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Predictive Factors of Return Home and Return to Work for Intensive Care Unit Survivors after Traumatic Brain Injury with a Follow-up Period of 2 Years

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Abstract

Intensive care unit (ICU) survivors after traumatic brain injury (TBI) frequently have serious disabilities with subsequent difficulty in reintegration into society. We aimed to investigate outcomes for ICU survivors after moderate to severe TBI (msTBI) and to identify predictive factors of return home (RH) and return to work (RTW). This single-center retrospective cohort study was conducted on all trauma patients admitted to the emergency ICU of our hospital between 2013 and 2017. Of these patients, adult (age ≥ 18 years) msTBI patients with head Abbreviated Injury Scale ≥ 3 were extracted. We performed univariate/multivariate logistic regression analyses to explore the predictive factors of RH and RTW. Among a total of 146 ICU survivors after msTBI, 107 were included (median follow-up period: 26 months). The RH and RTW rates were 78% and 35%, respectively. Multivariate analyses revealed that the predictive factors of RH were age < 65 years ($P < 0.001$), HR < 76 bpm ($P = 0.015$), platelet count ≥ 19 × 10^4/μL ($P = 0.0037$), D-dimer < 26 μg/mL ($P = 0.034$), and Glasgow Coma Scale (GCS) score > 8 ($P = 0.0015$). Similarly, the predictive factors of RTW were age < 65 years ($P < 0.001$) and GCS score > 8 ($P = 0.0039$). This study revealed that "age" and "GCS score on admission" affected RH and RTW for ICU survivors after msTBI.

Keywords: employment, ICU survivor, moderate to severe traumatic brain injury, return home, return to work

Introduction

Traumatic brain injury (TBI) is a major cause of death and severe disability. According to the recent Japan Trauma Data Bank, a national trauma registry in Japan, head injury accounts for approximately 19% of all trauma patients and is the second most frequent injury following lower limb injury.[1)] Patients with moderate to severe TBI (msTBI) often have multiple organ injuries that need to be treated in the intensive care unit (ICU). In recent years, the mortality rate in the field of trauma care has decreased with advances in ICU treatment methods.[2)] Nevertheless, 25% to 50% of patients with msTBI still die in the ICU within a year.[3-5)] Even if TBI patients survive the ICU, they are often transferred to a rehabilitation hospital or discharged to a skilled nursing facility, residential facility, or nursing home after acute treatment.[6)] In fact, it was reported that approximately 25% to 45% of ICU survivors after TBI were not discharged home.[7,8)] Return home (RH) is one of the most important goals for ICU survivors.[9)] Jette *et al.* have reported that the RH rate for ICU survivors after TBI was 43.2%.[10)]

Over one-third of ICU survivors (35%-43%) after TBI continue to have long-term motor and sensory impair-

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ments,[11,12] and some have permanent disabilities.[13] There is an increased risk of depression, post-traumatic stress, cognitive impairments, and physical weakness for several years after discharge, collectively known as post-intensive care syndrome.[14] Because these disabilities can significantly influence activity patterns, social participation, and quality of life,[15,16] ICU survivors after msTBI often have difficulty returning to work. It was reported that the return to work (RTW) rate was 38% to 54% for msTBI patients 1 year after TBI.[17,18] Based on these results, the long-term outcome of ICU survivors and the predictive factors related to these outcomes have attracted attention.[19] ICU survivors after TBI are sometimes able to achieve improvement in long-term physical function and reintegration into society (e.g., housework and occupation).

To the best of our knowledge, however, no clinical studies have evaluated the RH and RTW rates in tandem with these predictive factors for ICU survivors after msTBI. The aim of this single-center retrospective cohort study was to assess the RH and RTW rates of ICU survivors after msTBI, defined as head Abbreviated Injury Scale (AIS) ≥ 3, with a follow-up period of 2 years and to identify the predictive factors related to these results.

Materials and Methods

Study design and participants

This study was approved by the Institutional Review Board (IRB)/Ethics Committee of Okayama University Hospital, Japan (IRB No. 191-023). Based on the opt-out method, we disclosed information about this study and excluded data when the patient declined to participate directly or by proxy. Informed consent was obtained from all participants or their family members.

A single-center retrospective cohort study was conducted on all trauma patients who were taken to the emergency ICU at our hospital between April 2013 and March 2017. Patients who had msTBI, defined as head AIS ≥ 3, were included in this study.[20] The exclusion criteria were patients who died of cardiac arrest on arrival or who died after admission to our hospital and patients younger than age 18 years at the time of injury. The collected data included age, sex, mechanism of injury, GCS score on admission, Injury Severity Score, head AIS, mRS score at discharge or transfer, surgical intervention for TBI, length of stay at our hospital, vital signs on admission, and laboratory test results. Blood samples were obtained immediately on arrival at our hospital. Laboratory tests included hemoglobin (Hb) level, white blood cell count, platelet count, lactate level, base excess, prothrombin time-international normalized ratio, activated partial thromboplastin time, fibrinogen, and D-dimer level.

Outcome measurements were obtained from hospital medical records, outpatient follow-up records, and telemedicine records. We evaluated ICU survivors after msTBI with a follow-up period of 2 years. The primary endpoint was the patient being eventually able to RH, and the secondary endpoint was the patient being eventually able to RTW. RTW in this study was defined as return to work without consideration of the job type or working hours. A total of 107 ICU survivors after msTBI were used in the analyses to identify the predictive factors of RH and RTW.

Statistical analysis

Univariate analyses were performed using Fisher's exact probability test or χ^2 test for nominal variables and the Student's *t*- or Wilcoxon signed-rank sum test for continuous variables, as appropriate. Multivariate analyses were performed using logistic regression analysis. We selected $P < 0.05$ and clinically relevant variables (age, sex, heart rate [HR], Hb, platelet count, base excess, lactate, fibrinogen, prothrombin time-international normalized ratio, D-dimer, GCS score, and head AIS). According to the results of multivariate analyses and clinical relevance, the cutoff points for the predictive factors of RH and RTW were determined using a receiver operating characteristic curve analysis. JMP 13 software (SAS Institute, Cary, NC, USA) was used to perform all analyses. The results are presented as odds ratios (OR) with 95% confidence intervals. A P value < 0.05 was considered statistically significant.

Results

The flow diagram of this study is shown in Fig. 1. Over 5 years, 826 trauma patients were admitted to the emergency ICU at our hospital. A total of 185 patients had a brain injury with head AIS ≥ 3, and 21 were excluded because they died in the hospital within 3 months. Therefore, a total of 164 patients were included in the analysis. Eighteen patients younger than 18 years at the time of injury were excluded. The outcome was confirmed in 120 patients, of which 13 died within 3 months of discharge from our hospital. The remaining 107 adult patients were examined in our study analyses.

Patient characteristics

Patient baseline characteristics and outcomes are shown in Table 1. There were 66 (61.7%) males and 41 (38.3%) females with a median age of 55 years (range: 18-88 years). The follow-up period was 26 months (median: 80 months). The most common way of injury was motor vehicle accidents (65.4%, 70/107 patients), followed by falls (30.8%, 33/107 patients). The median initial GCS score of the patients was 12 (range: 3-15) and the number of patients with a GCS score of less than 8 was 39 (36%). The median Injury Severity Score was 29 (range: 9-66). Head AIS was used to estimate TBI severity; head AIS 4 was the most common (42.0%, 45/107 patients), followed by head AIS 5 (40.2%, 43/107 patients) and head AIS 3 (16.8%, 18/107 patients). Among 107 patients, 19 (17.8%) underwent surgical inter-

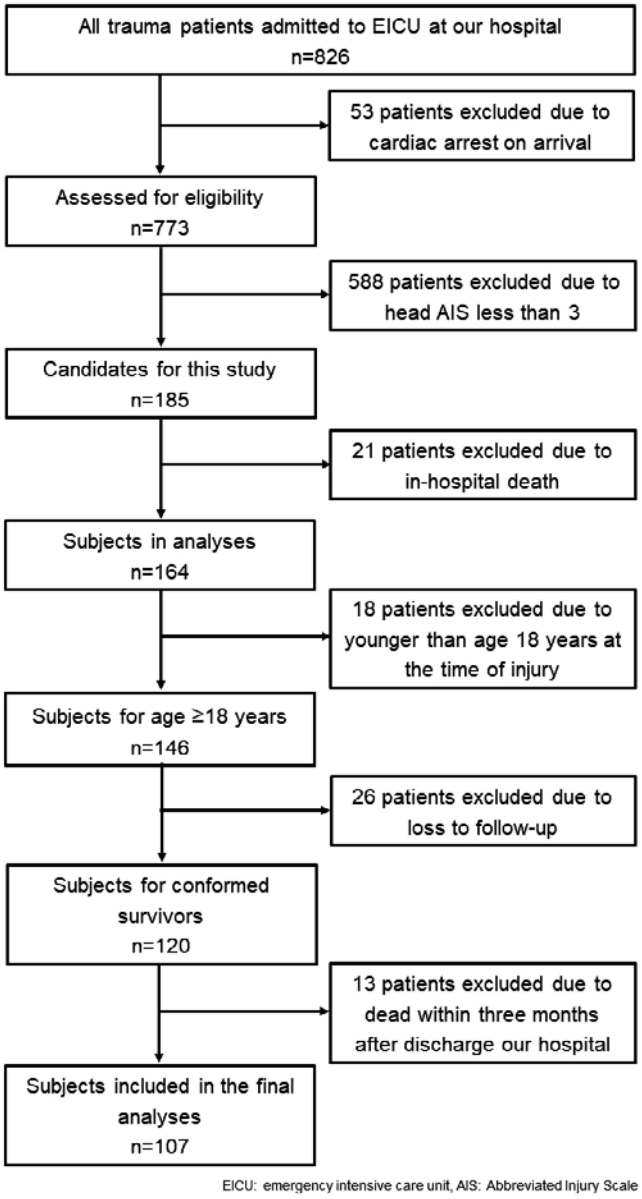

Fig. 1 Flow diagram showing the cases included in this study.
AIS: Abbreviated Injury Scale, EICU: emergency intensive care unit

vention for TBI and the median length of stay in our hospital was 18 days (range: 2-127 days). The components of the final mRS score were distributed as follows: mRS0, 9 (8.4%); mRS1, 44 (41.1%); mRS2, 20 (18.7%); mRS 3, 13 (12.1%); mRS 4, 9 (8.4%); mRS 5, 10 (9.3%); and mRS 6 (after 3 or more months of hospital stay), 2 (1.8%).

Return home and return to work rates

Of the 107 patients, the percentage (number) of patients who were able to RH was 78% (83 patients) and that of those that were not was 22% (24 patients). Moreover, the number of patients who were able to RTW was 35% (37 patients) and that of those that were not was 65% (70 patients).

Predictive factors related to return home

The results of the univariate analyses of the predictive factors related to RH are summarized in Table 2. In the univariate analyses, age ($P < 0.001$), HR ($P = 0.016$), Hb ($P = 0.021$), lactate ($P = 0.006$), D-dimer ($P = 0.028$), and GCS score ($P = 0.011$) were significantly associated with the predictive factors of RH. The results of the multivariate analyses of predictive factors related to RH are summarized in Table 3 (upper). In the multivariate analyses, age < 65 years (OR, 22.2; $P < 0.001$), HR < 76 bpm (OR, 8.2; $P = 0.015$), platelet count ≥ $19\times10^4/\mu L$ (OR, 8.8; $P = 0.0037$), D-dimer < 2.6 μg/mL (OR, 3.9; $P = 0.034$), and GCS score > 8 (OR, 9.7; $P = 0.0015$) were predictive factors of RH.

Predictive factors related to return to work

The results of the univariate analyses of the predictive factors related to RTW are summarized in Table 4. In the univariate analyses, age ($P < 0.001$), male sex ($P = 0.037$), Hb ($P = 0.005$), and GCS score ($P = 0.016$) were significantly associated with the predictive factors of RTW. The results of the multivariate analyses of predictive factors related to RTW are summarized in Table 3 (lower). In the multivariate analyses, age < 65 years (OR, 24.5; $P < 0.001$) and GCS score > 8 (OR, 5.4; $P = 0.0039$) were predictive factors of RTW.

Discussion

This retrospective cohort study is the first to evaluate the RH and RTW rates along with exploring their potential predictive factors for ICU survivors after msTBI, defined as head AIS ≥ 3. We revealed that the RH and RTW rates were 78% (83 patients) and 35% (37 patients), respectively, among the 107 confirmed ICU survivors after msTBI. Moreover, multivariate analysis revealed that the predictive factors of RH and RTW were age < 65 years and GCS score > 8.

Outcomes of intensive care unit survivors after moderate to severe traumatic brain injury with follow-up for 2 years

In our study, 78% of msTBI patients who survived the acute phase lived for 2 years; our result was higher than expected. Wilkins *et al.* reported that three-quarters of severe TBI (sTBI) patients who were alive at 6 months showed functional improvement and that 74% of the survivors at 2 years had a favorable outcome.[21] Corral *et al.* also reported that sTBI patients admitted to the ICU had a significant improvement in functional outcomes at 6 months and 1 year.[22] Our study is consistent with their results and it is conceivable that if patients with msTBI survive at least 6 months after injury, good outcomes can be ex-

Table 1 Patient baseline characteristics and outcomes for this study population

Variables	Total (n = 107)
Baseline	
Age at injury in years (median, [IQR])	55.00 [33.50-73.00]
Sex, n (%)	
Male	66 (61.7)
Female	41 (38.3)
Follow up period (months; median, [IQR])	26.00 [7.00-42.50]
Mechanism of injury, n (%)	
motor vehicle accident	70 (65.4)
fall	33 (30.8)
other	4 (3.7)
Vital signs (mean, SD)	
SBP (mmHg)	137.3 ± 30.1
HR (bpm)	92.0 ± 21.2
RR (/min)	22.2 ± 7.1
Head AIS	
Head AIS, n (%)	
3	19 (18)
4	45 (42)
5	43 (40)
GCS score	
GCS score (median, [IQR])	12 [7-14]
GCS score ≤ 8, n (%)	39 (36)
ISS (median, [IQR])	
ISS	29.00 [22.00, 36.00]
Laboratory test (mean, SD)	
Hb (g/dL)	13.01 ± 2.09
Plt ($\times 10^4/\mu L$)	21.26 ± 6.78
BE	−1.79 ± 3.29
Lac (mg/dL)	2.63 ± 1.49
Fib (mg/dL)	257.24 ± 80.96
PT-INR	1.02 ± 0.16
D-dimer (μg/mL)	41.46 ± 43.57
Treatment	
Surgical intervention for TBI, n (%)	19 (17.8)
Outcome	
Length of stay in our hospital (days; median, [IQR])	18.00 [10.50-28.00]
mRS at discharge our hospital, n (%)	
0	9 (8.4)
1	44 (41.1)
2	20 (18.7)
3	13 (12.1)
4	9 (8.4)
5	10 (9.3)
6	2 (1.9)

IQR: interquartile range, SD: standard deviation, SBP: systolic blood pressure, HR: heart rate, RR: respiratory rate, AIS: Abbreviated Injury Scale, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, Hb: hemoglobin, Plt: platelet count, BE: base excess, Lac: lactate, Fib: fibrinogen, PT-INR: Prothrombin Time-International Normalized Ratio, TBI: traumatic brain injury, mRS: modified Rankin Scale

Table 2 Univariate analysis for the predictive factors related to return home

Variables	Non-RH (n = 24)	RH (n = 83)	*P* value
Baseline			
Age (mean, SD)	65.50 ± 18	48.6 ± 21.4	<0.001
Sex, n (%)			
Male	16 (66.7)	50 (60.2)	0.64
Female	8 (33.3)	33 (39.8)	
Mechanism of injury, n (%)			
Motor vehicle accident	14 (58.3)	56 (67.5)	0.38
Fall	10 (41.7)	23 (27.7)	
Other blunt mechanism	0 (0.0)	4 (4.8)	
Vital signs (mean, SD)			
SBP (mmHg)	135.12 ± 35.60	137.90 ± 28.51	0.692
HR (bpm)	101.12 ± 21.47	89.37 ± 20.51	0.016
RR (/min)	23.54 ± 5.77	21.78 ± 7.47	0.289
Head AIS			
Head AIS ≥ 4 (%)	23 (95.8)	68 (81.9)	0.11
GCS score			
GCS ≤ 8, n (%)	14 (58.3)	25 (30.1)	0.011
ISS			
ISS ≥ 25, n (%)	18 (75)	57 (68.7)	0.55
Laboratory test (mean, SD)			
Hb (g/dL)	12.15 ± 2.09	13.26 ± 2.03	0.021
Plt ($\times 10^4/\mu L$)	18.97 ± 6.25	21.92 ± 6.81	0.006
BE	−2.88 ± 4.45	−1.48 ± 2.84	0.079
Lac (mg/dL)	3.39 ± 1.88	2.42 ± 1.29	0.006
Fib (mg/dL)	245.04 ± 80.84	260.61 ± 81.16	0.417
PT-INR	1.04 ± 0.14	1.02 ± 0.16	0.527
D-dimer (μg/mL)	58.62 ± 51.34	36.44 ± 39.99	0.028
Treatment			
Surgical intervention for TBI, n (%)	7 (29.2)	12 (14.5)	0.13
Outcome			
Length of stay in our hospital (days; median, [IQR])	20.50 [13.75-35.50]	17.00 [7.50-27.50]	0.105

RH: return home, SD: standard deviation, SBP: systolic blood pressure, HR: heart rate, RR: respiratory rate, AIS: Abbreviated Injury Scale, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, Hb: hemoglobin, Plt: platelet count, BE: base excess, Lac: lactate, Fib: fibrinogen, PT-INR: Prothrombin Time-International Normalized Ratio, TBI: traumatic brain injury, IQR: interquartile range

pected.

Return home and return to work rates

In Japan, a nationwide survey was carried out to identify the predictive factors for in-hospital mortality following TBI among elderly patients (J-ASPECT study-traumatic brain injury).[23] In this nationwide survey, they analyzed patients with mild (Japan Coma Scale [JCS] score: 1-digit code 1-3), moderate (JCS score: 2-digit code 10-30), and severe (JCS score: 3-digit code 100-300) TBI from not only advanced critical care and emergency centers but also municipal hospitals. This study showed that the RH rate of non-elderly TBI patients (<65 years) was 53.7% and that of elderly TBI patients (≥65 years) was 34.9% at discharge, that is, about 30 days after admission. Elderly patients had a lower RH rate than non-elderly patients, even though the level of consciousness on admission was better. For msTBI, the RH rates of non-elderly and elderly TBI patients decreased to 38.1% and 12.2%, respectively. In addition, the severity of the JCS score on admission was significantly related to the RH rate for elderly patients. Our RH rate after a median follow-up period of 26 months was higher (78%) than that of this nationwide survey because the latter analyzed the direct RH rate at discharge about 30 days after

Table 3 Multivariate analysis for the predictive factors related to return home (upper) and return to work (lower)

Predictive factors related to return home			
Variables	*P* value	Odds ratio	95% CI
Age < 65	<0.001	22.2	4.7-103.5
Male sex	0.08	3.7	0.8-16.5
HR < 76	0.015	8.2	1.5-44.8
Hb ≥ 13	0.56	0.63	0.14-2.9
Plt ≥ 19	0.0037	8.8	2.0-38.3
BE ≥ −2.4	0.84	1.2	0.21-6.9
Lac < 3.4	0.46	1.9	0.33-11.1
D-dimer < 26	0.034	3.9	1.1-13.6
GCS score > 8	0.0015	9.7	2.4-39.6
Head AIS < 4	0.1	17.4	0.6-529.7

Predictive factors related to return to work			
Variables	*P* value	Odds ratio	95% CI
Age < 65	<0.001	24.5	4.7-128.3
Male sex	0.76	0.82	0.24-2.8
Hb ≥ 13	0.75	1.2	0.34-4.3
Fib ≥ 275	0.099	0.4	0.13-1.2
D-dimer < 26	0.64	1.3	0.46-3.5
GCS score > 8	0.0039	5.4	1.72-17.2
Head AIS < 4	0.87	0.89	0.21-3.6

CI: confidence interval, HR: heart rate, Hb: hemoglobin, Plt: platelet count, BE: base excess, Lac: lactate, GCS: Glasgow Coma Scale, AIS: Abbreviated Injury Scale, Fib: fibrinogen

admission. The difference in the RH rate described above means that many patients recovered to the level of living at home in about 2 years after discharge from our hospital.

A multi-country retrospective study in Europe (The Collaborative European NeuroTrauma Effectiveness Research in TBI [CENTER-TBI] project) analyzed the RTW rate at 1 year after msTBI and found that 57% of moderate TBI and 41% of sTBI patients returned to work.[3,24] Post-injury employment prevalence after TBI was analyzed in several studies.[13,25-27] These systematic reviews reported an RTW rate ranging from 7.7% to 72.1%. It is conceivable that this significant range can be attributed to the follow-up period, injury severity, and sample size. These systematic reviews included employment outcomes after minor TBI,[27,28] while Gormley *et al.* reviewed employment outcomes after msTBI.[29] Gormley's review included 38 studies and reported that the RTW rate was 42.2%, regardless of the study follow-up intervals. Considering the study follow-up intervals, however, the RTW rate seems to increase over time, from 34.9% at 1 year to 42.1% up to 5 years and 49.9% beyond 5 years after injury. This result is unexpected because patients after sTBI would die as time passed and the RTW rate would therefore decrease.[30,31] The RTW rate of 2 years in our study (33%) corresponded to those reported by Odgaard *et al.* (34.9%).[32] Moreover, Odgaard *et al.* analyzed the prevalence of sTBI with a stable labor market attachment (17.7%) and found that sTBI patients have unstable employment. This differs from our study in terms of severity assessment method (AIS vs. GCS) and sample size (164 patients vs. 637 patients). Furthermore, Jackson *et al.* analyzed 58 traumatic ICU survivors without intracranial hemorrhage on head computed tomography 12 or 24 months and reported that the RTW rate was 66% (38 patients).[33] Their results did not correspond to those of our study because only 35% of the survivors in our study were able to RTW. This discrepancy may be attributed to the inclusion of msTBI patients in our study.

Predictive factors of return home and return to work

Several studies have focused on the predictive factors of RH in patients with msTBI[23,34-38] and ICU survivors.[34,39,40] In agreement with our results, these studies have suggested that the predictive factors of RH are age,[23,35,41] GCS score,[34,35,37] and HR.[38] Leitgeb *et al.* reported that the predictive factors of RH at 1 year in ICU survivors after sTBI were age and GCS score,[34] which are consistent with those found in our study. Other predictive factors were cited, i.e., length of stay in hospital,[37] Functional Status Score for the ICU,[39] and Acute Physiology and Chronic Health Evaluation II score.[40]

Although several studies have focused not on the predictive factors of RH but on the outcome and prognosis for TBI patients or ICU survivors in terms of laboratory tests on admission, these studies have suggested that low platelet count and high D-dimer levels were related to worse prognosis.[41-44] These poorer outcomes of msTBI patients[44,46] might be due to trauma-induced coagulopathy, such as hemostasis and platelet dysfunction[45]. Salehpour *et al.* reported that the platelet counts of ICU non-survivors after sTBI were significantly lower and that low platelet count and GCS score on admission were related to poor prognosis following sTBI.[46] Gayat *et al.* analyzed the clinical and biological parameters associated with the long-term life prognosis of ICU survivors (French and European Outcome reGistry in Intensive Care Units [FROG-ICU] study), suggesting that age and platelet count are associated with the predictive factors of 1-year mortality for ICU survivors after discharge from hospital.[19]

As for D-dimer in TBI patients, Chhabra *et al.* reported that a high D-dimer level on admission was a predictive factor of in-hospital mortality.[47] Based on the above results,[37-44] previous studies may help explain our results showing that platelet count and D-dimer are predictive factors for RH in msTBI patients and ICU survivors.

Table 4 Univariate analysis for the predictive factors related to return to work

Variables	Non-RTW (n = 70)	RTW (n = 37)	*P* value
Baseline			
Age (mean, SD)	60.4 (20.6)	37.2 (15.2)	<0.001
Sex, n (%)			
Male	38 (54.3)	28 (75.7)	0.037
Female	32 (45.7)	9 (24.3)	
Mechanism of injury, n (%)			
Motor vehicle accident	46 (65.7)	24 (64.9)	0.76
Fall	22 (31.4)	11 (29.7)	
Other blunt mechanism	2 (2.9)	2 (5.4)	
Vital signs (mean, SD)			
SBP (mmHg)	139.7 (33.5)	132.7 (21.8)	0.25
HR (bpm)	93.0 (23.8)	90.1 (15.1)	0.5
RR (/min)	22.8 (7.6)	21.1 (6.0)	0.24
Head AIS			
Head AIS ≥ 4, n (%)	62 (88.6)	29 (78.4)	0.17
GCS			
GCS ≤ 8, n (%)	40 (47.6)	9 (24.3)	0.016
ISS			
ISS ≥ 25, n (%)	64 (76.2)	23 (62.2)	0.11
Laboratory test (mean, SD)			
Hb (g/dL)	12.6 (2.1)	13.79 (1.80)	0.005
Plt ($\times 10^4/\mu L$)	20.9 (7.0)	21.89 (6.35)	0.48
BE	−1.6 (3.7)	−2.18 (2.47)	0.4
Lac (mg/dL)	2.6 (1.6)	2.68 (1.24)	0.82
Fib (mg/dL)	267.5 (83.9)	238.05 (72.33)	0.074
PT-INR	1.0 (0.2)	1.02 (0.09)	0.9
D-dimer (μg/mL)	47.3 (48.0)	30.6 (31.6)	0.082
Treatment			
Surgical intervention for TBI, n (%)	14 (20.0)	5 (13.5)	0.6
Outcome			
Length of stay in our hospital (days; median, [IQR])	17 [12.00, 27.78]	18 [7.0, 28.0]	0.48

RTW: return to work, SD: standard deviation, SBP: systolic blood pressure, HR: heart rate, RR: respiratory rate, AIS: Abbreviated Injury Scale, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, Hb: hemoglobin, Plt: platelet count, BE: base excess, Lac: lactate, Fib: fibrinogen, PT-INR: Prothrombin Time-International Normalized Ratio, TBI: traumatic brain injury, IQR: interquartile range

As for the predictive factors of RTW, several studies reported that age and GCS score were the predictive factors of RTW for ICU survivors after msTBI.[17,24,25,31,48,49] According to the aforementioned J-ASPECT study-traumatic brain injury and CENTER-TBI project, age and GCS score were important predictive factors of employment status after TBI for all TBI severities.[23,49] These studies reported that older age and lower GCS score were associated with a higher probability of unemployment. However, two systematic reviews on the predictive factors of RTW after TBI obtained inconclusive results regarding age and GCS score as predictive factors.[50,51] The systematic review by Donker-Cools *et al.* reported that a high education level is positively associated with RTW and that unemployment before injury and length of stay in rehabilitation are negatively associated with RTW.[50] Thus, the predictive factors of RTW after TBI remain controversial.

Future research topics

msTBI patients and ICU survivors are more likely to face psychiatric sequelae such as cognitive impairment, depression, and sleep disturbance or post-intensive care syndrome after RH and RTW.[52,53] These symptoms are also leading causes of poorer health-related quality of life

(HRQOL)[54,55] and it is important to understand them as well as to evaluate the HRQOL of ICU survivors after TBI.[56] Because previous studies have revealed that family and caregiver functioning affect the HRQOL of ICU survivors after TBI,[57,58] their cooperation and support are indispensable. The present study did not examine cognitive function, mental function, or HRQOL. Further studies are required to examine mental health and HRQOL of ICU survivors after msTBI with a longer follow-up period.

Study Limitations

This study has several limitations. First, this was a retrospective study. Because our data were limited to the medical records, electronic databases, and telemedicine records, we failed to evaluate important factors such as psychophysiological factors or ICU scores (e.g., functional status score for the ICU). Additionally, as this is a single-center study that was conducted in a provincial city in Japan, the small sample size and regional characteristics should be considered. Second, acute-phase rehabilitation was shown to improve both motor and cognitive functions.[59] In another report, a rehabilitation program for TBI patients was related to discharge from hospital and RTW.[60] We did not investigate the duration of rehabilitation, partly because of the short hospital stay for many cases in our study. Third, TBI patients and ICU survivors are frequently transferred to rehabilitation hospitals and nursing facilities, making follow-up difficult after transfer. The loss to follow-up rate in our study was 6.3% (26/164 patients). Because Altman *et al.* suggested that the minimum acceptable loss to follow-up rate should be 20%,[61] it is reasonable to assume that our loss to follow-up rate was minimal.

Conclusions

This is the first study that identified the predictive factors of RT and RTW for ICU survivors after msTBI in tandem with these rates with a follow-up period of 2 years. "Age" and "GCS score on admission" were the predictive factors of RH and RTW. Non-elderly (<65 years) and non-severe patients regarding consciousness (GCS score > 8) after msTBI were positive factors for RH and RTW. ICU survivors after msTBI can have good outcomes if they can overcome the acute phase.

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Abbreviations

AIS: Abbreviated Injury Scale, GCS: Glasgow Coma Scale, HRQOL: health-related quality of life, ICU: intensive care unit, IRB: Institutional Review Board, JCS: Japan coma scale, mRS: modified Rankin Scale, msTBI: moderate to severe traumatic brain injury, Hb: hemoglobin, RH: return home, RTW: return to work, sTBI: severe traumatic brain injury, TBI: traumatic brain injury

Ethical Approval

All procedures in this study involving human participants were carried out in accordance with the ethical standards of the institutional and/or national research committee (IRB#1911-023) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflicts of Interest Disclosure

The authors declare that they have no conflict of interest.

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