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Research Article

Evaluation of the Clinical Usefulness of Critical Patient Severity Classification System and Glasgow Coma Scale for Neurological Patients in Intensive Care Units

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S U M M A R Y

Purpose: The purpose of this study was to evaluate the clinical usefulness of the Critical Patient Severity Classification System (CPSCS) and Glasgow Coma Scale (GCS) for critically ill neurological patients and to determine the applicability of CPSCS and GCS in predicting their mortality.
Methods: Data were collected from the medical records of 187 neurological patients who were admitted to the intensive care unit of C university hospital. The data were analyzed through chi-square test, t test, Mann-Whitney, Kruskal-Wallis, goodness-of-fit test, and receiver operating characteristic curve.
Results: In accordance with patients' general and clinical characteristics, patient mortality turned out to be significantly different depending on intensive care unit stay, endotracheal intubation, central venous catheter, and severity by CPSCS. Hosmer-Lemeshow goodness-of-fit tests were applied to CPSCS and GCS. The results of the discrimination test using the receiver operating characteristic curve were $CPSCS_0$, .743, GCS_0 .583, $CPSCS_{24}$, .734, GCS_{24} .612, $CPSCS_{48}$, .591, GCS_{48} .646, $CPSCS_{72}$, .622, and GCS_{72} .623. Logistic regression analysis showed that each point on the CPSCS score signifies a 1.034 higher likelihood of dying.
Conclusion: Applied to neurologically ill patients, early CPSCS scores can be regarded as a useful tool.

Introduction

The tools that classify the severity of patients based on the prediction of their mortality include the Acute Physiology and Chronic Health Evaluation (APACHE), the Simplified Acute Physiology Score (SAPS), and the Mortality Probability Model (MPM). These tools rely crucially on the evaluation of the patients' general clinical status on the first date of their admission to intensive care unit (ICU). These tools allow us to identify both the severity and the mortality probability of the patients. Another set of tools based on therapeutic interventions is exemplified by the Therapeutic Intervention Scoring System (TISS-28; Kiekkas et al., 2007). APACHE, SAPS, and MPM which classify severity based on mortality have recently been revised, and the new versions of APACHE III, SAPS II, and MPM II continue to be useful and appropriate for predicting the patients' mortality (Lemeshow et al., 1993; Youn & Kim, 2005). However, as mentioned by some researchers, these indices do not involve nursing activities as an element of the evaluation and hence do not reflect nursing needs (Vincent & Ferreira, 2000). The TISS-28 tool, which shows that more severe patients require more treatments, can only account for 43% of the needs of nursing activities in the ICUs (Gonçalves, Padilha, & Cardoso Sousa, 2007). Nursing activity is one of the most crucial factors influencing the quality of treatment patients receive and one of the most important contributing factors for patient prognosis and safety (Carayon & Gurses, 2005). A study performed in North American general hospitals found that adding one patient per nurse resulted in a 7% increase in the risk of death 30 days after admission, and a 7% increase in the risk of death by complications (Taunton, Kleinbeck, Stafford, Woods, & Bott, 1994). For this reason, the Korean Association of Hospital Nurses developed the Critical Patient Severity Classification System (CPSCS) in 1994, which was partly revised in 2004 by the committee of intensive care nursing of the same association and are now used in many hospitals and other medical institutions. This system grades scores based on the TISS-28 classification tool and the Walter Reed Medical Center's classification of patients. The majority of ICU patients have brain damage (Oh et al., 2009). According to Padilha, Sousa, Queijo, Mendes, and Miranda's (2008) study of nursing activities in the ICU, 21.8% of patients there

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were admitted for intensive care after an operation, accounting for more than any other category. The next largest group is patients with brain damage or other neurological diseases. Neurological diseases, if severe, can threaten one's life. Brain hemorrhage, such as subarachnoid hemorrhage from aneurysmal rupture, may cause complications in the cardiovascular and respiratory systems even after the acute period. Additionally, if secondary damage to the brain, such as infection, hematoma, hypoxia, or increased intracranial pressure occur, they may lead to serious brain disabilities like cerebral hypertension, cerebral ischemia, seizure, coma, and eventually death. Thus, these are considered the most severe group of patients (Rovlias & Kotsou, 2004; Shutter & Narayan, 2008; Suarez, 2006; Youn & Kim).

The Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) is used to assess the patient's level of consciousness and to identify any early indications of deterioration especially for neurological conditions (Waterhouse, 2005). It provides a quick and easily performed tool for evaluating the severity of head injuries in neurological patients, the results and implications of which can be easily communicated to other health care workers by bedside support nurses, and thus leading to more favorable patient outcomes (McNett, 2007). This instrument is easily applicable to adults and is an evaluation tool for neurological patients that nurses in ICUs need to learn. However, not much research has been performed in relation to nursing activities. Thus, the necessity of investigating the usefulness of the CPSCS and GCS for neurological patients in ICUs has led us to perform this study to provide basic findings for nursing interventions.

Purpose

The main purposes of the present study are as follows: (a) To identify the mortality according to general and clinical characteristics; (b) to reveal the differences in severity grade according to the general and clinical characteristics of CPSCS; (c) to reveal the differences in severity grade according to the general and clinical characteristics of GCS; (d) to compare the validity and mortality of CPSCS and GCS. The study tested the validity of CPSCS and GCS for critically ill neurological patients and determined the applicability of CPSCS and GCS in predicting mortality in this group of patients.

The following research question guided this study: Are there any significant differences in severity according to the general and clinical characteristics of critical patients based on the CPSCS and GCS?

Methods

Study design

The current study is a survey of the critical patients in the ICU of C Hospital located in Seoul, Korea. It is a case-control study to test the usefulness of the CPSCS and GCS for neurological patients in ICUs.

Setting and samples

The present study analyzed the medical records of 187 critical patients who were hospitalized in the ICU of the C hospital from January 2008 to May 2009. Patients were all adults older than 18 years with neurological diseases. We excluded patients who had burns, coronary artery diseases, and heart surgeries. At a significance level of .05, power of .80 power, and an effect size of .3, using G-power 3.1.2 (Faul, Erdfelder, Buchner, & Lang, 2009) it was revealed that the sample size needed for a goodness-of-fit test is 199. Thus, we took the medical records of 205 patients, out of which 18 were excluded from the analysis, since their mortality could not be confirmed.

Instruments

General and clinical characteristics of the patients

General characteristics of the patients included gender, age, smoking, alcohol, route of admission to ICU, hypertension, diabetes, diagnosis, and the duration of ICU stay. The clinical characteristics consisted of four factors: endotracheal intubation, insertion of central line catheter, death, and survival. Among the general characteristics, the four items of smoking, alcohol, hypertension and diabetes were checked during admission. Additionally, two clinical characteristics, endotracheal intubation and insertion of central line catheter, were checked within 24 hours after admission.

GCS

The GCS is a tool developed by Teasdale and Jennett (1974) in order to evaluate the level of consciousness of patients. This tool is easy to use and has been widely employed as a representative tool for evaluating the severity of neurological patients (Choi, Narayan, Anderson, & Ward, 1988; Rovlias & Kotsou, 2004). The level of the patients' consciousness is evaluated by motor response (1–6 points), verbal response (1–5 points) and eye opening (1–4 points). The scores ranged from 3 to 15 and the tool classifies less than 9 as severe, 9–12 points as moderate, and 13 or more as mild brain damage. The current study is based on the scores checked at admission.

CPSCS

The present study generally adopts the framework of the CPSCS with several minor changes and additions. A higher score suggests a greater severity (Hospital Nurses Association, 1994). The CPSCS includes 82 items evaluating nine areas of nursing activities: vital sign (4 items), monitoring (13 items), activities of daily living (11 items), feeding (5 items), intravenous (IV) therapy and medication (9 items), treatment and procedure (15 min $\leq$ length $<$30 min: 16 items; 30 min $\leq$ length $<$1 hr: 12 items; $>$1 hr: 2 items), respiratory therapy (9 items), teaching and emotional support (3 items), and continuous therapy (2 items). The scores of the nine areas were added up and classified into six grades: 0–13 for grade 1, 14–32 for grade 2, 33–65 for grade 3, 66–98 for grade 4, 99–150 for grade 5, and 150 or more for grade 6. Data collected at admission were used for the analysis.

Data collection

The present research is a case-control study. The researchers received permission from the head of the hospital and also approval from the committee for medical research (institutional review board No.: C2012014[709]) after their deliberations on the goals and methods, the rights of patients, and the use of medical records. The researchers made a visit to the nursing department and the office of medical records and asked the managers for assistance. The medical records of 187 neurological patients in the ICU (137 lived and 50 died) hospitalized between January 2008 and May 2009 were analyzed.

Data analysis

The collected data were analyzed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA) and MedCalc 11.5.1.0. The general and clinical characteristics of the patients were analyzed to produce technical statistics, including the means, standard deviations, frequencies, and percentages. As far as the differences in death rates according to the general and clinical characteristics were concerned, the factors that showed normal distribution were analyzed with chi-square and t test and those without normal distribution were tested by Mann-Whitney and Kruskal -Wallis tests. The goodness-of-fit of the CPSCS and GCS validities was identified by the Hosmer-Lemeshow's test and the predictability of death rates of CPSCS and GCS was, in turn, identified by MecCalc 11.5.1.0, via contrastive analysis of area under the curve (AUC) of receiver operating characteristic curves. Predictions of their death rates were identified using a logistic regression analysis.

Results

Mortality according to general and clinical characteristics

The differences in mortality according to the patients' general and clinical characteristics are shown in Table 1. Among the clinical characteristics, the severity grade ($\chi^2 = 12.58$, $p = .006$), insertion of the central line catheter ($\chi^2 = 16.58$, $p < .001$), endotracheal intubation ($\chi^2 = 18.56$, $p < .001$), and duration of ICU stay ($Z = -2.53$, $p = .010$) exhibit significant differences in mortality. The GCS marked the highest death rate in the case of the highest severity (≤ 8), but it did not show a statistically meaningful difference.

Differences in severity grade according to the general and clinical characteristics of CPSCS

The scores of critical neurological patients in the CPSCS and the differences according to the patients' general and clinical characteristics are shown in Table 2. In the area of route of admission, the patients from wards and those via emergency rooms showed a statistically significant difference ($F = 3.555$ $p = .020$). Patients with hypertension ($M = 111.91$, $SD = 19.68$) and diabetes ($M = 112.30$, $SD = 13.59$) had a higher severity than those without these diseases, but the difference was not significant. In the area of disease category, the CPSCS exhibited high scores in neurosurgery ($M = 112.48$, $SD = 16.60$), trauma ($M = 111.97$, $SD = 23.70$), and neurological patients ($M = 108.11$, $SD = 15.60$); however, there was no statistically significant difference in this scale. The patients who had endotracheal tube insertion had a higher mean severity than those who did not: 120.52 ($SD = 17.46$) versus 100.73 ($SD = 14.72$). As expected, the patients who had endotracheal tube insertion and died ($M = 126.78$, $SD = 19.54$) showed a higher mean severity than those who survived ($M = 109.10$, $SD = 23.91$); this was statistically significant ($t = 8.297$, $p < .001$). Those with central venous catheter also had a higher mean severity than those without: 120.36 ($SD = 18.14$) versus 103.97 ($SD = 16.35$). Among the patients with central venous catheter, a significant difference was found ($t = 6.496$, $p < .001$), as expected, between the patients who died and those who survived: 125.49 ($SD = 20.58$) and 118.00 ($SD = 24.18$), respectively. We found that the medians of the severity of each group according to the CPSCS were as follows: 95.70 (range: 67–151) in grade 1–3, 94.00 (range: 72–146) in grade 4, 113.00 (range: 93–159) in grade 5, and 161.00 (range: 150–191) in grade 6. The average scores were found to be 96.38 ($SD = 27.01$) in grade 1–3, 97.50 ($SD = 13.15$) in grade 4, 116.10 ($SD = 13.10$) in grade 5, and 164.00 ($SD = 14.93$) in grade 6. It is also of note that

Table 1 *General and Clinical Characteristics and Difference of Mortality according to General and Clinical Characteristics (N = 187)*

Characteristics	Categories	*n* (%), *M* ± *SD* or Median (range)			Mortality rate	χ^2/ *t* / *Z*[a]	*p*
		All (*n* = 187)	Survival (*n* = 137)	Death (*n* = 30)			
Gender	Male	116 (62.0)	89 (76.7)	27 (23.3)	23.3	1.87	.170
	Female	71 (38.0)	48 (67.6)	23 (32.4)	32.4		
Age(yr)		60.0 ± 15.1	59.5 ± 14.2	61.3 ± 17.4	—	0.70	.090
Smoking	Yes	85 (45.5)	58 (68.2)	27 (31.8)	31.8	2.01	.160
	No	102 (54.5)	79 (77.5)	23 (22.5)	22.5		
Alcohol	Yes	90 (48.1)	68 (74.7)	23 (25.3)	25.3	0.12	.730
	No	97 (51.9)	70 (71.9)	27 (28.1)	28.1		
Source of admission	Emergency room	123 (68.5)	93 (76.4)	29 (23.6)	23.6	3.86	.280
	Ward	21 (11.2)	16 (76.2)	5 (23.8)	23.8		
	Operating room	25 (13.4)	17 (68.0)	8 (32.0)	32.0		
	Transfer	18 (9.6)	10 (55.6)	8 (44.4)	44.4		
Hypertension	Yes	82 (43.9)	58 (70.7)	24 (29.3)	29.3	0.48	.490
	No	105 (56.1)	79 (75.2)	26 (24.8)	24.8		
Diabetes mellitus	Yes	23 (12.3)	18 (78.3)	5 (21.7)	21.7	0.34	.560
	No	164 (87.7)	119 (72.6)	45 (27.4)	27.4		
Disease category	Trauma	61 (32.6)	46 (75.4)	15 (24.6)	24.6	0.68	.710
	Neurosurgery	88 (47.1)	62 (70.5)	26 (29.5)	29.5		
	Neurology	38 (20.3)	29 (76.3)	9 (23.7)	23.7		
ICU LOS		7.00 (1–81)	8.00 (2–81)	5.50 (1–78)	—	−2.53[a]	.010
Intubation	Yes	101 (54.0)	61 (60.4)	40 (39.6)	39.6	18.56	<.001
	No	86 (46.0)	76 (88.4)	10 (11.6)	11.6		
Central line	Yes	85 (45.5)	50 (58.8)	35 (41.2)	41.2	16.58	<.001
	No	102 (54.5)	87 (85.3)	15 (14.7)	14.7		
Number of death		50 (26.7)					
Number of survival		137 (73.3)					
Severity of CPSCS	≤ 65 (Grade 1, 2 & 3)	8 (4.3)	7 (87.5)	1 (12.5)	12.5	12.58	.010
	65< Grade 4 ≤98	54 (28.9)	47 (87.0)	7 (13.0)	13.0		
	98< Grade 5 ≤ 150	119 (63.6)	81 (68.1)	38 (31.9)	31.9		
	>150 (Grade 6)	6 (3.2)	2 (33.3)	4 (66.7)	66.7		
Severity of GCS	≤ 8	79 (42.2)	55 (69.6)	24 (30.4)	30.4	.964	.620
	9–12	18 (9.6)	14 (77.8)	4 (22.2)	22.2		
	≥ 13	90 (48.1)	68 (75.6)	22 (24.4)	24.4		

Note. CPSCS = Critical Patient Severity Classification System; GCS = Glasgow Coma Scale; ICU = intensive care unit; LOS = length of stay.
[a] *Z* value of Mann-Whitney test.

Table 2 *General and Clinical Characteristics of and Difference between CPSCS and GCS (N = 187)*

Characteristics		*n* (%)	CPSCS			CPSCS		GCS			GCS	
			M ± *SD* or Median (range)[a]			χ^2/*t* /*F*	*p*	*M* ± *SD* or Median (range)[a]			χ^2/*t* /*F*	*p*
			All (*n* = 187)	Survival (*n* = 137)	Died (*n* = 50)			All (*n* = 187)	Survival (*n* = 137)	Died (*n* = 50)		
Gender	Male	116 (62.0)	109.99 ± 19.81	104.83 ± 14.35	127.00 ± 25.45	−1.320	.190	9.97 ± 4.07	10.31 ± 3.63	8.81 ± 5.17	−.486	.630
	Female	71 (38.0)	113.76 ± 17.45	111.33 ± 17.83	118.83 ± 15.82			10.27 ± 4.19	11.21 ± 3.54	8.30 ± 4.89		
Smoking	Yes	164 (87.7)	112.54 ± 20.51	105.10 ± 14.21	128.52 ± 22.99	.725	.470	10.20 ± 4.17	10.95 ± 3.40	8.59 ± 5.18	.362	.720
	No	85 (45.5)	110.49 ± 17.68	108.58 ± 16.98	117.04 ± 18.82			9.98 ± 4.10	10.39 ± 3.76	8.57 ± 4.91		
Alcohol	Yes	102 (54.5)	112.44 ± 21.61	105.28 ± 15.93	133.30 ± 22.74	.700	.480	10.00 ± 4.28	10.76 ± 3.66	7.74 ± 5.20	−.259	.800
	No	90 (48.1)	110.47 ± 16.25	108.86 ± 15.79	114.67 ± 16.97			10.16 ± 3.98	10.49 ± 3.59	9.30 ± 4.81		
Source of admission	Emergency room	60 (15.1)	108.51 ± 18.86[b]	104.44 ± 15.25	121.72 ± 23.27	3.555 b < c	.020	10.18 ± 4.12	10.46 ± 3.74	8.40 ± 2.70	.746	.530
	Ward	123 (65.8)	120.48 ± 17.04[c]	111.06 ± 15.01	134.60 ± 16.70			10.90 ± 3.24	10.88 ± 3.34	8.25 ± 6.30		
	Operating room	21 (11.2)	117.48 ± 18.83[b,c]	109.88 ± 12.19	133.63 ± 20.93			9.60 ± 4.54	9.94 ± 4.47	8.00 ± 5.24		
	Transfer	25 (13.4)	112.33 ± 18.27[b,c]	113.20 ± 22.48	111.25 ± 12.58			9.11 ± 4.50	6.70 ± 3.92	11.75 ± 3.77		
Hypertension	Yes	18 (9.6)	111.91 ± 19.68	106.69 ± 13.86	124.54 ± 25.55	.310	.760	10.06 ± 4.22	10.74 ± 3.64	8.42 ± 5.10	−.220	.830
	No	82 (43.9)	111.04 ± 18.53	107.42 ± 17.33	122.04 ± 17.98			10.10 ± 4.06	10.54 ± 3.62	8.73 ± 5.00		
Diabetes mellitus	Yes	105 (56.1)	112.30 ± 13.59	109.50 ± 13.04	122.40 ± 11.41	.312	.760	10.22 ± 3.66	10.33 ± 3.50	9.80 ± 4.60	.170	.870
	No	23 (12.3)	111.30 ± 19.66	106.75 ± 16.31	123.33 ± 22.70			10.06 ± 4.19	10.67 ± 3.64	8.44 ± 5.08		
Disease category	Trauma	97 (51.9)	104.50 (72−191)	101.75 (72−152)	132.00 (92−191)	75.819[a]	.240	10.25 ± 4.31	11.07 ± 3.87	7.73 ± 5.44	.077	.930
	Neurosurgery	61 (32.6)	111.75 (67−160)	108.80 (67−160)	122.33 (94−159)			9.98 ± 4.15	10.45 ± 3.75	8.85 ± 4.87		
	Neurology	88 (47.1)	103.75 (74−144)	102.00 (91−135)	111.00 (74−144)			10.05 ± 3.83	10.31 ± 3.44	9.22 ± 5.01		
Intubation	Yes	38 (20.3)	120.52 ± 17.46	116.43 ± 14.36	126.78 ± 19.54	8.297	<.001	9.47 ± 4.31	10.36 ± 3.34	8.10 ± 5.22	−2.236	.030
	No	101 (54.0)	100.73 ± 14.72	99.63 ± 12.90	109.10 ± 23.91			10.80 ± 3.79	10.84 ± 3.83	10.50 ± 3.63		
Central line	Yes	86 (46.0)	120.36 ± 18.14	116.78 ± 15.44	125.49 ± 20.58	6.496	<.001	9.91 ± 4.30	10.70 ± 3.51	8.77 ± 5.05	−.524	.600
	No	85 (45.5)	103.97 ± 16.35	101.55 ± 13.36	118.00 ± 24.18			10.23 ± 3.98	10.59 ± 3.69	8.13 ± 5.03		
Severity grade	< Grade 3	8 (4.3)	95.50 (67−151)	95.00 (67−113)	151.00 (151−151)	151.819[a]	<.001	12.00 (4.78)[c]	11.57 ± 1.67	15.00 ± .00	3.026 b < c	.030
	Grade 4	54 (28.9)	64.00 (72−146)	94.00 (72−146)	94.00 (72−146)			10.85 (3.54)[b,c]	10.91 ± 3.50	10.43 ± 4.07		
	Grade 5	119 (63.6)	113.00 (93−159)	111.00 (93−147)	123.50 (100−159)			9.78 (4.19)[b,c]	10.33 ± 3.66	8.61 ± 5.00		
	Grade 6	6 (3.2)	161.00 (150−191)	156.00 (152−160)	165.50 (150−191)			6.50 (5.32)[b]	12.50 ± .71	3.50 ± 3.12		

Note. CPSCS = Critical Patient Severity Classification System; GCS = Glasgow Coma Scale; NS = Neurosurgery, NU = Neurology.
[a] Chi-square of Kruskal-Wallis test
[b,c] Post hoc by Duncan reveals that median range is statistically significant.

there was a significant difference ($\chi^2 = 15.819$, $p < .001$) between the CPSCS scores and severity classification using the Kruskal-Wallis test.

Differences in severity according to general and clinical characteristics of GCS

Table 2 shows the differences in the GCS based on general and clinical characteristics of critical neurological patients. Those who underwent endotracheal tube insertion ($M = 9.47$, $SD = 4.31$) showed a higher mean severity than those who did not ($M = 10.80$, $SD = 3.79$); the difference was significant ($t = -2.236$, $p = .030$). Patients who died with tube insertion were higher in mean severity than those who survived with tube insertion: 8.10 ($SD = 5.22$) versus 10.50 ($SD = 3.63$). Patients with central venous catheter, in turn, showed a higher mean severity than those without, but there was no statistical significant difference 9.91 ($SD = 4.31$) compared to 10.23 ($SD = 3.98$).

As expected, different grades were different in mean severity: 12.00 ($SD = 4.78$) in grades 1–3, 10.85 ($SD = 3.54$) in grade 4, 9.78 ($SD = 4.19$) in grade 5, 6.50 ($SD = 5.32$) in grade 6. As the severity of CPSCS became higher, that of GCS also showed a higher severity with a significant difference ($F = 3.026$, $p = .030$).

Usefulness of CPSCS and GCS

Table 3 and Figure 1 present the results from the Hosmer-Lemeshow's goodness-of-fit test of the validity of the CPSCS and GCS. Both were found to be positive ($\chi^2 = 4.151$, $p = .840$). As for the prediction of death discrimination using MecCalc 11.5.1.0, AUCs of the CPSCS and GCS at admission were found to be .734 and .583, respectively, with CPSCS being significantly better than the GCS ($Z = 2.653$, $p = .010$). The AUCs, measured 24 hours after admission were .734 for CPSCS and .612 for GCS. Again, prediction of death discrimination by the CPSCS turned out to be significantly better than that of the GCS ($Z = 2.220$, $p = .030$). In 48 hours, on the other hand, the AUC of GCS was slightly better than that of CPSCS: .646 versus .691, although the difference was not statistically significant ($Z = 0.077$, $p = .440$). In 72 hours, the AUCs for both were very similar: .622 for CPSCS and .623 for GCS. It is natural in this case that no statistically significant difference was found ($Z = 0.018$, $p = .990$).

The logistic regression analysis controlling for influential factors, such as length of ICU stay, intubation, and central venous catheter, is shown in Table 4. The GCS does not have any significant effect, although an increase of 1 in the CPSCS score signifies that a patient is 1.034 times more likely to die.

Discussion

The analysis reveals that several statistically significant differences are found in the test of differences in mortality based on general and clinical characteristics in such areas as length of ICU stay, endotracheal tube insertion, central venous catheter, and severity of CPSCS. The difference in relation to the length of ICU stay is supported by Knaus, Wagner, Zimmerman, and Draper's (1993) report on the mortality of their patients. Lemeshow et al. (1993) reported a rapid increase in mortality with the length of ICU stay: 3.0% within 24 hours and 21.8% after 24 hours. Lee et al. (2003) reported that the length of stay was closely related to infection symptoms and argued that infection was crucial factor influencing the mortality of ICU patients. It has been suggested that the system should prepare nursing interventions aimed at decreasing the length of ICU stay. The effect of presence or absence of endotracheal intubation and central venous catheter insertion on mortality was also supported by Murray et al.'s (2000) report, which found that the patients with intubation were more likely to die than those without.

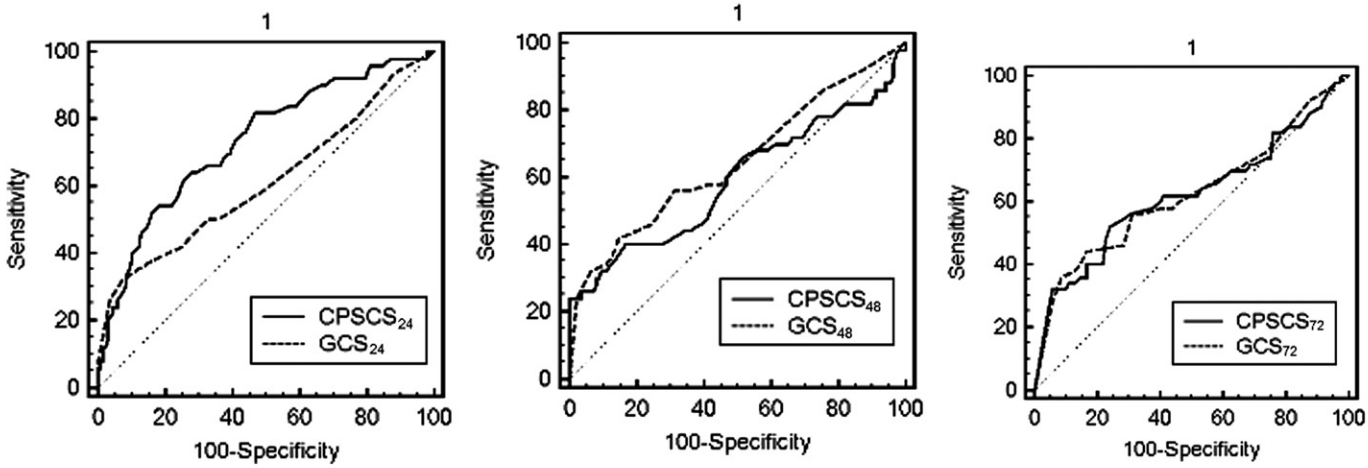
Such a result might emphasize the importance of nursing interventions, including aseptic technique, intubation care, oral care, and suction care. We expect that thorough aseptic techniques and careful intubation care will help protect patients from secondary infection, injuries, and other complications. Central catheter-related bloodstream infections may lead to complications such as septicemia, and significantly increase the morbidity, mortality, and medical costs, a finding supported by Siempos, Kopterides, Tsangaris, Dimopoulou, and Armaganidis (2009). Again, this result emphasizes the importance of possible infections and continuous monitoring of critical neurological patients who have undergone invasive procedures. The severity as measured by the CPSCS and mortality are shown to have a statistically significant difference. The present analysis finds that a higher score of severity means a lower rate of survival and an increased rate of death. This result is supported by other research, including Shin (2004) and Lee (2006).

We now consider the nine different areas of the CPSCS. First, the vital sign showed a significant difference in mortality. A higher severity is accompanied by a more frequent measurement of vital sign and, as a consequence, will naturally result in significant differences between patients that survive and those that die. The monitoring section consists of nursing activities, such as an evaluation of nervous system, intracranial pressure monitoring, central venous pressure (CVP), pulmonary arterial pressure (PAP), pulmonary capillary wedge pressure (PCWP) and right ventricular

Table 3 *Hosmer-Lemeshow Goodness-of-fit Test and Receiver Operating Characteristic (ROC) Curve for CPSCS and GCS (N = 187)*

Hosmer-Lemeshow goodness-of fit							ROC curve			
Characteristics	Survived		Died		χ^2	p	Characteristics[a]	AUC	Z	p
Probability of dying	Observed	Expected	Observed	Expected						
CPSCS & GCS										
1 ($0.0 \le p < 0.1$)	17	18.106	2	.894	4151	.840	$CPSCS_0$	.734	2.563	.010
2 ($0.1 \le p < 0.2$)	18	17.637	1	1.363			GCS_0	.583		
3 ($0.2 \le p < 0.3$)	17	17.184	2	1.816			$CPSCS_{24}$	.734	2.220	.030
4 ($0.3 \le p < 0.4$)	17	16.476	2	2.727			GCS_{24}	.612		
5 ($0.4 \le p < 0.5$)	16	15.402	3	3.598			$CPSCS_{48}$	.591	.077	.440
6 ($0.5 \le p < 0.6$)	13	14.055	6	4.945			GCS_{48}	.646		
7 ($0.6 \le p < 0.7$)	13	12.597	6	6.403			$CPSCS_{72}$	.622	.018	.990
8 ($0.7 \le p < 0.8$)	13	10.989	6	8.011			GCS_{72}	.623		
9 ($0.8 \le p < 0.9$)	7	9.022	12	9.978						
10 ($0.9 \le p < 1.0$)	6	5.735	10	10.265						

Note. CPSCS = Critical Patient Severity Classification System; GCS = Glasgow coma scale; AUC = area under the curve.
[a] Refers to CPSCS and GCS at 0, 24, 48, 72 hours.



		AUC	Z	p
24 hours	CPSCS GCS	.734 .612	2.200	.028
48 hours	CPSCS GCS	.591 .646	0.774	.439
72 hours	CPSCS GCS	.622 .623	0.018	.986

Figure 1. ROC Curves of $CPSCS_{24}$, GCS_{24}, $CPSCS_{48,}$ GCS_{48}, and $CPSCS_{72}$, GCS_{72}. Note. ROC = receiver operating characteristic; CPSCS = Critical Patient Severity Classification System; GCS = Glasgow Coma Scale; AUC = area under curve.

pressure (RVP) monitoring, A-line, intracranial pressure (ICP), and input and output (I/O) monitoring. Considering the characteristics of critical neurological patients, we understand that more activities are in this monitoring category than any others. However, no significant difference in scores is found in the monitoring area between survival and death. Our finding is different from that of Lee (2006). The discrepancy might have resulted from the types of patients used for analysis: 54.9% of the patients in Lee's study were internal patients and 27.3% were neurological ones, while those of the present study are all neurological patients. It is possible that the lack of significant differences in monitoring between the surviving and dead patients results from critical neurological patients requiring a larger amount of monitoring activities, regardless of how severe the conditions are.

Activities of daily living include nursing activities, such as total care, position and skin care, and partial bathing. Critical neurological patients with damage to a variety of brain functions find it hard to perform daily activities by themselves (Rovlias & Kotsou, 2004), and this demands total care. To prevent problems like pressure sores from long term bed rest, activities such as position changes, partial bathing, and skin care are necessary; these care activities result in high scores for both survival and death (Oh et al., 2009). The present

Table 4 *Logistic Regression of CPSCS and GCS (N = 187)*

Variables	B	SE	Wald	Exp (β)	95% CI for Exp (β)	
					Lower	Upper
ICU LOS	−0.008	0.015	0.298	0.992	0.962	1.022
Central line (1)	0.666	0.430	2.397	1.947	0.838	4.526
Intubation (1)	0.651	0.480	1.835	1.917	0.748	4.913
GCS	−0.050	0.044	1.254	0.952	0.873	1.038
CPSCS	0.033	0.012	8.252	1.034*	1.011	1.058
Constant	−5.019	1.368	13.451	0.007		

Notes. CPSCS = Critical Patient Severity Classification System; GCS = Glasgow coma scale; SE = standard error; CI = confidence interval; ICU = intensive care unit; LOS = length of stay.
*$p < .01$.

analysis also shows that there are significant differences in mortality in the areas of intravenous therapy and medication. A secondary brain injury might result in infection, hematoma, hypoxia, and increased intracranial pressure, and could eventually lead to death (Suarez, 2006). In order to prevent such secondary injuries, it is very important to try to maintain proper cerebral perfusion (Geeraerts et al., 2008). These activities belong to intravenous therapy and medication, which naturally result in significant differences in mortality. The area of treatment/procedure also shows significant differences in mortality. The nursing activities in this category include nasogastric tube insertion, preventative care of deep vein thrombosis, simple dressing, collection of blood, urine, and sputum, lumbar puncture, pericardiocentesis, nelaton catheterization, tracheostomy care, peritoneal dialysis, and cardiopulmonary resuscitation. This category marked a lower score than the areas of daily living, monitoring, and intravenous infusion and feeding. This result might be due to the nature of critical neurological patients who are in demand of surgical treatments rather than medical ones. As such, this category which consists mainly of medical treatments and procedures, shows a lower score than other areas, such as daily living, monitoring, and intravenous infusion and feeding. Oh et al. also reported similar results. Respiratory therapy consists of nursing activities, such as oxygen therapy, chest physiotherapy, cough and deep breathing, suctioning, ventilator usage, and prone position therapy. These nursing activities are required for patients whose respiratory ability has dropped. A high score in this category is very understandable, since respiration is mainly controlled by the medulla oblongata and pons of the brain. According to Mass, Stocchetti, & Bullock (2008), the focus in the intensive care for brain-damaged patients should be given to the activities of arresting the progression of brain damage, maintaining optimal brain status, and preventing increased intracranial pressure and brain edema. They also reported that optimum oxygen and brain perfusion are crucial for care. Thus, a higher score in respiratory treatment implies a more severe damage to the brain, which would naturally result in a significant difference between survival and death.

The GCS scores are found to be higher in patients who survive, which means these patients showed a lower severity than those who die, but there is no significant difference in mortality. The result of our analysis shows that 44% of the patients classified as mild with 13–15 points of GCS died unexpectedly, in contrast to the prediction of mortality. Cavanagh & Gordon (2002) reported that a psychometric concern with the GCS is the meaning of the scores. In practical terms, it is possible for patients to have identical scores but present different clinical findings at the same time. This has led to the discussion of the break points of GCS, that is, the positions in the scale at which two adjacent scores can be predictive of significant differences in outcomes. This might support the findings of the current study. In particular, mortality is not significantly different in the areas of the eye response score and verbal response in the GCS. The eye score is a measure of arousal; patients with a subarachnoid hemorrhage experience headache and meningeal irritation that can affect eye opening: a patient may be alert but keep eyes closed to avoid light or pain (Cavanagh & Gordon). The GCS score may also be low, for example, when an intubated patient receives a lower score even with orientation. Sternbach (2000) notes that an important current issue is the appropriate application of GCS to intubated patients. This might support the findings of our research. Such a result calls for the necessity of discussion of when the GCS should be measured. Eventually GCS-motor, unlike GCS-eye and GCS-verbal, is correlated with a significant difference in mortality.

Much of the earlier research on the predictive ability of the GCS score used the summed GCS score, rather than the scores of the individual components of the GCS (eye, motor, and verbal). However, one of the earlier studies described in the preceding section not only included the summed GCS score, but also investigated if the separate components of the scale could be used to predict outcome (Choi, Narayan, Anderson & Ward, 1988). Ross, Leipold, Terregino, and O'Malley (1988) argued that the motor component of the GCS score accurately predicted outcome in head injury patients with nearly the same accuracy as the total GCS score and motor score; the total GCS score sensitivity was 91% and specificity was 85%. This outcome is different from that of our study. Some past analyses have reported that the ROC curves of the GCS motor score and the total score are similar, .894 and .906, respectively (Gill, Windemuth, Steele & Green, 2005). Other studies, including one by Meredith et al. (1995), examined the motor component of the GCS and reported 59% sensitivity and 97% specificity rates in the ability of the motor score to predict outcomes. Therefore, these findings suggest the necessity of evaluating the relationship between the GCS total score and motor score. The present logistic regression analysis finds that the CPSCS exerts more significant influence on the prediction of mortality than the GCS does. However, as time increases after admission to the ICU, the difference between the two disappears between 48 hours and 72 hours after admission. This may lead us to conclude that the CPSCS applied to critical neurological patients is very important at its initial application, that is, at admission and within 24 hours after admission.

Limitations

The current study has several limitations. First, the goodness-of-fit of CPSCS and GCS are compared at the time of admission and, as a consequence, cannot present appropriate information on what happens afterwards. Second, we cannot generalize too much from our findings since we performed the survey on critical neurological patients only. To overcome these limitations, further research comparing the CPSCS and other severity test instruments is needed. We must also address how the lapse of time influences the severity grade of critical patients. Rovlias and Kotsou (2004) reported that age, GCS scores, and pupillary reactions were found to be the most significant variables in predicting patient outcomes. It is worthwhile to investigate whether age and eye responses have any bearing on the outcomes of critical neurological patients.

Conclusion

We find the outcome of the current research meaningful in that some basis for the clinical evaluation of nursing activities for critical neurological patients in ICU are presented. Nurses are in a pivotal position to provide support and education to family members of head-injured patients throughout the course of treatment. Nurses who take care of critical neurological patients should obtain and connect the resources and information of patients, provide support for their families, and be able to work often with other medical personnel to bring good results. A correct initial evaluation of patients may lead to good outcomes since it can help provide the correct information to the family and other medical team members.

Conflict of interest

The authors declare no conflict of interest.

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