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Article

Characteristics and Functional Impact of Unplanned Acute Care Unit Readmissions during Inpatient Traumatic Brain Injury Rehabilitation: A Retrospective Cohort Study

Poo Lee ONG [1,2], Anna ROSIANA [1] and Karen CHUA [1,2,3]

1 Institute of Rehabilitation Excellence (IREx), Tan Tock Seng Hospital Rehabilitation Centre
2 Lee Kong Chian School of Medicine, Nanyang Technological University
3 Yong Loo Lin School of Medicine, National University of Singapore
* Correspondence: poolee_ong@ttsh.com.sg, Telephone (65) 64506164, Fax (65) 64590414

Abstract: Background: This study investigated the incidence, characteristics and functional outcomes associated with unplanned Acute Care Unit Readmissions (ACUR) during inpatient traumatic brain injury (TBI) rehabilitation in an Asian cohort. Methods: Retrospective review of electronic medical records from single rehabilitation unit was conducted from 1 Jan 2012 to 31 Dec 2014. Inclusion criteria were first TBI, aged >18 years, admitted < 6 months of TBI. ACUR were characterized into either of neurological, medical or neurosurgical subtypes. The main outcome measure was discharge Functional Independence Measure (FIM). Secondary outcomes included rehabilitation length of stay (RLOS). Results: Of 121 eligible TBI records, the incidence of ACUR was 14% (n=17), comprising neurologic (76.5%) and medical (23.5%) subtypes, occurring at median of 13 days (IQR 6, 28.5) after rehabilitation admission. Patients without ACUR had significantly higher admission mean (SD) FIM score compared to those with ACUR (FIM ACUR-negative 63.4 (21.1) vs FIM ACUR-positive 50.53(25.4), P =0.026). Significantly lower discharge FIM was noted in those with ACUR compared to those without. (FIM ACUR-positive 65.8(31.4) vs FIM ACUR-negative 85.4 (21.1), P = 0.023) Furthermore, a significant near-doubling of RLOS was noted in ACUR patients compared to non-ACUR counterparts [ACUR-positive median 55 days (IQR 34.50, 87.50) vs ACUR-negative median 28 days (IQR 16.25, 40.00), P = 0.002]. Conclusion: This study highlights the significant negative functional impact and lengthening of rehabilitation duration of ACUR on inpatient rehabilitation outcome for TBI.

Keywords: rehabilitation; traumatic brain injury; Acute Care Unit Readmissions; head injury; functional independence measure; length of stay

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1. Introduction

Traumatic brain injury (TBI) is a recognized global health problem according to World Health Organization (WHO)22 and the National Institutes of Health (NIH). The estimated global incidence across all severity of TBI is approximately 939 cases per 100,000 people. Approximately 69 million individuals worldwide are estimated to sustain TBI each year with varying degrees of severity and functional impairments [1]. According to the Centres for Disease Control and Prevention (CDC) reports, TBI accounts for a significant proportion of emergency department visits, hospitalizations, and deaths in the United States, making it a pressing public health concern [2]. In fact, individuals with moderate to severe TBI often require continuous care and support throughout their recovery journey. The effect extends beyond the individual's life and severely impacts their family and society, leading to health economic burden. The expenses associated with TBI encompassing both direct and indirect medical cost, were estimated at approximately $76.5 billion (in 2010 dollars) [3].

Rehabilitation plays a crucial role in addressing the complex needs of individuals with moderate to severe TBI, facilitating functional recovery, and improving long-term outcomes [4]. Specialized acute TBI rehabilitation programs aim to maximize independence, enhance quality of life, and promote community reintegration for TBI survivors.

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Traumatic brain injury (TBI) has often been associated with diverse medical complications towards patients that are discharged from acute care hospital to inpatient rehabilitation settings. These complications are unplanned occurrences which disrupt inpatient rehabilitation or required treatment. The challenges of having secondary complications such as functional deficits as well as impaired cognition persist throughout the discharge phase that would have serious impact on long-term patient outcome due to interrupted rehabilitation as the result of readmissions [5].

However, a subset of TBI patients experience frequent readmissions to acute care facilities during their rehabilitation journey. These unplanned acute care unit readmissions (ACUR) pose significant management challenges and are associated with adverse outcomes and increased healthcare costs. One of the key factors driving the increased healthcare costs related to ACUR is the longer length of inpatient rehabilitation stay [6,7]. This extended stay is often necessitated by the occurrence of complications and setbacks, which demand additional specialized interventions and treatments that utilized greater amount of healthcare resources.

Previous studies have reported on the incidence, characteristics, and impact of readmissions to acute care facilities during TBI rehabilitation [6-10]. A multicentre study in United States and Canada [6] had shown ACUR patients were associated with longer rehabilitation length of stay and higher discharge rates to institutional setting. Similarly, a study from Italy [11] reported an almost double duration of rehabilitation length of stay for those patients with ACUR, poorer functional outcome and higher risk of mortality.

However, more research is needed to better understand the implications of frequent ACUR and its effect on functional outcomes in diverse patient populations. In fact, there is a gap in the literature regarding the specific context of Asian TBI, where cultural, social, and healthcare system factors may influence the patterns and consequences of ACUR during TBI rehabilitation.

Therefore, the primary objective of this study was to determine the ACUR incidence and subtypes in an Asian tertiary rehabilitation centre, explore the relationships between ACUR and acute TBI characteristics and functional outcome and discharge placement. The discharge total Functional Independence Measure (FIM) was the main primary outcome. Through identification of ACUR correlates and outcomes, patient stratification and improved care models could be anticipated from acute hospital to inpatient rehabilitation settings.

2. Materials and Methods

2.1. Study Design

A retrospective review of electronic medical records (EMRs) for patient who were admitted and discharged from inpatient TBI rehabilitation at a single tertiary rehabilitation centre was performed from 1st January 2012 to 31st Dec 2014. The demographic, patients' characteristics, clinical information, and functional data were independently extracted from a functional database registry recorded prospectively during inpatient rehabilitation. Institutional ethical approvals were obtained by the National Healthcare Group-NHG Domain Specific Review Boards (NHG DSRB 2018/01114) prior to data extraction. Informed consent was waived as the study involved the use of de-identified data with no human subjects.

2.2. Study Settings

The study was conducted at Tan Tock Seng Hospital (TTSH) Rehabilitation Centre, Singapore, which has direct links with National Neuroscience Institute(NNI) acute neurosurgical unit and is a level II trauma centre. Suitable TBI patients were admitted to TTSH rehabilitation centre for further inpatient rehabilitation after pre-admission screening by rehabilitation physician. The TBI rehabilitation program at TTSH rehabilitation centre consists of rehabilitation therapies conducted over 3 hours daily, delivered 5.5 days a week by an interdisciplinary team of physiotherapists, occupational therapists, speech therapists, nurses, social workers and psychologists. The programme consists of components including; management of disorder of consciousness, post traumatic amnesia assessment and management, mobility and basic activities of daily living training, cognitive assessment and training, rehabilitation nursing care, dietary intervention, TBI psychoeducation and discharge planning. The Functional Independence Measures (FIM) [12], is recorded by FIM-certified rehabilitation therapists for all patients within 72hours of admission and prior to discharge from rehabilitation centre.

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2.3. Study Participants

No human subjects were recruited and EMRs were selected based on the following inclusion and exclusion criteria. Inclusion criteria were patients aged above 18 years with first-onset TBI confirmed by CT or MRI brain imaging and admitted within 6 months of TBI from acute neurosurgical services. Exclusion criteria were EMR with non-TBI diagnoses (e.g. stroke, intracerebral haemorrhage, subarachnoid haemorrhage, arteriovenous malformation, tumour, infection), those with missing admission or discharge FIM data.

2.4. Data Collection Procedures and Study Variables

Post-discharged inpatient cases medical records were identified from Tan Tock Seng Hospital (TTSH) rehabilitation centre standing database registry (SDB # 2010/0039). Data were extracted without personal identifiers and used to construct a case record form consisting of two main data points, i.e. admission and discharge from inpatient TBI rehabilitation for both ACUR and non-ACUR patients.

Independent variables included for analysis were age, sex, race, employment status, TBI mechanism, acute length of stay (LOS), post traumatic amnesia (PTA) duration and emergence [measured using Westmead PTA scale (WPTAS)[13], admission Glasgow Coma Scale(GCS), presence of any premorbid comorbidities, management of TBI (surgical/conservative), ICU duration, complication from TBI(VP shunt, tracheostomy, skull fracture) and complications during inpatient rehabilitation stay.

Dependent variables included for analysis were days to ACUR after rehabilitation ward admission, reason for ACUR, FIM data, rehabilitation length of stay, discharge disposition, carer need, and Glasgow outcome scale on discharge.

ACUR was defined as any occurrence of readmission to acute care facilities exceeding 24 hours, primarily due to medical or neurological necessitating further treatment. ACUR for elective reasons, such as surgical procedures or medical investigations were not considered as ACUR occurrence.

Complications occurring during inpatient rehabilitation stay were defined as those that interrupted rehabilitation progress and /or necessitated treatment. Not all of these complications including infection, cardiac issues, or neurological problems necessitated ACUR although they warranted treatment.

The duration of the acute care stay, referred to as Acute Length of Stay (Acute LOS), was defined as the time span from admission to the acute care facility until the transfer to the rehabilitation center. On the other hand, the length of stay in rehabilitation, known as Rehabilitation Length of Stay (RLOS), was calculated by subtracting the total duration spent in acute care facilities after rehabilitation admission, which encompassed the period of unplanned acute care unit readmissions (ACUR), from the RLOS.

2.5. Statistical Analysis

Statistical analyses were generated using SPSS (Statistical Product and Service Solutions) Version 26.0 (IBM Corp., Armonk, New York, USA). Descriptive statistics were utilized to illustrate patient demographics and clinical characteristics. Tests of normality were performed using Shapiro-Wilk test. Ordinal data presented as means, SD for normally distributed data, or medians IQR for non-normally distributed data. The distribution of categorical variables was compared using chi-square or Fisher's exact test. Comparison of differences between groups for ordinal data were done using Mann Whitney-U test. A $p < 0.05$ was considered statistically significant for a two-tailed test.

3. Results

3.1. Baseline Demographic and TBI Characteristics

A total of 131 medical records were screened and 121 records were available for analyses. 10 cases were excluded due to missing FIM data. Table 1. presents the demographics and characteristics of patients with and without ACUR.

Table 1. Demographics and characteristics between ACUR and non-ACUR group (N= 121).

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Characteristic	Total (n = 121)	Non ACUR (n = 104)	ACUR (n = 17)	P value
Age				
Age in years, mean(SD)	58.84 (19.24)	59.50 (19.25)	54.82 (19.29)	0.355[a]
Sex, n(%)				
Male	87 (71.9)	74 (71.2)	13 (76.5)	0.777[d]
Female	34 (28.1)	30 (28.8)	4 (23.5)	
Race, n(%)				
Chinese	103 (85.1)	89 (85.6)	14 (82.4)	0.462[d]
Malay	9 (7.4)	8 (7.7)	1 (5.9)	
Indian	6 (5.0)	4 (3.8)	2 (1.2)	
Others	3 (2.5)	3 (2.9)	0 (0)	
Employment status*, (N=83), n(%)	43 (51.8)	34 (47.9)	9 (75)	0.208[c]
Employed	40 (48.2)	37 (52.1)	3 (25)	
Unemployed				
TBI Mechanism, n(%)				
Road traffic accident	33 (27.3)	28 (26.9)	5 (29.4)	0.385[d]
Fall	78 (64.5)	68 (65.4)	10 (58.8)	
Assault	6 (5.0)	4 (3.8)	2 (1.2)	
Others	4 (3.3)	4 (3.8)	0 (0.0)	
Presence of comorbidity, n(%)				
No	37 (30.6)	32 (30.8)	5 (29.4)	0.910[c]
Yes	84 (69.4)	72 (69.2)	12 (70.6)	
Admission GCS , n(%)				
3-8	17 (14.0)	13 (12.5)	4 (23.5)	0.361[d]
9-12	20 (16.5)	17 (16.3)	3 (17.6)	
13-15	84 (69.4)	74 (71.2)	10 (58.8)	
PTA Duration (days), Median, (IQR)	30.5(18.8, 42.3)	30.0 (19.0, 42.0)	60.0(36.0, 76.5)	0.324[b]
Emergence from PTA upon discharge*, (N=57), n(%)				
Emerged	34 (59.6)	32 (60.3)	2 (50)	0.131[d]
Not emerged	23 (40.4)	21 (39.6)	2 (50)	
TBI Management, n(%)				
Surgical	57 (47.1)	49 (47.1)	8 (47.1)	
Conservative	64 (52.9)	55 (52.9)	9 (52.9)	>0.950[c]

Acute hospital LOS (days), median (IQR)	21.00 (13.0, 32.5)	20.00 (12.25, 31.75)	26.00(15.00, 45.50)	0.247[b]
ICU duration, n(%)				
>72hours	49 (42.2)	40 (40)	9 (56.3)	0.339[d]
<72hours	67 (59.3)	60 (60)	7 (43.8)	
Presence of skull fracture, n(%)				
Yes	63 (52.1)	53 (51.0)	10 (58.8)	0.608[c]
No	58 (47.9)	51 (49.0)	7 (41.2)	
Presence of tracheostomy, n(%)				
Yes	9 (7.4)	9 (8.6)	0 (0.0)	0.357[d]
No	112 (92.6)	95 (91.3)	17 (100)	
Presence of ventriculoperitoneal (VP) shunt, n(%)	6 (5.0)	2 (2)	4 (23.5)	**0.003**[d]
Yes	115 (95.0)	102 (98)	13 (76.4)	
No				

[a]Independent samples T test, [b]Mann Whitney U Test, [c]Pearson Chi Square Test, [d]Fisher Exact Test.
*Missing data.

The mean age of the patients was 58.8 years old with 72% male. The most common mechanism of injury at the time of admission was falls (64.5%) followed by road traffic accidents (27.3%). Of the 121 patients admitted for TBI, 17(14%) had at least one readmission to the acute care unit with a median of 13 days ±14.19 since admission to rehabilitation centre. 69.4% out of the study population had one comorbidity (p=0.910). No deaths occurred during rehabilitation.

From the study population, 84 patients (69.4%) had a mild GCS score ranging from 13 to 15 upon admission. However, it was observed that 78.5% of these patients still needed a caregiver at the time of discharge. Majority of patients were discharged from the acute care hospital returned home (89.3%) while a smaller percentage (10.7%) were discharge to other health care facilities or acute hospitals.

3.2. ACUR Incidence, Classification and Acute Correlations

The incidence of ACUR in our sample was 14% (17/121). Table 2 summarizes the primary causes of ACUR episodes, with the most common reason being neurological (n=13, 76.47%), whereas medical reasons accounted for 23.53% (n=4).

Table 2. Classification of causes of ACUR episodes (N=17).

Events leading to ACUR	N (%)
Neurological	13(76.5)
Hydrocephalus	3(17.6)
New Intracerebral haemorrhage	3(17.6)
Seizure/Epilepsy	2(11.8)
Worsen midline shift	2(11.8)
Stroke	1(5.9)
Cranial wound infection	1(5.9)
Sunken Brain	1(5.9)
Medical	4(23.5)
Sepsis with unknown source	2(11.8)

Agitation and violent behaviour	1(5.9)
Autonomic dysfunction	1(5.9)
Total 17(100%)	

There were no significant differences in baseline demographic or injury or acute management characteristics between ACUR and non -ACUR patients. The median acute hospital length of stay was 21 days, with a slightly higher number of days (26 days) for patients with ACUR (p = 0.247) Patients with ACUR had a higher number VP shunts (p=0.003) than those without ACUR. (Table 1)

3.3. Relationships between ACUR and Functional Outcome

Table 3 shows the comparison of FIM by ACUR status. Multiple significant functional improvements were observed in both Glasgow Outcome Scale (GOS) and across FIM categories for patients with ACUR episodes. TBI patients without ACUR had significantly higher admission FIM by 12.8 FIM points (mean 63.4 SD 21.1, vs 50.5(25.4), p=0.026) and GOS score (GOS 4-5: 81 (91%) vs 8(9%), p=0.026). Patients who experienced ACUR achieved significantly poorer clinical outcome as indicated by lower discharge FIM score by 20 points (mean 65.8 SD 31.4, p=0.023) compared to patients without ACUR (mean:85.4 SD:21.1 p=0.023).

Patients with ACUR exhibited a significantly lower discharge score in the FIM motor domain(mean 47.2 SD 23.8) compared to those without ACUR(mean 63.1 SD 16.5, p=0.016). However, in terms of the discharge FIM cognitive score, ACUR patients(mean 18.5, SD 8.5) had slightly lower cognitive functioning compared to those without ACUR(mean 22.2 SD 7.6, p=0.069), although the difference did not reach statistical significance. The occurrence of ACUR may have directly impact the physical recovery and motor functioning of individuals undergoing TBI rehabilitation. The medical or neurological complications leading to ACUR could potentially hinder the progress of motor rehabilitation and results in lower motor function scores at discharge, while the impact of ACUR to cognitive domains may be less pronounced compared to its effect on motor functioning.

The rehabilitation length of stay observed to be significantly almost doubled in patients with ACUR [median:55 days (34.50-87.50)] compared to non-ACUR counterparts, [median:28 days (16.25-40.00), p=0.002]. There was no significant difference for FIM gains between ACUR patients (mean 15.24 SD:23.59) and non-ACUR (mean:21.99 SD:14.90, p= 0.117).

Table 3. Comparison of functional outcome between ACUR and non-ACUR groups (N=121).

Functional Outcome	**Total(n=121)**	**Non ACUR (n = 104)**	**ACUR (n = 17)**	**P value**
FIM (admission)				
Total, mean (SD)	61.6 (22.1)	63.4 (21.1)	50.5 (25.4)	**0.026[a]**
Motor, mean(SD)	43.1(16.7)	44.3(16.2)	36.0 (18.28)	0.059[a]
Cognition, mean(SD)	18.5(8.04)	19.1(7.9)	14.5(8.2)	**0.029[a]**
FIM (discharge)				
Total, mean (SD)	82.6 (23.7)	85.4 (21.1)	65.8 (31.4)	**0.023[a]**
Motor, mean(SD)	60.9(18.4)	63.1(16.5)	47.2(23.8)	**0.016[a]**
Cognition, mean(SD)	21.7(7.8)	22.2(7.6)	18.5(8.5)	0.069[a]
FIM gain, mean(SD)	21.0(16.4)	22.0(14.9)	15.2 (23.6)	0.117[a]

[a]Independent samples t test.

3.4. Correlations between Complications and Functional Outcome

Table 4 describes the functional outcomes compared with the associated number of complications during inpatient stay. Among the study cohort, 63 patients (52%) experienced at least one complication during inpatient TBI rehabilitation, with 21 patients (17.4%) encountered two or more complications.

The commonest medical complication was noted in the acute care setting was that of urinary tract infection (UTI) (33.3%, n=21/89 complications). Patients with at least one complication had significantly poorer functional outcomes, as demonstrated by significantly lower motor FIM(p=0.017) by 8 points with 1 complication and 14 points with 2 complications. In the case of total FIM on discharge (p=0.049), this was reduced by 6 points with 1 complication and 17 points with 2 complications. For RLOS, this was lengthened by 6 days in those with 1 complication and 39 days in those with 2 or more complications (p<0.001).

Table 4. Univariate analysis of complications and functional outcomes (N=121).

Variables	No complication (n = 58)	1 complication (n = 42)	2 or more complications (n = 21)	P value
GOS, n(%)				
1-3	11 (36.7)	8 (26.7)	11 (36.7)	**0.004[c]**
4-5	47 (52.8)	33 (37.1)	9 (10.1)	
FIM (admission)				
Total, median (IQR)	66.50 (50.00, 78.25)	61.50 (48.00, 75.50)	58.00(20.00, 92.80)	0.327[b]
Motor, median (IQR)	45.50(31.75, 59.00)	43.00(32.75, 51.00)	41.00(15.00, 57.00)	0.251[b]
Cognition, median (IQR)	20.00(13.00,23.25)	18.00(14.50, 23.00)	13.00(5.50, 24.50)	0.207[b]
FIM (discharge)				
Total, median (IQR)	91.00(74.50, 105.25)	85.00(71.00, 99.25)	74.00(40.50, 91.00)	0.049[b]
Motor, median (IQR)	69.00(53.00, 78.00)	61.00(54.00, 72.25)	55.00(28.00, 68.50)	**0.017[b]**
Cognition, mean (SD)	21.78(7.77)	22.86(7.01)	19.24(9.02)	0.220[a]
FIM Gain				
Total, median (IQR)	20(12, 32)	21(10,33)	14.5(4.5, 25.5)	0.121[b]
RLOS, median (IQR)	24.50 (15.00, 38.00)	30.00(17.25, 45.25)	63.00(30.50, 99.00)	**<0.001[b]**

[a]One way ANOVA, [b]Kruskal Wallis test, [c]Pearson Chi Square test

3.5. Factors Affecting Post TBI Rehabilitation Outcome

Table 5 presents the various factors affecting post TBI rehabilitation outcomes. The majority of TBI patients (n=108, 89.3%) were discharged back to their homes, while 8.3% (10) were discharged to nursing homes. It is notable that even among patient with mild Glasgow Coma Scale (GOS) scores (GOS 4-5), a significant proportion (n=95,78.5%) still required care upon discharge, indicating ongoing support needs.

In terms of rehabilitation duration, ACUR patients experienced a significant increase in their length of stay compared to non-ACUR patients (55 days vs 28 days, p=0.002).

On logistic regression analysis, an association was observed between presence of VP shunt and the impact on ACUR, with odd ratio of 0.109, p=0.028.

Table 5. Correlations between GOS and ACUR status (N=121).

Variables	Total(n=121)	Non ACUR (n = 104)	ACUR (n = 17)	P value
GOS, n(%)*				
1-3	30 (24.8)	22 (73.3)	8 (26.7)	
4-5	89 (73.6)	81 (91.0)	8 (9.0)	**0.026[a]**
RLOS, median (IQR)	28.00(17.00, 47.00)	28.00(16.25, 40.00)	55.00(34.50, 87.50)	**0.002[b]**
Needed carer on discharge, n (%)				

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Yes	95 (78.5)	82 (78.8)	13 (76.5)	0.759[a]
No	26 (21.5)	22 (21.2)	4 (23.5)	
Discharge destination, n (%)				
Own Home	108 (89.3)	94 (90.3)	14 (82.4)	0.391[a]
Others	13 (10.7)	10 (9.6)	3 (17.6)	

[a]Fisher Exact test [b]Mann Whitney U test *Missing data

4. Discussion

4.1. ACUR Incidence, Its Impacts on Functional Outcome and Length of Stay

Our study aimed to quantify the differences between ACUR and non-ACUR patients during inpatient TBI rehabilitation. We found that a total of 17 patients (14%) experienced ACUR in our population which is consistent with the rates reported in other studies ranging from 9% to as high as 29.8% [6,11]. Such large variations could be related to definitions and temporal diversity.

While other reports suggested ACUR was higher in older patients, surgically managed TBI, history of coronary artery disease, congestive heart failure, depression and presence of dysphagia [6], our study did not find any significant demographic or correlations between older age, comorbidities and risk of ACUR. This finding suggests that there may be other factors beyond the acute TBI or initial care phase that may contribute to ACUR risk. Another reason was the selection bias of small cohort of relatively young, robust TBI (mean age 58 years).

Contributions to readmissions in our small sample study at TTSH rehabilitation centre were primarily neurological causes, accounting for 76.5% of ACUR cases. This finding is consistent with another larger scale study conducted in an American hospital, however, still elevated in comparison with 65% ACUR reported by Hammond et al attributed to neurosurgical reasons [6]. This could be explained by systematic reasons as the rehabilitation centre had no on-site CT Imaging or acute neurosurgical services, hence ACUR was the preferred pathway of care to access expedient diagnostic imaging and consultation, to prevent further neurological deterioration. The relative lower proportion of medical issues contributing to ACUR could be attributed to the earl intra-rehabilitation management of medical issues during inpatient TBI rehabilitation stay as long as patients were hemodynamically stable.

Notably, our study revealed that patients with ACUR experienced poorer functional outcomes compared to those without ACUR, this was consistent with previous studies [6,11]. This was evident in the lower admission FIM scores and lower discharge FIM scores of the ACUR patients. However, we did not find a significant difference in FIM gains between the two groups, indicating that while patients with ACUR may initially have lower functional status, they still make comparable progress during rehabilitation. These findings are similar with other studies showing ACUR patients were more disabled [11]. In fact, our study further revealed that patients with higher admission FIM Motor scores were less likely to experience ACUR [6], indicating the importance of functional abilities on admission.

Our study also found a significant difference in the length of rehabilitation stay between patients with ACUR and those without, this was consistent with other studies [6,11]. Patients with ACUR had almost double the length of rehabilitation stay compared to non-ACUR patients. This finding suggests that ACUR not only impacts functional outcomes but also extends the duration of rehabilitation and impacts direct healthcare costs. The reasons for the prolonged rehabilitation stay in the ACUR group may include the need for additional interventions, management of complications, or delays in achieving rehabilitation goals due to lower FIM on readmission. The latter reason is speculative.

4.2. Intra-Rehabilitation Complications and Its Associated Functional Outcomes

As for the association between number of complications to functional outcomes, our study findings suggest that TBI patients without complications and those with only one complication experienced meaningful functional improvements, as indicated by meeting the Minimal Clinically Important Differences (MCID)[14] thresholds for total FIM and motor scores. However, patients with two or more complications reported a poorer discharge FIM not meeting MCID of 25 for TBI (Table 4), in particular, motor FIM score. These implies significant negative rehabilitation functional gains for patients facing multiple complications. Hence, it becomes imperative to consider modifying rehabilitation goals, implementing targeted rehabilitation and extending rehabilitation LOS to achieve comparable functional outcome once the first complication arise.

Common medical complications following TBI studied previously in the acute care setting would include sepsis, respiratory infections, hypertension, acute kidney injury, diabetes, cardiac arrhythmias, and extremity fractures [15-18]. Inpatient rehabilitation is also commonly associated with diverse disorders such as hydrocephalus, seizures, paroxysmal autonomic dysfunction, ventricular dilatation, abnormal liver function, hypertension, thrombophlebitis, respiratory infections, heterotopic ossification, fractures, and pituitary-hypothalamic dysfunction, psychiatric and behavioural disturbances, and problems with eyes, ears, nose, and throat[20-25]. High complication rates in acute TBI are proposed to be due to acute cytokine and chemokine release[19].

4.3. Caregiver Support and Discharge Placement

Despite the difference in functional outcome between ACUR patients, we found no significant difference in the need for caregiver support upon discharge between the ACUR and non-ACUR groups. Although ACUR groups had associated impact on functional outcomes and rehabilitation length of stay, the need for caregiver support upon discharge was similar between the two groups. This finding could possibly attributed to similar TBI severity level in both group as evidenced by lack of significance in PTA duration(Table 1).

Majority of the TBI patients in this study were discharged home irrespective of their ACUR status and functional outcomes. This finding contrasts with another study where ACUR group was associated with higher likelihood of not being discharge home [6]. This may be due to strong community supports and Asian social supports locally.

4.4. Study Limitations

We highlight the following study limitations; a small sample size, retrospective study design from a single center, which may restrict the generalizability of the findings to older or younger TBI populations and clinical preselection for admission to rehabilitation. Additionally, we were unable to ascertain the duration or nature of pre-existing comorbidities. Therefore, the results of this study should be interpreted with caution. Future research should aim to include diverse patient populations through multi-centre studies to improve validity of the results.

5. Conclusions

In conclusion, our study provides evidence that ACUR during traumatic brain injury (TBI) rehabilitation are associated with poorer functional outcomes and longer length of stay in rehabilitation. This highlights the importance of addressing and minimizing ACUR impacts to optimize patient outcomes and reduce the socioeconomic burden. Reducing the readmission to acute care facilities remains a significant challenge in TBI. This may be achieved by either ongoing rehabilitation therapy albeit modified during acute illness to reduce deconditioning and secondary decline. Future research should focus on identifying the underlying causes and risk factors associated with ACUR to develop targeted interventions and preventive strategies.

6. Patents

Nil

Supplementary Materials: Nil.

Author Contributions: Conceptualization: PLO, AR, KSGC; Investigation: PLO, AR, KSGC; Methodology: PLO, AR, KSGC; Resources: PLO, AR, KSGC; Data curation: PLO, AR, KSGC; Analysis: PLO, AR, KSGC; Writing—original draft preparation: PLO, AR; Writing—review and editing: PLO, AR, KSGC; **Supervision:** KSGC Project administration: PLO, AR; All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of National Healthcare Group-NHG Domain Specific Review Boards (NHG DSRB 2018/01114).

Informed Consent Statement: Waiver of consent was obtained from NHG DSRB as only de identified data was involved without human subjects.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to institutional review board regulations.

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Conflicts of Interest: The authors declare no conflicts of interest.

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