Does Additional Head Trauma Affect the Long-term Outcome After Upper Extremity Trauma in Multiple Traumatized Patients: Is There an Additional Effect of Traumatic Brain Injury?

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Published online: 9 May 2013
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Abstract

Background Musculoskeletal injuries are common in patients with multiple trauma resulting in pain, functional deficits, and disability. Traumatic brain injuries (TBIs) are common in severely injured patients potentially resulting in neurological impairment and permanent disability that

would add to that from the musculoskeletal injuries. However, it is unclear to what degree the combination affects impairment.

Questions/purposes We therefore asked whether added upper extremity injuries or TBI worsened the functional, psychological, and vocational status in multiple trauma patients.

Methods We retrospectively reviewed 281 patients with multiple trauma: 229 with upper extremity injuries but without TBI (Group I), 32 with concomitant upper extremity injuries and TBI (Group II), and 20 with TBI but no upper extremity injuries (Group III). We assessed patients with the Glasgow Outcome Score (GOS), Hannover Score for Polytrauma Outcome, SF-12 (Physical Component Summary Score and Mental Component Summary Score), medical aid requirements, need of psychological support, and vocational living circumstances. The minimum followup was 10 years (median, 17.5 years; range, 10–28 years).

Results Additional TBI in multiple trauma patients led to reduced function (GOS: Group I: 4.9 ± 0.2 , Group II: 4.5 ± 0.7 , Group III: 4.5 ± 0.8) resulting in vocational restrictions (job change: Group I: 74%, Group II: 91%, Group III: 90%). The combination of upper extremity and TBIs did not result in worse long-term scores compared with TBI alone.

Conclusions Rehabilitation and social reintegration in multiple trauma patients with TBI requires particular emphasis to minimize disability and vocational isolation. Musculoskeletal injuries should not be neglected to ensure the maximum extremity function given the impaired cognitive functions after TBI.

Level of Evidence Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

The institution of one or more of the authors (CP, CK, FH) has received, during the study period, funding from the Hannover Life Re-Insurance, Hannover, Germany.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained. This work was performed at the Hannover Medical School, Hannover, Germany.

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Introduction

Mortality of severely injured patients in many industrialized countries has decreased during the last decades as a result of enhanced prehospital treatment and improved clinical experience and treatment algorithms [33]. However, the social, functional, and financial circumstances are reduced in patients surviving multiple trauma [23]. Functional recovery after multiple trauma is a long-term process [1] and long-term followup information should include assessments of function as well as quality of life [1, 14, 23, 25].

Musculoskeletal injuries are common in patients with multiple trauma resulting in functional deficits, disability, and increased pain levels [10, 20]. The function of the extremities is critical for work as well as activities of daily living [9]. Several studies have reported long-term function after lower extremity trauma in patients with multiple trauma [22, 24, 34]. Poor physical and psychosocial functioning has been associated with lower extremity amputation (odds ratio = 15) [22], whereas most frequent rates of ongoing local pain have been reported by patients with fractures of the acetabulum (50%) and the proximal femur (45%) [24]. In addition, the incidence of abnormal gait is reportedly lower in patients with femoral shaft fractures compared with patients with fractures of the acetabulum (35%), proximal femur (20%), and tibial shaft (15%) [24].

After musculoskeletal trauma, traumatic brain injury (TBI) is a most common type of injury in patients with multiple trauma [14]. TBI is a major public health concern frequently resulting in neurological impairment and permanent disability [12, 18]. Despite an increasing interest in research on long-term function after trauma in general, patients with TBI are frequently excluded from study populations as a result of excessive loss to followup [17, 36] or the difficulties of participation [6, 8, 26, 32]. However, patients with multiple injuries and concomitant TBI may have worse function attributable to additional consequences of cognitive impairments and changes in personality impacting interpersonal, educational, and occupational functioning [30]. Gross et al. [14] compared multiple traumatized patients without and with TBI and found worse living and work circumstances in patients with TBI. Furthermore, Steel et al. [30] reported worse psychological functioning and a higher incidence of chronic pain although reduced needs of medical aids (crutches, walkers, canes, wheelchairs, or prosthetic limbs) at followup when compared with severely injured patients without TBI. However, it is unclear whether or how added upper extremity injury or TBI influences the long-term status of patients with multiple traumatic injuries elsewhere.

We therefore asked whether added upper extremity injuries or TBI worsened the functional, psychological, and vocational status in multiple trauma patients.

Patients and Methods

Patients were identified from our databank and included in the study if the following criteria were fulfilled: (1) multiple trauma between 1973 and 1990; (2) followup at least 10 years after trauma; (3) aged between 18 and 60 years at the time of injury; and (4) Abbreviated Injury Scale (AIS) [2, 3] ≥ 2 for upper extremity injuries and TBI. We presumed an Injury Severity Score (ISS) of 16 or more points reflected multiple trauma [24]. During the study period, 637 patients were treated with an ISS ≥ 16 . We excluded 131 patients not meeting the inclusion criteria of age at time of injury and 225 patients not having sustained the required injury distribution of upper extremity and TBIs. All 281 patients meeting the inclusion criteria were included; of these, 229 sustained injuries of the upper extremities without TBI (Group I), 32 had concomitant TBI and upper extremity injuries (Group II), and 20 had TBI without any upper extremity injuries (Group III). The overall study population (637 patients) has been used for specific analyses in different studies focusing on divergent scientific questions [22–25, 30]. The assessment and reexamination of the included patients were performed from January 1, 2000, to February 31, 2003. The minimum followup was 10 years (median, 17.5 years; range, 10–28 years). This study followed the guidelines of the revised UN Declaration of Helsinki in 1975 and its latest amendment in 1996 (42nd general meeting). The study was approved by the institutional ethical review board. Written informed consent was obtained from all participants.

Demographic and clinical data were extracted from the patients' charts including patient's age and sex. Injury severity was measured by the ISS [2, 3]. The ISS score has a total of 75 points with 0 being the least severe [2, 3]. Injury distribution was described by the maximum AIS as patients' most severe injury to reveal differences between the study groups. In case of the Hannover Polytrauma Score, the defined injuries distributed to five body regions—head, chest, abdomen, extremities, and pelvis/vertebral column—were scored based on an established quantification system, and the individual scores were then added together to summarize an overall score. Age was recorded. There were no differences in age or sex between the study groups (Table 1). According to the ISS, patients with TBI and concomitant injuries of the upper extremities demonstrated the highest injury severity (Table 1). The maximum AIS [22] injury distribution was comparable between the study groups.

To assess the neurological outcome, we used the Glasgow Outcome Score (GOS) [16]: (1) death; (2) persistent vegetative state: the patient exhibits no obvious cortical function; (3) severe disability: conscious but disabled. The patient depends on others for daily support as a result of mental or physical disability or both; (4) moderate disability; disabled but independent. The patient is independent as far as daily

Table 1. Demographic data, injury severity, and injury distribution among the three groups

Demographic, injury severity, or injury distribution	Group I	Group II	Group III	p value
Number of patients	229	32	20	–
Age (years)	30.2 ± 11.5	32.0 ± 11.0	30.7 ± 11.8	0.663
Sex distribution (male)	171 (75%)	23 (72%)	18 (90%)	0.275
Maximum AIS head	(1.6 ± 1.2)	4.1 ± 0.3	4.4 ± 0.5	0.052*
Maximum AIS upper extremity	2.3 ± 0.5	2.4 ± 0.5	(1.3 ± 0.6)	0.200*
Maximum AIS chest	3.3 ± 1.1	2.9 ± 1.2	3.8 ± 0.7	0.149
Maximum AIS abdomen	2.6 ± 0.8	2.0 ± 0.7	2.4 ± 1.0	0.245
Maximum AIS spine	2.6 ± 0.9	2.0 ± 0.5	2.3 ± 1.0	0.259
Maximum AIS lower extremity	2.8 ± 0.5	2.7 ± 0.5	2.6 ± 0.6	0.496
Hannover Polytrauma Score	30.5 ± 15.1	36.1 ± 11.8	29.0 ± 11.7	0.023
ISS	20.2 ± 8.6	32.1 ± 6.4	33.8 ± 10.6	< 0.001

* Statistical comparison was performed only between Group I and II or Group II and III, respectively, as a result of the definition of the different study groups; AIS = Abbreviated Injury Scale; ISS = Injury Severity Score.

life is concerned. The disabilities include varying degrees of dysphasia, hemiparesis, or ataxia as well as intellectual and memory deficits and personality changes; and (5) good recovery; resumption of normal activities although there may be minor neurological or psychological deficits.

We assessed the presence of posttraumatic mental disability using the SF-12 in a modified German version [5]. The scale includes a Physical Component Summary Scale and a Mental Component Summary Scale [31].

The Hannover Score for Polytrauma Outcome [28, 29] was developed to specifically classify the status of rehabilitation of severely injured patients. In brief, it consists of a self-assessment part containing a detailed patient questionnaire on individual, social, financial, vocational, and medical items and a provider report summarizing the results of a physical examination and a questionnaire by a physician. The Hannover Score for Polytrauma Outcome has a total of 418 points (range, –8 to 410) with –8 being best.

The necessity of medical aids implied the requirement of crutches, walkers, canes, wheelchairs, or prosthetic limbs. Psychological support was defined by recurrent treatment by professional psychologists or psychiatrists. Early retirement comprised patients who were retired as a result of trauma sequelae before reaching the statutory retirement age of 62 years in females and 65 years in males. Job change referred to a change of occupation because of trauma sequelae either with or without professional retraining. The duration of unemployment was evaluated. Unemployed patients were not able to work in their pretrauma job because of injury sequelae or were dismissed as a result of sick leave taken while they were generally able to work.

Incidences were determined with counts or percentages, whereas continuous values were determined as mean ± SD. Differences in age, AIS, Hannover Score for Polytrauma

Outcome, ISS, GOS, SF-12, and duration of unemployment between the groups were evaluated with Kruskal-Wallis one-way analysis of variance for continuous data. Pearson's chi-square test was used to determine differences in proportions of sex distribution, medical aids, patients requiring psychological support, financial problems, job changes, professional retraining, and early retirements among the three groups. The data were analyzed using the Statistical Package for the Social Sciences (SPSS; Version 20; IBM Inc, Somers, NY, USA).

Results

The lowest mean Hannover Score for Polytrauma Outcome and highest mean GOS occurred in Group I (patients with extremity injuries without TBI) indicating best function and rehabilitation in the overall study population (Table 2). We found no differences in the mean physical SF-12 scores or the necessity of medical aids among the three groups. Patients in Groups II and III required the most psychological support (Table 2).

Seventy-four percent of patients without concomitant TBI (Group I) had to change their jobs (Table 3), whereas concomitant TBI and extremity trauma led to an additional percentage required to change of approximately 15%. Nevertheless, duration of unemployment was comparable among the study groups. Compared with extremity trauma, the presence of TBI (either isolated or in combination with extremity trauma) led to a trend toward early retirement. We saw no differences in change of financial status or requirement for retraining among the three groups. Concomitant upper extremity and TBI did not worsen the vocational situation in general.

Table 2. Physical and psychological outcome measurement according to the different study groups

Outcome measurement	Group I	Group II	Group III	p value
Hannover Score for Polytrauma Outcome (mean $\pm$ SD)	66.2 $\pm$ 44.1	89.8 $\pm$ 53.2	88.3 $\pm$ 50.4	0.010
GOS (mean $\pm$ SD)	4.9 $\pm$ 0.2	4.5 $\pm$ 0.7	4.5 $\pm$ 0.8	< 0.001
SF-12 Physical Component Scale (mean $\pm$ SD)	43.1 $\pm$ 10.7	41.9 $\pm$ 8.7	43.6 $\pm$ 11.2	0.639
Medical aids (number [%])	75 (33%)	13 (41%)	11 (55%)	0.108
SF-12 Mental Component Scale (mean $\pm$ SD)	50.6 $\pm$ 10.1	49.4 $\pm$ 10.7	49.5 $\pm$ 9.2	0.504
Psychological support (number [%])	29 (13%)	10 (31%)	5 (25%)	0.012

GOS = Glasgow Outcome Score.

Table 3. Vocational status

Vocational status	Group I	Group II	Group III	p value
Financial problems (number [%])	111 (49%)	20 (63%)	9 (45%)	0.300
Job change (number [%])	170 (74%)	29 (91%)	18 (90%)	0.043
Professional retraining (number [%])	37 (16%)	6 (19%)	7 (35%)	0.106
Unemployment (mean years $\pm$ SD)	0.6 $\pm$ 1.6	0.3 $\pm$ 1.4	0.8 $\pm$ 2.2	0.143
Early retirement (number [%])	57 (25%)	13 (41%)	8 (40%)	0.079

Discussion

Apart from musculoskeletal trauma, TBI is the most common entity after multiple trauma [14]. According to the German Trauma Registry, multiple traumatized patients sustain upper extremity trauma in 34% and TBIs in 61% of the cases. With respect to musculoskeletal injuries in general, Michaels et al. [20] demonstrated that severely injured patients with musculoskeletal injuries showed worse physical as well as psychological functioning. Moreover, musculoskeletal injuries led to reduced capability to return to work resulting in financial difficulties [20]. Physical as well as psychological aspects reportedly worsen with increasing time after trauma [20]. Only several studies describe the long-term outcome of upper extremity injuries [11, 15, 21] but are restricted to followup investigations of individual fractures or treatment options. Furthermore, isolated upper extremity fractures are commonly associated with low-energy trauma mechanisms [11]. Consequently, the findings in isolated fractures are likely to differ considerably from those of multiple trauma patients who have sustained high-energy trauma and concomitant injuries. We therefore asked whether added upper extremity injuries or TBI worsened the functional, psychological, and vocational status in multiple trauma patients.

The following limitations should be considered when interpreting our study results. First, as a result of the followup period of at least 10 years, many critical events might have occurred in a person's life potentially affecting outcome. Although the participating patients have been asked for life-changing events between trauma and followup, life-changing events or additional trauma not

reported by the participants would lead to underestimation. Given the functional scores and number of patients, we do expect such underestimation to substantially influence our findings. Second, the long followup including patients treated decades ago and data collection from a single center might be limitations. It is likely that the presented findings cannot reflect the advances made in acute care as well as rehabilitation during the last decades. Third, the large number of excluded patients could introduce selection bias. Although exclusion of a large number of patients resulting from missing data and difficult reassessment are common in long-term followup studies [22–25, 34], we believe the long followup period and the detailed evaluation of patients using the previously described standardized methods provide important information [24].

We found patients with TBI had the lowest physical status, which is in accordance with the current literature [14] (Table 4). Gross et al. [14] recently focused on the impact of TBI on multiple injured patients. They found patients with TBI experienced a more pronounced reduction of function as well as quality of life more than 2 years after injury compared with patients without TBI. Furthermore, we found comparably reduced scores to those reported by Braden et al. [4] when analyzing 74 patients with moderate to severe TBI demonstrating physical SF-12 scores. Our data suggest that in multiple trauma patients, the addition of TBI rather than upper extremity trauma determines the function. Potential reasons can only be suspected. The most obvious reason might be assumed by the impact of TBI in general without any important effect of additional injuries. This assumption is supported by Livingston et al. [19] who found GOS was

Table 4. Overview of study results in comparison to the current literature

Study	Followup (years)	Study groups of multiple trauma	Functional outcome	Psychological outcome	Vocational situation
Current study	≥ 10	UE (229 patients) UE and TBI (32 patients) TBI (20 patients)	Worst outcome in presence of TBI, no aggravation in combination with upper extremity injuries	Most psychological support in combination of TBI and extremity trauma	75% job change in patients with UE, approximately 90% in presence of TBI with and without UE
Braden et al. [4]	≥ 1	TBI (74 patients)	Reduced functional outcome compared with normal population-based sample	Reduced psychological outcome compared to normal population-based sample	Not evaluated
Gross et al. [14]	≥ 2	TBI (45 patients) Non-TBI (66 patients)	Reduced functional outcome after TBI compared with non-TBI patients	Reduced functional outcome after TBI compared with non-TBI patients	Reduction of life quality including vocational situation in presence of TBI
Mkandawire et al. [21]	5	Different musculoskeletal injuries (158 patients)	UE led to 48% disability, 66% functional detriments	Not evaluated	Not evaluated
Livingston et al. [19]	≥ 2.1	241 patients: 50 TBI, 27 UE	25% long-term disability	Not evaluated	Unemployment: 63% TBI, 51% extremity injury

UE = upper extremity; TBI = traumatic brain injury.

associated only with the injury severity of TBI. However, the raised physical SF-12 scores as well as the need of medical aids did not differ among our study groups. Consequently, one might conclude that upper extremity trauma substantially restricted functional long-term outcome in multiple trauma patients. This suggestion is supported by Mkandawire et al. [21] who analyzed persisting disability in 158 multiple traumatized patients with a followup period of 5 years focusing on musculoskeletal recovery. In patients with shoulder girdle injuries, they found persisting disability in 48%, whereas 66% with arm or forearm injuries had functional deficits. Moreover, moderate to severe persisting pain occurred in over 50%. However, Mkandawire et al. did not investigate disability and psychological or vocational restrictions thereby limiting further suggestions toward influences on daily living circumstances.

We found the most psychological support was required in the presence of concomitant TBI and upper extremity injuries although the measured mental SF-12 scores were comparable among our three study groups. Focusing on TBI alone, Braden et al. reported reduced SF-12 scores between patients with TBI and a normative population. Comparability to the presented results seems limited as a result of the comparison with a normative population. Nevertheless, SF-scores evaluated by Braden et al. were similar to those we found in patients who had sustained TBIs. Gross et al. [14] analyzed 111 multiple traumatized patients distinguished according to the presence or absence of TBI. They reported a decreased psychological score (Mental Component Scale) in patients with TBI but a

comparable physical score (Physical Component Scale) between TBI and non-TBI patients. Gross et al. explained this finding by the discriminatory power of the SF-12. However, the current literature contains relatively little information on psychological impairment after multiple trauma with TBI and upper extremity injuries (Table 4). Therefore, we can make only general suggestions on concomitant extremity and head injuries on psychological impairments. We hope our findings will stimulate further studies regarding the treatment of psychological impairment in these patients.

Apart from functional and psychological impairments after multiple trauma, unemployment is a major problem after TBI [7, 35]. Grauwmeijer et al. [13] reported that patients after moderate and severe TBI with an impaired cognitive function at hospital discharge were at high risk of long-term unemployment 3 years later. They found unemployment rates up to 44% after severe TBI, a figure comparable to our findings on early retirement. The number of patients with early retirement in the presence of upper extremity trauma (Group I) seems particularly low compared with that of Livingston et al. [19]. They analyzed 241 multiple trauma patients a mean of 3.3 years after discharge from an intensive care unit and found an unemployment rate of 51% related to extremity injury. The reason for this divergent result could be assumed resulting from different health care and social systems, which might complicate an international comparison, and the prediction of long-term vocational outcome [27]. However, we were not able to demonstrate any aggravation of the vocational

living status in case of concomitant TBIs and upper extremity injuries in multiple trauma patients.

Additional upper extremity injuries in multiple trauma patients resulted in functional and vocational restrictions. The combination of upper extremity and TBI injuries did not worsen long-term outcome compared with TBI alone. Consequently, we suggest rehabilitation and social reintegration should focus on patients with TBI to minimize disability and vocational isolation. Musculoskeletal injuries should not be neglected to ensure the best extremity function consistent with impaired cognitive functions after TBI in multiple trauma patients.

Acknowledgments We thank Alexander Sittaro MD, and Ralf Lohse PhD, for advice and assistance during the study and Martin Panzica MD, for contacting patients and physical reexamination.

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