Outcomes of major trauma

Sluis, Corry Klasina van der

CHAPTER 8

Pediatric polytrauma: short-term and long-term outcomes

C.K. van der Sluis, MD
J. Kingma, PhD
W.H. Eisma, MD
H.J. ten Duis, MD, PhD

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Abstract

Objective: To assess the short-term and long-term outcomes of pediatric polytrauma patients and to analyze the extent to which short-term outcomes can predict long-term outcomes.

Materials and methods: All pediatric polytrauma patients (ISS of ≥ 16, ≤ 15 years of age) who were treated at a level I trauma centre between 1985-1989 and who were 18 years or older at follow-up (1996) were included. Short-term outcomes were quantified using the Glasgow Outcome Scale (GOS). The Functional Independence Measure (FIM), the RAND-36 and questions on social outcome were used to assess long-term outcomes.

Measurements and main results: Fifty-nine out of 74 patients survived (80%). At one year post-injury, 22% were disabled, mainly due to severe brain injuries, and 32% had changed school. After 9 years of follow-up, the degree of physical disablement was low (12%). Cognitive impairments were found in 42% of the patients. Only 10% were in receipt of disablement allowances; 76% were employed or attended school. The quality of life enjoyed by the patients (RAND-36) did not differ from that enjoyed by a healthy reference population. The GOS (from 6 weeks onwards) was a good predictor of long-term disablement.

Conclusions: Although the short-term impact of injuries is extensive, the long-term outcomes are satisfactory. Severe injuries sustained during childhood do not lead to a diminished quality of life during adulthood.

8.1 : Introduction

Among children, injuries are the leading cause of death after the age of one year. Trauma accounts for 27% of child fatalities (i.e. among children aged between 1 and 15) in the Netherlands each year.[1] For every child that dies, 4 are permanently disabled.[2] As such, injuries are the main threat to the health and well-being of children in Western societies. Remarkably, recent literature has focused primarily on outcomes following pediatric brain injury,[3,4] but not on polytraumatized patients: there is a profound dearth of short-term and long-term outcome studies on severely injured children. A literature review of all relevant articles in a large database for the period from 1975 onwards (Silverplatter Medline, version 2.0) produced only seven studies on the sequelae of major trauma in children.[5-11] The maximum duration of follow-up in these studies was only 2.4 years.[10] As a consequence, we know relatively little about the long-term effects of major injuries into young adulthood (i.e. in the form of permanent disablement, school and vocational career and quality of life).
The purpose of this study was to investigate the short-term outcomes and long-term physical, mental and social consequences of major injuries among children. Secondly, we analyzed how long-term outcomes could be predicted from short-term outcomes.

8.2 : Methods

8.2.1 : Subjects

All polytrauma patients (ISS of $\geq$ 16) who were 15 years of age or younger at the time of the incident and at least 18 years of age at the time of long-term follow-up (1996) were included in the study. They were all treated at University Hospital Groningen (UHG) between January 1985 and December 1989. Patients meeting these inclusion criteria who were known to have (premorbid) mental retardation or a severe psychiatric disorder were excluded. In addition, no account was taken of cases where suicide was the mechanism of injury. The severity of the injuries in all patients was assessed by means of the Injury Severity Score (ISS).[12] The ISS was computed from the Abbreviated Injury Scale (AIS).[13] Patients with an ISS greater than or equal to 16 were considered to be severely injured.[14]

8.2.2 : Setting

University Hospital Groningen (UHG) is a teaching hospital with 1,056 beds located in the city of Groningen, the Netherlands. The trauma centre of the UHG is designated with 'level A' by the Dutch Society of Traumatology, which is comparable to a level I trauma centre in the United States.[15] The UHG provides emergency care and special trauma care to the inhabitants of Groningen (population: 170,000) and the three northern provinces of the Netherlands (totalling 1.5 million inhabitants).

8.2.3 : Design

General data were retrieved from the trauma registry at UHG and from medical charts (i.e on age, sex, and the site and severity of the injury (AIS/ISS), the mechanism of injury, mortality, length of hospitalization and discharge destination). The study also consisted of four short-term outcome measurements (at 6 weeks, 3 months, 6 months and 1 year post-injury) and one long-term outcome assessment, 7 to 11 years after the trauma (in 1996). The study protocol was approved by the medical ethics committee at UHG (MEC 96/07/143).

Short-term outcomes. The Glasgow Outcome Scale (GOS)* was used to quantify short-term outcomes.[16] The GOS was originally designed to be used in head injury research. This scale has also been employed in recent literature to measure physical and mental disabilities in both adult and pediatric trauma patients.[8,11,17,18]

Long-term outcomes. The questionnaire used for measuring long-term follow-up outcomes consisted of (a) self-devised questions about the social impact of the trauma (i.e. on schooling and vocational careers; see Appendix), (b) the Functional Independence Measure (FIM)# and (c) the RAND-36 short-form health survey (RAND-36)‡.[19,20] The FIM measures the degree of disablement by assessing the patient's usual ability to perform daily activities. The validity and reliability of the scale were found to be acceptable.[21]

The RAND-36 is a generic health status measurement that is designed to measure a patient's quality of life. The version we used in this study was identical to the MOS short-form 36 health survey questionnaire (SF-36) as described by Ware and Sherbourne.[22] The psychometric qualities of the RAND-36 were considered to be satisfactory.[23]

Conduct of the long-term follow-up interviews. After receiving information on the purpose and nature of the study, patients were asked by telephone to participate in a follow-up interview. Those who agreed to participate were invited to an interview at UHG. Where a patient was unable to come to the hospital, the questions on the social outcome and the FIM were conducted by telephone and the RAND-36 was mailed. Next-of-kin were allowed to help the patient complete the questionnaire if the patient was unable to do so due to a disability of some sort.

* Glasgow Outcome Scale (GOS)
1. Death
2. Persistent vegetative state
3. Severe disability (requires assistance with activities of daily living)
4. Moderate disability (independent, but disabled)
5. Mild or no disability (capacity to resume normal occupational and social activities)

\# The FIM consists of 18 items covering self care, sphincter control, mobility, locomotion, communication and social cognition skills. The scale has a range from 18 to 126; increased independence is reflected in a higher score.

‡ The RAND-36 measures health from 8 multi-item perspectives: physical functioning, social functioning, role limitations due to physical or emotional problems, mental health, vitality, bodily pain, general health perception and health change. Each subscale score ranges from 0 to 100, with a higher score indicating a better quality of life.

8.2.4 : Statistical analysis

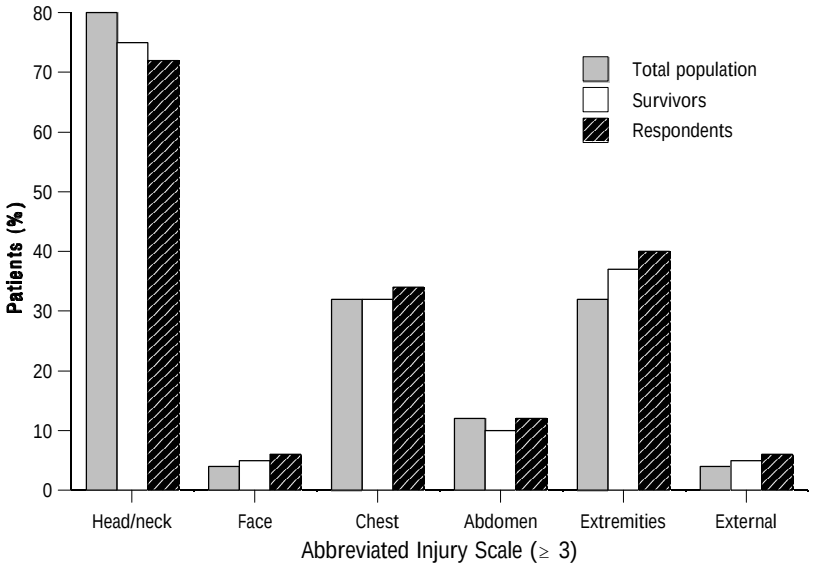
Statistical analysis was performed with the aid of SPSS/PC+ (version 5.0.1). The Wilcoxon signed-rank test was used to compare the results of the GOS scores. A one-sample Student t-test was used to compare the study group's RAND-36 scores with the scores of a healthy reference population of 18-24 years of age.[23] A p value of < 0.05 was considered to be statistically significant. The relation between short-term and long-term outcome measures was assessed by single linear regression analysis.

8.3 : Results

8.3.1 : Study population

Seventy-four patients met the study inclusion criteria during the 5-year study period. Traffic accidents were the cause of injury in 85% of the patients; cyclists and pedestrians were involved in 50% and 23% of the cases respectively. As far as the injury profile is concerned, the head/neck area, chest and extremities were the most common sites of severe injury (80%, 32% and 32% respectively; see Figure 8.1).

Figure 1.1 Injury distribution per body region (Abbreviated Injury Scale score ≥ 3) for the total study population (n=74), survivors (n=59) and long-term follow-up respondents (n=50)

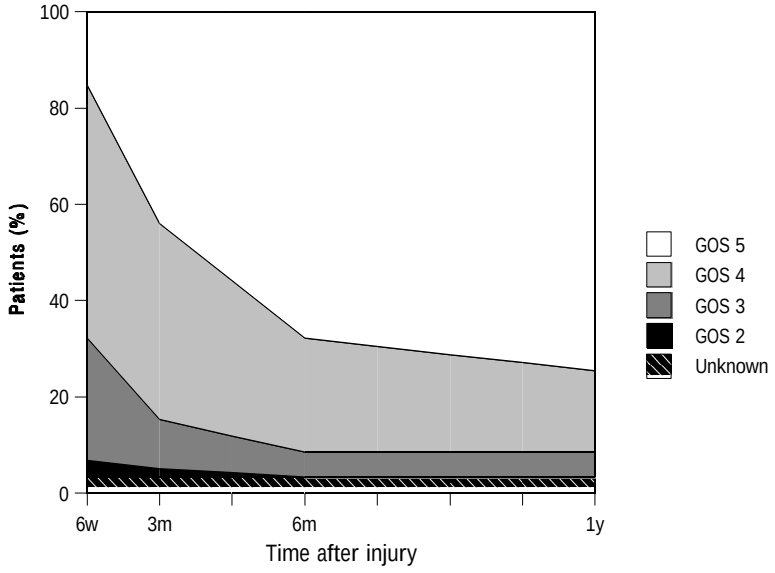


Non-survivors. Fifteen patients died during hospitalization (20%); the mean ISS among the non-survivors was 34 (range 22-75). Twelve fatalities were caused by cerebral injuries, 2 patients died as a result of a combination of a cerebral injury and profuse bleeding, and respiratory failure was the cause of death in the remaining patient. Nearly all patients (n=12) died within 1 day of admission.
Survivors. Of the 59 survivors, 24% (n=14) could not be discharged straight from hospital to their homes. Eight patients were admitted to a rehabilitation centre, mainly because of the consequences of severe cerebral injuries or injuries to the extremities. One patient had to be transferred to a nursing home due to prolonged coma and the remaining 5 children were admitted to an acute care facility nearer to their homes.

8.3.2 : Short-term outcomes

An assessment of the functional outcome at six weeks post-injury (as measured by the Glasgow Outcome Scale) made clear that the majority of the pediatric polytrauma patients (78%) were disabled (GOS 3 or 4) and that a further 2 patients (3%) were comatose (GOS 2). Only 9 patients (15%) had mild disabilities or had recovered completely (GOS 5; see Figure 8.2).

Figure 1.2 Glasgow Outcome Scale (GOS) scores at 6 weeks (6w), 3 months (3m), 6 months (6m) and 1 year (1y) post-injury for surviving patients (n=59)



Outcomes improved considerably during the first half-year after the injury: statistically significant differences were found between the GOS scores at 6 weeks and 3 months and at 3 months and 6 months. Twenty-nine per cent of the patients were still disabled at 6 months post-injury.

There were no statistically significant differences between the GOS scores at 6 months and 1 year (p=0.11). At one year after the trauma, 13 patients (22%) were disabled due to cerebral injuries (8), spinal cord and peripheral nerve lesions (4), acetabular fractures (2), shoulder disarticulation (1) and peri-articular ossifications (1). Combinations of disabilities were found in 3 patients.

8.3.3 : Long-term outcomes

Long-term outcomes were assessed by using a questionnaire containing questions about the social outcome, degree of disablement and quality of life. The follow-up interviews took place 9 years (range 7-11 years) after the trauma on average. Fifty out of the 59 survivors agreed to participate (representing an 85% response rate; see Table 8.1). The non-respondents either did not reply to our introductory letter despite receiving a second and third reminder (6), refused to participate (2) or could not be traced (1). All non-respondents had recovered completely or had only mild disabilities at one year post-injury (GOS 5).

Table 1.1 Characteristics of the survivors (n=59) and the respondents taking part in the long-term follow-up interviews (n=50)

Patient characteristics	Survivors		Respondents	
Mean age (range)	11	(6-15)	11	(6-15)
Sex (M/F)		32/27		25/25
Mechanism of injury:				
Cyclist	30	(51%)	24	(48%)
Pedestrian	15	(25%)	13	(26%)
Car occupant	4	(7%)	4	(8%)
Moped rider	2	(3%)	2	(4%)
Machinery	3	(5%)	3	(6%)
Other	5	(9%)	4	(8%)
Mean ISS (range)	28	(17-57)	29	(17-57)
Mean length of stay in days (range)	31	(5-132)	32	(5-132)

Social outcome: school and vocational career. Thirty-two per cent (n=16) of the pediatric polytrauma patients needed to move to a school offering education of a lower standard as a result of diminished cognitive abilities (due to the consequences of severe brain injuries). Patients with physical disabilities mostly succeeded in returning to their former school. A further twenty-two patients (44%) reported that they had failed to pass one or more classes due to the trauma.

Twenty out of the 50 patients (40%) were employed at the time of follow-up. Of those who were unemployed, the majority were still attending school or college (n=18, 36%), 6 were looking for work and 1 had chosen to be a housewife. Only 5 patients were in receipt of a partial or full disablement allowance. Most of them were unable to work because of the effects of severe cerebral injuries. One third of the patients reported that the trauma had affected their later choice of profession.

Degree of disablement (FIM). The overall degree of disablement measured by the FIM among our pediatric polytrauma patients was low: 47 out of the 50 patients (94%) recorded maximum or submaximum scores on the FIM (≥ 120). The scores on the 'somatic' sections of the FIM (i.e. self-care, sphincter control, mobility and locomotion) were maximal in 86% of the cases. Lower 'somatic' scores were recorded for patients with cerebral injuries (4), spinal cord and peripheral nerve injuries (2) and peri-articular ossifications (1). Twenty-one patients (42%) failed to record maximum scores for the two 'cognitive' domains (i.e. social cognition and communication); in 90% of the cases, this may be attributable to the effects of severe brain injuries.
Quality of life (RAND-36). The RAND-36 scores of the 50 survivors were compared with those of a healthy Dutch reference population of 18-24 years of age. In all eight concepts, there were no statistically significant differences between the pediatric patients and the reference population, suggesting that the respondents enjoyed a good quality of life, both physically and emotionally.

8.3.4 : Short-term versus long-term outcomes

The predictive value of the GOS measurements at 6 weeks, 3 months, 6 months and 1 year post-injury with regard to the FIM scores was investigated with the aid of linear regression analysis (see Table 8.2). This evaluation made clear that the short-term follow-up measurements were related to the degree of disablement at long-term follow-up (as measured by the FIM). These results indicate that the patients who are severely disabled at 6 weeks post-injury, will still be disabled at several years after the trauma in the majority of cases. The mobility, social cognition skills and communication subscales were the best predictors on average. There was no point in calculating the relation between GOS measurements and RAND-36 scores, because the quality of life assessments in the study population did not deviate from the scores of the healthy reference population.

Table 1.2 Results of linear regression analysis (multiple r) between Glasgow Outcome Scale scores at 6 weeks (GOS 6w), 3 months (GOS 3m), 6 months (GOS 6m), 1 year (GOS 1y) post-injury and FIM-scores at long-term follow-up (9 years after trauma on average)

FIM subscales	GOS 6w	GOS 3m	GOS 6m	GOS 1y
Self care	.37*	.49**	.41**	.44**
Sphincter control	.28**	.42**	.44**	.48**
Mobility	.40*	.57**	.54**	.58**
Locomotion	.31**	.46**	.44**	.48**
Social cognition skills	.48**	.51**	.47**	.51**
Communication	.51	.52	.50	.52
Total	.47**	.59**	.53**	.58**

* p<0.05, ** p<0.01

8.4 : Discussion

Trauma is generally considered to be a 'disease' affecting young people in particular. Severe injuries are assumed to have a tremendous impact on these youngsters' future course of life. In the younger age categories, disablement due to severe trauma is thought to lead to long-term dependency on social security. It is unclear whether these assumptions are correct, because we do not have access to essential information on the long-term outcomes of young trauma patients.

This study is the first in the trauma literature to reveal not only short-term outcomes, but also the long-term physical, social and emotional consequences of severe injuries sustained during childhood. The study also assessed the predictive value of short-term outcomes with regard to long-term outcomes.

It is widely accepted that motor vehicle-related injuries are the leading cause of mortality and morbidity in severely injured children.[2,6,24] Our results confirmed this finding, since most children were injured as either cyclists or pedestrians. Such high velocity/high energy incidents frequently lead to severe injuries in the head/neck area. Brain injuries and other neural injuries have a major impact on the outcomes of trauma patients.[6,17,25] In our series, the consequences of neural injuries not only determined the high mortality rate (due to cerebral injuries), but also affected short-term and long-term disablement (i.e. cerebral, spinal cord or peripheral nerve injuries). Injuries to the extremities were the second reason for disablement (e.g. acetabular fractures and shoulder disarticulation).

The extensive impact of severe injuries on the lives of pediatric patients was made particularly obvious by the short-term outcome results. The time required for recovery (i.e. 3 to 6 months on average according to the Glasgow Outcome Scale scores) and the severe social consequences of the trauma (e.g. in the form of classes repeated at school, enrollment at lower schools for education and the effect on the choice of profession) should be taken into account in this regard.

The main finding of the present study is that, despite the severity of the injuries sustained and despite the impact of the injuries on short-term outcome results, the long-term outcomes are very satisfactory. The answers to questions about vocational careers made clear that only 5 out of 50 patients received some form of disablement allowance. Most patients either were employed or still attended school at the time of follow-up.

These good long-term outcome results were further confirmed by the FIM scores: nearly all respondents were totally independent in relation to self-care, sphincter control, mobility and locomotion. Whilst the scores in the cognitive domains were lower on average compared with the scores for the somatic concepts, only a small number of patients needed the assistance of a helper or a supervisor for problem-solving, social interaction, communication, etc. Although the cognitive domains of the FIM are of limited value compared with extensive neuropsychological tests, the FIM scores are a reliable indication of whether patients are capable of acting independently or not. If we extend our findings to the general population, these results imply that only a minority of pediatric polytrauma patients form a long-term burden on society.

Not only measurements of disablement such as the FIM, but also outcome assessments such as the RAND-36 provide important information for physicians dealing with pediatric polytrauma patients. In our opinion, the quality of life after the trauma should be one of the main guiding factors in the treatment of polytrauma patients. We may conclude from

our series that pediatric polytrauma patients experience a comparable quality of life at adulthood as their healthy contemporaries (i.e. the reference population of the same age category). These results imply that the degree of disablement in pediatric polytrauma patients does not correlate with the quality of life. Previous investigations of other diseases have also demonstrated the absence of such a correlation.[26-28] Patients are apparently able to adjust to their disabilities. Their sense of well-being is determined by other factors than self-care or independence, for example by job satisfaction, leisure time activities, standard of living, etc.[29]

Our results seem to be rather confusing considering the proportion of children that needed to move to a school offering education of a lower standard (32%), the proportion of patients who had maximal somatic scores on the FIM (86%), the relatively high proportion of patients with diminished cognitive capacities (42%) and the RAND-scores which did not differ from the reference population. These seemingly paradoxes can be explained by the fact that the children who were unable to return to their former school were mainly cognitively disabled and generally did not have long-term physical disabilities. RAND-scores reflect the quality of life and are not necessarily correlated with the degree of physical or cognitive disablement. It is surprising, however, that the respondents judged their mental health as being equal to or even slightly better than the mental health of the reference population. However, one should realize that the cognitive measurements of the FIM do not easily lend themselves to comparison with the mental health subscale questions of the RAND. The FIM measures the ability to deal with social interaction, problem-solving, memory, comprehension and expression. The RAND-36 registers whether a patient feels depressed, nervous, happy, etc. In other words, the FIM measures other cognitive abilities than the RAND-36, which may explain the different results on the mental subscales. Furthermore, we should be aware of the fact that high scores on mental subscales may be the consequence of brain-injured patients overestimating their health status. Finally, we know that physical incapacities are generally reported more easily than mental impairments.

We acknowledge that our study has certain limitations. One may argue that our long-term outcome measurements reflect an overestimation of the actual outcomes due to response bias (because there is no information available on the non-respondents). Such an overestimation is unlikely, however, since the response rate in our series was high (85%) and all non-respondents recorded maximal short-term outcome scores at one year post-injury (GOS 5).

A further limitation of this study may be the use of the Glasgow Outcome Scale as the primary measure of short-term outcomes. The choice of such a measurement tool is inherent to a retrospective study design. However, the GOS proved to be a valuable tool, since all GOS scores were related to the degree of disablement at long-term follow-up. These findings may have important implications for the treatment of pediatric polytrauma patients: prediction of a patient's functional prognosis at an early stage may lead to a more rapid identification of those patients who are at risk of long-term disablement. Such information can be used to pinpoint those patients who are in need of aggressive rehabilitation programmes. As a consequence, rehabilitation treatment can start earlier and can be adjusted better to the needs of individual patients. We realize, however, that a more sensitive measurement scale than the GOS should be used before our findings are translated into day-to-day practice. In our opinion, this is a subject which certainly merits more attention in future research.

In conclusion, our study results refute the common consensus that severe injuries during childhood lead to a permanent deterioration in the course of life of the youngsters concerned, and that the majority will be long-term recipients of disablement allowances. Nevertheless, the mortality rate (20%) among our severely injured children is still too high and 42% deficit rates in social cognition skills and communication at long-term follow-up are not acceptable. Despite the good long-term quality of life results, the outcomes of pediatric polytrauma patients are still susceptible to improvement.

8.5 : Appendix

Questions about the social consequences of the injury. The answers are cited between parentheses.

1. What type of school were you enrolled at before you were injured? (elementary school, secondary school, special education)
2. What type of school were you enrolled at after you were injured? (the same school as before the injury, a different secondary school, special education)
3. Did you fail to pass one or more classes due to your injury? (yes, no)
4. Did your injury interfere with your choice of profession? (yes, no)
5. What is your principal occupation at the moment? (paid work, looking for work, housekeeping, retired-disability (partial/full allowance), attending school/college)

8.6 : References

1. Vademecum of health statistics of the Netherlands 1996: *Statistics Netherlands, Ministry of Health, Welfare and Sports*. Voorburg/Heerlen, the Netherlands, 1995.
2. Cramer KE: The pediatric polytrauma patient. *Clin Orthop Rel Res* 318:125, 1995.
3. Klonoff H, Clark C, Klonoff PS: Long-term outcome of head injuries: a 23 year follow-up study of children with head injuries. *J Neurol Neurosurg Psych* 56:410, 1993.
4. Greenspan AI, MacKenzie EJ: Functional outcome after pediatric head injury. *Pediatrics* 94:425, 1994.
5. Jaimovich DG, Blostein PA, Rose WW, et al.: Functional outcome of pediatric trauma patients identified as 'non-salvageable survivors'. *J Trauma* 31:196, 1991.
6. Marcus RE, Mills MF, Thompson GH: Multiple injury in children. *J Bone Joint Surg* 65-A:1290, 1983.
7. Hu X, Wesson DE, Logsetty S, et al.: Functional limitations and recovery in children with severe trauma: a one-year follow-up. *J Trauma* 37:209, 1994.
8. Wesson DE, Williams JI, Spence LJ, et al.: Functional outcome in pediatric trauma. *J Trauma* 29:589, 1989.
9. Wesson DE, Scorpio RJ, Spence LJ, et al.: The physical, psychological, and socioeconomic costs of pediatric trauma. *J Trauma* 33:252, 1992.

10. Harris BH, Schwaitzberg SD, Seman TM, et al.: The hidden morbidity of pediatric trauma. *J Pediatr Surg* 24:103, 1989.
11. Colombani PM, Buck JR, Dudgeon DL, et al.: One-year experience in a regional pediatric trauma center. *J Pediatr Surg* 20:8, 1985.
12. Baker SP, O'Neill B, Haddon W Jr, et al.: The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 14:187, 1974.
13. American Association for Automotive Medicine: *The abbreviated injury scale, 1985 revision*. Des Plaines, Ill., The Association, 1985.
14. Buckley SL, Gotschall C, Robertson W Jr, et al.: The relationships of skeletal injuries with trauma score, injury severity score, length of hospital stay, hospital charges, and mortality in children admitted to a regional pediatric trauma center. *J Pediatr Orthop* 14:449, 1994.
15. Nederlandse Vereniging voor Traumatologie: Notitie van de Nederlandse Vereniging voor Traumatologie. *Manifest van de Nederlandse Vereniging voor Traumatologie* SISO 605.8, ISBN 90-800306-1-9:73.
16. Jennett B, Bond M: Assessment of outcome after severe brain damage: a practical scale. *Lancet* 1:480, 1975.
17. Rhodes M, Aronson J, Moerkirk G, et al.: Quality of life after the trauma center. *J Trauma* 28:931, 1988.
18. Sluis CK van der, Duis HJ ten, Geertzen JHB: Multiple injuries: an overview of the outcome. *J Trauma* 38:681, 1995.
19. Functional independence measure: *Guide for the uniform data set for medical rehabilitation (adult FIM℠), version 4.0*. Buffalo, NY 14214: State University of New York at Buffalo, 1993.
20. RAND Health Science Program: *RAND 36-item health survey 1.0. manual*. Santa Monica, CA: RAND, 1992.
21. Hamilton BB, Laughlin JA, Granger CV, et al.: Interrater agreement of the seven level functional independence measure (FIM). *Arch Phys Med Rehabil* 72:790, 1991.
22. Ware JE, Sherbourne CD: The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 30:473, 1992.
23. Zee K van der, Sanderman R, Heyink J: De psychometrische kwaliteiten van de MOS 36-item short form health survey (SF-36) in een Nederlandse populatie. *T Soc Gezondh* 71:183, 1993.
24. Moront M, Eichelberger MR: Pediatric trauma. *Pediatr Ann* 23:186, 1994.
25. Tepas III JJ, DiScala C, Ramenofsky ML, et al.: Mortality and head injury: the pediatric perspective. *J Pediatr Surg* 25:92, 1990.
26. Kinney WB, Coyle CP: Predicting life satisfaction among adults with physical disabilities. *Arch Phys Med Rehabil* 73:863, 1992.
27. Wilson IB, Cleary PD: Linking clinical variables with health-related quality of life. *J Am Med Ass* 273:59, 1995.
28. Fuhrer MJ, Rintala DH, Hart KA, et al.: Relationship of life satisfaction to impairment, disability and handicap among persons with spinal cord injury living in the community. *Arch Phys Med Rehabil* 73:552, 1992.
29. Kirchman MM: Measuring quality of life. *Occupat Ther J Res* 6:21, 1986.