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Comparison of Care System and Treatment Approaches for Patients with Traumatic Brain Injury in China versus Europe: A CENTER-TBI Survey Study

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Abstract

Traumatic brain injury (TBI) poses a huge public health and societal problem worldwide. Uncertainty exists on how care system and treatment approaches for TBI worked in China may differ from those in Europe. Better knowledge on this is important to facilitate interpretation of findings reported by Chinese researchers and to inform opportunities for collaborative studies. We aimed to investigate concordance and variations in TBI care between Chinese and European neurotrauma centers. Investigators from 52 centers in China and 68 in Europe involved in the Collaborative European Neuro Trauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) study were invited to complete provider profiling (PP) questionnaires, which covered the main aspects of care system and treatment approaches of TBI care. Participating Chinese and European centers were mainly publicly funded and academic. More centers in China indicated available dedicated neuro-intensive care than those in Europe (98% vs. 60%), and treatment decisions in the ICU were mainly determined by neurosurgeons (58%) in China while in Europe, (neuro)intensivists often took the lead (61%). The ambulance dispatching system was automatic in half of Chinese centers (49%), whereas selective dispatching was more common in European centers (74%). For treatment of refractory intracranial hypertension, a decompressive craniectomy was more frequently regarded as general policy in China compared with in Europe (89% vs. 45%). We observed both concordance and substantial variations with regard to the various aspects of TBI care between Chinese and European centers. These findings are fundamental to guide future research and offer opportunities for collaborative comparative effectiveness research to identify best practices.

Keywords: comparison; provider profiling; TBI care; traumatic brain injury; variation

Introduction

TRAUMATIC BRAIN INJURY (TBI) is one of the leading causes of death and disability worldwide, with a global annual incidence of more than 50 million cases.¹ With a population of 1.4 billion, the number of patients with TBI in China exceeds that of most other countries, causing an enormous burden to society and families, and meanwhile offering a vast potential for research.²

Outcome after TBI has substantially improved in China over the past two decades. The population-based mortality of TBI in China

(12.99/100,000 people) is now very similar to that in Europe (11.7/100,000 people).^{3,4} However, uncertainty exists on how care system and treatment approaches for TBI worked in Chinese centers compare to European countries. Mapping potential variations and concordance is essential for appropriate interpretation of results originating from China. Also, it would be a necessary step when conducting collaborative clinical research on TBI between China and Europe. Potential variations constitute opportunities rather than challenges in enabling comparative effectiveness research (CER), which uses between-center differences to compare the effectiveness of specific practices.

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The Collaborative European Neuro Trauma Effectiveness Research in TBI study (CENTER-TBI: www.CENTER-TBI.eu) is a large-scale observational multi-center study focusing on characterization and CER in TBI.⁵ CER is especially suitable for TBI research since large between-center differences have been previously reported across the chain of TBI management in European countries.^{6–16} Comparison of care system and treatment approaches of TBI care between China and Europe has, however, not been performed. Therefore, we aimed to investigate the variations and concordance in TBI care between Chinese and European centers participating in CENTER-TBI.

Methods

Study sample

The CENTER-TBI study was conducted in 68 centers from Europe and Israel and in 52 neurotrauma centers from 21 provinces in China. Participants in the study were approached to complete a provider profiling (PP) questionnaire about the care system and treatment approaches of TBI care. In this study, we aim to analyze the questionnaire results of Chinese centers and compare these to results previously obtained in Europe.

Provider profiling of CENTER-TBI for China

The PP questionnaires were developed through a comprehensive process including a literature study and expert opinion meetings, and have been previously applied in the European centers participating in the CENTER-TBI study.¹⁶ Clinical experts from Europe and China selected questions covering most relevant aspects of TBI care in China and Europe from PP questionnaires (Supplementary Appendix S1). Topics included general hospital characteristics, medical ethics, pre-hospital trauma care, emergency department (ED), in-patient admission, intensive care unit (ICU), neurosurgical care, and rehabilitation.

The questionnaires (illustrations included) were translated into Chinese by two bilingual editors with a neurosurgical background to avoid the language barrier affecting the quality and reliability. The translated questionnaires were pilot-tested by several doctors proficient in Chinese and English and subsequently refined according to feedback provided.

In the provider profiling, we explicitly required respondents to fill in the “general policy” for their institution, which was defined as standard treatment or policy estimated to be used in more than 75% of patients, recognizing that there might be exceptions. Most questions used categorical answers.

Questionnaire distribution

Local investigators supervising the study in a specific center were extensively informed in person and by email about the aim of the study. We emphasized the confidentiality of their responses. Instructions were provided on how to respond to the questions, aiming to achieve unequivocal responses. Questionnaires were completed using WeChat relevant application (Shenzhen Tencent computer system Co. Ltd.). Any questions from local investigators could be answered by email, WeChat, or telephone by the corresponding author. The local investigator in each center was responsible for the completion process in their center and was encouraged to involve other staff members with specific expertise when appropriate.

Statistical analysis

We calculated frequencies and percentages for categorical variables, medians, and interquartile ranges (IQRs) for continuous variables. Centers in which the investigator did not respond to

every question remained in our study in order to keep groups for descriptive statistics as large as possible. For the question about ambulance dispatching, respondents could fill in more answer categories. Therefore, the responses exceed 68 (100%). Since percentages were rounded to whole numbers, some results added up to 99% or 101%. Respondents could indicate how frequently certain management strategies were used (always 100–90%, frequently 90–70%, sometimes 70–30%, rarely 30–10%, never 10–0%). The sum of “always” and “frequently” were interpreted as representing the general policy of a center, in line with previous reports.⁶ Where appropriate, we used Mann-Whitney U test (continuous) or chi-squared test (categorical) to determine significance of differences. Analyses were performed using R statistical software version 3.6.0 (The R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>).

Results

In total, 45 out of 52 centers in China and 68 centers in Europe completed almost all questions of the PP and approved use of their data for research purposes. The PP questionnaire in China was completed mainly by neurosurgeons, trauma surgeons, and/or ED physicians.

Structural characteristics

We found concordance and variations regarding structural characteristics between 45 centers in China and 68 centers in Europe. Participating centers were both predominately academic, in an urban location, and funded by public resources. Among the participating centers, the median number of beds in Chinese hospitals (median of 1966 [IQR: 1200–2500]) was generally higher than that in European hospitals (median of 1000 [IQR: 755–1390]), while the number of beds in ICU were quantitatively comparable (median of 40 [IQR: 24–60] in China and 31 [IQR: 22–44] in Europe). In this study, the proportions of hospitals with dedicated neuro-intensive care available ($n=44$; 98% vs. $n=40$; 60%) and separate 24/7 emergency operating rooms ($n=43$; 96% vs. $n=49$; 73%) in China were larger than that in Europe. Compared with China ($n=14$; 31%), European centers were equipped with more helicopter platforms ($n=54$; 81%). Treatment decisions regarding medical management in TBI patients in the ICU were mainly determined by neurosurgeons in Chinese centers ($n=26$; 58%), compared with neuro-intensivists in European centers ($n=41$; 61%). However, no significant difference was found in the use of guidelines for ICU management (Table 1).

Ethics and consent

Approaches towards ethical and consent aspects varied on all reported items. Chinese centers ($n=39$; 87%) in the CENTER-TBI study had a higher proportion of medical ethics departments than that in European centers ($n=38$; 56%). More than half of European centers ($n=50$; 74%) in the study reported that emergency research involving mentally incapacitated patients without prior patient or proxy consent was ethically feasible, while fewer centers in China ($n=14$; 31%) indicated that. With regard to decisions on surgery for acute subdural hematoma patients or on referral of patients to rehabilitation facilities, compared with centers in China, higher proportions of centers in Europe indicated that age had a substantial influence on these decisions (Table 2).

TABLE 1. STRUCTURAL CHARACTERISTICS OF THE PARTICIPATING CENTERS (CHINA VERSUS EUROPE)

Structural characteristics	China n=45	Europe n=68	p value	Missing values	
				China	Europe
Number of hospital beds (median [IQR])	1966 [1200, 2500]	1000 [755, 1390]	< 0.001	0	3
Number of ICU beds (median [IQR])	40 [24, 60]	31 [22, 44]	0.135	0	1
Dedicated neuro-intensive care available	44 (98%)	40 (60%)	< 0.001	0	1
Academic hospital	37 (82%)	61 (91%)	0.275	0	1
Public funding system supporting the hospital	44 (98%)	56 (86%)	0.081	0	3
Urban location of the hospital	42 (94%)	66 (99%)	.354	0	1
Separate 24/7 emergency operating rooms available ¹	43 (96%)	49 (73%)	0.005	0	1
Treatment decisions regarding medical management in TBI patients in your ICU are mainly determined by:			< 0.001	0	1
General intensivist	2 (4%)	19 (28%)			
General surgeon or orthopedic surgeon	0 (0%)	1 (2%)			
(Neuro)intensivist	17 (38%)	41 (61%)			
Neurologist	0 (0%)	1 (2%)			
Neurosurgeon	26 (58%)	5 (8%)			
Guidelines used for ICU management of TBI			0.371	0	2
Institutional, national or BTF guidelines	41 (91%)	55 (83%)			
No specific guidelines	4 (9%)	11 (17%)			
Helicopter platform for helicopter trauma medical services is available	14 (31%)	54 (81%)	< 0.001	0	1

¹Separate 24/7 emergency operating rooms=operating rooms that are exclusively used for emergency surgery, and never used for planned or elective surgery.

IQR, interquartile range; TBI, traumatic brain injury; ICU, intensive care unit; BTF, Brain Trauma Foundation.

Pre-hospital care and ED organization of the participating centers

In-hospital multidisciplinary teams alerted for severe trauma victims was the general policy for the majority of the participating centers in both China and Europe. Apart from that, we found variation regarding all reported items. Significantly, helicopter use was not a general policy in Chinese centers ($n=0$; 0%), whereas this was a general policy in nearly half of European centers ($n=31$; 46%). Also, with regard of the system used for ambulance dispatching, including the basic type of response to the scene of trauma and the policy at the scene, all varied significantly between centers in China and Europe: Automatic dispatching of ambulances, basic life support and the scoop and run policy were reported to be priorities in Chinese centers, whereas selective dispatching, advanced life support, and stay and play strategy were dominant in European centers. Besides, severe TBI patients were transferred to the participating center directly in more than half of European centers ($n=46$; 71%); however, only 13 centers (29%) in China indicated that. Severe TBI patients were transferred to the majority of Chinese centers indirectly in this study. Lastly, with regard to applying guidelines to determine which mild TBI (mTBI) patients should have an initial head CT, centers

in China ($n=25$; 56%) had a lower utilization rate than European centers ($n=52$; 80%; Table 3).

In-hospital treatment

Reported in-hospital treatment indicated significant differences in participating centers between Europe and China. However, we found no significant differences in the general policy concerning the management of extremity (limb) fractures in TBI patients, and the general policy for management of intraparenchymal mass lesions (contusions). Routine repetitive CT scanning was more often reported to be used in TBI patients in the ICU in Chinese centers ($n=45$; 100%) compared with European centers ($n=44$; 67%). Decompressive craniectomy in severe TBI patients with refractory intracranial hypertension was a general policy in more Chinese centers ($n=40$; 89%) than in European centers ($n=29$; 45%). Thresholds for treating elevated intracranial pressure (ICP) were slightly higher in China (> 25 mm Hg in 11 centers; 24%) compared with Europe ($n=6$; 9%). ICP was measured mostly by both parenchymal monitors without optional ventricular drainage and ventricular catheters in both China and Europe. However, in some European centers ($n=21$; 32%), parenchymal monitors were the only way ICP was measured. Coma stimulation was used more

TABLE 2. CONSENT AND ETHICS OF THE PARTICIPATING CENTERS (CHINA VERSUS EUROPE)

Consent and ethics	China n=45	Europe n=68	p value	Missing values	
				China	Europe
Department for medical ethics available	39 (87%)	38 (56%)	0.001	0	0
Emergency research involving mentally incapacitated patients without prior patient or proxy consent is ethically feasible	14 (31%)	50 (74%)	< 0.001	0	0
The decision to do surgery in acute SDH patients is generally influenced by age	6 (13%)	27 (42%)	0.003	0	3
Patient's age has a major influence on the referral decision to rehabilitation facilities	4 (9%)	31 (46%)	< 0.001	0	1

SDH, subdural hematoma.

TABLE 3. PRE-HOSPITAL TRAUMA CARE AND EMERGENCY DEPARTMENT (ED) OF THE PARTICIPATING CENTERS (CHINA VERSUS EUROPE)

<i>Pre-hospital trauma care and emergency department (ED)</i>	<i>China n=45</i>	<i>Europe n=68</i>	<i>p value</i>	<i>Missing values</i>	
				<i>China</i>	<i>Europe</i>
Helicopter use to transport the patient to the hospital=general policy (%)	0 (0%)	31 (46%)	< 0.001	0	0
System used for ambulance dispatching ¹			< 0.001	0	0
Automatic	22 (49%)	7 (10%)			
Dynamic	14 (31%)	21 (31%)			
Selective	7 (16%)	50 (74%)			
Other	2 (4%)	1 (2%)			
Basic type of response that is sent to the trauma scene if there is no indication for an MMT/MERIT ²			0.037	0	0
ALS crew	15 (33%)	35 (52%)			
BLS crew	29 (64%)	26 (38%)			
Crew without medical training	0 (0.0%)	2 (3%)			
Other	1 (2%)	5 (7%)			
Policy at the scene of trauma ³			< 0.001	0	0
Always scoop and run	19 (42%)	3 (4%)			
Always stay and play	12 (27%)	7 (10%)			
Mostly scoop and run; stay and play on indication	9 (20%)	23 (34%)			
Mostly stay and play; scoop and run on indication	5 (11%)	30 (44%)			
Other	0 (0%)	5 (8%)			
Direct or indirect transfer to the hospital of severe TBI patients			< 0.001	0	3
Directly	13 (29%)	46 (71%)			
Indirectly	9 (20%)	1 (2%)			
Both	23 (51%)	18 (28%)			
Guidelines are used to determine which mild TBI patients should have an initial head CT	25 (56%)	52 (80%)	0.011	0	3
An in hospital multidisciplinary team will be alerted if a serious trauma victim comes in	44 (98%)	62 (95%)	0.888	0	3

TABLE 4. IN-HOSPITAL TREATMENT OF THE PARTICIPATING CENTERS (CHINA VERSUS EUROPE)

<i>In-hospital treatment</i>	<i>China n=45</i>	<i>Europe n=68</i>	<i>p value</i>	<i>Missing values</i>	
				<i>China</i>	<i>Europe</i>
Routinely repetitive CT scanning is used in TBI patients in the ICU	45 (100%)	44 (67%)	< 0.001	0	2
Kind of ICP sensor used			0.013	0	3
Parenchymal monitors without optional ventricular drainage	3 (7%)	21 (32%)			
Ventricular catheters	7 (16%)	5 (8%)			
ICP sensors are not used	1 (2%)	1 (2%)			
Both	34 (76%)	38 (59%)			
Threshold for medical management of elevated ICP			0.043	0	3
> 15 mm Hg	5 (11%)	3 (5%)			
> 20 mm Hg	29 (64%)	54 (83%)			
> 25 mm Hg	11 (24%)	6 (9%)			
Other	0 (0%)	2 (3%)			
General policy with regard to management of extremity (limb) fractures in TBI patients			0.029	0	3
Definitive care	14 (31%)	8 (12%)			
Damage control	31 (69%)	57 (84%)			
General policy for management of intraparenchymal mass lesions (contusions)			0.609	0	3
Pre-emptive surgery to prevent deterioration	3 (7%)	2 (3%)			
Delayed surgery only after deterioration including intracranial hypertension	27 (60%)	44 (68%)			
Variable; depending on surgeon	14 (31%)	16 (25%)			
Other	1 (2%)	3 (5%)			
General policy to use decompressive craniectomy in severe TBI patients with refractory intracranial hypertension	40 (89%)	29 (45%)	< 0.001	0	3
Coma stimulation is used in comatose TBI patients	36 (80%)	34 (51%)	0.003	0	1

CT, computed tomography; TBI, traumatic brain injury; ICU, intensive care unit; ICP, intracranial pressure.

often in comatose TBI patients in Chinese centers ($n=36$; 80%) than in European centers ($n=34$; 51%; Table 4).

Discussion

We found both substantial variations and varying degrees of concordance regarding the various aspects of TBI care between Chinese and European centers participating in the CENTER-TBI study. To our knowledge, this is the first study that compares care system and treatment approaches in TBI between Chinese and European TBI centers. Although the participating neurotrauma centers indicated agreement in some basic structural features (e.g., publicly funded and academic), there was substantial variation in structures and processes of TBI care, such as emergency medical service system and treatment policies.

We found substantial variations in pre-hospital trauma care and the ED care between Chinese and European centers. The variation already has been reported between European centers.^{9,13} In consideration of superior characteristics such as high speed, reliable mobility, and less vulnerability to traffic conditions, many developed countries have established a well-organized, command-efficient helicopter emergency medical service (HEMS). Nearly half of the European centers in CENTER-TBI study had a general policy to transport a TBI patient to the hospital by helicopter.^{9,17} However, helicopter use was not a general policy for any Chinese center in this study, even though around one-third of Chinese centers reported to have a helicopter platform. China's HEMS has actually only recently been launched. Lack in using HEMS may partly reflect the differences in socioeconomic situations between China and Europe. More awareness of the importance of helicopter management and additional capital investments may stimulate the development of HEMS in Chinese centers. Moreover, more research is essential to further enhance the development of HEMS in China.¹⁸

The ambulance dispatching system, life support crew, and policy at the scene varied between Chinese and European centers, and also differs among Chinese centers, which may result in more indirect transfers of severe TBI patients in China.¹⁹ Diversified modes in pre-hospital trauma care exist across the vast territory of China due to regional differences in geographical and socioeconomic situation. For example, instead of implementing rescue aid itself, the emergency command center in Guangzhou appoints emergency units from different hospitals for rescue tasks. In contrast, the emergency center in Shanghai and its substations take charge of pre-hospital rescue and then transfer patients to cooperative hospitals for further care. Strong evidence for the effectiveness of different formats of pre-hospital trauma care is lacking, but different practices in pre-hospital trauma care may influence the outcome of TBI patients. Therefore, more research on this topic is needed to inform improvement of TBI care in China and Europe.

Substantial variations also were found in medical ethical topics between Chinese and European centers. In our study, a department of medical ethics was deemed to be an academic department of ethics and philosophy of medicine, and not an office for institutional reviews of research documents. The lower proportion of ethic department in Europe was caused by part of European centers did not establish such a specific department for medical ethics. However, they have the ethicists and faculty members who stand for research and education in medical ethics or collaborate with clinicians on topics in different research areas in biomedical ethics. In other words, the process of ethical review is commonly centralized in Europe.

The variation regarding the use of CT scan is in line with previous research.^{20,21} Compared with most Western countries, CT scan is more accessible and much cheaper in China. Although CT scan is a very important diagnostic method to evaluate patients with intracranial injuries, excessive use has been questioned due to potential adverse effects of radiation risk, unnecessary resource occupation, and economic costs. Especially when considering low risk of intracranial damage, CT scan is not always necessary in patients with mild TBI (mTBI).²² Various prediction rules and guidelines (e.g., the Canadian CT head rule [CCHR] and New Orleans Criteria) have been developed to estimate the risk of intracranial abnormalities in mTBI.^{23,24} Besides, these worldwide popular criteria also show high sensitivity and specificity to prevent missing timely neurosurgical intervention and to avoid the overuse of CT in different countries by various studies.²⁴⁻²⁸ Although national or local guidelines for cranial CT among patients with mTBI are still absent in China, a study to evaluate the effectiveness of clinical decision rules for CT scanning in Chinese patients with mTBI has indicated high sensitivity and specificity, which indicates applicability of these rules to Chinese patients.²¹ However, our study demonstrated that only 55.6% of centers in China applied guidelines to triage initial head CT for mTBI patients, and their utilization rate was significantly lower than that in European centers. This might partly be attributed to relatively lower awareness of these criteria among Chinese doctors.^{20,27} In 2013, a survey study in 247 emergency physicians from different Chinese hospitals reported that awareness and utilization rate of CCHR were 41.7% and 24.7%, respectively.²⁰ In addition, fear of insufficient medical practice and low awareness of radiation risk were the two principal barriers to use the CCHR in the triage of CT scanning for patients with mTBI. Further study is necessary to explore whether the variation in CT scan policies is associated with outcome in TBI patients.

Similarities in guidelines adherence and implementation for ICU management were found, which might suggest the importance of guidelines in reducing variation in clinical practice. However, substantial differences were found in guidelines adherence and implementation among neurotrauma centers in Europe in previous studies, which indicated that the goal of guidelines to minimize variation has not always been achieved.^{6,12,15} Guidelines resulting from weak evidence underpin the recommendations for the treatment of patients with TBI. The threshold for medical management of elevated intracranial hypertension (ICP), for instance, as recommended in the guidelines for severe TBI is not based on high-level evidence.²⁹ Moreover, we found that decompressive craniectomy (DC) in refractory ICP was performed in Chinese centers more often than that in European centers. This procedure is recommended (level II A evidence) in the Brain Trauma Foundation guidelines.²⁹ DC for refractory ICP may be considered an intuitive choice for neurosurgeons but may not be for neuro-intensivists, which may explain its higher utilization in China compared with Europe. In China, neurosurgeons mainly make treatment decisions regarding the management of TBI patients in the ICU, whereas neuro-intensivists make the decision in the majority of European centers.

This study has limitations that should be taken into account when interpreting the results. First, although we requested the general policy rather than individual preferences, we cannot exclude that the results reflect personal treatment preferences. Second, respondents might have (even subconsciously) presented a more favorable picture of their centers. Third, this PP questionnaire did not cover all the subtleties that underpin clinical practice. Importantly,

because the majority of centers in our study were academic centers interested in TBI research, the data may not be representative for all TBI centers within China and Europe. Thus, findings should be interpreted with caution. It also should be pointed out that our results reflect practices reported by respondents, rather than actual documentation of clinical practice.

Although we only reported on general structures and processes of TBI care, it is evident that the between-continent variation is substantial and provides an opportunity for collaborative comparative effectiveness research for identifying best practices. Based on the fact that the CENTER-TBI study has collected individual patient data, especially considering a vast potential for research causing by large number of patients with TBI in China, future research could focus on the source and effect of these variations. For example, we can study the influence of medical management decisions in ICU on severe TBI patients by comparing patients' outcome in centers whose decisions are mainly determined by neurosurgeon and in centers where neuro-intensivists are in charge. Further studies, involving multidisciplinary and national/international groups, are expected to advance care system and treatment approaches on TBI patients.

Conclusion

Both similarities and significant differences regarding the various aspects of TBI care were observed when comparing the neurotrauma centers in CENTER-TBI between China and Europe. The findings provide a new perspective to better understand TBI care in China and Europe. This study may guide possible future comparative effectiveness research for better medical practices, advanced guidelines, and ultimately for improving outcome of TBI patients.

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GG and AIRM developed the idea for current paper. JF, EvV, and CY analyzed the data and wrote the first draft of the manuscript. All authors gave feedback on the manuscript. All authors were involved in the development of the questionnaire, critically commented on the manuscript, and approved the final version.

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Supplementary Material

Supplementary Appendix S1

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