Validity for the critical patients severity classification system developed by the Korean Clinical Nurse Association

AUTHORS

HyunSoo Oh
RN, PhD
Professor, Department of Nursing, College of Medicine, Inha University, YongHyun Dong, Republic of Korea.

WhaSook Seo
RN, PhD
Professor, Department of Nursing, College of Medicine, Inha University, YongHyun Dong, Republic of Korea.
wschang@inha.ac.kr

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KEY WORDS

severity classification; prediction; traumatic brain injury

ABSTRACT

Objective
This study aimed to evaluate whether the Critical Patient Severity Classification System (CPSCS) can be effectively used to predict mortality, functional disability, and cognitive ability of brain injury patients at 1 month and 6 months after admission to an intensive care unit.

Design
This study was conducted using a prospective prediction study design.

Setting
Data were collected at a university hospital located in Incheon, South Korea.

Subjects
The study subjects were 190 brain injury patients admitted to a surgical intensive care unit.

Main outcome measures
Mortality, functional disability, and cognitive ability were evaluated directly at 1 month and 6 months after admission to an intensive care unit.

Results
The probability of discriminating survival and death correctly using identified significant predictors of the Critical Patient Severity Classification System (CPSCS) was 77.3% and 81.3% respectively, which are considerably high. However this system was less reliable at predicting functional and cognitive recovery in brain injury patients.

Conclusions
The result of the present study showed that the Critical Patient Severity Classification System can be used to predict a restricted area of the outcome: mortality, in brain injury patients. To expand its applicability on functional or cognitive recovery, this system needs to include brain injury specific nursing activities such as, for example, managing brain oedema or brain tubes.

INTRODUCTION

The Critical Patient Severity Classification System (CPSCS) was initially used to stratify patients according to disease severity and later its use was extended to predict outcome - particularly mortality. Such abilities of the classification system can be used to provide objective information to improve patient management (Knaus et al 1985) and to establish selection criteria for admission to intensive care units (ICUs). Furthermore, the classification system also functions as a tool for comparing the efficiencies of medical treatment and nursing care among different units or hospitals (Tan et al 1998; Shann et al 1997).

Of various tools developed for measuring severity, the Acute Physiology, Age, and Chronic Health Evaluation (APACHE), Therapeutic Intervention Scoring System (TISS), and Sickness Score, Multiple Organ Failure (MOF) appear to be the most frequently used (Cassinello et al 1994; Rutledge et al 1993; Bion et al 1988). These three systems are widely used due to their high reliability and validity, which have been demonstrated by many researchers. However the following limitations of these tools have also been reported: 1) they place a great deal of weight on physiological measures, 2) they require considerable time commitments, and 3) they are unsuitable for evaluating treatment and care efficiency in the ICU because they were designed to predict mortality rather than morbidity (Vincent and Ferreira 2000).

In the nursing area, one of the primary purposes of a patient classification is to efficiently allocate nursing resources according to demand based on the level of nursing care required (Hass 1988; Giovannetti and Mayer 1984). In particular, appropriate allocation of limited ICU resources must be determined based on a classification system that fits well the ICU setting (Kim and Jang 2002). In 1994, the Korean Clinical Nurse Association (KCNA) developed a classification system, ie the Critical Patient Severity Classification System (CPSCS), which aimed at estimating demand, supply, and priority of nursing activities (KCNA 1994). The CPSCS has now been acknowledged as a valuable tool for nursing management, in-line with its original purpose.

However if the CPSCS is used only for estimating nursing demand and supply, this system can be considered to have limited applicability. To increase the value of clinical usage of the CPSCS, nursing demands and workloads computed using the CPSCS should be verified to significantly relate to the prognostic prediction. Such verification can be convincing evidence of a close connection between nursing activities and patient prognosis. Therefore, further studies on evaluating the predictive value of the CPSCS were needed.

In ICUs, the most important outcome should be mortality, because the major cause of admittance is brain injury, which is also one of the most common causes of death (Rovlias and Kotsou 2004; Schreiber et al 2002; Ono et al 2001). On the other hand, many brain injury survivors remain disabled and are discharged to their own homes to lead a somewhat independent life, even after completing rehabilitation. Therefore, predictions of the functional, cognitional, and sociological recovery of brain injury patients are as meaningful as mortality predictions. The purpose of the present study was to evaluate whether the CPSCS can be effectively used to predict mortality, functional disability, and cognitive ability of brain injury patients at 1 month and 6 months after admission to an ICU.

METHOD

Design and subjects

The present study was conducted using a prospective prediction study design. The study subjects were 190 brain injury patients admitted to a surgical ICU at a university hospital located in Incheon, South Korea.

Data Collection

CPSCS was applied on the third day of admission to all study subjects. Outcome variables, ie mortality, functional disability, and cognitive ability were evaluated directly at 1 month and 6 months after admission to the ICU. For subjects discharged before the 6 months evaluation, the information required to assess outcome variables was obtained by telephone interviews.

Measurements

The CPSCS consists of 8 specific areas of nursing activities: 'vital signs measurement', 'monitoring', 'activities of daily living (ADL)', 'feeding', 'IV therapy and medication', 'treatments and procedures', 'respiratory therapy', and 'teaching and emotional support'. Each of these 8 areas is composed of 9~22 items, and each item can be scored based on nursing activity demand, difficulty, and time (Diagram 1). According to CPSCS total scores, patients were classified into 6 groups: group 1, 0~13 (lowest severity); group 2, 14~32; group 3, 33~65; group 4, 66~98, group 5, 99~150; and group 6, above 151 (highest severity).

Diagram 1: The Critical Patient Severity Classification System (CPSCS)

Total score	Classification
0~13	I
14~32	II
33~65	III
66~98	IV
99~150	V
above 151	VI

Items	Content
VITAL SIGNS (Manual TPR, BP)	(1) Vital signs four times a day or less (2) Vital signs every 4 hours or x 6 (3) Vital signs every 3 hours or x 8 (4) Vital signs every 2 hours or x 12 (8) Vital signs every 1 hour or x 24 (2) Rectal or axillary temperature or apical pulse four times a day or more (2) Femoral or pedal pulses or foetal heart tones every 4 hours or more (2) Tilt tests every 4 hours or more (6) Post-op, post-partum, or post-new born vital signs
MONITORING	(2) Intake and output every 8 hours or x3 (4) Intake and output every 4 hours or x6 (8) Intake and output every 2 hours or x12 (16) Intake and output every 1 hour or x24 (2) Circulation or fundus check every 2 hours or x12 (3) Neurological checks every 4 hours or x6 (6) Neurological checks every 2 hours or x12 (12) Neurological checks every 1 hour or x24 (2) CVP/ICP/LAP(manual) every 2 hours or x12 (4) CVP/ICP/LAP(manual) every 1 hour or x24 (6) Cardiac/Apnoea/Temp/Pressure monitor(not accumulative) (6) Transcutaneous monitor (4) A-line or ICP(monitor) or Swan Ganz set-up (2) A-line or ICP(monitor) reading every 2 hours or x12 (4) PAP/PCWP/RVP reading every 2 hours or x12 (2) Cardiac output three times a day or x3
RESPIRATORY THERAPY	(2) Oxygen therapy or oxyblood (2) Incentive spirometer or cough and deep breathing every 4 hours (2) IPPB or Nebulizer twice a day or x2 (4) IPPB or Nebulizer every 6 hours or x4 (6) IPPB or Nebulizer every 4 hours or x6 (8) Crop tent or mist tent (2) Chest physiotherapy twice a day or x2 (4) Chest pulmonary therapy every 6 hours or x4 (6) Chest pulmonary therapy every 4 hour or x6 (2) Suctioning every 4 hours or x6 (4) Suctioning every 2 hours or x12 (8) Suctioning every 1 hour or x24 (18) Suctioning every 30 minutes or over (10) Ventilator (4) Tracheostomy care x3 (after 48 hours) (6) Tracheostomy care x3 (before 48 hours)

Diagram 1: The Critical Patient Severity Classification System (CPSCS) *continued...*

Items	Content
ACTIVITIES of DAILY LIVING	(6) Infant/toddler care (<5years) (2) Self/minimal care (adult or child >5years) (6) Assisted care (>5years), position self (14) Completed care (<5years), assists with positioning (18) Total care (<5years), position and skin care (32) Total care (<5years), position and skin care every 2 hours (4) Extra line change and partial bath per shift (14) Turning Frame (2 staff to turn every 2 hours) (8) Paediatric recreation/observation (0-12years)
FEEDING	(5) Tube feed (bolus) every 4 hours or x6 (8) Tube feed (bolus) every 3 hours or x8 (10) Tube feed (bolus) every 2 hours or x2 (2) Tube feed (continuous) per bottle change (6) Adult meals> 5years, spoon feed x3 (10) Child meals> 5years, spoon feed x3 (2) Infant/neonate bottle x1 feeding (12) Infant/neonate bottle every 4 hours or x6 (18) Infant/neonate bottle every 3 hours or x8 (24) Infant/neonate bottle every 2 hours or x12
IV THERAPY and MEDICATIONS	(4) KVO (change bottle twice a day or less) (4) Heparin lock or Broviac (6) Simple (change bottle three or four times a day) (8) Complex (2 or more sites or change bottle every 4 hours or multilumen line) (2) IV medication every 8 hours or x3 (3) IV medication every 6 hours or x4 (4) IV medication every 4 hours or x6 (2) Blood products (each administration) (2) Medication every 3 hours or x8 (up to 12 trips), exclude IV medication (4) Medication every 2 hours or more (>12trips), exclude IV medication
TREATMENTS, PROCEDURES	(2) Star IV or NG or Foley or EKG (2) OR preparation or enema or Ace wraps/Teds (2) Lab studies x6; ABG stick or Blood culture x3 (2) Simple dressing x2 or tube care x2 or Foley care x2 (2) Irrigation or instillation x4 or less (2) Restraints (2 or 3 areas) (2) Assist out of bed to chair/stretch x3 (2) Assist out of bed, walk and return x1 (2) Infant circumcision or phototherapy (2) Accompany patient off ward >15min but <30min (2) Other activities requiring >1 min but <30min (2) Isolation (gown and glove x8) Complex>30min and <1 hour total (4) Chest tube insertion or lumbar puncture (4) Thoracentesis, paracentesis, pericardiocentesis (4) Straight catheterization > x4 (4) Complex dressing change (>30min) (4) Range of motion exercise x3 (4) Accompany patients off ward >30min (4) Other activities requiring >30min <1hr Special procedure >1h and <4h (8) Other activities requiring continuous nursing care or every 1 hour (12) New admission (assessment and orientation) (4) Transfer (in-house)
TEACHING and EMOTIONAL SUPPORT	Teaching (2) Group teaching (4) Preoperative teaching (4) Special structured teaching (Diabetic, cardiac, etc) Emotional support (>30min every 24 hours) 10 = maximum points for emotional support (4) Patient/family support (anxiety, denial, loneliness, etc) (4) Lifestyle modification (prosthesis behavior, image, copying, etc) (6) Sensory deprivation (retarded, blind, deaf, mute, etc) Continuous (99) Patients requiring 1:1 coverage (151) Patients requiring greater than 1:1 coverage

To evaluate functional disability, the Rappaport Disability Rating Scale (DRS) was used. This scale is an 8-item rating scale and consists of four main areas: 'arousability and awareness', 'ability for self-care', 'dependence on others', and 'psychosocial adaptability' (Rappaport et al 1982). Higher scores represent higher levels of functional disability. The DRS has been reported to be reliable and valid (van Baalen et al 2003; Fleming and Maas 1994; Gouvier et al 1987) and was found to have a Cronbach's α of 0.93 in the present study.

Cognitive ability was measured using the Functional Cognitive Index (FCI), which was designed to assess attention, communication, behavior/safety, behavior/social, problem solving, and memory. The FCI is a 6-item, 6-point rating scale, and has been acknowledged to be highly applicable in various clinical settings. The reliability coefficient of this scale in the present study was 0.98.

Ethical considerations

Data collection was performed with the permission of the institutional research review board at the hospital where data were collected. Subjects or families were informed of the purpose of this study and of the data collection procedures. Only those that expressed an intention to participate voluntarily were recruited.

Data analysis

Statistical analysis was performed using SPSS (version 12.0). Descriptive analysis was used to analyse general subject characteristics. Discriminant analysis was used to determine the statistical significance of the predictive accuracy of independent variables with respect to categorical outcome variables, like mortality. For interval type outcome variables, ie degree of functional disability and cognitive ability, multiple regression analysis was used.

FINDINGS

General and illness related subject characteristics

Study subjects included 119 male (62.6%) and 71 female (37.4%) brain injury patients of mean age 52.42(± 14.95) years. Eighty-two subjects (43.2%) had a traumatic brain injury, 49 (25.8%) a spontaneous intra-cerebral haemorrhage (ICH), and 49 (29.5%) a sub-arachnoid haemorrhage (SAH) with aneurysm rupture. Fifty-five subjects (28.9%) had hypertension and 12 (7.8%) diabetes mellitus. Of the 106 subjects, 98.9% had an intracranial haematoma and 22.1% a midline shift.

Regarding surgical modalities related to brain injury, 35.1% of subjects had clipping surgery, 27.7% haematoma removal surgery, 22.3% extra-ventricular drainage or extra-lesional drainage, and 14.9% decompressive craniectomy. Mean GCS score at ICU admission was 7.81 (± 4.07, range 3~15).

The mean scores of the 8 CPSCS areas were as follows: 'vital signs measurement' 9.04 (± 2.71, range 0~22), 'feeding' 0.73 (± 1.93, range 0~8), 'activities of daily living' 18.06 (± 5.19, range 0~32), 'monitoring' 16.27 (± 4.73, range 0~34), 'teaching and emotional support' 8.37 (± 2.97, range: 0~14), 'IV therapy and medication 18.86 (± 6.08, range 0~39), and 'respiratory therapy' 6.65 (± 6.14, range 0~23). The mean total score was 93.18. Most of the study subjects were classified as group 3 (n=3, 1.6%), 4 (n=96, 50.5%), and 5 (n=59, 31.1%). No subject was classified as group 1, 2, or 6 in the present study.

Thirty-six subjects (18.9%) died within 6 months of ICU admission with an average survival of 28.69 (± 38.81) days. Of these expired subjects, 34.4% died within 1 week. ICU stay averaged 14.48 days (± 13.35, range 1~71).

The predictors of mortality

Ten potential predictors were evaluated, ie the eight areas of CPSCS, total CPSCS score, and grade classified according to CPSCS total score. Discriminant analysis showed that 'vital signs measurement' (p=0.00), 'teaching and emotional support' (p=0.00), total score (p=0.00), 'respiratory therapy' (p=0.00), 'IV therapy and medication' (p=0.01), and classified grade (p=0.01) were significant predictors of mortality (table 1). Using these six significant predictors, 51% (canonical correlation=0.51) of mortalities could be explained, and this was statistically significant (Wilks' Lambda=0.74, p=0.00).

Table 1: Discriminant analysis for mortality (n=190)

Variables and significant test		Survive mean(SD)	Death mean(SD)	Structure matrix[1]	Univariate analysis F(*p*)
Predictors	Vital sign	8.65(1.87)	11.20(4.83)	-0.61	20.49(0.00)
	Teaching	8.74(2.72)	6.00(3.16)	0.61	20.24(0.00)
	Total score	91.23(13.21)	104.80(19.42)	-0.58	18.66(0.00)
	Respiratory	5.96(5.70)	10.48(7.15)	-0.47	12.06(0.00)
	IV therapy	18.29(5.32)	21.84(8.85)	-0.37	7.28(0.01)
	Classified grades	4.32(0.52)	4.50(0.50)	-0.34	6.34(0.01)
Significant test for Canonical Discriminant Function	Eigen value				0.36
	Canonical correlation				0.51
	Wilks' Lambda (*p*)				0.74(0.00)
Correct classification rate	Overall				77.3%
	Death				72.0%
	Survival				78.3%

[1] Correlation coefficients between discriminating variables and standardized canonical discriminant functions

Table 2: Multiple regression analysis for 1 month and 6 months functional disability (n=190)

Predictors	β	t(p)	Adjusted R^2	Model test F(p)
1 month Functional Disability				
Respiratory therapy	0.46	3.55(0.00)	0.29	6.77(0.00)
Teaching	-0.29	-3.16(0.00)		
Activities of daily living	0.23	2.15(0.03)		
Monitor	0.19	1.96(0.05)		
6 months Functional Disability				
Respiratory therapy	0.32	2.40(0.02)	0.26	5.87(0.00)
Teaching	-0.33	-3.53(0.00)		

Predictive accuracy for deaths, survivals, and overall (both death and survival) using these six significant variables were 72.0%, 78.3%, and 77.3%, respectively. The best predictors were 'vital signs measurement' (-0.61) and 'teaching and emotional support' (0.61) followed by 'total score' (-0.58), 'respiratory therapy' (-0.47), 'IV therapy and medication' (-0.37), and 'classified grade' (-0.34). Survivors had lower scores for 'vital signs measurement', 'respiratory therapy', 'IV therapy and medication', 'total score', and 'classified grade', whereas non-survivors had lower scores in 'teaching and emotional support'.

The predictability of 1- and 6-month functional disabilities

The significant predictors of 1 month functional disability were 'respiratory therapy' (β=0.46, p=0.00), 'teaching and emotional support' (β= -0.29, p=0.00), 'activities of daily living' (β= 0.23, p=0.03), and 'monitoring' (β= 0.19, p=0.05, table 2). Using these four significant predictors, 29% of 1 month functional disability could be explained (adjusted R-square=0.29), and this was statistically significant (p=0.00). Subjects with a better functional recovery at 1 month had lower scores in 'respiratory therapy', 'activities of daily living', and 'monitoring', but higher 'teaching and emotional support' scores. 'Total score' and 'classified grade' were not found to significantly predict 1 month functional recovery.

The significant predictors of 6 months functional disability were 'teaching and emotional support' (β=-0.33, p=0.00) and 'respiratory therapy' (β=0.32, p=0.02) (table 2). The explicability of

these two significant predictors, was 26% (adjusted R2=0.26), and this was statistically significant (p=0.00). The subjects with a better functional recovery at 6 months had higher scores for 'teaching and emotional support', but lower scores for 'respiratory therapy'. 'Total score' and 'classified grade' were not found to significantly predict 6 months functional recovery.

Prediction of 1 month and 6 months cognitive ability

The significant predictors of 1 month cognitive ability were 'teaching and emotional support' (β=0.39, p=0.00) and 'respiratory therapy' (β=-0.31, p=0.03) (table 3). Using these two significant predictors, 28% of 1 month functional disabilities could be explained (adjusted R2 =0.28), and this was statistically significant (p=0.00). Subjects with better cognitive recovery at 1 month had higher scores for 'teaching and emotional support', but lower scores for 'respiratory therapy'. 'Total score' and 'classified grade' were not found to significantly predict 1 month cognitive recovery.

The only significant predictor of 6 months cognitive ability was 'teaching and emotional support' (β=0.31, p=0.00, table 3). The explicability of this significant predictors for 6 months cognitive ability was 17% (adjusted R2=0.17) and this was statistically significant (p=0.00). The subjects with a better cognitive recovery at 6 months had higher scores for 'teaching and emotional support'. 'Total score' and 'classified grade' were not found to significantly predict 6 months cognitive recovery.

Table 3: Multiple regression analysis for 1 month and 6 months cognitive ability (n=190)

Predictors	β	t(p)	Adjusted R^2	Model test F(p)
1 month cognitive ability				
Teaching	0.39	3.70(0.00)	0.28	5.35(0.00)
Respiratory therapy	-0.31	-2.17(0.03)		
6 months cognitive ability				
Teaching	0.31	3.02(0.00)	0.17	3.58(0.00)

DISCUSSION

Several studies have evaluated the validity and reliability of the CPSCS for estimating the time, amount, cost, and personnel demand required for ICU nursing activities (Ham 1997; Yu and Cho 1996; Kang 1993). Based on the results obtained, the CPSCS is now acknowledged to be a valuable classification system for nursing management and its usage continues to increase in Korea. However few studies have been conducted to further examine the prognostic predictability of CPSCS. As far as we are aware, only one study has investigated the predictability of CPSCS for 1 month recovery in brain injury patients (Hyun 2003). In the case of the Glasgow Coma Scale, it was initially developed to grade patients with acute traumatic brain injury and later it was extended to evaluate the probability of early death (Handschu et al 2005; Cho and Wang 1997). Therefore the present study was conducted to assess the ability of the CPSCS to predict various aspects of outcome for acute and post-acute stage brain injury patients. This evaluation was expected to be valuable in terms of expanding the applicability of CPSCS and its clinical usage.

Of the eight CPSCS areas, 'vital signs measurement', 'teaching and emotional support', 'respiratory therapy', and 'IV therapy and medication' were found to significantly predict mortality. In addition, 'total scores' and 'classified grade' were also identified as significant predictors of mortality. The probability of discriminating survival and death correctly using these significant predictors was 77.3% and 81.3%, respectively, which are considerably higher than the 50% expected by chance. This result implies that CPSCS can be used to efficiently predict brain injury patient mortality.

According to the result of the present study, patients with good functional recovery at one month had a higher 'teaching and emotional support' score, but lower 'respiratory therapy', 'activities of daily living', and 'monitor' scores. This signifies that the subjects who need less nursing time and effort for respiratory therapy, activities of daily living, and monitoring, but more for teaching and emotional support will achieve a good functional recovery. Similarly, the Therapeutic Intervention Scoring System (TISS) evaluates illness severity based on type of equipment and services and the level of nursing care for patient care.

In fact, a high 'respiratory therapy' score is the result of airway intubation or ventilator management, implying severe brain injury. In the same manner, a high 'monitoring' score is due to the need for neurological or intake/output assessments, or for the monitoring of intracranial pressure, central venous pressure, or pulmonary capillary wedge pressure (PCWP), which again imply severe brain injury. Therefore, high 'respiratory therapy', 'activities of daily living', and 'monitoring' scores indicate severe illness. However patients with severe brain injury need prolonged psychological or social support due to a low level of consciousness, which would result in low 'teaching and emotional support' scores.

Patients that achieved good functional recovery at 6 months had lower 'respiratory therapy' scores but higher 'teaching and emotional support' scores. As did our 1 month functional disability findings, this result seems persuasive, because patients with severe brain injury probably preferentially require respiratory therapy, but hardly need a psychological or social support. However 'activities of daily living' and 'monitoring', which were found to significant predictors of 1 month functional recovery, were not found to significantly predict 6 months functional recovery.

Patients with good cognitive recovery at 1 month also had lower 'respiratory therapy' scores but higher 'teaching and emotional support' scores. On the other hand, 'teaching and emotional support' score was the only significant predictor of 6 months cognitive recovery.

Taken together, our results signify that CPSCS can be used to efficiently predict a restricted area of the outcome in brain injury patients. That was, CPSCS was found to be a valuable tool for mortality prediction, but less reliable at predicting functional and cognitive recovery in brain injury patients.

CONCLUSIONS AND RECOMMENDATIONS

The result of the present study showed that the CPSCS can be used to efficiently predict mortality, but less reliable at predicting functional and cognitive recovery in brain injury patients. Outcome prediction is not expected to be perfect, in part because injury severity is so difficult to quantify. More importantly patient response to brain injury is complex and thus difficult to model adequately. Therefore multiple scoring systems may be needed in clinics.

Some limitations of the present study require mention. First, the study subjects were mainly of group 4 and 5 according to the CPSCS, and this might affect results. Therefore further studies on subjects with diverse CPSCS scores are needed. Second, because the CPSCS was originally developed for application to all types of ICU patients, it does not specifically address brain injury patients and as a result does not include particular nursing activities for brain injury patients (eg managing brain oedema or convulsion, preparation for medical examination, monitoring re-bleeding, assessing respiratory activity, or requirements for specific facilities or equipments (Park 2001). To use the CPSCS to predict functional or cognitive recovery in brain injury patients, such data should be included in the CPSCS. Further studies are also required on this issue.

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