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Assessment of the charlson comorbidity index score, CHADS2 and CHA2DS2-VASc scores in predicting death in patients with thoracic empyema

Jengyuan Wu, MD, PhD [a,b,c,1], Chienming Liu, MD [c,d,1], Shangsen Lee, MD [a,b,c], Yuhung Kuo [b], Tengfu Hsieh, MD, PhD [a,b,c,*]

[a] Department of Surgery, Taichung Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taichung, Taiwan
[b] Department of Research, Taichung Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taichung, Taiwan
[c] School of Medicine, Tzu Chi University, Hualian, Taiwan
[d] Department of Chest Medicine, Taichung Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taichung, Taiwan

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ABSTRACT

Background: Patients with thoracic empyema have an increased risk of mortality, but their absolute rate of mortality depends on age and comorbidities.
Objective: This study seeks to assess the predictive value of the Charlson Comorbidity Index score (CCIS), CHADS2 and CHA2DS2-VASc scores for mortality risk in patients with empyema thoracis.
Methods: From Taiwan's National Health Insurance Research Database we identified a total of 484 participants diagnosed with thoracic empyema. The CCIS, CHADS2 and CHA2DS2-VASc scores were used to stratify mortality risk.
Results: The incidence rate of mortality in the present study was 20.39 per 1000 person-months. A strong correlation was found between thoracic empyema and CCIS score.
Conclusions: Our results show that patients with thoracic empyema have a significantly high incidence rate of mortality and that CCIS can be used as an indicator of risk for mortality.
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Introduction

Thoracic empyema is usually a complication of pneumonia, and typically results in long hospital stays, putting the patient at a high risk of death.[1,2] It is a serious illness for which current treatment methods include antibiotics and surgical drainage.[1] The current literature indicates that, even with aggressive treatment, mortality rates are still as high as 10–20%.[1–4] In Taiwan, the in-hospital mortality rate of thoracic empyema is 12.8–13.5%.[5,6] Thus, early prediction of the risk of mortality in empyema patients in clinical settings remains a crucial issue for physicians, patients and their families.[7,8]

Many studies have indicated that most empyema patients had additional chronic underlying diseases, such as coexisting cancer, chronic lung disease, chronic renal insufficiency, and liver cirrhosis.[5,6] These underlying diseases make patients more vulnerable and are associated with high mortality rates.[5]

The Charlson Comorbidity Index score (CCIS) was originally developed to predict mortality in cancer patients,[9] while CHADS2 and CHAD2DS2 are used to predict the probability of ischemic stroke in patients with atrial fibrillation (AF).[10] However, many studies have found that CCIS, CHADS2 and CHA2DS2-VASc can be used to predict post-illness mortality.[11–13] CCIS, CHADS2 and CHA2DS2-VASc are very convenient and popular prediction tools, requiring only the patient history, age and gender. At the same time, the use of these models produces a quantifiable number, making it easier to explain disease status and eliminate human subjectivity. For example, Ho et al. showed that COPD patients with higher age-adjusted CCIS had a higher incidence of empyema than those with moderate or low age-adjusted CCIS, and that the overall incidence of empyema remained stable over the observed period.[14] However, to our best knowledge, CCIS, CHADS2 and CHA2DS2-VASc have yet to be used to predict mortality in patients with thoracic empyema.

Taiwan's National Health Insurance Research Database (NHIRD) includes the comprehensive medical records of the 99% of Taiwan's population enrolled in the National Health Insurance scheme,

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* Corresponding author. Fax: +886-4-36065928.
E-mail address: hdf95@yahoo.com.tw (T. Hsieh).
[1] These authors contributed equally to this work.

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and is an excellent resource for medical research.[15] We previously applied CCIS, CHADS2 and CHA2DS2-VASc to NHIRD data to predict ischemic stroke in PAD patients.[16] In the present study, we use a similar method to evaluate the predictive power of CCIS, CHADS2 and CHA2DS2-VASc for mortality rates among thoracic empyema patients.

Methods

Data source and ethics statement

This study is a nationwide cohort study. From 1 January, 2010 to 31 December, 2012, we retrieved records for all patients with newly-diagnosed thoracic empyema from NHIRD, which is maintained by Taiwan's National Health Research Institutes, and is made available to researchers (http://nhird.nhri.org.tw/date_01_en.html). Briefly, NHIRD consists of detailed health care data from more than 23 million enrollees, representing more than 99% of Taiwan's entire population.[17,18] Diagnosis accuracy for major diseases in NHIRD has been validated.[15,19] The Institutional Review Board of Taichung Tzu Chi General Hospital in Taiwan approved the study protocol (REC104-11).

Study design

The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes and ICD-9-CM treatment codes were evaluated in this study. Patients with newly-diagnosed thoracic empyema (ICD-9-CM codes 510, 510.0, 510.9) and received follow up care between 1 January, 2010 to 31 December, 2012 were included in the study group. The index date was the date of first diagnosis of thoracic empyema. These patients were followed from the date of enrollment until death, determined by linking records with inpatient care data of main diagnosis in the NHIRD, or to the end of 2012.

We further identified comorbidities and characteristics of patients from inpatient or outpatient files in the six months interval before the index date. For diagnosis accuracy, patients had to have had at least in three or more consistent diagnoses in outpatient care or one in inpatient care. The scores of patient's comorbidities, such as CCIS, CHADS2 scores and CHA2DS2-VASc scores, were calculated by these comorbidities.

The CCIS were calculated for each patient by assigning 1 point each for myocardial infarct, congestive heart failure, peripheral vascular disease, dementia, cerebrovascular disease, chronic lung disease, connective tissue disease, ulcer, chronic liver disease and diabetes, 2 points each for hemiplegia, moderate or severe kidney disease, diabetes with end organ damage, tumor, leukemia and lymphoma, 3 points for moderate or severe liver disease, and 6 points each for malignant tumor, metastasis and acquired immune deficiency syndrome.[9,20–22] CHADS2 scores were calculated for each patient by assigning 1 point each for the presence of chronic heart failure, hypertension, age 75 and above, and diabetes. Two points were assigned for history of stroke or transient ischemic attack (TIA).[10] CHA2DS2-VASc scores were calculated for each patient by assigning 1 point each for the presence of vascular disease (history of myocardial infarction, peripheral artery disease, or vascular plaques), age 65–74 years, and sex category (female) and by assigning 2 points each for congestive heart failure, hypertension, age >75 years, diabetes mellitus, and history of stroke or transient ischemic attack.[10]

Other variables

Subjects were classified into three groups by monthly income: (1) low socioeconomic status (SES): below US$528; (2) moderate SES: US$528–833; and (3) high SES: US$833 or more. We selected US$528 as the low income cutoff point because this was the government-stipulated minimum wage for full-time employees in Taiwan in 2006.[23] Geographic region of residence was recorded as northern, central, southern, and eastern Taiwan. The regions where the individuals resided in Taiwan were classified into 7 levels of urbanization based on 5 indices: population density, percentage of residents with college level or higher education, percentage of residents > 65 years of age, percentage of residents who work in agriculture, and the number of physicians per 100,000 residents.[24] The urbanization level of residences was categorized as urban (urbanization level: 1), suburban (urbanization level: 2–4), and rural (urbanization level: 5–7).

Statistical analysis

We used SPSS version 15 software (SPSS Inc., Chicago, IL, USA) for all data analyses. The cumulative risk of mortality was estimated using Kaplan-Meier survival curves. A Cox proportional hazards regression model adjusted for patient characteristics was used to analyze the clinical characteristics of empyema patients with subsequent mortality. Hazard ratios (HRs) along with 95% confidence intervals (CIs) were calculated using a significance level of 0.05. Statistical significance was set at a two-sided $p < 0.05$.

The C statistic was used for the discriminatory capacity of the risk models for mortality. Acceptable discriminatory capacity was set when a model with a C statistic value above 0.70.[25] The C statistic was calculated using logistic regression models, introducing each clinical event as a dependent variable and each score as a continuous quantitative independent variable.[26,27] The receiver operating characteristics curve was used to assess the probability to actual occurrence of mortality. The C statistics for CCIS, CHADS2 scores and CHA2DS2-VASc scores were compared to each other using the null-hypothesis z-test.[28]

Results

From January 1, 2010 to December 31, 2012, 484 NHIRD patients were diagnosed with thoracic empyema. Table 1 shows the number, age, gender, type of drainage, intensive care unit stay, and distribution of patients in different CHADS2 score, CHA2DS2-VASc score and CCIS groups. The mean age at diagnosis was 66.1 ± 16.2 years. Male patients represented 76.7% of the total study group. There were 342 patients (70.7%) with chest tube for drainage of abscess and 108 patients (22.3%) with pig-tail tube.

The cumulative mortality risk based on the CHADS2 scores, CHA2DS2-VASc score and CCIS is shown in Table 2. Fig. 1 shows the Kaplan-Meier survival curves. Thoracic empyema patients with higher CCIS, CHADS2 scores or CHA2DS2-VASc scores were more likely to have ischemic stroke ($P < 0.05$).

In multivariate analysis, each additional CCIS point was found to be associated with a 1.29-fold (95% CI, 1.22–1.38) increased risk for mortality (Table 3).

As shown in Fig. 2, the CCIS risk models accurately predicted risk of death, while the CHADS2 and CHA2DS2-VASc score risk models did not. The c-statistic was 0.753 for CCIS, 0.623 for the CHADS2 score and 0.635 for the CHA2DS2-VASc score. Subgroup analysis results are shown in supplementary Fig. S1 and Table S1. In the subgroup analysis, the CCIS risk models still provided accurate prediction of risk of death. The C statistic of CCIS was 0.70 in patients with intensive care unit stay, as opposed to 0.86 for patients without.

The null-hypothesis z-test result is shown in Table 4 to compare the C statistic for these 3 risk models. The C statistic for the CCIS risk model was different from that of the CHADS2 and CHA2DS2-VASc score models ($z = 0.1300$, $p < 0.001$ and $z = 0.1178$, $p < 0.001$,

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