



# Better ICU Management by Analysis of Clinical Profile and Outcomes of Neuro-Critical Patients in Neurocritical Care Unit

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## Abstract

**Background:** Nowadays, it has been suggested that the care of neurocritically ill patients in the Neurocritical Care Unit can outcome, hospitalization time and ICU stay. Therefore, the aim of this study was to evaluate the clinical condition and outcomes of these patients in our setting.

**Methods:** We conducted a cross-sectional study in patients in the neurocritical care unit (NCCU) of Loghman Hakim hospital. The medical findings and outcome (discharge/death) were gathered in the data collection form. We used SPSS version 18 for statistical analysis with significant level  $< 0.05$ .

**Results:** A total of 432 patients, including 237 (56.2%) male and 185 (43.8%) female ( $P = 0.01$ ) were enrolled. There was statistically no significant difference in the mean age between them ( $41.87 \pm 18.52$ ,  $45.15 \pm 16.26$  respectively,  $P = 0.05$ ). The most common admission diagnosis of patients was neuro-oncology (65.5%). The prolong length of stay (LOS) in NCCU ( $\geq 10$ ) was found in 56 (13.5%). The highest rate of it was due to the neuro-oncology disease. There are statistically significant differences among the diagnosis groups in terms of age, LOS, and Charlson Comorbidity index ( $P = 0.002$ ,  $P < 0.001$ , respectively). The mortality rate of patients was 11.6%, which neuro-oncology had the most frequency.

**Conclusions:** The outcome of neuro-critical ill patients and length of stay in ICU can improve using special care and facilities in the neurocritical care unit. According to our results, most of our patients had neuro-oncology disease, which makes it necessary to expand the treatment interventions and various specialties in care of NCCU.

**Keywords:** Neuro-Critical Care Unit, Length of Stay, Outcome

## 1. Background

Intensive care unit (ICU) or critical care unit is a special ward that seriously ill patients are admitted and cared for by specially trained staff. In recent years, the development of unhealthy lifestyle and incidence of acute or chronic neurological problems makes it necessary to provide neurocritical care in hospitals as neurocritical care units (NCCUs) (1).

NCCU is considered a separate and full specially unit with the advanced expertise for accurate diagnosis, and effective treatment of patients. These patients consisted of traumatic brain injury, neuro-vascular, status epilepticus, neuro-muscular, and neuro-oncology (2, 3). Several studies showed the effectiveness of, hospitalization time and cost of treatment. Nevertheless, many hospitals of developing countries are not equipped (2, 4, 5).

In order to obtain better patient management in the NCCU, it is necessary to provide the quality improvement in terms of structure, performance and standardization of process. Based on our knowledge, in our country there are not enough studies regarding this subject (6), therefore, we decided doing situation analysis as the first step of quality improvement. Thus, we analyzed the characteristics and outcome of patients admitted in the NCCU of our setting.

## 2. Methods

This retrospective cross-sectional study was conducted in the NCCU of the Loghman hospital. This hospital is specialized in the teachings of the Shahid Beheshti University of Medical Sciences, Tehran, Iran. The Medical Ethics Committee of our university approved this study. Our NCCU has

14 beds, which provide special care to critically ill neuro-surgical patients.

All patients from March 30, 2015 to April 29, 2017 who were admitted in the NCCU were included. We used a data collection form for gathering data. Then, a databank named NCCU was designed in SQL format and data were collected over time. The information form included demographic (age and sex), clinical diagnosis, date of hospitalization, date of ICU admission and discharge, outcome (discharge or death), comorbidity, surgery planning (elective, emergency) and complications such as fever, abnormal blood sugar level, bed sore, meningitis, aspiration pneumonia, diabetes insipidus, seizure, acute kidney injury, deep venous thrombosis, as well as pulmonary thromboembolic disease. We calculated the Charlson comorbidity index (CCI) and presented with mean  $\pm$  standard deviation. Furthermore, we used four classifications based on CCI, which includes none (0), mild (1 - 2), moderate (3 - 4), and sever ( $\geq 5$ ) (7). The disease of diagnosis was classified to 5 categories: head Injury, neuro-oncology, neuro-vascular, spinal disease, and others. The neuro-oncology consisted of brain tumor and pituitary adenoma.

### 2.1. Statistical Analysis

In order to present continuous variables, we used the mean with standard deviation and median (range). Qualitative variables were reported with frequency and percentage. Data were analyzed using the Chi-square test, Independent t-test, one-way ANOVA, and kruskal-wallis test. In complementary analysis, post-hoc Tukey test was used for significant differences that were found in analysis of variances. The significant level was less than 0.05.

## 3. Results

A total of 423 patients were admitted in the NCCU of Loghman hospital during a period of 2 years. Out of the 423 patients, 237 patients (56.2%) were male and 185 (43.8%) female ( $P = 0.01$ ). The mean age of patients was  $43.30 \pm 17.62$  years. There was statistically no significant difference in the mean age between the males and females ( $41.87 \pm 18.52$ ,  $45.15 \pm 16.26$  respectively,  $P = 0.05$ ). The age of patients was divided into 3 groups: less than 40 ( $n = 189$ , 44.9%), between 40 to 59 ( $n = 151$ , 35.7%), and more than or equal 60 years old ( $n = 81$ , 19.1%). The maximum female patients were from middle age ( $n = 77$ , 41.8%) and the majority of male ( $n = 120$ , 50.6%) were younger than 40 years ( $P = 0.02$ ). The youngest patients were less than 18 years ( $n = 24$ , 5.7%) and the oldest were more than or equal to 75 years ( $n = 18$ , 4.3%). Admission diagnosis of patients was divided to 5 groups including neuro-oncology ( $n = 277$ , 65.5%), neuro-vascular ( $n = 46$ ,

10.9%), head trauma ( $n = 37$ , 8.7%), spinal disorder ( $n = 17$ , 4%), and other ( $n = 19$ , 4.5%) that 27 missed. Table 1 showed characteristic of patients in clinical diagnosis group. The patients from neuro-oncology had brain tumor (173, 43.7%) and pituitary adenoma (104, 24.6%). Of the total patients, 383 (90.5%) underwent neurosurgery, which consists of 331 (78.6%) planned surgery, 52 (12.4%) unplanned.

Median hospital stay was 9 days (range: 1 - 247) and length of stay in ICU (LOS) was 4 days (range: 1 - 55). A total of 107 patients (27.9%) were admitted to the NCCU before surgery, which LOS was minimum 1 and maximum 22 days. The prolonged LOS in the ICU ( $\geq 10$ ) was found in 56 (13.5%) vs. 359 (86.5%) patients admitted less than 10 days. The highest rate of prolonged NCCU was due to neuro-oncology disease.

Complications after surgery consisted of diabetes insipidus ( $n = 39$ , 9.3%), meningitis ( $n = 36$ , 8.6%), pneumonia ( $n = 28$ , 6.8%), fever ( $n = 21$ , 5.0%), abnormal blood sugar level ( $n = 15$ , 3.6%), seizure ( $n = 15$ , 3.6%), acute kidney injury ( $n = 14$ , 3.3%), deep vein thrombosis ( $n = 6$ , 1.4%), pulmonary thromboembolic disease ( $n = 4$ , 1.0%), and myocardial infarction ( $n = 1$ , 0.2). There are statistically significant differences among diagnosis groups in terms of age, LOS, and CCI (Table 1). We conducted complementary analysis and found that the patients with neuro-vascular disease were older than patients with neuro-oncology disease. The mean of LOS was significantly higher in the neuro-vascular group than the neuro-oncology and spinal disease group. There was a significant linear correlation between the CCI and LOS in the NICU ( $R = 0.16$ ,  $P = 0.001$ ). Surgery interventions (planned and unplanned) were more in the neuro-oncology group, while non-surgical management for neuro-vascular group. The majority of mortality was due to the neuro-oncology group ( $n = 23$ , 54.8%).

The mortality rate of patients was 11.6% (49 of 421), where 42 of them underwent surgery. The mean age of non-survivor patients was  $52.38 \pm 20.88$  years, where 2 patients were under 18 years. The discharge-death ratio was 7.73, where 372 patients (88.4%) were discharged, 338 (80.3%) had a complete recovery, 19 (4.5%) with mild disability, and 6 (1.4%) sever disability. Two patients had persistent vegetative life and 7 patients were not identified.

Table 2 shows the statistically significant difference of age, LOS in NICU, hospital stay, and CCI between non-survivor and survivor patients. Almost all complications were significantly higher in non-survivor than survivor patients.

## 4. Discussion

Nowadays, most university hospitals in the world are equipped to special critical intensive care unit for neu-

**Table 1.** The Characteristic of Patients and Main Variables Based on Clinical Diagnosis in NICU<sup>a, b</sup>

Variables	Total (N = 423)	Neuro Oncology Disease (N = 277)	Neuro Vascular Disease (N = 46)	Head Injury (N = 37)	Spinal Disease (N = 17)	Others (N = 19)	P Value
Age, y	43.30 ± 17.62	42.09 ± 16.83	50.96 ± 19.67	48.32 ± 16.60	47.65 ± 16.34	41.05 ± 17.31	0.006
<b>Age groups, y</b>							0.173
< 40	173 (43.7)	129 (74.6)	15 (8.7)	12 (6.9)	7 (4.0)	10 (5.8)	
40 - 59	144 (36.4)	102 (70.8)	15 (10.4)	15 (10.4)	6 (4.2)	6 (4.2)	
≥ 60	79 (19.9)	46 (58.2)	16 (20.3)	10 (12.7)	4 (5.1)	3 (3.8)	
<b>Sex</b>							0.063
Male	237 (56.2)	153 (69.2)	20 (9.0)	28 (12.7)	10 (4.5)	10 (4.5)	
Female	185 (43.8)	124 (70.9)	26 (14.9)	9 (5.1)	7 (4.0)	9 (5.1)	
<b>Hospital stay</b>	12.62 ± 16.28	11.14 ± 8.11	12.82 ± 7.75	11.15 ± 13.43	8.87 ± 5.46	26.56 ± 56.30	0.074
<b>LOS in NICU stay</b>	5.84 ± 5.93	5.36 ± 5.47	8.68 ± 6.48	6.53 ± 8.36	2.94 ± 1.63	5.06 ± 2.38	< 0.001
<b>LOS categories</b>							NA
< 10 days	340 (87.2)	248 (90.2)	28 (63.6)	30 (83.3)	17 (100)	17 (94.4)	
≥ 10 days	50 (12.8)	27 (9.8)	16 (36.4)	6 (16.7)	0 (0.0)	1 (5.6)	
<b>CCI</b>	1.41 ± 1.58	1.16 ± 1.40	2.84 ± 1.72	1.62 ± 1.26	1.47 ± 1.58	1.16 ± 1.54	< 0.001
<b>Outcomes, No. (%)</b>							NA
Non-survivor	42 (10.6)	23 (54.8)	8 (19.0)	8 (19.0)	3 (7.1)	0 (0.0)	
Survivor	353 (89.4)	254 (72.0)	38 (10.8)	29 (8.2)	14 (4.0)	18 (5.0)	
<b>Type of treatment</b>							NA
Planned surgery	314 (79.5)	244 (77.7)	22 (7.0)	17 (5.4)	15 (4.8)	16 (5.1)	
Non-planned	46 (11.6)	25 (54.3)	9 (19.6)	10 (21.7)	1 (2.2)	1 (2.2)	
Non-surgical treatment	35 (8.9)	8 (22.9)	15 (42.9)	10 (28.6)	1 (2.9)	1 (2.8)	

Abbreviation: NA, Not Applicable.

<sup>a</sup> Qualitative variables were presented with number and percentage. Quantitative variables with mean ± standard deviation.<sup>b</sup> Significant level P < 0.05.

rology or neurosurgery patients. Consequently, we obtained the neuro-critical care condition and outcomes of our patients, which these findings could be effective to improve hospital care management and health promotion of neuro-critically ill patients.

In our study, there was a significant difference in terms of gender; the majority of patients were males who were less than 40 years of age and females were more middle age. The mean age of our patients in contrast with a similar study in Iran was 10 years younger (6). Because, the majority of our patients admitted for neurosurgery, but in that study, the patients had medical neurology disease.

We didn't find any difference in mortality rate between male and female; however, the mortality rate was higher in females in a cohort study that was conducted with a large sample size. It seems that there isn't any gender disparity in receiving supportive care in our setting vs. the mentioned study (8).

According to the clinical diagnosis, we showed that the neuro-oncology disease and head trauma were more common in males than females. On the other hand, neuro-vascular disease mostly occurred in females that might be due to high prevalence of obesity and metabolic syndrome as risk factors of stroke in middle age females (9). The patients less than 40 years were mostly admitted due to

neuro-oncology disease. The mean age of neuro-vascular disease was more than other diseases and can be rational and explainable due to the nature of the illness. In this study, the mortality rate was 11.6%, which was in the range of high-income countries (8% - 18%) and lower than low-income countries (21% - 64%) (10-12). This finding certainly depends on multiple factors, where one of the most important factors is the presence of neuro-critical care facilities. The discharge-death rate of our setting was better than the similar study, which was conducted in south Iran. We believe the cause of it may be justifiable because of our younger patients (6).

The majority of non-survivors were equal or higher than 60 years, which is reasonable and explainable due to the variety of comorbidity and severity of disease. Overall, the outcome of the patients has direct relationship to concurrent comorbidities and its severity at the same time and before admission (13, 14). Charlson's comorbidity index (CCI) is defined to predict hospital mortality (15). If CCI takes a high score, the probability of mortality will be high. We found significant relationship between LOS in NCCU and CCI, although this effect size isn't very strong. In the Hampshire and colleagues study, they suggested a direct correlation between CCI, ICU stay (16).

There is controversy about definition of prolonged ICU

**Table 2.** Comparison Study Variables Between Non-Survivor and Survivor Groups<sup>a,b,c</sup>

Variable	Non-Survivor Group (N = 49)	Survivor Group (N = 372)	P Value
Age	52.38 ± 20.88	42.09 ± 17.18	0.002
Hospital stay	17.18 ± 13.86	11.97 ± 16.54	0.03
Length of stay in ICU (LOS)	11.65 ± 9.72	5.07 ± 4.73	< 0.001
Charlson comorbidity index	2.69 ± 2.12	1.26 ± 1.43	< 0.001
<b>CCI categories</b>			< 0.001
None (0)	10 (23.8)	153 (43.6)	
Mild (1 - 2)	11 (26.2)	129 (36.8)	
Moderate (3 - 4)	10 (23.8)	59 (16.8)	
Sever (≥ 5)	11 (26.2)	10 (2.8)	
<b>Age group</b>			< 0.001
< 40	13 (27.1)	176 (47.3)	
40 - 59	16 (33.3)	134 (36.0)	
≥ 60	19 (39.6)	62 (16.7)	
<b>Sex</b>			0.186
Male	31 (63.3)	206 (55.4)	
Female	18 (36.7)	166 (44.6)	
<b>LOS</b>			< 0.001
< 10 days	26 (53.1%)	333 (91.0)	
≥ 10 days	23 (46.9)	33 (9.0)	
<b>Type of surgery</b>			0.328
Planned	35 (71.4)	296 (79.6)	
Unplanned	7 (14.3)	45 (12.1)	
Non surgical treatment	7 (14.3)	31 (8.3)	
<b>Complications</b>			
Meningitis	18 (36.7)	18 (4.8)	< 0.001
Pneumonia	19 (38.8)	9 (2.4)	< 0.001
Acute kidney injury	12 (24.5)	2 (0.5)	< 0.001
Fever	11 (22.4)	10 (2.7)	< 0.001
Abnormal blood sugar level	12 (24.5)	3 (0.8)	< 0.001
seizure	6 (12.2)	9 (2.4)	0.004
Deep vein thrombosis	4 (8.2)	2 (0.5)	0.002
Pulmonary thromboembolic disease	3 (6.1)	1 (0.3)	0.005
Diabetes insipidus	2 (4.1)	37 (9.9)	0.14

<sup>a</sup> Mean ± SD refers to continues variables that had analyzed with independent-t -test.

<sup>b</sup> Categorical variables were presented and analyzed with number (percentage) and Chi -square test respectively.

<sup>c</sup> P value < 0.05 level.

stay. Based on our knowledge, some studies have mentioned 7, 10, and 14 days (6, 10, 17). William and colleagues showed that by using a survival analysis, the slope of mortality risk was high in the first 10 days and after that, this risk was slow slope (17). We considered equal or higher than 10 days as prolonged ICU stay. Overall, 14% of patients had prolonged ICU stay and almost half of non-survivors had LOS less than 10 days. However, it seems that ICU stay time should be one of the important factors in the out-

come of these patients. Other factors such as type of primary disease, severity, and complications affect outcome (18, 19).

Some complications and type of treatment have a main role in ICU stay as well as survival of the patients. Nosocomial infections and fever have been reported as a poor prognosis (20, 21). In our study, the most common complications were meningitis, pneumonia, and diabetes insipidus. However, in the Tamar and colleagues study, fever

and pneumonia were reported as the most common (6). According to the majority of our patients who underwent neurosurgery, meningitis was a common complication and it is necessary to exploit the ability of the infection control team for decreasing poor outcome.

The existing literatures have shown when neuro-critical ill patients admitted in NICU, outcome, LOS in ICU and cost of services was better than general ICU. Due to the fact that these patients were under intensive monitoring for intracranial pressure and hemodynamic as well as took less sedative drugs and had nutritional support (22-24).

This study had several limitations. First, the patients were not followed for evaluating long-term outcome. Second, we were not able to investigate other illness scores (acute physiology and chronic health evaluation: APACHE and sequential organ failure assessment: SOFA).

#### 4.1. Conclusion

The better patient management can affect directly on the outcome and length of stay of neuro-critical ill patients in the NCCU and indirectly on burden of neurosurgical disease. According to the high cost of care services in the NCCU, a special attention of health policy makers is needed to develop quality management as a beneficial tool for increasing life expectancy of the patients.

Based on our results, most of our patients had neuro-oncology disease, which makes it a necessary to provide the expansion of treatment interventions and various specialties in care of NICU with considering standardization of care process.

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