ORIGINAL ARTICLE

NEUROLOGICAL SEVERITY CLASSIFICATION SYSTEM (CSN-SYSTEM) IN ADULTS WITH BTI, HOSPITAL CAYETANO HEREDIA, LIMA - PERU, 2020. PRELIMINARY STUDY

Sistema de clasificación de severidad neurológica (sistema CSN) en adultos con TEC, Hospital Cayetano Heredia, Lima, Perú, 2020. Estudio preliminar

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ABSTRACT

Objectives: Traumatic Brain Injury (TBI) is the disruption of brain function and architecture. The Glasgow Coma Scale (GCS) is the most widely used TBI severity classification; however, it assesses the functional status of the brain resulting from highly heterogeneous lesions and has little accuracy. The Neurological Severity Classification System (NSC System), a clinical-tomographic instrument designed to overcome lesion heterogeneity, assesses brain function and structure in determining the severity of BTI.
Methods: Observational, prospective, and cross-sectional study in adults with BTI from the emergency service of the Cayetano Heredia Hospital, April - August 2020. It included patients aged 18 years or older with acute BTI. The NSC system was compared with the GCS in the BTI classification.
Results: Of 29 patients, 82.76% were male and 82.76% were between 18 and 64 years old. The severity of the TBI through the NSC System was very mild 6.70%, mild 17.24%, moderate 51.72%, severe 17.24%, and critical 6.70%. There was an association between the NSC System and the Rotterdam Computed Tomographic Score (RCTS) (p = 0.005), a moderate positive correlation of the NSC System with the RCTS (Rho 0.6773, p = 0.0001), an association between the NSC System and the indication for neurosurgical intervention (p = 0.002), as well as high sensitivity-specificity in the distinction of severity categories with the NSC System, and lower GCS performance.
Conclusions: The NSC clinical-tomographic system improves the determination of the severity of BTI in comparison with GCS and provides an excellent relationship with the indication for neurosurgical intervention.
Keywords: *Brain Injuries, Traumatic, Brain, Glasgow Coma Scale, Functional Status (Source: MeSH NLM)*

RESUMEN

Objetivos: El traumatismo encéfalo craneano (TEC), es la disrupción de la función y arquitectura encefálica. La Escala del Coma de Glasgow (ECG) es la clasificación de severidad de TEC más utilizada; sin embargo, esta evalúa el estado funcional del encéfalo resultante de lesiones muy heterogéneas, y tiene poca exactitud. El Sistema de Clasificación de Severidad Neurológica (Sistema CSN), un instrumento clínico-tomográfico diseñado para superar la heterogeneidad lesional, evalúa la función y estructura encefálica en la determinación de severidad del TEC.
Métodos: Estudio observacional, prospectivo y transversal en adultos con TEC del servicio de emergencia del Hospital Cayetano Heredia, abril - agosto 2020. Incluyó pacientes de 18 años o más con TEC agudo. Se comparó el Sistema CSN con la ECG en la clasificación del TEC.
Resultados: De 29 pacientes, el 82.76% fue masculino y el 82.76% tuvo de 18 a 64 años. La severidad del TEC mediante el Sistema CSN fue: Muy leve 6.70%, leve 17.24%, moderado 51.72%, severo 17.24% y crítico 6.70%. Existió asociación entre el Sistema CSN y el Puntaje Tomográfico de Rotterdam PTCR (p=0.005), correlación positiva moderada del Sistema CSN con el PTCR (Rho 0.6773, p=0.0001), asociación entre el Sistema CSN y la indicación de intervención neuroquirúrgica (p=0.002), así como alta sensibilidad-especificidad en la distinción de categorías de severidad con el Sistema CSN; y un menor rendimiento de la ECG.
Conclusiones: El Sistema CSN clínico-tomográfico, mejora la determinación de severidad del TEC comparada con la ECG y brinda excelente relación con la indicación de intervención neuroquirúrgica.
Palabras clave*: Lesiones Traumáticas del encéfalo, Cerebro, Escala de Coma de Glasgow, Estado Funcional (Fuente: DeCS Bireme)*

https://doi.org/10.53668/2021.PJNS33253 Peru J Neurosurg 2021, 3 (3): 109-119

Submitted *: March 04, 2021*
Accepted *: June 29, 2021*
HOW TO CITE THIS ARTICLE: Castro E, Rodríguez R. Neurological Severity Classification System (CSN-System) in adults with BTI, Hospital Cayetano Heredia, Lima - Peru, 2020. Preliminary study. *Peru J Neurosurg 2021*; 3(3): 109-119. doi:10.53668/2021.PJNS33253

Trauma Brain Injury (TBI) is the disruption of the architecture and function of the brain as a result of the transmission of an external physical force to the skull, which can generate heterogeneous lesions and neurological deterioration.[1, 2]

The term "severe", frequently replaced by "severe", is used in TBI and applied to a life-threatening entity or one with significant complications.[3] Therefore, "severity" in TBI involves its relationship with the prognosis outcome or mortality. In this regard, there are clinical and tomographic instruments to classify the severity of TBI, but with limitations in its performance. These limitations arise from non-integrated evaluations (neurological and tomographic) of the brain and the absence of other variables of importance.[1] Saatman et al., highlight the heterogeneity of brain lesions in TBI as a barrier to achieving a reliable, efficient, and valid classification.[4]

The Glasgow Coma Scale (GCS) is the most widely used classification in TBI, but its categorization is arbitrary and with statistical limitations.[5] The initial study considered GCS scores from 14 to 15 as mild; from 8 to 13, as moderate; and from 3 to 7, as severe. This, due to clinical differences between scores 13 and 15 of the mild group.[5-9]

Transcendental in BTI is the association between severity and unfavorable outcomes or mortality. Genarelli et al., showed that increased GCS severity was associated with higher mortality.[10] However, Jolobe O., observed that in a group of patients with a GCS score of 15, 23% had an unfavorable result; many required neurosurgical intervention; 41% had abnormalities in the brain tomography (CT) and, of these, 27% required neurosurgical intervention. In addition, there was a superiority of the tomographic evaluation of the brain compared with that of the GCS in predicting morbidity and mortality due to TBI. Likewise, the image was associated with the indication for surgery. It was suggested that the tomographic evaluation of the brain and the criteria for the indication of neurosurgical intervention can provide significant information on severity and prognosis in TBI, with the GCS having limitations on this aspect.[11, 12]

Computed tomography evaluation of the brain is the gold standard for acute TBI; there is a prognostic system in TBI, superior to other models, called the Rotterdam Tomographic Score (PTCR) that includes some groups of non-hierarchical lesions and some specific structure.[5,13-15] Maas et al., showed that the displacement of the Interhemispheric Midline (MLD), cranial base cisterna collapse, and the presence of a specific hemorrhagic lesion on tomography, were associated with mortality; these constitute the Rotterdam model. [16] The PTCR shows that a greater number of intracranial injuries can determine greater mortality, with the occurrence of greater severity being implicit. Currently, In-Suk et al., Analyzed components of the GCS and PTCR, generating a new predictive model of mortality that surpasses its predecessors.[17]

In the previous context, an instrument with acceptable diagnostic validity of severity in TBI assesses the functionality and complete structure of the brain (lesion heterogeneity), corresponds to referential parameters (The Score PTCR and surgical indication), provides the highest possible sensitivity and specificity and comply with the definition of severity.[17]

With clinical and tomographic variables, the Neurological Severity Classification System (NSC System) allows determining the degree of severity (very mild, mild, moderate, severe, and critical) of TBI. The neurological clinical variables used are state of consciousness, language, pupillary dilation, and photoreactivity, corneal reflex, oculocephalogyrus reflex, respiratory pattern, motor response, and muscle strength in the hemibody. Their frequencies and associations with mortality in TBI were analyzed to rank them.[5, 10, 17-22]

The tomographic variables of the NSC System describe the state of the supra and infratentorial structures, conservation or deviation of the interhemispheric midline, and location of the brainstem or structures of the posterior cranial fossa. They evaluate the visibility or not of sulci of the convexity, cisternae, and ventricles. They determine whether there is blood in the grooves of the convexity, around the Falx and tentorium, or within cisterns, ventricles, or epidural-subdural spaces. Through the analysis of frequencies and associations with mortality in TBI, it was possible to rank them. [19, 23-40]

The research considers that the current severity classifications of the BTI are practical in their daily use in the emergency services, with acceptable sensitivity. However, they are clinical or tomographic evaluations, isolated and disaggregated, with low specificity that considerably affects their validity. Added to this is the evidence that the clinical situation, determined with some classification, does not correspond to the tomographic result and, above all, if there is sufficient argument to indicate neurosurgical intervention.

The NSC System aims to be a valid severity classification of TBI, which allows a better decision in neurosurgical management. Consequently, it is necessary to evaluate the performance of this new model compared to the GCS.

METHODS

The present study was observational, prospective, cross-sectional from a sample of patients with TBI from the emergency service of the Cayetano Heredia Hospital (CHH), April - August 2020.

The study population was all adult patients with TBI who were admitted to the Emergency Department of CHH between April and August 2020. The sample was non-probabilistic, made up of the total population, in compliance with the study criteria.

Inclusion and exclusion criteria:

The inclusion criteria were all patients with TBI, 18 years of age or older, and with a traumatic event of fewer than 24 hours (acute). The exclusion criteria were the following:

Table 1A: Types of variables, definition and their classification into categories according to the severity of the TBI. Cayetano Heredia National Hospital, Lima Peru, 2020.

VARIABLE	OPERATIONAL DEFINITION	CATEGORY
Severity of TBI with the NSC System	8 points	Very mild
	9-15 points	Mild
	16-55 points	Moderate
	56-75 points	Severe
	>75 points	Critical
Severity of TBI with GCS [5,27]	3-8 points	Mild
	9-13 points	Moderate
	14-15 points	Severe
Score TC Rotterdam [5.16]	Score obtained	1-6
Indication of neurosurgical intervention	Need for surgery to treat TBI, determined by the neurosurgeon team	Yes
	No need for surgery to treat TBI, determined by the neurosurgeon team	No

polytraumatized patient with a high risk of life, of non-neurological origin, with a motor deficit of extremities of spinal trauma origin, the low effect of substances that depress the functioning of the NSC, and with comorbidity that causes disorder of consciousness or respiratory.

Procedures and techniques

Acute traumatic injury patients admitted to the CHH emergency department received multidisciplinary care by a neurosurgeon, general surgeon, chest surgeon, and others, after which TBI patients who met the study criteria were identified.

To classify the severity of TBI, the GCS and the NSC System were compared, using as comparative parameters the relationship of both with the prognosis (PTCR) and the indication for neurosurgical intervention for the cases under study. *(Table 1A)*

Informed consent and a data collection form with the demographic variables, NSC System *(Table 1B),* GCS, and PTCR were applied to the participants.

Frequency tables were made for information management and analysis with Stata 16.0 (Pearson's Chi-Square, Fisher's Exact, Rho Spearman, and Logistic Regression).

RESULTS

The study population consisted of 29 patients with TBI, after meeting the inclusion and exclusion criteria. Thus, 82.76% were male and 17.24% were female. 82.76% were between 18 and 64 years old; while 17.24%, from 65 to more years. *(Table 1C)*

The percentages of the population according to the severity categories in the GCS were: 44.83% (n = 13) for the mild grade; 41.38% (n = 12) moderate; and 13.79% (n = 4) severe. The percentages according to severity categories in the NSC System were: 6.70% (n = 2) for very mild; 17.24% (n = 5) mild; 51.72% (n = 15) moderate; 17.24% (n = 5) severe; and 6.70% (n = 2) for the critical grade. *(Table 2) (Fig 1)*

Table 1C: Demographic characteristics of the population and classification of severity of TBI with the GCS. Cayetano Heredia National Hospital, Lima Peru, 2020.

VARIABLES		GCS			SUBTOTAL n (%)	TOTAL n
		MILD	MODERATE	SEVERE		
Sex	Male	11	9	4	24 (82.76)	29
	Female	2	3	0	5 (17.24)	
Age	18-64 years	11	9	4	24 (82.76)	29
	>= 65 years	2	3	0	5 (17.24)	

Source: *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital*

Table 1B: Neurological Severity Classification System (NSC). Cayetano Heredia Hospital, Lima Peru, 2020.

NEUROLOGICAL SEVERITY CLASSIFICATION SYSTEM					INICIAL VALUE	COEFICIENT MULTIPLY	POINTS
SUBSYSTEM OF NEUROLOGIC EVALUATION	NEUROLOGIC STATE	CONSCIOUSNESS STATE	ALERT		1	1	
			SOMNOLENCE		2	1	
			ESTUPOR		3	1	
			COMMA		4	1	
		LANGUAJE	COHERENTE		1	1	
			NO COHERENTE O SOUNDS		2	1	
			SPEECHLESS		3	1	
		PUPILS: DILATION AND REACTIVITY	ISOCORIC AND REACTIVES		1	1	
			UNILATERAL MIDRIASIS HIPO OR NOT REACTIVE		2	1	
			BILATERAL MIDRIASIS, HIPO OR NOT REACTIVE		3	1	
		CORNEAL REFLEX	PRESENT		1	1	
			AUSENT	UNILATERAL	2	1	
				BILATERAL	3	1	
		OCULOCEFALOGIRUS REFLEX	PRESENT		1	1	
			AUSENT	UNILATERAL	2	1	
				BILATERAL	3	1	
		CENTRAL RESPIRATORY PATTERN	REGULAR RYTHM		1	1	
			IRREGULAR RYTHMO TAQUIPNEIC		2	1	
		MOTOR RESPONSE	OBEYS COMMAND		1	1	
			LOCALISES PAIN		2	1	
			WITHDRAWS FROM PAIN		3	1	
			FLEXION RESPONSE TO PAIN		4	1	
			EXTENSION RESPONSE TO PAIN		5	1	
			NO MOTOR RESPONSE		6	1	
		STRENGHT IN HEMIBODIES	NORMAL		1	1	
			UNILATERAL ABNORMAL		2	1	
			BILATERAL ABNORMAL		3	1	
SUBSYSTEM OF TOMOGRAPHIC EVALUACION OF BRAIN	STATE OF BRAIN PARENQUIMA (SEARCH OF INTRACEREBRAL HEMORRHAGE OR ISQUEMIA)	ICH CEREBRAL HEMISPHERES	NO EVIDENT LESION		0	1	
			ONE HEMORRHAGE FOCUS		1	1	
			MORE THAN ONE FOCUS OF HEMORRHAGE		2	1	
			LMD	NO	0	1	
				1-5mm	1	1	
				6-15mm	2	1	
				>15mm	3	1	
		ICH BASAL GANGLIA	NO EVIDENT LESION		0	2	
			UNILATERAL		1	2	
			BILATERAL		2	2	
		ICH CEREBELLUM	NO EVIDENT LESION		0	3	
			UNILATERAL		1	3	
			BILATERAL		2	3	
		ICH DIENCEPHALUM	NO EVIDENT LESION		0	4	
			UNILATERAL		1	4	
			BILATERAL		2	4	
		ICH MIDBRAIN	BRAINSTEM HEMORRHAGE	MEDIAL	0	5	
				LATERAL	1	5	
			NO EVIDENT LESION			5	
			ANTERIOR REGION			5	
			POSTERIOR REGION			5	
			ANTERIOR AND POSTERIOR			5	
		ICH BULB AND PONT	NO EVIDENT LESION		0	6	
			ANTERIOR REGION		1	6	
			POSTERIOR REGION		2	6	
			ANTERIOR AND POSTERIOR		3	6	
	VISIBILITY OF INTRACRANIAL SPACES (SEARCH FOR OPENING OR CLOSURE OF NATURAL SPACES)	SULCAL WIDTH	VISIBLE SPACES		0	1	
			NO VISIBLE IN SMALL AREA OF CONVEXITY		1	1	
			NO VISIBLES IN HALF OR TOTAL OF CONVEXITY		2	1	
		CISTERNAL WIDTH	MAGNUM CISTERN	VISIBLE	0	2	
				NO VISIBLE (PARCIAL-TOTAL)	1	2	
			SUPRASELAR/SILVIANA	VISIBLE	0	2	
				NO VISIBLE (PARCIAL-TOTAL)	2	2	
			PERIMESENCEPHALIC	VISIBLE	0	2	
				NO VISIBLE (PARCIAL-TOTAL)	3	2	
			PONTOBULBAR	VISIBLE	0	2	
				NO VISIBLE (PARCIAL-TOTAL)	4	2	
		VENTRICULAR WIDTH	I-II	VISIBLES	0	3	
				1 NO VISIBLE (PARCIAL-TOTAL)	1	3	
				2 NO VISIBLES (PARCIAL-TOTAL)	2	3	
			III	VISIBLE	0	3	
				NO VISBLE (PARCIAL-TOTAL)	3	3	
			IV	VISIBLE	0	3	
				NO VISIBLE (PARCIAL-TOTAL)	4	3	
	VISIBILITY OF HEMORRHAGE IN INTRACRANIAL NATURAL SPACES (SEARCH OF SUBARACHNOID, INTRAVENTRICULAR, EPIDURAL Y SUBDURAL HEMORRHAGE)	SULCAL IN SAH	CONVEXITY	ABSENT	0	1	
				HEMORRHAGE PRESENT	1	1	
		FALX SAH	INTERHEMISPHERIC	ABSENT	0	1	
				HEMORRHAGE PRESENT	2	1	
		TENTORIAL SAH	TENTORIAL	ABSENT	0	1	
				HEMORRHAGE PRESENT	2	1	
		CISTERNAL SAH	MAGNUM CISTERN	ABSENT	0	2	
				HEMORRHAGE PRESENT	1	2	
			SUPRASELAR/SILVIANA	ABSENT	0	2	
				HEMORRHAGE PRESENT	2	2	
			PERIMESENCEPHALIC	ABSENT	0	2	
				HEMORRHAGE PRESENT	3	2	
			PONTOBULBAR	ABSENT	0	2	
				HEMORRHAGE PRESENT	4	2	
		IVH	I-II	ABSENT	0	3	
				HEMORRHAGE PRESENT	1	3	
			III	ABSENT	0	3	
				HEMORRHAGE PRESENT	2	3	
			IV	ABSENT	0	3	
				HEMORRHAGE PRESENT	3	3	
		EPIDURAL AND SUBDURAL HEMORRHAGE	SUPRATENTORIAL	ABSENT	0	4	
				IN 1 QUADRANT	1	4	
				IN 2 QUADRANTS	2	4	
				IN 3 QUADRANTS	3	4	
				IN 4 QUADRANTS	4	4	
			INFRATENTORIAL	ABSENT	0	4	
				IN 1 QUADRANT	2	4	
				IN 2 QUADRANTS	3	4	
				IN 3 QUADRANTS	4	4	
				IN 4 QUADRANTS	5	4	
TOTAL, POINTS							##

Source: *Authorship of the researchers. ICH: Intracerebral Hemorrhage. SAH: Subarachnoid Hemorrhage. IVH: Intraventricular Hemorrhage. MLD: Middle Line Deviation*

Table 2: Severity classification of TBI (GCS and NSC System). Cayetano Heredia National Hospital, 2020

SCALE THE SYSTEM		SUBTOTAL n (%)	TOTAL n
GCS	Mild	13 (44.83)	29
	Moderate	12 (41.38)	
	Severe	4 (13.79)	
NSC system	Very mild	2 (6.90)	29
	Mild	5 (17.24)	
	Moderate	15 (51.72)	
	Severe	5 (17.24)	
	Critical	2 (6.90)	

Source: *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital*

The NSC System variables associated with severity (p <0.05) determined by the GCS were: state of consciousness (p = 0.002), coherence of language (p <0.001), pupillary dilation and reactivity (p = 0.010), the oculocephalogyrus reflex (p = 0.015), the respiratory pattern (p = 0.002), the motor response (p = 0.001), the muscular strength in the hemibodies (p = 0.006), the amount of lesions in the cerebral hemispheres (p = 0.010), the MLD (p = 0.045), the collapse of suprasellar / silvian cisterns (p = 0.031) and perimesencephalic (p = 0.042), in addition to the collapse of the lateral ventricles (p = 0.012). *(Table 3)*

When looking for a relationship between TBI classification models and prognosis, no association was found between the GCS and PTCR categories (p = 0.193). On the contrary, there was an association between the categories of the NSC System and PTCR (p = 0.005). *(Table 4)*

Furthermore, a moderate negative correlation (Rho Spearman -0.5687, p = 0.0013) was found between GCS and PTCR. On the other hand, a moderate positive correlation (Rho Spearman 0.6773, p = 0.0001) was found between the NSC System and the PTCR.

The evaluation of the indication or not for neurosurgical intervention for the cases in this study, carried out by the team of neurosurgeons, determined the existence of a relationship with one of the two severity classification models in TBI. Thus, the results showed an association between the NSC System and the indication for neurosurgical intervention (p = 0.002). Whereas there was no association between the GCS and the indication for neurosurgical intervention (p = 0.058). *(Table 5) (Fig 2)*

In the comparative evaluation of the diagnostic performance of both classification models for the severity of TBI, notable distinctive characteristics were evidenced in sensitivity, specificity, likelihood ratios, and global index.

When comparing both classifications of the severity of the TBI, it was obtained that the NSC System offers greater sensitivity and specificity (both close to 100%), acceptable values of negative likelihood ratio in the desired intervals, excellent areas under the COR curve (ABC = 1) and higher values in global performance (YI = 1) than the evaluation according to the GCS. *(Table 6)*

Table 4: Classification of severity of TBI (GCS and NSC System) and PTCR. Cayetano Heredia National Hospital, 2020.

SCALE OR SEVERITY SYSTEM	SEVERITY CATEGORY	TC ROTTERDAM SCORE						TOTAL n	p-VALUE*
		1	2	3	4	5	6		
GCS	Mild	4	4	2	2	1	0	13	0.193
	Moderate	0	2	3	4	2	1	12	
	Severe	0	0	0	2	2	0	4	
NSC system	Very mild	2	0	0	0	0	0	2	0.005
	Mild	1	4	0	0	0	0	5	
	Moderate	1	1	3	7	2	1	15	
	Severe	0	1	2	0	2	0	5	
	Critical	0	0	0	1	1	0	2	

Source: *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital.* GCS*: Glasgow Coma Scale. NSC System: Neurological Severity Classification System. PTCR: Rotterdam Computer Tomographic Score. *P-value of applying the Fisher's* test *(significant value: p<0.05)*

Table 3: Variables of the NSC System and TBI Severity Classification with GCS

VARIABLES			GCS			TOTAL	p-VALOR*
			MILD	MODERATE	SEVERE	n	
CONSCIOUSNESS STATE	ALERT		7	2	0	9	0.002
	SOMNOLENCE		6	7	0	13	
	ESTUPOR		0	2	3	5	
	COMMA		0	1	1	2	
LANGUAJE	COHERENTE		12	7	0	19	0.000
	NO COHERENTE O SOUNDS		1	5	0	6	
	SPEECHLESS		0	0	4	4	
PUPILS: DILATION AND REACTIVITY	ISOCORIC AND REACTIVES		12	11	1	24	0.010
	UNILATERAL MIDRIASIS HIPO OR NOT REACTIVE		1	1	2	4	
	BILATERAL MIDRIASIS, HIPO OR NOT REACTIVE		0	0	1	1	
CORNEAL REFLEX	PRESENT		13	12	3	28	0.138
	AUSENT	UNILATERAL	0	0	1	1	
		BILATERAL	0	0	0	0	
OCULOCEFALOGIRUS REFLEX	PRESENT		13	12	2	27	0.015
	AUSENT	UNILATERAL	0	0	1	1	
		BILATERAL	0	0	1	1	
CENTRAL RESPIRATORY PATTERN	REGULAR RYTHM		13	11	1	25	0.002
	IRREGULAR RYTHMO TAQUIPNEIC		0	1	3	4	
MOTOR RESPONSE	OBEYS COMMAND		12	6	0	18	0.001
	LOCALISES PAIN		1	6	2	9	
	WITHDRAWS FROM PAIN		0	0	1	1	
	FLEXION RESPONSE TO PAIN		0	0	0	0	
	EXTENSION RESPONSE TO PAIN		0	0	0	0	
	NO MOTOR RESPONSE		0	0	1	1	
STRENGHT IN HEMIBODIES	NORMAL		11	4	1	16	0.006
	UNILATERAL ABNORMAL		2	8	2	12	
	BILATERAL ABNORMAL		0	0	1	1	
ICH CEREBRAL HEMISPHERES	NO EVIDENT LESION		7	2	3	12	0.010
	ONE HEMORRHAGE FOCUS		3	0	0	3	
	MORE THAN ONE FOCUS OF HEMORRHAGE		3	10	1	14	
	LMD	NO	10	5	1	16	0.045
		1-5mm	2	5	0	7	
		6-15mm	1	2	2	5	
		>15mm	0	0	1	1	
ICH BASAL GANGLIA	NO EVIDENT LESION		11	10	3	24	0.818
	UNILATERAL		1	0	0	1	
	BILATERAL		1	2	1	4	
ICH CEREBELLUM	NO EVIDENT LESION		13	10	4	27	0.424
	UNILATERAL		0	2	0	2	
	BILATERAL		0	0	0	0	
ICH DIENCEPHALON	NO EVIDENT LESION		13	10	3	26	0.175
	UNILATERAL		0	0	0	0	
	BILATERAL		0	2	1	3	
ICH MIDBRAIN	BRAINSTEM HEMORRHAGE	MEDIAL	11	10	1	22	0.071
		LATERAL	2	2	3	7	
	NO EVIDENT LESION		13	12	3	28	0.138
	ANTERIOR REGION		0	0	0	0	
	POSTERIOR REGION		0	0	1	1	
	ANTERIOR AND POSTERIOR		0	0	0	0	
ICH BULB AND PONT	NO EVIDENT LESION		13	12	4	29	-
	ANTERIOR REGION		0	0	0	0	
	POSTERIOR REGION		0	0	0	0	
	ANTERIOR AND POSTERIOR		0	0	0	0	
SULCAL WIDTH	VISIBLE SPACES		3	0	0	3	0.387
	NO VISIBLE IN SMALL AREA OF CONVEXITY		3	3	0	6	
	NO VISIBLES IN HALF OR TOTAL OF CONVEXITY		7	9	4	20	
CISTERNAL WIDTH	MAGNUM CISTERN	VISIBLE	13	11	3	27	0.133
		NO VISIBLE (PARCIAL-TOTAL)	0	1	1	2	
	SUPRASELAR/SILVIANA	VISIBLE	8	2	0	10	0.031
		NO VISIBLE (PARCIAL-TOTAL)	5	10	4	19	
	PERIMESENCEPHALIC	VISIBLE	8	3	0	11	0.042
		NO VISIBLE (PARCIAL-TOTAL)	5	9	4	18	
	PONTOBULBAR	VISIBLE	12	11	2	25	0.168
		NO VISIBLE (PARCIAL-TOTAL)	1	1	2	4	
VENTRICULAR WIDTH	I-II	VISIBLES	9	2	0	11	0.012
		1 NO VISIBLE (PARCIAL-TOTAL)	1	5	3	9	
		2 NO VISIBLES (PARCIAL-TOTAL)	3	5	1	9	
	III	VISIBLE	9	6	0	15	0.062
		NO VISBLE (PARCIAL-TOTAL)	4	6	4	14	
	IV	VISIBLE	13	10	3	26	0.175
		NO VISIBLE (PARCIAL-TOTAL)	0	2	1	3	
SULCAL IN SAH	CONVEXITY	ABSENT	7	4	0	11	0.144
		HEMORRHAGE PRESENT	6	8	4	18	
FALX SAH	INTERHEMISPHERIC	ABSENT	12	8	4	24	0.239
		HEMORRHAGE PRESENT	1	4	0	5	
TENTORIAL SAH	TENTORIAL	ABSENT	13	9	3	25	0.129
		HEMORRHAGE PRESENT	0	3	1	4	
CISTERNAL SAH	MAGNUM CISTERN	ABSENT	13	12	4	29	-
		HEMORRHAGE PRESENT	0	0	0	0	
	SUPRASELAR/SILVIANA	ABSENT	13	12	3	28	0.138
		HEMORRHAGE PRESENT	0	0	1	1	
	PERIMESENCEPHALIC	ABSENT	13	12	3	28	0.138
		HEMORRHAGE PRESENT	0	0	1	1	
	PONTOBULBAR	ABSENT	13	12	4	29	-
		HEMORRHAGE PRESENT	0	0	0	0	
IVH	I-II	ABSENT	13	11	3	27	0.133
		HEMORRHAGE PRESENT	0	1	1	2	
	III	ABSENT	13	10	3	26	0.132
		HEMORRHAGE PRESENT	0	1	1	2	
	IV	ABSENT	13	9	3	25	0.129
		HEMORRHAGE PRESENT	0	3	1	4	
EPIDURAL AND SUBDURAL HEMORRHAGE	SUPRATENTORIAL	ABSENT	8	6	1	15	0.143
		IN 1 QUADRANT	4	4	0	8	
		IN 2 QUADRANTS	1	2	3	6	
		IN 3 QUADRANTS	0	0	0	0	
		IN 4 QUADRANTS	0	0	0	0	
	INFRATENTORIAL	ABSENT	11	12	4	27	1.000
		IN 1 QUADRANT	1	0	0	1	
		IN 2 QUADRANTS	1	0	0	1	
		IN 3 QUADRANTS	0	0	0	0	
		IN 4 QUADRANTS	0	0	0	0	

Source: *Database of the Neurosurgery Service of the Cayetano Heredia Hospital. GCS: Glasgow Coma Scale. NSC System: Neurological Severity Classification System. * P-value of applying Pearson's Chi-Square test, or failing that, Fisher's Exact Test when the former was not applicable (significant value: p <0.05)*

Table 5: Classification of TBI severity (GCS and NSC System) and indication of neurosurgical intervention. Cayetano Heredia National Hospital. 2020.

SCALE OR SEVERITY SYSTEM	CATEGORY OF SEVERITY	INDICATION OF NEUROSURGICAL INTERVENTION		TOTAL n	p-VALUE*
		yes	no		
GCS	Mild	4	9	13	0.058
	Moderate	9	3	12	
	Severe	3	1	4	
NSC system	Very mild	0	2	2	0.002
	Mild	0	5	5	
	Moderate	10	5	15	
	Severe	5	0	5	
	Critical	1	1	2	

Source: *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital. *P-value of applying the Fisher's test (significant value: p<0.05). GCS: Glasgow Coma Scale. NSC: Neurological Severity Classification System.*

DISCUSSION

TBI is more frequent in males, and the most prevalent age group is 18 and 64 years old, findings that were evidenced in this study. These findings are comparable to those reported by some authors, who also report that male and adult patients are the largest groups in TBI.[41-43] (Table 1C)

Regarding severity, in our study, the highest percentage (44.83%) was mild BTI according to the GCS; but according to the NSC system, the highest percentage was moderate (51.72%), with the groups being very mild and mild 23.94%. Savioli et al. cited, from other studies, an incidence of 75% of mild TBI with the GCS, being the predominant severity group, like that found in this study.[44]

The GCS used to evaluate the severity of TBI, in its "mild" category, clinically groups patients with or without evidence of cranioencephalic lesions on tomographic images. In this regard, Jolobe11 questioned whether the GCS can correctly classify a patient with TBI, as it presents difficulties in matching the brain lesions; especially if it is "mild" and occurs in older adults. However, the NSC system has generated a category called "very mild" for those patients with TBI who clinical or tomographic evidence of injury do not have, to differentiate them from those "mild" that may show some clinical and/or tomographic alteration in the TBI. In the same way, the NSC system distinguishes the "critical" category for those patients with TBI with clinical and tomographic evidence of lesions that manifest with little-no response to stimuli, and extensive multiple affected brain structures, respectively. All this explains the severity discrepancy between the GCS and NSC system classifications.

Table 6: Characteristics of the receiver operating curve for the GCS and the NSC System. Cayetano Heredia National Hospital. 2020.

SCALE OR SEVERITY SYSTEM		CUT-OFF POINT			RECEIVER OPERATING CURVE			YOUDEN INDEX (S+E)-1
		Sensitivity	Specificity	Likelihood Ratio	Area	Standar Deviat.	IC 95%	
GCS	Score 13	6.25%	0.00%	RV+ 0.0625	1.00	0.00	1.00	-0.94
	Score 8	50.0%	0.00%	RV+ 0.5000	1.00	0.00	1.00	-0.50
NSC system	Score 19	100.00%	100.00%	RV- 0.0000	1.00	0.00	1.00	1.00
	Score 56	100.00%	100.00%	RV- 0.0000	1.00	0.00	1.00	1.00

Source: *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital. GCS: Glasgow Coma Scale. NSC System: Neurological Severity Classification System.*

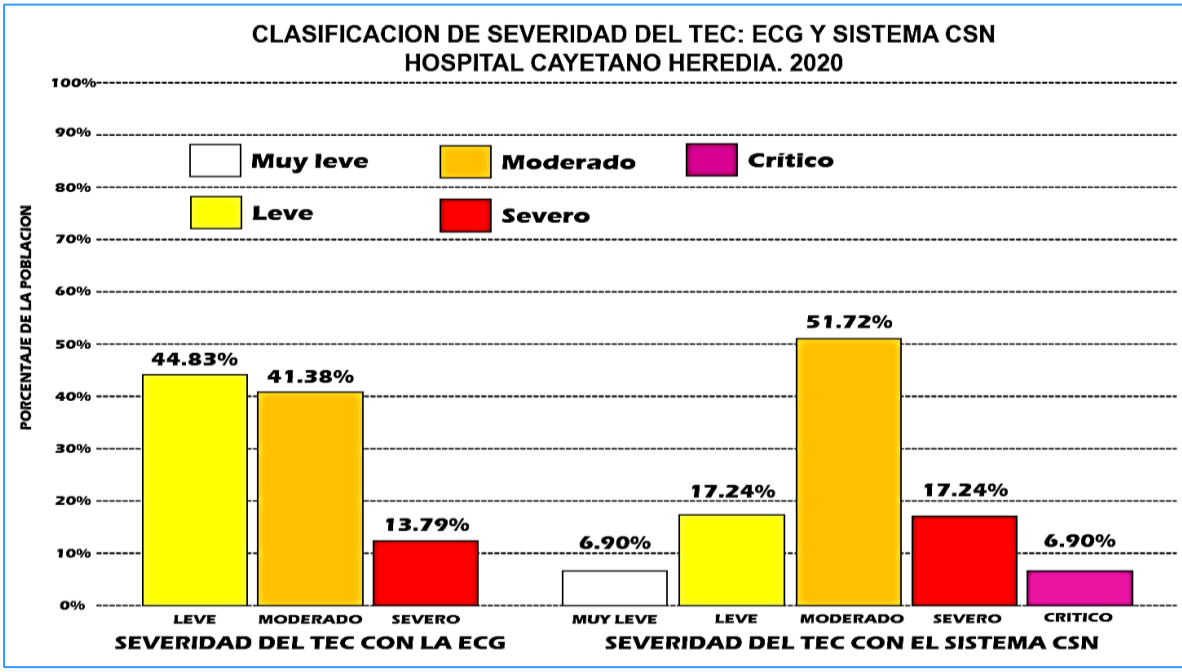

Fig 1: Classification of severity of the TBI (by GCS and NSC System). Cayetano Heredia Hospital, 2020. (***Source:*** *Database from the Neurosurgery Service of the Cayetano Heredia National Hospital. GCS: Glasgow Coma Scale. CSN System: Neurological Severity Classification System.)*

In various publications on TBI, the association between clinical manifestations and/or brain structural alterations with the survival or mortality of these patients has been determined, which suggests a lesser or greater severity of the TBI. However, some of these alterations have been little studied or are not part of a group of variables in the severity classifications of TBI.[10,16,18,19,21,22,24-26] The inclusion of these and other variables in The NSC System improves its sensitivity and specificity in determining the severity of TBI, thus systematizing the functional and structural evaluation of the brain.

Thus, it is established that the state of consciousness, according to Ropper,[5] is related to the lateral displacement of the brain due to a mass; this was found to be significant in TBI and was associated with its severity. Likewise, a manifestation of acute brain injury is the alteration of the coherence of language, which is a subtle deficit of the same that is associated with the severity of the TBI and, according to some authors, also related to mortality. This was evidenced by In-Suk et al. when using the verbal response parameter of the GCS to predict TBI results.[3,20,45,46]

Pupillary diameter and photoreactivity, as well as the oculocephalogyrus reflex, are related to the function of the brainstem, being of great prognostic value.10 In the same way, the abnormal respiratory pattern of central origin can predict poor results.[22] In our study, these signs were found to be associated with the severity of the TBI. Another parameter in the research is the motor response, which is associated with the severity of the TBI and mortality, the latter being demonstrated by Colohan et al.10 Also, the alteration of the muscular strength in the hemibodies is related to the severity of the TBI, being a manifestation of unilateral or bilateral encephalic lesions of the motor pathway.[5]

On the other hand, Chesnut et al.[10], on prognostic indicators in TBI, found that multifocal lesions in the cerebral hemispheres, MLD, and cisternal and ventricular collapses were associated with unfavorable results. The same structures have been associated with severity in this study, to which is added the collapse of the lateral ventricles.

Finally, it is still necessary to investigate whether some specific injuries due to TBI, in structures that include the posterior cranial fossa, are associated with greater severity. This, even though it has been shown in some series that the rate of poor results exceeds 50%. [39,40]

In general, the characteristics of the NSC system *(Table 1B)* in classifying the severity of TBI are: Use prognostic outcome variables, evaluate the function, and complete structure of the brain, associate referential parameters (PTCR and indication for neurosurgical intervention), have high diagnostic sensitivity and specificity, and correspond to the definition of severity.[1-4,17] The study showed that the NSC system is superior to the GCS in the characteristics described above.

The severity of TBI according to the GCS is not related to the number of abnormal findings in the brain categorized using the PTCR, as found in our study. (Perhaps it could be due to the reduced number of cases).

However, the severity categories of the NSC system are associated with the number of brain alterations categorized by the PTCR prognostic system, and there is also the possibility of association with the percentage of mortality of the PTCR categories. The latter must be confirmed with the respective prognostic study.

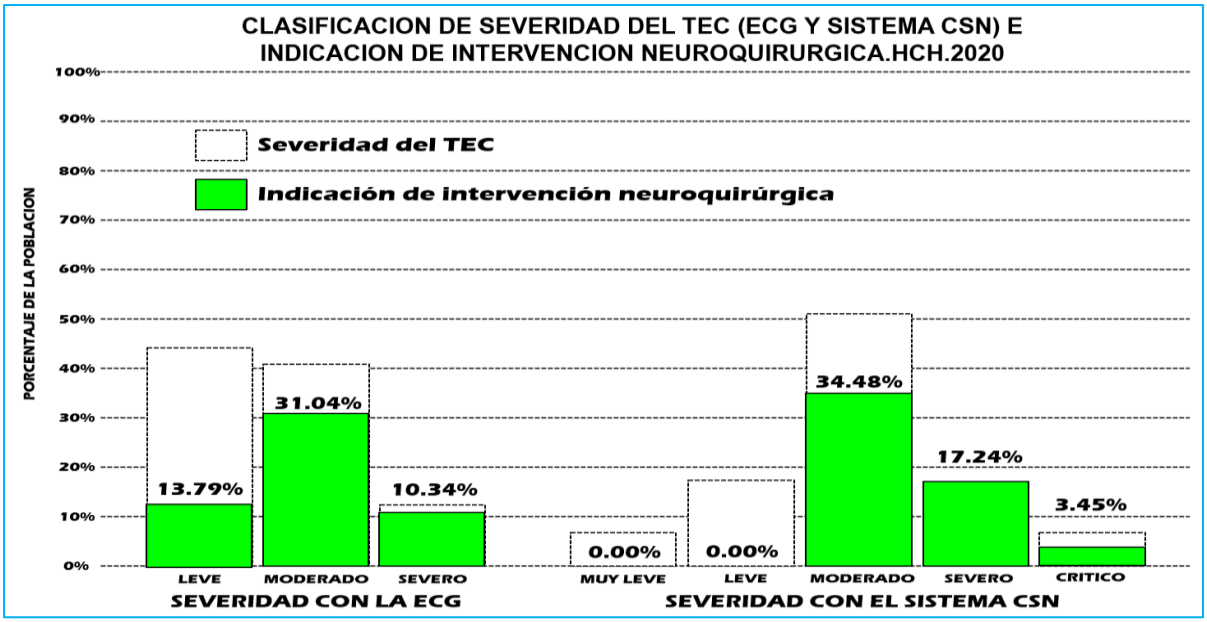

Fig 2: Classification of severity of TBI (by GCS and NSC System) and indication for neurosurgical intervention. HCH. 2020. (***Source**: Database of the Neurosurgery Service of the Cayetano Heredia National Hospital. GCS: Glasgow Coma Scale. NSC System: Neurological Severity Classification System.)*

In this regard, Maas et al.,[16] determined that the sum of some structural alterations in the brain as a result of a TBI causes greater mortality. They estimated that each category in their system (PTCR), in ascending order, had an estimated mortality risk of 0%, 6.8%, 16%, 26%, 53%, and 61%. Now, if these findings on mortality can be associated with a classification of severity of the TBI (such as the NSC system), said the system would fulfill the role for which it was designed according to the definition of severity, which is to identify the status of the potentially fatal TBI.[3] The foregoing has also been demonstrated in multiple publications, such as those made by Genarelli and Fearnside, 10 where severity and mortality are associated. This relationship of the NSC system with a prognostic system, unlike the GCS, gives it greater suitability as a TBI classification system.

In the correlation of the GCS with the PTCR, a moderate negative correlation was obtained. On the other hand, a moderate positive correlation was found in the correlation between the NSC system and the PTCR. These results show the existence of a correlation between both TBI severity classification systems with the PTCR, with a greater magnitude that favors the NSC System; Thus, it is indirectly demonstrated that the severity and mortality determined by a prognostic system in TBI can be related; condition required in the definition of severity.[3] In this way, lower GCS scores and higher scores from the NSC System correspond to a higher PTCR score and, with probable higher mortality.

The PTCR tries, in a simple way, to systematize the heterogeneity of lesions produced by the TBI using only the brain tomography.[16] Likewise, the NSC system has achieved the systematization of said lesional heterogeneity of the brain structure to which it adds the clinical systematization of brain function and verifying that the entire construct shows a significant correlation with the PTCR. A similar system was devised by In-Suk et al.,[20] using the GCS and PTCR, but with prognostic utility and not classifying severity. The clinical-tomographic model called the NSC System, created to classify the severity of TBI has an indisputable correspondence with the PTCR tomographic system and the same possibility of becoming a prognostic scale, the latter not being the objective of the investigation, and for which a prospective study is required in the future.

Regarding the association with an indication for neurosurgical intervention, our study found that there was an association between the NSC System and the indication for neurosurgical intervention. Whereas there was no association between the GCS and the indication for neurosurgical intervention. *(Table 5) (Fig 2)*

The results show that the severity classification of the TBI, through the NSC System, helps in the surgical decision. Well, the moderate and severe TBI groups frequently required emergency neurosurgical intervention due to their severity. This could not be replicated with the GCS in this investigation, since the emergency neurosurgical intervention occurred, indistinctly, in any of its categories (including "mild"). Similarly, the results of the Jolobe study[11] showed that, within a group of mild TBI classified by GCS, 41% had visible brain lesions on tomography and, of this, 27% required neurosurgical intervention, similar results in this study they disfavor the use of GCS in this regard. In this sense, the NSC System can distinguish, with better precision, the severity of the patient with TBI that warrants emergency neurosurgical intervention.

According to the study, at the cut-off points relative to the GCS categories, the sensitivity and specificity values were 50% and 0%, respectively. On the contrary, these values reached 100% in the analogous categories of the NSC

System, for both parameters. *(Table 6)* Theoretically, an ideal diagnostic test has 100% sensitivity and specificity values, which allows it to correctly identify whether or not a subject belongs to a certain category (severity, if it is the study); This was evidenced with the NSC System.47 Likewise, when applying the Youden Index (YI) to the previous data, the value of one (YI = 1) was obtained in the cut-off points of the NSC System categories, which means better global performance compared to the corresponding one of the GCS, whose YI were <0.[48] *(Table 6)*

Analyzing the probability ratios for both study models, the positive likelihood ratios (RV +) less than two (RV + <2) determine that a test has poor utility to guarantee the correct inclusion in a category (of severity, according to the study) versus its incorrect inclusion. Therefore, its value is required to be five or more (> = 5) for a test to be good or highly relevant; this did not occur with the GCS. (Table 6) On the other hand, the negative likelihood ratio (RV-) determines the incorrect inclusion of a severity category (different from the real one) compared to its correct inclusion; therefore, values less than 0.1 (RV- <0.1) of a test guarantee that this does not happen. The NSC system achieved this condition, which is highly relevant.[47,49] *(Table 6)*

On the other hand, the area under the COR curve, relative to certain categories of the classification models understudy, did not contribute to differences. However, this area was better delimited with the NSC System due to the numerous cut-off points that include high specificity.

CONCLUSIONS

The NSC System is a clinical-tomographic, systematized, and comprehensive instrument for evaluating the brain applied to acute TBI, which is associated and corresponds to prognostic outcome parameters, according to what is defined as severity in TBI. It distinguishes five categories of severity in TBI, of which some are associated with a greater need for emergency neurosurgical intervention.

The NCS system has high sensitivity and specificity in the determination of severity in TBI, compared to GCS, becoming a useful classification model that improves the determination of the severity of TBI, in addition to providing an excellent relationship with the indication for neurosurgical intervention. However, further studies are required to apply this severity model in a larger population to better determine its characteristics and refine its construct.

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Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Authors Contributions
Conception and design: All the authors. *Drafting the article:* Castro E. Critically revising the article: Rodriguez R. *Reviewed submitted version of manuscript:* Castro E. *Approved the final version of the manuscript on behalf of all authors: Rodriguez R.*

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PERUVIAN JOURNAL OF NEUROSURGERY
Vol 3 | Issue 4 | Oct-Dec 2021
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