Comparison of Alert, Response to Verbal Stimulus, Response to Pain, Unresponsive (AVPU) Scale with Pediatric Glasgow Coma Scale for Assessing Level of Consciousness in Infants and Children

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Citation

Prakash B, Shrestha NJ, Prakash K, Sah SK, Prakash P, Raymajhi A. Comparison of Alert, Response to Verbal Stimulus, Response to Pain, Unresponsive (AVPU) Scale with Pediatric Glasgow Coma Scale for Assessing Level of Consciousness in Infants and Children. *Kathmandu Univ Med J.* **Online First.**

ABSTRACT

Background

Altered consciousness is a neurological emergency in pediatrics, with high morbidity and mortality. The Pediatric Glasgow Coma Scale (pGCS) is commonly used to assess altered sensorium in children. The Alert, Verbal, Pain, Unresponsive (AVPU) scale is a simple and easy-to-use alternative assessment tool that records patient response to verbal, painful stimuli, and unresponsiveness.

Objective

To compare the effectiveness of the Alert, Verbal, Pain, Unresponsive with the pediatric glasgow coma scale in assessing conscious level in infant and children with altered sensorium.

Method

This hospital-based observational study was conducted in Kanti Children's Hospital, Maharajgunj, Kathmandu Nepal, for 12 months. All children aged from 2 months to 14 years with altered sensorium in the emergency department and pediatric intensive care unit (PICU), who met inclusion criteria, were enrolled and assessed using AVPU and pGCS scales.

Result

The study included 55 cases, with a male-to-female ratio of 1.2:1. Most cases (60%) were under 5 years old, with a mean age of 2.16 years. Infectious origin was the most common etiology (64%), where meningitis was the most common diagnosis (38%). AVPU and pGCS scores varied based on patient response: A/V/P/U of AVPU scale corresponded with mean pGCS score of 14, 12.5, 9.29 and 3.80 respectively.

Conclusion

After the statistically comparison, it was significantly easier to use AVPU scale for assessing conscious level in infants and children at peripheral and tertiary centers with busy emergency departments as compared to the pGCS scale.

KEY WORDS

Alert, response to verbal stimulus, response to pain, unresponsive scale (AVPU), Glasgow coma scale, Level of consciousness, Pediatric glasgow coma scale

INTRODUCTION

Coma is an alteration of consciousness in which a child appears to be asleep, cannot be aroused, and shows no awareness of the environment.[1] In Pediatric population altered consciousness is a neurological emergency associated with high morbidity and mortality. Studies have reported a high incidence of coma in children, with 30 per 100,000 under the age of two years and 40 per 100,000 between two and sixteen years.[2-4] Children receiving medical treatment within six hours are only 15% that have good or moderate recovery, otherwise 61% dies or 12% remains in vegetative state.[5]

GCS scale is most commonly used method to assess conscious level as validated in many studies.[5-8] Although the GCS has not been validated as a prognostic scoring system for infants and young children as it has been in adults, Pediatric GCS (pGCS) is commonly used instead.[5] Alert, Verbal, Pain, Unresponsive (AVPU) scale is a simple scoring system, that merely records patient's response to verbal, painful stimulus and unresponsiveness.[9] Unlike the GCS the AVPU scale is not developmentally dependent, so that the child does not have to understand spoken language or follow commands, can merely respond to a stimulus. AVPU scale being simple, easy to apply and not requiring sophisticated training for assessing patients in emergency department can have wide implication even among paramedics in a resource poor setting, in a developing country like Nepal. This study aims to compare the effectiveness of AVPU with pGCS in assessing conscious level in infant and children with altered sensorium.

METHODS

This Observational, comparative study was conducted in Kanti Children hospital, Kathmandu, Nepal after getting ethical clearance from Institutional Review Board of National Academy of Medical sciences (NAMS) ethical clearance number 139/2078/079. Total enumeration sampling techniques was used to select 55 patients with altered sensorium of age 2 months to 14 years. Sample size was calculated using formula $n=Z^2S^2/d^2$ where, n stands for sample size, Z refers to deviate corresponding to the reliability level (1.96 for 95%reliability) and S^2 is a variance (s-standard deviation, for mean 11.7) and d refers to maximum tolerable error (0.5).

Infants and children (2 months to 14 years) with altered sensorium visiting emergency department (ED) and admitted to Pediatric Intensive Care Unit (PICU) of Kanti Children Hospital, Kathmandu from August 2021 to June 2022 were included in the study. Complete demographic data of enrolled cases were recorded in a pretested and standardized proforma. The level of consciousness was then assessed by using AVPU and pGCS scale after obtaining consent from guardian and was entered in pretested proforma. The patient on intubation and receiving positive pressure ventilation, without brain stem reflexes, with febrile seizures, receiving sedatives or paralytic drugs and infants under 2 months of age (primitive reflex responses may present and simply 'withdraws' or 'flexes' after any form of painful stimulus) were excluded from the study. Final diagnosis was noted to differentiate between infectious and noninfectious etiology of altered consciousness level. The cases were followed up until discharge from ED or PICU. The collected data were recorded and presented in Microsoft excel and Statistical Package for Social Sciences (SPSS) version 16 for both descriptive and inferential analysis. Minimum and maximum Pediatric Glasgow Coma Scale scores in each component Of AVPU Scale were calculated. Mean Value of pGCS scores and standard deviation for each component of AVPU scale was calculated. Box and whisker plot was used to show mean pGCS scores for the AVPU responsive scale where, the boxes represent the interquartile range (IQR), the whisker represents the range for pGCS score. One way analysis of variance technique (ANOVA) was employed for comparison of AVPU scale and pGCS scale. Post hoc test, Bonferroni corrected multiple comparisons were used for final comparison of AVPU.

RESULTS

Among total 55 recruited subjects, children with age group < 5 years constituted larger number (60%). In this study, male predominance was found among total recruited cases, with male to female ratio 1.2:1 (Table 1).

Table 1. Demographic distribution of recruited children (n=55)

Age group	Number (%)
< 1 year	13(24)
1-5 year	20(36)
> 5 year	22(40)
Sex	
Male	30(55)
Female	25(45)

Etiological distribution

The most common cause of altered sensorium was found to be of infectious in origin (64%), with meningitis (bacterial, viral, tubercular) the most common diagnosis among infectious etiology (38%). Among non-infectious causes (36%), AGE with severe dehydration, hypertensive and hepatic encephalopathy were the leading causes of altered sensorium, whereas other causes like diabetic ketoacidosis, poisoning, conversion disorder, Guillain Barre Syndrome were 16% among total enrolled cases (Table 2).

Distribution of subjects based on AVPU and pGCS

Nearly half of the patients (47%) were found to be responsive to voice when they were assessed using AVPU

Table 2. Etiological distribution of altered sensorium in recruited child (n=55)

Etiology	Number (%)
Infectious (n=35, 64%)	
Meningitis (Viral/bacterial/tubercular)	21 (38%)
Acute Encephalitis	8 (14%)
Septic shock	6 (11%)
Noninfectious (n=20, 36%)	
AGE with severe dehydration	3 (5%)
Pediatric stroke	2 (4%)
Hypertensive encephalopathy	3 (5%)
Hepatic encephalopathy	3 (5%)
Others (DKA, poisoning, conversion disorder, GBS)	9 (16%)

Table 3. Distribution of subject based on obtained score of pGCS (n=55)

Components		Score		Score obtained by subjects	f	%
	pGCS	3 – 15				
Eyes Opening	Spontaneous (E4)	4	4	3	3	5
	To Voice (E3)	3		5	2	4
	To Pain (E2)	2				
	None (E1)	1				
	Not assessable (eye closed by swelling or bandage) (C)	-		8	3	5
Verbal	Orientated (Alert, babbles, coos, uses words or sentences to usual ability) (V5)	5	5			
	Confused (Less than usual ability, irritable cry) (V4)	4		9	7	13
	Inappropriate words (cries to pain) (V3)	3				
	Incomprehensible sounds (Moans to pain) (V2)	2		10	7	13
	No response (V1)	1				
	Not assessable (intubated) (T)	-		11	3	5
Motor	Obeys commands (Normal spontaneous movement) (M6)	6	6			
	Localise pain (>9 months of age) or withdraws to touch (M5)	5		12	10	18
	Withdrawal to pain (M4)	4				
	Abnormal flexion (decorticate rigidity) (M3)	3		13	9	16
	Abnormal extension (decerebrate rigidity) (M2)	2				
	No response (M1)	1		14	11	20

f = frequency, % = percentages

responsive scale, whereas least number of cases (9%) was found to be unresponsive. Among recruited cases, patient with pGCS score > 8 were maximum in number (90%) as compared to those with pGCS <8. On assessment of cases with AVPU responsive scale, among patients of age group > 5 years, most of them had shown response to voice (62%) as compared to those of < 5 years who had maximum response to pain (38%), whereas in both age group minimum cases were found to be of unresponsive (Table 3, 4, 5).

Table 4. Distribution of patients according to AVPU scale (n=55)

AVPU scale	Number (%)
Alert	7 (13%)
Verbal	26 (47%)
Pain	17 (31%)
Unresponsive	5 (9%)

Table 5. Age distribution of patients in each component of AVPU scale (n=55)

AVPU SCALE	< 5 years, n (%)	> 5 years (n=24) n (%)
A	5(16%)	2(8%)
V	11(35%)	15(63%)
P	12(39%)	5(21%)
U	39(10%)	2(8%)

Analysis of AVPU and pGCS

It was found that, those who were alert had a mean pGCS score of 14 with range (14-14) and IQR (14-14), patient responding to voice had mean PGCS score 12.5 with range 10-14 and IQR (12-13), those who responded to pain had a mean pGCS score of 9.3 with range 8-11 and IQR (9-10). Unresponsive patients had mean pGCS score of 3.80 with range 3-5 and IQR (3-5). One way analysis of variance indicated that all the components of AVPU had significantly different average GCS scores ($p < 0.001$) (Table 6) (Fig. 1).

Bonferroni corrected multiple comparisons indicated no two components are similar with respect to the pGCS score, and each component of AVPU described a statistically distinct range of pGCS values (Table 7).

Table 6. Mean value of PGCS score and standard deviation for each component of AVPU scale

AVPU Scale	pGCS score					p-value
				95% Confidence Interval for Mean		
	n=55	Mean	Std. Deviation	Lower Bound	Upper Bound	
Alert	7	14	0.00	14.00	14.00	<0.001
Verbal	26	12.5	0.99	12.10	12.90	
Pain	17	9.3	0.85	8.86	9.73	
Unresponsive	5	3.8	1.09	2.44	5.16	

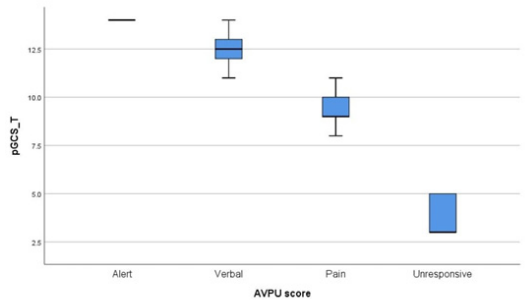

Figure 1. Box–and–whisker plot showing mean pGCS scores for the AVPU responsive scale. The boxes represent the IQR; the whisker represents the range.

Table 7. Bonferroni corrected multiple comparisons

AVPU score		Mean Difference	p-value
Alert	Verbal	1.500*	0.002
	Pain	4.706*	<0.05
	Unresponsive	10.200*	<0.05
Verbal	Alert	-1.500*	0.002
	Pain	3.206*	0.05
	Unresponsive	8.700*	<0.05
Pain	Alert	-4.706*	<0.05
	Verbal	-3.206*	-<0.05
	Unresponsive	5.494*	<0.05
Unresponsive	Alert	-10.200*	<0.05

DISCUSSIONS

GCS and AVPU scales are frequently used scoring system to assess consciousness level and these two scales have been compared in adult studies; however, such studies in pediatric patients are limited. Hence, this study was conducted to determine how the AVPU responsive scale corresponds with the pGCS in children with altered sensorium presenting to emergency department or admitted to a pediatric intensive care unit. In this study, children with age group 5 years constituted larger number (60%) as compared to children with age group > 5 years (40%). The mean age group of the study was 2.16 years, as shown in table 1. This was similar to study done by Hoffman F in 2015 in Germany, where median age group was 2.3 years among 302 recruited children, which contradicts with the results of study done by Rao et al. in India where mean age of child was 57 months.[9,10] In this study male predominance was seen with 30 (55%) male while remaining 25 (45%) were female children, with male to female ratio 1.2:1. Similar findings were found in studies done by Rao et al. in India and Amy GL Nuttall in UK where 60% and 61.4%of the study population were male respectively.[10,11] One of the reasons of male dominance seen in our study could be the fact that male children are prioritized in this part of the world thus seeking more medical care compared to female children. In this study, the most common cause of altered sensorium among recruited children was of infectious etiology (64%), among infectious causes meningitis(viral, bacterial, tubercular) was found to be more common 21 (38%) followed by acute encephalitis 8 (14%), whereas case of septic shock was least 6 (11%), among infectious causes. There were total 20 (36%) cases with altered sensorium due to non-infectious etiology. Among them, cases of acute gastroenteritis with severe dehydration 3 (5%), hypertensive encephalopathy 3 (5%) and hepatic encephalopathy 3 (5%) were equal in number. Other causes of altered sensorium among enrolled cases, like diabetic ketoacidosis, poisoning, conversion disorder, Guillian baree syndrome constituted 9 (16%) of total enrolled cases. This result is in agreement with studies done by Rao et al. in India, Sofiah in Malaysia and Prabha et al. in India.[12-14] The incidence of meningitis in younger age group might be due to vulnerability of their choroid plexus to penetration by bacteria during the septicemic process and to low immunological status.[15] The high incidence of meningitis among children of Asian region could be due to poor nutrition status, lack of adequate vaccine coverage and delayed health service seeking practices.

In this study, among total enrolled cases, most of the patients were found to be responsive to voice when assessed using AVPU scale, which was 47% of the total enrolled cases, however on further analyzing the cases according to age distribution in each component of AVPU scale, maximum number of patients in age group > 5 years (n1 = 24), had shown response to voice (62%) as compared to those of < 5 years (n2 = 31) who had maximum response to painful stimulus (38%) , whereas in both age group minimum cases were found to be of unresponsive , which was 10% among those of < 5 years and 8% among those of ≥ 5 years, as show in table 2. The difference in response in both age groups could be due to older children following verbal command easily as compared to younger one. Same Cases when assessed using pGCS score, maximum number of patients had GCS score 14, which were 20% of total cases, whereas patient with minimum GCS score “3” were least in number and was only 5% among total recruited cases. This result contradicts with the result reported by Agrawl et al. in India and Nuttall et al. in U.K. where maximum number of cases were found to be Alert as compared to response to verbal stimulus.[11,16] This difference in result could be due to the fact that in my study maximum number of cases were of < 5 years, where as in study of Nuttall et al. more cases are of > 5 years, and in study of Agrawal et al. mean age group is 18 months, so AVPU scale might have been easier to apply in older children and more accurate result had been concluded as compared to those with younger children.[11,16]

In this study, in next step of analysis the mean PGCS score with interquartile ranges (IQR) and standard deviation was calculated for each component AVPU scale. Box–and–whisker plot has been used to show correlation between each component of AVPU score and pGCS score where, boxes represent the IQR and the whisker represents the range. Those who were alert had a mean pGCS score of 14 with (IQR 14-14), patient responding to voice had

mean PGCS score 12.5 with (IQR 12-13), and those who responded to pain had a mean pGCS score of 9.29 with (IQR 9-10). Unresponsive patients had mean pGCS score of 3.8 with (IQR 3-5). In this study, pGCS score of 10 divides categories V and P. All category "U" patient had a pGCS score less than 5, whereas all "A" patients showed a pGCS score above 13. However, pGCS scores for AVPU category V and P showed more overlap. Major practical relevance in this study was that category P strongly correlates with a pGCS score of 8 or more. Similar result was reported by Hoffman et al. and Mackay et al. in their study where pGCS score of 10 divides categories V and P, as mean pGCS score for V and P was 12 and 8.5 respectively in their studies.[9,17] However, for category A and V, results contradict with result of my study, where median pGCS score for A is 15 (IQR 15-15) and pGCS score 13 divides category A and P (9,17) This difference could be due to the fact that patients with pGCS < 15were only included in my study, those with pGCS 15/15 were excluded.

One-way analysis of variance indicated that all the components of AVPU had significantly different average pGCS scores ($p < 0.001$). Post hoc, Bonferroni corrected multiple comparisons indicated no two components are similar with respect to the pGCS score and significant difference between the two scales was found ($p < 0.05$). This result is consistent with the result of the study done by Rao.Set and Agrawal A. in India, where they had reported significant difference between the two scales (Wilcoxon matched pairs, $p < 0.0001$) and each component of AVPU has a statistically distinct range of GCS values.[10,16]

Based on the results of our study and various other studies mentioned, there was a clear correlation between Alert and pGCS=14 and between Unresponsive and pGCS=3, but a wider range of pGCS scores for responsive to Pain or Voice. We demonstrated good correlation of the simple and fast AVPU scale with the standard pGCS. AVPU category "P" (response to pain) identified patients with a pGCS score of 8 or more and, therefore, easily indicated those unlikely to need more invasive procedures as well as those with an urgent need for intervention such as mechanical ventilation.

The AVPU is simple, but none of the components are clearly defined. When considering the theoretical equivalence of AVPU to the components of the pGCS, there is a range of total pGCS that could be equivalent to each AVPU component. The definitions of eye-opening scores (E1-4) can be directly related to the AVPU responses, however, an alert child could be equivalent to a GCS of 15 or 14 as they may be Alert but confused and have a verbal score of V4, however a verbal response would only be precisely detectable in older children, because of varying verbal skill. Due to its reliability and ease of use, we therefore believe that AVPU score should be routinely incorporated in the pre hospital as well as hospital setting to assess consciousness level during the evaluation of critically ill children.

CONCLUSION

This study has concluded that, AVPU responsive scale is comparable to pediatric GCS scale for assessing level of consciousness in infants and children with altered sensorium in both infectious and noninfectious etiology. In this study, most of the children presenting to emergency department with altered sensorium were of infectious etiology, and meningitis was most common cause among them. Younger age group (< 5 years) had shown maximum response to pain as compared to older (≥ 5 years) children, who had maximum response to verbal stimulus, when assessed using AVPU responsive scale. Our data would suggest that A/V/P/U corresponds with mean pGCS score of 14, 12.5, 9.29 and 3.80 respectively. Hence, AVPU scale being a simple to use can be used to assess conscious level at the earliest in peripheral settings as well as tertiary centers with busy emergency department, where human, physical and financial resources are very limited.

ACKNOWLEDGEMENTS

The authors express heartfelt gratitude to the research assistant, health personals of emergency department and PICU of Kanti Children Hospital and the patient and patient parties who helped for the completion of this study.

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