Traumatic brain injury mortality prediction

Identifying patients with high risk of traumatic brain injury mortality is important to maximize the resource for trauma care, and so that family members receive appropriate counsel and treatment decisions [1) 2)].

Zheng et al. developed and validate a radiomic prediction model using initial non-contrast computed tomography (CT) at admission to predict in-hospital mortality in patients with traumatic brain injury (TBI).

A total of 379 TBI patients from three cohorts were categorized into training, internal validation, and external validation sets. After filtering the unstable features with the minimum redundancy maximum relevance approach, the CT-based radiomics signature was selected by using the least absolute shrinkage and selection operator (LASSO) approach. A personalized predictive nomogram incorporating the radiomic signature and clinical features was developed using a multivariate logistic model to predict in-hospital mortality in patients with TBI. The calibration, discrimination, and clinical usefulness of the radiomics signature and nomogram were evaluated.

The radiomic signature consisting of 12 features had areas under the curve (AUCs) of 0.734, 0.716, and 0.706 in the prediction of in-hospital mortality in the internal and two external validation cohorts. The personalized predictive nomogram integrating the radiomic and clinical features demonstrated significant calibration and discrimination with AUCs of 0.843, 0.811, and 0.834 in the internal and two external validation cohorts. Based on decision curve analysis (DCA), both the radiomic features and nomogram were found to be clinically significant and useful.

This predictive nomogram incorporating the CT-based radiomic signature and clinical features had maximum accuracy and played an optimized role in the early prediction of in-hospital mortality. The results of this study provide vital insights for the early warning of death in TBI patients [3)].

One widely applied predictor of mortality outcome is the Trauma and Injury Severity Score (TRISS), which shows good discrimination in identifying the patients with TBI at high risk of mortality [4)].

The Corticosteroid Randomization after Significant Head Injury CRASH and the International Mission for Prognosis and Analysis of Clinical Trials in Traumatic Brain Injury [IMPACT]) based on large clinical trial datasets have shown good discrimination and have enabled accurate outcome predictions [5) 6) 7)].

A study predicts a strong correlation between respiratory failure, pathological pupillary response, a higher ISS, and substantial midline shift with poor outcomes in elderly patients sustaining an isolated severe TBI [8)].

Nine studies demonstrated prognostic value of the FOUR score in predicting mortality and functional outcomes. Thirty-two studies demonstrated equivalency or superiority of the FOUR score compared to Glasgow Coma Scale in prediction of mortality and functional outcomes.

The FOUR score has been shown to be a useful outcome predictor in many patients with depressed level of consciousness. It displays good inter-rater reliability among physicians and nurses [9].

The purpose of a study was to build a model of machine learning (ML) for the prediction of mortality in patients with isolated moderate and severe traumatic brain injury (TBI).

Hospitalized adult patients registered in the Trauma Registry System between January 2009 and December 2015 were enrolled in this study. Only patients with an Abbreviated Injury Scale (AIS) score ≥ 3 points related to head injuries were included in this study. A total of 1734 (1564 survival and 170 non-survival) and 325 (293 survival and 32 non-survival) patients were included in the training and test sets, respectively.

Using demographics and injury characteristics, as well as patient laboratory data, predictive tools (e.g., [logistic regression]] [LR], support vector machine [SVM], decision tree [DT], naive Bayes [NB], and artificial neural networks [ANN]) were used to determine the mortality of individual patients. The predictive performance was evaluated by accuracy, sensitivity, and specificity, as well as by area under the curve (AUC) measures of receiver operator characteristic curves. In the training set, all five ML models had a specificity of more than 90% and all ML models (except the NB) achieved an accuracy of more than 90%. Among them, the ANN had the highest sensitivity (80.59%) in mortality prediction. Regarding performance, the ANN had the highest AUC (0.968), followed by the LR (0.942), SVM (0.935), NB (0.908), and DT (0.872). In the test set, the ANN had the highest sensitivity (84.38%) in mortality prediction, followed by the SVM (65.63%), LR (59.38%), NB (59.38%), and DT (43.75%).

The ANN model provided the best prediction of mortality for patients with isolated moderate and severe TBI [10].

A study concluded that The Marshall CT score was more accurate for prediction of mortality on 2 weeks, at one month, and at three months were than The Marshall CT score with higher ROC. The correlation of the Rotterdam CT score with mortality was significant [11].

The GCS as a single variable may have limited value as a predictor of functional outcome [12].

Serial basal blood glucose, serum insulin, cortisol, growth hormone, glucagon and catecholamine examinations were performed in 81 brain-injured patients. 32 patients with severe injuries of other parts of the body (chest, abdomen, limbs or polytrauma), and 17 patients with non-traumatic acute brain lesions served as double control. In the brain-injured patients there is a close relation between

changes of the state of consciousness and those of basal blood glucose levels: the deeper coma the higher and wider is the pathological glucose-level range. Four types of blood-glucose changes could be identified in the background of which different alterations of each hormone level were observed. Fatal outcome could be predicted in a non-diabetic patient in the first days when seeing: 1) Fasting hyperglycaemia above 14 mmol/l; 2) Fluctuating basal blood glucose levels between 5 and 22 mmol/l; 3) Deeply depressed and unchanged basal insulin level; 4) Extremely high cortisol level; 5) Decreased plasma epinephrine level. These changes in the carbohydrate metabolism seen after acute brain lesions are not identical to diabetes mellitus [13)].

Artificial neural network for traumatic brain injury mortality prediction

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1)

Densmore JC, Lim HJ, Oldham KT, Guice KS. Outcomes and delivery of care in pediatric injury. Journal of pediatric surgery. 2006; 41(1):92–8; discussion -8. Epub 2006/01/18. https://doi.org/10.1016/j.jpedsurg.2005.10.013 PMID: 16410115.

2)

Rogers SC, Campbell BT, Saleheen H, Borrup K, Lapidus G. Using trauma registry data to guide injury prevention program activities. The Journal of trauma. 2010; 69(4 Suppl):S209–13. Epub 2010/10/22. https://doi.org/10.1097/TA.0b013e3181f1e9fe PMID: 20938310.

3)

Zheng RZ, Zhao ZJ, Yang XT, Jiang SW, Li YD, Li WJ, Li XH, Zhou Y, Gao CJ, Ma YB, Pan SM, Wang Y. Initial CT-based radiomics nomogram for predicting in-hospital mortality in patients with traumatic brain injury: a multicenter development and validation study. Neurol Sci. 2022 Feb 24. doi: 10.1007/s10072-022-05954-8. Epub ahead of print. PMID: 35199252.

4)

Wong GK, Teoh J, Yeung J, Chan E, Siu E, Woo P, et al. Outcomes of traumatic brain injury in Hong Kong: validation with the TRISS, CRASH, and IMPACT models. Journal of clinical neuroscience: official journal of the Neurosurgical Society of Australasia. 2013; 20(12):1693–6. Epub 2013/09/03. https://doi. org/10.1016/j.jocn.2012.12.032 PMID: 23993210.

5)

Han J, King NK, Neilson SJ, Gandhi MP, Ng I. External validation of the CRASH and IMPACT prognostic models in severe traumatic brain injury. J Neurotrauma. 2014; 31(13):1146–52. Epub 2014/02/27. https://doi.org/10.1089/neu.2013.3003 PMID: 24568201.

6)

Sun H, Lingsma HF, Steyerberg EW, Maas AI. External Validation of the International Mission for Prognosis and Analysis of Clinical Trials in Traumatic Brain Injury: Prognostic Models for Traumatic Brain Injury on the Study of the Neuroprotective Activity of Progesterone in Severe Traumatic Brain Injuries Trial. J Neurotrauma. 2016; 33(16):1535–43. Epub 2015/12/15. https://doi.org/10.1089/neu.2015.4164 PMID: 26652051.

7)

Perel P, Arango M, Clayton T, Edwards P, Komolafe E, Poccock S, et al. Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. BMJ. 2008; 336(7641):425–9. Epub 2008/02/14. https://doi.org/10.1136/bmj.39461.643438.25 PMID: 18270239

8)

Ostermann RC, Joestl J, Tiefenboeck TM, Lang N, Platzer P, Hofbauer M. Risk factors predicting prognosis and outcome of elderly patients with isolated traumatic brain injury. J Orthop Surg Res.

2018 Nov 3;13(1):277. doi: 10.1186/s13018-018-0975-y. PubMed PMID: 30390698; PubMed Central PMCID: PMC6215630.
9)

Almojuela A, Hasen M, Zeiler FA. The Full Outline of UnResponsiveness (FOUR) Score and Its Use in Outcome Prediction: A Scoping Systematic Review of the Adult Literature. Neurocrit Care. 2018 Nov 8. doi: 10.1007/s12028-018-0630-9. [Epub ahead of print] Review. PubMed PMID: 30411302.
10)

Rau CS, Kuo PJ, Chien PC, Huang CY, Hsieh HY, Hsieh CH. Mortality prediction in patients with isolated moderate and severe traumatic brain injury using machine learning models. PLoS One. 2018 Nov 9;13(11):e0207192. doi: 10.1371/journal.pone.0207192. eCollection 2018. PubMed PMID: 30412613.
11)

Mohammadifard M, Ghaemi K, Hanif H, Sharifzadeh G, Haghparast M. Marshall and Rotterdam Computed Tomography scores in predicting early deaths after brain trauma. Eur J Transl Myol. 2018 Jul 16;28(3):7542. doi: 10.4081/ejtm.2018.7542. eCollection 2018 Jul 10. PubMed PMID: 30344974; PubMed Central PMCID: PMC6176390.
12)

Zafonte RD, Hammond FM, Mann NR, Wood DL, Black KL, Millis SR. Relationship between Glasgow coma scale and functional outcome. Am J Phys Med Rehabil. 1996 Sep-Oct;75(5):364-9. PubMed PMID: 8873704.
13)

Pentelényi T. Significance of endocrine studies in the general assessment and prediction of fatal outcome in head injury. Acta Neurochir Suppl (Wien). 1992;55:21-4. PubMed PMID: 1414538.