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The Impact of the Pandemic of COVID-19 on the Head Injury Fast-Track System and Surgical Outcome

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Abstract

Objective This study aims to evaluate the impact of the coronavirus disease 2019 (COVID-19) pandemic on the head injury fast-track system and surgical treatment outcomes.

Materials and Methods A retrospective review was conducted on patients who underwent emergency neurological procedures according to the head injury fast-track system. Data from April 2018 to April 2020 (pre-COVID) were compared with data from May 2020 to May 2022 (during COVID).

Results The analysis comprised 128 patients in the prepandemic group and 119 patients in the pandemic group, with 5 patients diagnosed with COVID infection during the pandemic. Acute subdural hematoma resulting from motorcycle accidents was the most common diagnosis in both groups (56.3 and 47.5%, respectively). The initial Glasgow coma scale (GCS) score was significantly lower during the pandemic compared to the prepandemic period ($p = 0.025$). Time metrics in the emergency department, including door to computed tomography (CT), emergency room (ER) exit, and incision times, were significantly longer in the pandemic group ($p < 0.05$). However, there were no statistically significant differences in in-hospital mortality rates (25.8 and 17.7%, respectively; $p = 0.12$) or the percentage of patients with a favorable functional outcome (Glasgow outcome scale ≥ 4). At 1 month, a favorable functional outcome was observed in 51.6% of prepandemic patients and 57.1% of pandemic patients ($p = 0.69$), while at 6 months, the percentages were 56.8 and 64.5%, respectively ($p = 0.23$).

Conclusions Our study revealed significant delays in hospital processes for head injuries during the COVID-19 pandemic. However, we found no significant impact on mortality rates or functional outcomes of patients.

Keywords
- COVID-19
- head injury
- severe
- fast-track system
- neurological outcome
- time metrics
- traumatic brain injury
- pandemic impact

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Introduction

Coronavirus disease 2019 (COVID-19) infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected millions of patients worldwide.[1] COVID-19 was thought to originate in Wuhan, China, and was classified as a pandemic by the World Health Organization (WHO) in March 2020.[2] The COVID-19 pandemic impacted on the health care and workflow system with the need to prevent COVID-19 complications.

Traumatic brain injury (TBI) is the leading cause of death and disability worldwide. Recent literature has demonstrated that TBI has a significant impact on low- and middle-income countries (LMICs), with road traffic accidents being the main underlying cause.[3–6] Treatment for TBI is critically time sensitive. The approach of the health care system to TBI is associated with both pre- and perihospital processes. Tien et al revealed that reducing time to treatment decreases the mortality of patients with acute subdural hematoma.[7] Moreover, reducing time to brain computed tomography (CT) protocol to within 30 minutes of arrival of patients with a Glasgow coma scale (GCS) score $\leq$13 was associated with lower mortality.[8] Since 2015, in Thailand, many hospitals, including our institution, have developed the use of a head injury fast-track system with the aim of shortening the time process and improving the outcome of TBI.[9,10] A study by Arundon et al showed that using a head injury fast-track system reduced the mortality rate among severe head injury patients.[9]

During the COVID-19 pandemic, the process of the head injury fast-track system was highly impacted in both the pre- and perihospital period due to the need for standard protection techniques in the emergency room (ER), operating room preparation, and testing of COVID-19 status. Several studies showed a higher mortality rate of TBI during COVID-19, especially in LMICs.[11–13] However, no studies have explored the impact of the time metric of the head injury fast-track process during COVID-19. Our study aimed to investigate the impact of COVID-19 on the head injury fast-track system with regard to time metrics and clinical outcomes when comparing the prepandemic and pandemic eras.

Materials and Methods

We retrospectively reviewed our database of all head injury fast-track patients who underwent emergency neurosurgical procedures between April 2018 and April 2022 from electronic medical records. Before data collection, approval from the Research and Ethics Committee was obtained (approval number: 242/2561) and the study was carried out in accordance with the Declaration of Helsinki.

The patients were divided into two groups according to the treatment periods. The first group comprised patients treated before the COVID-19 pandemic (between April 2018 and April 2020). The second group comprised patients treated during the pandemic (between May 2020 and April 2022). May 2020 was selected as the initiation month for the COVID-19 cohort as, in our country, this represented the beginning of the lockdown policy and decrease in elective surgery cases. We excluded patients who had unstable vital signs, associated injuries that required further investigation and management or loss to follow-up.

Head Injury Fast-Track System

Our hospital, which is a university hospital (level I trauma center), in charge of TBI treatment in our region, covers three provinces in Northern Thailand. Patients who have severe TBI (GCS $\leq$8) or patients with moderate TBI (GCS 9–12) who underwent CT scans at other hospitals prior to admission and required emergency neurosurgical intervention are brought to our emergency department. The activation of head injury fast-track process is started after the patients arrive at the ER. The emergency physician then evaluates the patients and decides on appropriate management in accordance with the Advanced Trauma Life Support (ATLS) guidelines. Then, the emergency team activates the head injury fast-track procedure with the consultant neurosurgical and trauma team evaluating the patient within 15 minutes. The head injury fast-track goal is a door-to-CT time within 30 minutes and door-to-ER exit time within 60 minutes. After being evaluated by the neurosurgical team, neurosurgical intervention including the decision regarding craniotomy, decompressive craniectomy, or ventriculostomy in accordance with the guidelines for the Management of Severe Traumatic Brain Injury, fourth edition.[14] The goal of door-to-incision time is within 120 minutes (►**Fig. 1**)

During the COVID-19 pandemic from May 2020, the infection with SARS-CoV-2 was confirmed by the rapid antigen test or polymerase chain reaction (PCR) status in all patients, if the patients or relatives could not provide any history of COVID infection. We routinely used the rapid antigen test and PCR before the operation. To obtain the result for the rapid antigen, a waiting time of at least 45 to 60 minutes is required. The preoperative COVID-19 testing delays transfer to the operating room. However, patients with signs of brain herniation and brain edema are rapidly transferred to the operating room without waiting for the

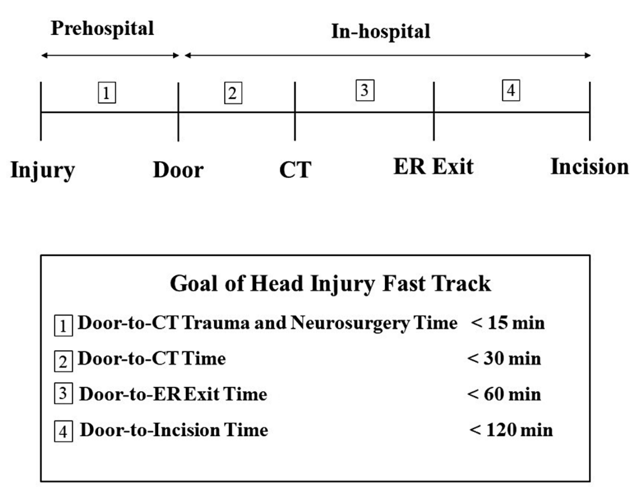

Fig. 1 Summary of the time metric of the head injury fast-track process and goals. CT, computed tomography; ER, emergency room.

COVID test result, with the operative setting and protective equipment prepared with precautions for potential COVID-19 infection.

The time metrics of the head injury fast-track system were evaluated, including (1) injury to ER, (2) door to CT, (3) door to ER exit, and (4) door to incision. The clinical outcome was assessed at the time of hospital discharge using GCS and functional outcome (Glasgow outcome scale [GOS]) at 1 and 6 months, respectively.

Statistical Analysis

Statistical analyses were carried out using STATA version 16.0 (StataCorp LLC). Variables were described using the frequency, mean, and standard deviation for normally distributed data and median and interquartile range (IQR) for non-normally distributed data. Normally distributed continuous data were compared by using a *t*-test, while those with a non-normal distribution were compared using the Mann–Whitney *U* test. Nonparametric qualitative analysis was carried out with the chi-squared test. A *p*-value less than 0.05 was considered statistically significant.

Results

In the 4-year study period from 2018 to 2022, electronic medical records were searched, according to which 2,119 patients had undergone emergency neurosurgery. After application of the exclusion criteria, 271 patients were included in our study. The prepandemic group numbered 128 and the pandemic group numbered 119. Based on the emergence of COVID-19 cases and health policy measures, the date of May 1, 2020, was identified as the starting point of the COVID-19 pandemic (►**Table 1**). Five patients were diagnosed with COVID-19 infection.

The median age of all the patients was 36 years (IQR: 24–54, with a range from 3 to 87 years) and 85.8% of the patients were males. The common diagnoses were acute subdural hematoma (52%), acute epidural hematoma (40.2%), and traumatic brain contusion (15.4%). The GCS ranged from 3 to 12. The most common cause of injury was motorcycle accident (74.8%) followed by falling (12.2%) and other (7.7%).

The baseline characteristics between the prepandemic and pandemic groups are presented in ►**Table 1**. The median age of patients in the two groups did not differ. The predominant type of intracranial hemorrhage in both groups was acute subdural hematoma (53.6 and 47.5%) and the primary cause of injury was motorcycle accident (75.8 and 73.7%) without statistical difference. The midline shifts that indicated subfalcine herniation with a median of 6.6 mm (IQR: 1.5–10.3) and 8 mm (IQR: 3–13) were not different between the two treatment periods. However, the severity of the injury evaluated by the initial GCS at the emergency department in the prepandemic group was lower than that during the pandemic, with mean values of 6.3 (±1.7) and 6.8 (±1.6), respectively ($p = 0.025$). Very severe head injury, defined as

Table 1 Comparison of patient characteristics

	Prepandemic ($n = 128$)	During pandemic ($n = 119$)	*p*-Value
Age (y), median (IQR)	36.5 (23–52.5)	36 (26–55)	0.36
Male (%)	110 (85.9)	101 (85.6)	
Diagnosis			
1. Epidural hematoma	51 (39.8)	48 (40.7)	0.89
2. Subdural hematoma	72 (56.3)	56 (47.5)	0.17
3. Traumatic brain contusion	16 (12.5)	22 (18.49)	0.19
4. Traumatic SAH	3 (2.3)	3 (2.5)	0.93
5. Traumatic ICH	10 (7.8)	5 (4.2)	0.24
6. Depressed skull fracture	6 (4.7)	6 (5.0)	0.89
7. Intraventricular hemorrhage	3 (2.3)	0	0.09
GCS, mean (±SD)	6.3 (1.7)	6.8 (1.6)	0.025
GCS at ED, no. (%)			
3–5	33 (26)	19 (16)	0.054
>5	94 (74)	100 (84)	
GCS motor score at ED			0.089
1 or 2	21 (16.5)	11 (9.2)	
3–6	106 (83.5)	108 (90.8)	
Cause			0.594
1. Motorcycle accident	97 (75.8)	87 (73.7)	
2. Car accident	2 (1.6)	4 (3.4)	
3. Falling	18 (14.1)	12 (10.2)	
4. Physical assault	2 (1.6)	2 (1.7)	
5. Gun shot	0	2 (1.7)	
6. Others	8 (6.3)	11 (9.3)	
Midline shift (mm), median (IQR)	6.6 (1.5–10.3)	8 (3–13)	0.19

Abbreviations: ED, emergency department; GCS, Glasgow coma scale score; ICH, intracerebral hemorrhage; IQR, interquartile range; SAH, subarachnoid hemorrhage; SD, standard deviation.

GCS score of 3 to 5 and a lower GCS motor response of 1 to 2, was higher in the prepandemic group than that in the pandemic group with borderline statistical significance with *p*-values of 0.054 and 0.089.

The Time Metrics of Head Injury Fast Track System

The injury to ER time in both groups did not differ, with median values of 180 minutes (IQR: 103–300 minutes) and 175 minutes (IQR: 110–345 minutes; ►**Table 2**). The processing time in the emergency department, including door-to-CT time and door-to-ER exit time, was significantly longer during the pandemic than in the prepandemic period, with *p*-values of 0.02 and less than 0.001, respectively. Finally, the delay in processing in the emergency department caused a statistically significant delay in the door-to-incision time: 133 minutes (IQR: 120–155 minutes) prepandemic compared to 160 minutes (IQR: 140–194 minutes) during the pandemic, with $p < 0.001$. The operative time in the pandemic group was significantly higher than that in the prepandemic era.

Six patients COVID-19 positive before emergency operation. All the patients had a door-to-incision time delay of at least 60 to 90 minutes due to the time required for preparation of the operating room, setting up protective device (personal protective equipment [PPE], powered air purifying respirator [PAPR]), and disposable operative sets.

The Surgical Outcome

The primary operative treatment, specifically 46 and 74%, was craniotomy to remove hematoma in both groups (►**Table 2**). Decompressive craniectomy before the pandemic was 38.3% compared with 18.5% during the pandemic, indicating the severity of intracranial injury in the prepandemic period. Surgical outcome including operative blood loss, length of stay in the hospital, and days requiring mechanical ventilation did not differ between the two groups. The GCS at discharge in the pandemic group was slightly higher than that in the prepandemic group with a median value of 13 (IQR: 10–14) and 13 (IQR: 11–14), with a *p*-value of 0.06. However, the mortality rate in the hospital

Table 2 Comparison of time metrics and surgical outcomes

	Prepandemic ($n = 128$)	During the pandemic ($n = 119$)	*p*-Value
Injury to ER (min), median (IQR)	180 (103–300)	175 (110–345)	0.89
Door to CT (min), median (IQR)	25 (20–35)[a]	30 (20–45)[a]	0.02
Door to ER exit (min), median (IQR)	70 (60–90)	90 (73–115)	<0.01
Door to incision (min), median (IQR)	133 (120–155)	160 (140–194)	<0.01
Operative time (min)	155 (113–213)	180 (145–225)	0.02
Surgery			
1. Craniotomy removal of hematoma	59 (46.1)	88 (74)	<0.01
2. Decompressive hemicraniectomy	49 (38.3)	22 (18.5)	<0.01
3. Bifrontal craniectomy	4 (3.1)	2 (1.7)	0.46
4. Ventriculostomy	16 (12.5)	8 (6.7)	0.12
5. Craniotomy to elevate skull	1 (0.8)	2 (1.7)	0.52
Blood loss (mL), median (IQR)	700 (300–1000)	600 (500–900)	0.85
Length of stay (d), median (IQR)	11 (5–18.5)	11 (6–15)	0.67
Days requiring ventilation, median (IQR)	4 (2–8)	3 (2–6)	0.16
GCS at discharge, median (IQR)	13 (10–14)	13 (11–14)	0.06
Mortality at discharge	33 (25.8)	21 (17.7)	0.12
Glasgow outcome score[a] at 1 mo, no. (%)			
1. Dead	33 (25.8)	22 (19.6)	0.79
2. Permanent vegetative state	6 (4.7)	4 (3.6)	
3. Severe disability and dependent	23 (18)	22 (19.6)	
4. Moderate disability but dependent	21 (16.4)	22 (19.6)	
5. Good recovery	45 (35.2)	42 (37.5)	
Good functional outcome at 1 mo (GOS $\geq$ 4)	66 (51.6)	64 (57.12)	0.39
Glasgow outcome score[a] at 6 mo, no. (%)			
1. Dead	35 (28)	23 (21.5)	0.70
2. Permanent vegetative state	3 (2.4)	2 (1.9)	
3. Severe disability and dependent	16 (12.8)	12 (12.2)	
4. Moderate disability but independent	10 (8)	12 (12.2)	
5. Good recovery	61 (48.8)	56 (52.34)	
Good functional outcome at 6 mo (GOS $\geq$ 4)	71 (56.8)	69 (64.5)	0.23

Abbreviations: CT, computed tomography; ER, emergency room; GOS, Glasgow outcome scale; IQR, interquartile range.
[a]Calculated from patients due to missing data.

Table 3 Subgroup analysis of low Glasgow coma scale score (GCS 3–5)

	Prepandemic ($N=33$)	During pandemic ($N=19$)	p-Value
Operation			
1. Craniotomy remove hematoma	9 (27.3)	12 (63.2)	0.018
2. Decompressive hemicraniectomy	22 (66.7)	7 (36.9)	0.047
Length of stay (d), mean (SD)	11.4 (10.1)	11.8 (10.6)	0.89
Days with ventilator, mean (SD)	5.8 (0.8)	6.1 (0.9)	0.88
GCS at discharge, mean (SD)	8.6 (0.9)	8.9 (1.3)	0.84
Mortality at discharge	18 (54.5)	9 (47.4)	0.77
Good functional outcome at 1 mo (GOS $\geq$ 4)	4 (11.1)	4 (21.1)	0.43
Good functional outcome at 6 mo (GOS $\geq$ 4)	5 (15.2)	6 (35.3)	0.15

Abbreviations: GOS, Glasgow outcome scale; SD, standard deviation.

did not differ between the two groups. Three patients in the prepandemic group and seven patients in the pandemic group were lost to follow-up, and their data were not included in the calculation of functional outcome at 1 and 6 months. At 1 month, good functional outcomes, defined as GOS $\geq$ 4, were found in 51.6% of patients in the prepandemic group compared to 57.1% in the patients in the pandemic group ($p=0.69$). At 6 months, good functional outcomes were found in 56.8% in the prepandemic group and 64.5% in the pandemic group ($p=0.23$).

Subgroup Analysis in Low Glasgow Coma Score Patients

We were focusing on severe TBI with low GCS with subgroup analysis (►**Table 3**). The result shows the craniotomy procedure was significantly higher during the pandemic period (63 vs. 27%, respectively, $p=0.018$). Otherwise, decompressive hemicraniectomy was the most common procedure in the prepandemic period (67 vs. 37%; $p=0.047$). The other hospital parameters such as length of stay, day with ventilator, GCS, or mortality at discharge were not different between the two groups. The good functional outcomes at 1 and 6 months were not different between the two groups.

Discussion

The study examined the impact of COVID-19 on the head injury fast-track system. Our data show that COVID-19 causes significant delays in time metrics during the ER-to-operation process including door to CT, door to ER exit, door to incision, and operative time, but there is no significant effect on the injury-to-ER time interval or the prehospital period. However, this delay in time metrics did not affect surgical outcomes between these two periods including intraoperative blood loss, length of stay, days requiring ventilation, mortality rate, GCS at discharge and at 1 and 6 months, and good functional outcome at 1 and 6 months.

The COVID-19 pandemic impacted neuro-emergent patient transfer by decreasing interhospital patient transfers and increasing the length of stay without impacting clinical outcomes, according to the Woodward et al study.[15] However, no prior study has demonstrated the impact of COVID-19 on the head injury fast-track workflow system, mortality rate, and functional outcome.

It is evident that COVID-19 caused a delay in the hospital process as shown by our results. For example, unconscious patients with no history of COVID-19 needed to stay in a negative pressure room and were transferred with the capsule for CT scan. The door-to-ER exit timings were also delayed in the patients treated during the pandemic in addition to the delay in CT time. The patients needed to be swabbed for the COVID-19 test before surgery and the laboratory collection and processing also added to the delay in time. The transfer teams needed time to prepare the infection protection devices. The preparation of the operation room and the universal protection for the anesthesiologists also caused a delay in the door-to-incision time. Moreover, the limited health care resource during COVID-19 also impacted the fast-track workflow system. Interestingly, the prehospital period time metrics were not affected by COVID-19. This may be due to shorter duration of evaluation and treatment process in the primary hospital before rapid transfer to our center.

During the prepandemic period, patients with TBI showed lower GCS with lower motor response and there was a greater association with greater severity of injury in comparison to the pandemic period. Many factors contributed to this seemingly protective effect of COVID-19 on TBI. The factors include country lockdown, public mobility limits, and a restricted alcohol consumption policy, which all resulted in a lower incidence of traffic-related injury during the pandemic.[16,17] The major cause of head injury is traffic accident. In addition, the risk factors such as alcohol consumption and nonhelmet use in motorcycle accidents increased the severity of the injury.[18] These more severe cases of injury with lower GCS resulted in a higher incidence of the performance of decompressive hemicraniectomy in the prepandemic period when compared with during the pandemic period.

However, the effect of severity of injury in the prepandemic period did not significantly affect the long-term outcome as shown by half of the patients in both groups having good functional outcomes 6 months after discharge even though the GCS at discharge was lower in the prepandemic group. This may be explained by the lower median age of the patients who had good recovery in our study.[19]

The mortality rate in our study (25.8% prepandemic and 17.7% during the pandemic) did not differ from the similar studies examined in the literature review.[1,6] Damara et al performed a meta-analysis of TBI during the COVID-19 pandemic.[1] The study showed no significant differences in the mortality in patients treated before and during the COVID-19 pandemic, with an overall mortality of 38 versus 46%.

A previous study reported a decrease in the mortality rate from 23.1 to 12.4% after using a head injury fast-track system.[9] However, benefits in mortality were demonstrated after adjusting for associated factors such as acute subdural, linear skull fracture, and diffused brain injury. Acute subdural hematoma, the most common of diagnosis in our study both prepandemic and during the pandemic, is an important factor as the condition is associated with a high mortality rate (45–63%).[20] Tien et al investigated the correlation between time to treatment and mortality in patients with acute subdural hematoma and found that increased prehospital time was associated with increased mortality. However, there were no differences in mortality in the patients who underwent craniotomy within 4 hours or after 4 hours.[7]

Despite the in-hospital delays associated with COVID-19 in our study, the rate of mortality and functional outcome was not affected. Moreover, although the time metrics of the in-hospital process in our study did not reach the goal of fast-track protocol, the mortality rate and functional outcome were not different from those observed with the standard protocol.[21] These results may be explained by the median door-to-incision time being less than 200 minutes in both groups, which is a reasonable time according to Matsushima et al.[22] Matsushima et al's study found the benefit of performing emergency surgery within less than 200 minutes in cases of severe TBI as this resulted in a lower in-hospital mortality rate of 34.5%, compared with 59.1% in a group operated on after a longer delay.[22] So, a door-to-incision time of less than 200 minutes may be important an factor for decreased mortality and improved functional outcome of TBI when compared with other parameters such as prehospital time or injury-to-incision time.

Our study highlights the effectiveness of a fast-track system for TBI aimed at reducing mortality and morbidity among patients in the future. However, during the COVID-19 pandemic, there were significant delays in the preoperative process. Therefore, revising protocols during pandemic outbreaks and enhancing preparation and resource allocation from the prehospital stage to the hospital setting can help address this health care challenge effectively.

One limitation of the study is the retrospective design of the study, so some outcomes, especially clinical and functional outcomes, were missing in 12 patients, especially in relation to the transfer of the patients back to the local hospital as shown in ►**Table 2**. Some patients in our study did not have a door-to-CT time because they were transferred from other hospitals and had already had a CT scan. Different teams of surgeons performed emergency surgeries in the two different periods of the study; in particular, surgeries performed by our resident team would impact the surgical and operative outcomes; however, all the team members were trained and supervised by the same instructors.

Conclusion

In comparison to the period before the pandemic, COVID-19 had a significant impact on the time metrics of the head injury fast-track system, resulting in a delay in the hospital process including door-to-CT, ER entry, and incision times. However, the delay in the processes, as a consequence of COVID-19, did not affect the mortality and functional outcomes of the patients with head injuries that required emergency neurosurgical treatment.

Authors' Contributions

T.N. and J.V. contributed to conceptualization. J.V. performed data collection. J.V., T.N., T.V., K.L., and T.K. performed formal analysis. T.N., J.V., and T.K. contributed to writing the original draft. T.N., K.L., T.V., W.W., C.J., T.P., W.V., C.S., T.K., and J.V. contributed to writing, reviewing, and editing of the manuscript.

Patients' Consent

In accordance with the ethical approval, patient consent was not needed due to the observational nature of the study.

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Conflict of Interest

None declared.

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