic parameter (AIS 05 grade of organ injury). The outcome measure was any recorded in-hospital mortality.

From development data set, univariate analysis was performed with *t*-test and Chi-square test. Significant ($p < 0.05$) anatomic variables were included in multivariable analysis. The multivariable analysis was done with binary logistic regression using Enter method. A value of $P < 0.05$ is considered statistically significant. From this, the model and its coefficients were determined (Chart 1).

From validation data set, the newly developed anatomic score and existing trauma scores (GCS, GAP, mGAP, Shock Index (HR/SBP) [15], Age Shock Index (Age multiplied with Shock Index) [16]) were analysed with Area under ROC curve for comparison. From

Table 1
Characteristics of sample populations in development and validation dataset.

Characteristics	Development dataset N = 2683	Validation dataset N = 1142
Age, mean (SD)	36.0 (16.1)	36.7 (16.3)
GCS, mean (SD)	13.3 (3.4)	13.4 (3.4)
RR, mean (SD)	20.3 (3.6)	20.2 (3.6)
HR, mean (SD)	93.6 (20.7)	93.2 (21.2)
Temp, mean (SD)	37.0 (0.2)	37.0 (0.2)
SBP, mean (SD)	125.6 (25.2)	126.5 (26.1)
Shock Index, mean (SD)	0.8 (0.3)	0.8 (0.3)
RTS, mean (SD)	7.4 (1.0)	7.4 (1.0)
TRISS, mean (SD)	0.92 (0.2)	0.92 (0.2)
NISS, median (IQR)	16 (9 to 27)	16 (9 to 27)
Gender, n (%)		
Male	2389 (89.0%)	999 (87.5%)
Female	294 (11.0%)	143 (12.5%)
Ethnicity, n (%)		
Malay	1216 (45.3%)	521 (45.6%)
Chinese	635 (23.7%)	275(24.1%)
Indian	504 (18.8%)	208 (18.2%)
Other Local Ethnicity	191 (7.1%)	74 (6.5%)
Foreigners	137 (5.1%)	64 (5.6%)
Mechanism, n (%)		
Blunt	2462 (91.8%)	1045 (91.5%)
Penetrating	221 (8.2%)	97 (8.5%)
Outcome, n (%)		
Alive	2403 (89.6%)	1022 (89.5%)
Death	280 (10.4%)	120 (10.5%)
Type of Blunt Mechanism, (n%)		
Car	413 (16.8%)	156 (14.9%)
Heavy Vehicle	35 (1.4%)	16 (1.5%)
Motorcycle	1566 (63.6%)	669 (64.0%)
Bicycle	22 (0.9%)	6 (0.6%)
Fall	255 (10.4%)	117 (11.2%)
Pedestrian	95 (3.9%)	44 (4.2%)
Assaulted	29 (1.2%)	16 (1.5%)
Other Blunt Injury	47(1.9%)	21 (2.0%)
Total	2462 (100.0%)	1045 (100.0%)
Type of Penetrating Mechanism, (n%)		
Knife	153 (69.2%)	60 (61.9%)
Tool Agriculture	38 (17.2%)	21 (21.7%)
Tool Industrial	17 (7.7%)	11 (11.3%)
Handgun	9 (4.1%)	3 (3.1%)
Shotgun	3 (1.4%)	2 (2.1%)
Other Penetrating Injury	1 (0.5%)	0 (0.0%)
Total	221 (100.0%)	97 (100.0%)

GCS =Glasgow Coma Scale; RR=Respiratory Rate; HR= Heart Rate; Temp= Temperature; SBP= Systolic blood pressure; RTS= Revised Trauma Score; NISS= New Injury Severity Score; TRISS= Trauma and Injury Severity Score.

the combined dataset, a graph chart is created to estimate the probabilities of mortality for each total score points.

Sample size calculation for developing risk prediction models

It was estimated that at least 10 predictors will be significant for trauma mortality, hence the total number of regression coefficients will be 10. Based on past registry records from April 2011 until April 2014, there is an estimated count of 239 in-hospital mortalities & 1969 survivors. Assumed 70% percent of the dataset for development of risk model has a similar pattern of mortalities; events per variable are calculated as follows: Events per variable = (239 in-hospital mortalities divided by 10 regression coefficients) => 23.9. As the events per variable were more than 10, the sample size from the registry is suffice prevent model overfitting [17].

Results

A total of 3825 trauma patients were included in the analysis. They were randomly divided into 2 separate groups of development (70%, n = 2683) and validation (30%, n = 1142). The characteristic of the 2 study groups is as illustrated in (Table 1). The patients

Table 2
Univariate analysis of all variables versus mortality [development dataset].

	Mortality	Survivor	OR (95% CI)	p-value
Gender, n (%)				
Male	254 (10.6%)	2135 (89.4%)	1.23 (0.80 To 1.87)	0.344
Female	26 (8.8%)	268 (91.2%)		
Mechanism, n (%)				
Blunt	275 (11.2%)	2187 (88.8%)	5.43 (2.22 To 13.30)	<0.001
Penetrating	5 (2.3%	216 (97.7%)		
Type Of Blunt Injury, n (%)				
Car	45 (10.9%)	368 (89.1%)		0.217
Heavy Vehicle	5 (14.3%)	30 (85.7%)		
Motorcycle	168 (10.7%)	1398 (89.3%)		
Bicycle	2 (9.1%)	20 (90.9%)		
Fall	27 (10.6%)	228 (89.4%)		
Pedestrian	19 (20.0%)	76 (80.0%)		
Assaulted	2 (6.9%)	27 (93.1%)		
Other	7 (14.9%)	40 (85.1%)		
Type of Penetrating Injury, n (%)				
Knife	3 (2.0%)	150 (98.0%)		0.585
Tool Agriculture	1 (2.6%)	37 (97.4%)		
Tool Industrial	0 (0.0%)	17 (7.9%)		
Handgun	1 (11.1%)	8 (88.9%)		
Shotgun	0 (0.0%)	3 (100.0%)		
Other	0 (0.0%)	1 (100.0%)		
Organ Injuries	(See Table 3)			
Age (SD)	39.3 (18.8)	35.7 (15.7)		<0.001
SBP (SD)	119.3 (37.2)	126.3 (23.3)		<0.001
RR (SD)	21.9 (5.2)	20.1 (3.4)		<0.001
HR (SD)	102.6 (28.1)	92.5 (19.4)		<0.001
Temp (SD)	36.9 (0.3)	37.0 (0.2)		<0.001
GCS (SD)	9.1 (4.9)	13.8 (2.8)		<0.001

Table 3
Organs injured versus mortality [development dataset].

	Survival N,(%)	Death N,(%)	OR	95% CI	p-value
No Head Injury	2009 (94.30)	121 (5.7)			
Head Injury	394 (71.2)	159 (28.8)	6.70	5.17 to 8.69	<0.001
No Heart Injury	2397 (89.6)	277 (10.4)			
Heart Injury	6 (66.7)	3 (33.3)	4.33	1.08 to 17.40	0.024
No Cervical Spine Injury	2355 (90.1)	260 (9.9)			
Cervical Spine Injury	48 (70.6)	20 (29.4)	3.77	2.21 to 6.46	<0.001
No Lung Injury	1493 (93.7)	100 (6.3)	2.95	2.28 to 3.82	<0.001
Lung Injury	910 (83.5)	180 (16.5)			
No Liver Injury	2207 (90.6)	2390 (9.4)	2.45	1.74 to 3.44	<0.001
Liver Injury	196 (79.7)	50 (20.3)			
No Pelvic Fracture	2327 (90.1)	257 (9.9)	2.74	1.69 to 4.45	<0.001
Pelvic Fracture	76 (76.8)	23 (23.2)			

● Non Significant Organ Injury Are Listed In Supplementary File.

in 2 datasets shared similar demographics characteristics (age, gender or ethnicity), physiologic parameters (GCS, RR, HR, Temperature, SBP), injury scoring (RTS, NISS, TRISS), mechanism of injury (type of blunt or penetrating injury), mortality rate.

Blunt mechanism and physiologic parameters is a significant predictor for death in univariate analysis as shown in Table 2.

Univariate analysis with chi square test revealed head, heart, cervical spine, lung, liver, pelvic injury were significant anatomic variables leading to mortality (Table 3).

Multivariable analysis of the development dataset showed organ injury involving head, cervical spine, liver, lung or pelvic bone have significant higher odds of death with p- value <0.01 (Table 4). Hence, regression analyses of these anatomic variables were performed (Table 5).

The predicted probability for mortality for each score points were calculated based on the coefficients (B) from the regression analyses (Table 5, Fig. 1).

Based on the odd ratio value from regression analysis (Table 5), score points for each component of the HeCLLiP score were estimated. The score is an abbreviated anatomic score made up of 5 different organs which include head, cervical spine, liver, lung and pelvic bone. Presence of any of the injuries shall be assigned score points as below (Table 6).

The score point of each component can be easily remembered as 74,245 (Table 6). The maximum allocated score points are 22. A cut off of more than 2 points was obtained with Youden index analysis. The cut off value (>2) predicts the mortality with sensitivity of 79.2 and specificity of 70.6% on the validation dataset (Fig. 2).

The AUC values of HeCLLiP, GAP, MGAP, GCS, Shock Index and Age Shock Index were 0.802, 0.825, 0.806, 0.810, 0.603 and 0.580 respectively (Fig. 3 and Table 7). The predictive ability of the HeCLLiP score is reflected by the AUC. It revealed a fairly good discrimination when compared to GAP, MGAP, GCS but it was not statistically significant, p value>0.05 (Table 7).

Discussion

The HeCLLiP score is a useful tool to substitute the current available simplified scores that is able to accurately estimate mortality risk of individual trauma patients. Having introduced only 5 components, the score performed equally well in comparison to other well known scoring systems. The accuracy in discriminating death was represented with a comparable AUC value of 0.802. It is also an easy, objective and well calibrated anatomic scoring system to predict mortality.

It is easily scored after the initial evaluation of patients from the trauma bay. Simple chest and pelvic x-ray will identify any rib or pelvic fractures. Easy availability of Head, Neck and Abdominal CT scan in the majority of tertiary hospitals will ease the scoring for head, cervical spine or liver injury. However, if there is no CT imaging available, clinical judgement with supplementary investigations may assist in scoring. The clinical suspicion of head injury can be diagnosed based on poor GCS and obvious wounds to the head. Cervical spine injury can be suspected based

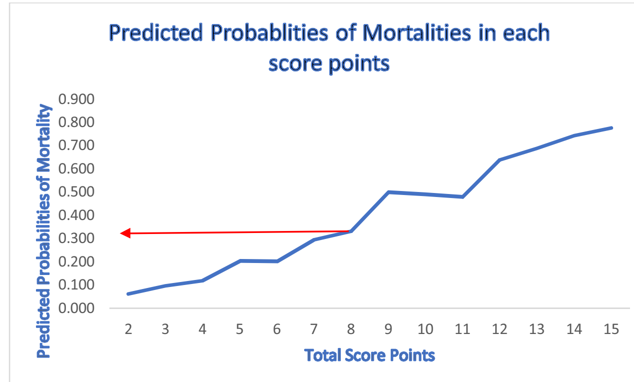

Fig. 1. Predicted Probabilities of In Hospital Mortality based on Total Score Points of HeCLLiP score. (Combined Dataset).

Table 6
Score Components of HeCLLiP score.

Score Components	Score Points
Head	7
Cervical spine	4
Lung	2
Liver	4
Pelvis fracture	5

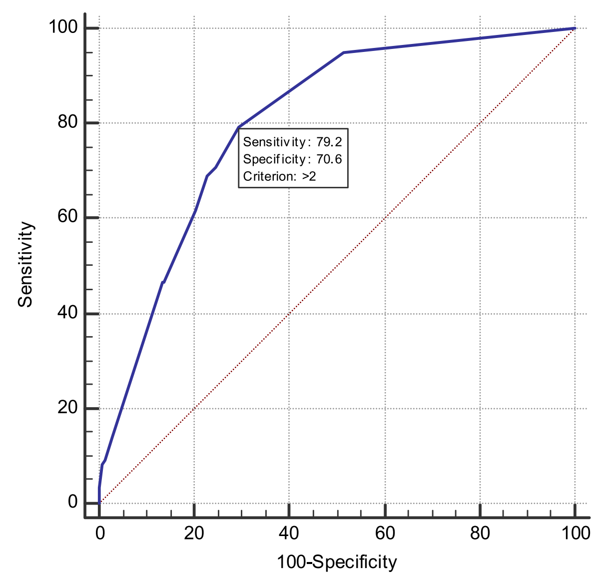

Fig. 2. ROC analysis of HeCLLiP score with Validation dataset.

Table 4
Multivariable Analysis of All Significant Anatomic Organ from Univariate Analysis. [Development Dataset].

	p-value	OR	95% CI		B
Head	<0.001	6.97	5.26	9.24	1.942
Cervical Spine	<0.001	4.08	2.25	7.40	1.405
Lung	<0.001	2.36	1.78	3.13	0.858
Liver	<0.001	3.79	2.60	5.52	1.331
Pelvis Fracture	<0.001	4.78	2.78	8.19	1.563
Heart	0.029[a]	5.47	1.19	25.25	1.699

[a] not significant.

Table 5
Regression Analysis of All Significant Anatomical Variables to Create Mortality Prediction Model. [Development Dataset].

	p-value	OR	95% CI		B
Head	<0.001	6.88	5.20	9.12	1.929
Cervical Spine	<0.001	4.02	2.22	7.29	1.391
Lung	<0.001	2.38	1.80	3.16	0.868
Liver	<0.001	3.77	2.59	5.50	1.327
Pelvis Fracture	<0.001	4.85	2.84	8.31	1.580
Constant					−3.591

on cervical tenderness or swelling with neurological deficits. Liver injury can be suspected based on focused assessment of sonography in trauma (FAST) with presence of free fluid at Morrison's pouch.

The other advantages of HeCLLiP score is the avoidance of utilising a potential false physiologic parameter which may be due to fluctuation of physiology either due to too early or late recording during the resuscitative phase.

The easy and quick application of HeCLLiP score in a clinical setting is explained as follows: 1. Presence of head injury, cervical spine fracture, liver injury, pelvic fracture represents a significant risk of mortality as the total score points are above the cut off value which is greater than 2 points. Presence of any of these 4 injuries represents more than 10% of mortality risk. This is shown in Fig. 1 for which score points of 4 and above carries at least 10% probabilities of death. This group of patients shall be triaged to early resuscitation with early involvement of trauma surgical team members. 2. Mortality risk estimation by using total score points from HeCLLiP can be refered to Fig. 1. For example, score points of 8 corresponds to around 30% risk of mortality (Fig. 1).

Previous literature identified that the accuracy of the anatomic score increases if it is done by a trained trauma care provider or trauma surgical team. [18] The majority of trauma victims would have received initial resuscitation at pre-hospital setting or emergency department resuscitation bay prior to the involvement of senior trauma care provider or trauma surgical team members.

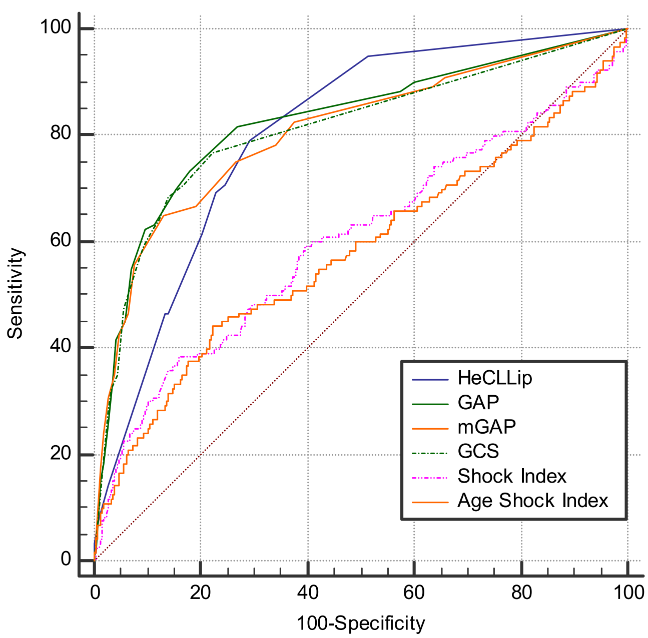

Fig. 3. Comparison of AUROC of HeCLLiP score with GAP, mGAP, GCS, Shock Index and Age Shock Index.

As a result, the trauma surgical team may not have the best initial physiologic parameters for accurate scoring for scores that heavily relies on physiologic parameters.

Previous paper showed a fairly good predictive ability for shock index (SI) in the case of predicting early mortality due to trauma [19,20]. The AUROC analysis after inclusion of all patients from the validation set had a reasonably good value of AUROC for shock index of 0.6. (refer to Table 7/ Fig. 3 in the manuscript). On separate sub-analysis of AUROC according to age groups of 15 years and below, 16 to 64 years and greater than 65 years revealed that the second and third group had significant accuracy in predicting mortality with SI $\geq$ 0.9 (Tables 2 and 3 in the Supplementary file), similar to previous report [19]. For the age group of 15 years and below had poor association with mortality probably due to small sample size.

The authors identified that the lower AUROC value of SI in our analysis in comparison to previous reports is probably due to the different endpoint (which is in hospital mortality) used in this current study. We did not restrict the definition of in-hospital mortality in current study with a specific duration. However, the maximum number of days from trauma to death recorded in our study was 140 days with a mean time to death of 11 days. Previous published articles report on the shock index (heart rate divided by blood pressure) revealed that it can accurately predict early mortality rather than in hospital mortality after adequate intervention was performed [16,19]. The score correlates not only to early mortality but also heavily relies on hospital resource. In contrary to SI, the HeCLLiP score is a better prediction for in-hospital mortality rather early mortality because the anatomical components of the score (for eg. head, cervical and pelvis) which may be associated with higher risk of subsequent debilitating state and risk of eventual death.

Though physiologic scores such as mGAP, GAP, GCS may appear easy in terms of scoring, but from our analysis these triage tools did not showed a significant higher AUC value to suggest superior mortality predictive ability. The limitations of such physiologic scores were identified in a previous study by Huei et al. [21]. The discrepancy in physiologic parameter scoring is more apparent in blood pressure monitoring. This is due to delayed blood pressure recordings after rigorous resuscitation at the scene of mishap or recorded too early prior to physiological deterioration. This may limit the accuracy of physiologic scores. Furthermore, accurate and continuous documentation of blood pressure recording require a dedicated and adequate staffing for most accurate data procurement. Adding the inadequacy of staff in low to middle-income country, this may further reduce the accuracy of physiologic scoring.

In India, which is also a low to middle income country; Gerdin et al devised a chart which requires two physiological parameters (GCS and Systolic blood pressure) to predict risk of mortality [22]. Though this is easy to score and has shown to have good predictive ability, but the usage of physiologic parameters shared the same inconsistent issues mentioned earlier [23].

Table 7
AUC values of each score and their pairwise comparison.

Scores	AUC	95% CI	Pairwise comparison between the scores (p value)				
			GAP	MGAP	GCS	Shock Index	Age Shock Index
HeCLLiP	**0.802**	**0.777 to 0.824**	0.3353	0.8670	0.6998	<0.001	<0.001
GAP	**0.825**	**0.801 to 0.846**	–	0.0022	0.2709	<0.001	<0.001
mGAP	**0.806**	**0.782 to 0.828**	–	–	0.7757	<0.001	<0.001
GCS	**0.810**	**0.786 to 0.832**	–	–	–	<0.001	<0.001
Shock Index	**0.603**	**0.573 to 0.631**	–	–	–	–	0.4654
Age Shock Index	**0.580**	**0.551 to 0.609**					–

Age, which is a component of the aforementioned scores involved stratifying patient aged more than 60 years with higher risk. However, it may not be useful in the local Malaysian hospital setting as majority of the major trauma involved man less than 60 years of age [18,21,24].

GCS is a good objective score to predict prognosis or mortality in trauma patients. However, its predictive ability varies with the presence or absence of intracranial injuries. It is shown to have better prediction in head injured patient rather than non-head injured patient. The accuracy of score is also affected by alcohol influence, prior sedation and endotracheal intubation [25].

As mentioned above, GAP and mGAP may be affected by inaccurate physiologic parameters which may be scored at inadequate times and the HeCLLiP score may serve as an alternative predictive score to be used at early trauma care setting. Nevertheless, the trauma care provider needs be familiarized and trained in clinical assessment and interpreting basic investigation such as FAST Scan and Chest x-ray to determine presence of this injury.

With the simplicity of this new scoring system, there are multiple possibilities that the user may falsely score a higher mortality risk. For instance, the presence of head injury resulted in a score of at least 7 which is above the proposed cut off value. A mild cerebral concussion if scored positive for the ‘head injury’ component, will resulted in a falsely high mortality risk prediction. Therefore, we proposed that the ‘head injury’ component should be scored positive only if there is any intracranial hemorrhage on CT scan or GCS of 8 or less. Another limitation of scoring is with regards to pelvic fracture injuries. A minor chip fracture of pelvis bone may also falsely score positive for the ‘pelvic fracture’ score component. As ‘pelvic fracture’ contributes 5 points, which is also above the cut off value, we identify that it should only be scored positive only when the fracture is involving sacroiliac joints or associated hemodynamically instability. However, subsequent study to refine these 2 scores component into different grades and more precise definition to each score component may improve the accuracy for future use.

This study is limited by data of a single tertiary centre. The newly developed HeCLLiP scores may require external validation in other trauma patients from different nations. Though this study is based on a retrospective analysis but the data was collected prospectively by the trauma nurse, which minimized the risk of missing and inaccurate data.

Conclusion

HeCLLiP Score is a newly developed abbreviated anatomic score suited to the local Malaysian trauma setting with good predictive ability for mortality. The score may serve as an alternative to the simplified physiological score such as GAP and mGAP, especially when accurate physiologic parameters may be a limitation.

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Authors’ contributions

Tan Jih Huei was involved in data collection and analysis, drafting and reporting of the work described in the article. Yuzaidi, Henry and Affirul were involved in the drafting of this manuscript. Rizal and Razman were involved in critically reviewed the article, supervised the study.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Study was done retrospectively. Subject recruited were made anonymous. Informed consent was waived by the Malaysia Research Ethic Committee.

Ethics approval and consent to participate

Ethical approval was granted by Ministry of Health Malaysia Medical Research Ethics Committee.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2019.01.027.

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