Preclinical care of children with traumatic brain injury (TBI)

Präklinische Versorgung von Kindern mit Schädelhirntrauma

Abstract

The fact that injuries caused by accidents are the most common cause of death in children and adolescents in Germany gave rise to the study, which mainly deals with traffic accidents in this group. 200,221 records of emergency-service physicians in Bavaria which cover the period 1995-1999 were analysed with respect to the importance of traumatic brain injury (TBI) in children and adolescents (n = 721 - representing 45.8% of traffic injuries in this age group). The highest incidence of TBI was in summer (34.3%) and in the evening between 16.00 and 18.00 (23.7%). The time taken between accident and arrival of the emergency services was 8.8 ± 3.1 minutes. The preclinical phase lasted 19.3 ± 5.8 minutes. The probability of having an accident with TBI increases with age, the maximum being in the age-range 7 - 14 years (61.6%). Boys (63.2%) were almost twice as susceptible to injury as girls. 36.8% of all cases had no noticeable neurological disorder, 71.1% resulted in a Glasgow Coma Scale (GCS) score of 15. Only 6.3% had most severe neurological disorders, resulting in a GCS score of 3 - 5. Circulation parameters in the form of adapted hypotension were abnormal in only 3.4%, 21.9% of the children had a bradycardia and in 12.3% the blood oxygen saturation fell below 94%. The most frequent intervention was the laying of an i.v. line for infusions. 8.6% of the patients were intubated to allow for ventilation with oxygen. Analgesics were given in 16.7% of the cases. In 84.7% of all cases, the condition was stable and in only 3.3% was a severe deterioration to be observed. The assessments were made using both the National Advisory Committee for Aeronautics (NACA) and Glasgow Coma Scales (GCS). Discrepancies occurred, as a NACA scale of I-III and a GCS score of < 9 was reported in 4.9% of cases. In contrast a NACA scale of IV - VI was reported with a GCS score of 15 in 30% of all cases. TBI symptoms in children are less obvious than in adults, which leads to an age-dependent restriction in implementing therapeutic measures. If these restrictions are a result of misinterpretation of the situation or due to a lack of practice in the preclinical phase, then further training and education of the physicians involved in emergency service work are necessary.

Zusammenfassung

Vor dem Hintergrund der Tatsache, dass unfallbedingte Verletzungen die häufigste Todesursache im Kindes- und Jugendalter in Deutschland sind, wurde das Patientenkollektiv des Notarztdienstes in Bayern (n = 200.221) analysiert mit der Frage des Stellenwertes des Schädelhirntraumas (SHT). In den Notarztprotokollen fanden sich 721 Kinder mit SHT, das waren 45,8% der kindlichen Verkehrsunfälle. Der Häufigkeitsgipfel war in den Sommermonaten (34,3%), während die täglichen Einsatzspitzen am Nachmittag zwischen 16:00 und 18:00 Uhr (23,7%) lagen. Die durchschnittliche Eintreffzeit des Notarztes liegt in Bayern bei 8,8 Minuten (± 3,1 Min.), während für die präklinische Therapie am Notfallort (vor Abfahrt des Rettungswagens) durchschnittlich 19,3 Minuten (± 5,8 Min) benötigt wurden. Mit zunehmendem Alter steigt der
Anteil der verunglückten Kinder mit einer deutlichen Betonung der 7 - 14-Jährigen (61,6%). Jungen sind doppelt so häufig verunfallt (63,6%) wie Mädchen. 36,8% der Kinder waren neurologisch unauffällig, während für 71,1% ein GCS-Wert von 15 dokumentiert wurde. Nur 6,3% hatten schwerste neurologische Störungen (GCS 3 - 5). Die Kreislaufparameter wichen nur in 3,4% von der Norm im Sinne einer kindlich adaptierten Hypotonie ab. Auch eine Bradykardie betraf nur 21,9% der Kinder. Lediglich 12,3% wiesen einen Abfall der Sauерstoffsättigung des Blutes auf unter 94% auf. Die häufigste Maßnahme war das Anlegen einer Infusion, die jedes zweite Kind (49,6%) erhielt. Allerdings war bei dieser Maßnahme eine deutliche Altersabhängigkeit auszumachen, was auch für die Applikation von Sauерstoff als Therapiemaßnahme zutrifft. Unabhängig vom Alter wurde fast jedes zehnte Kind intubiert (8,6%). Eine altersabhängige Zurückhaltung war auch bei der medikamentösen Analgesierung auszumachen, die insgesamt nur in 16,7% der Fälle erfolgte. Insgesamt konnte der Zustand der Kinder bis zur Klinikübergabe in 84,7% der Fälle gehalten werden, nur in 3,3% kam es zu einer Verschlechterung. Bei einem Vergleich zwischen der subjektiven Beurteilung des Notarztes mittels der NACA-Skala und dem GCS-Wert werden deutliche Diskrepanzen offenbar, wenn bei einem NACA von I - III in 4,9% ein GCS-Wert von unter 9 und umgekehrt bei einem NACA von IV - VI ein GCS-Wert von 15 bei 30% vorlag. Im Gegensatz zu Erwachsenen sind die Leitsymptome des SHT bei Kindern nicht so deutlich, was zu einer altersabhängigen Zurückhaltung bei den therapeutischen Maßnahmen führt. Ob diese Zurückhaltung ausschließlich auf einer Fehleinschätzung der Dringlichkeit oder aber auf mangelnder Praxis bei der präklinischen Durchführung der Therapie beruht, bleibt offen, macht aber eine dringende Fortbildungsnotwendigkeit deutlich.

Introduction

In Germany, injuries, mainly caused by traffic accidents [1], are the most common cause of death during childhood and adolescence [2], accounting for around 50% of mortalities in this age group [3]. The results of a study by the air rescue service in Munich showed that 54% of patients suffered traumatic brain injury (TBI) as a result of a traffic accident. Those aged between 14 and 25 years represented a third of this group [4]. In the literature, between 25% and 80% of fatalities in children are attributed to traumatic brain injury resulting from an accident [5], [6]. These figures are independent of which country or population segment is involved. In view of this tragic situation, it appears to be justified to analyse the circumstances leading to injury in children and adolescents with the aim of improving preclinical care.

Treatment by the emergency rescue service only shows its maximum efficiency during the early posttraumatic period [7] if the emergency physician not only prevents the immediate threat to life but also stabilises the patient's condition, thus improving the clinical course and outcome.

The ability of the Glasgow Coma Scale (GCS) to define the severity of traumatic brain injury (TBI), as well as its widespread acceptance and application in neurological assessment of both preclinical and clinical phases, allows for comparison between different studies [8] and provides a sound basis for quality-patient-management in such cases [9].

As a result, there must not only be a collection of data focussing on children with TBI - but also an analysis of clinical course and outcome as a result of preclinical analysis of the situation and the course of action taken, using the GCS as a basis. It must be borne in mind that for such injuries no clinical data is available on the injured person and therefore the emergency doctor must rely solely on his skills to master the situation he is confronted with. He would invariably profit from results from such a cause-treatment-effect analysis of data collected from similar cases.

Materials and methods

The investigation and collection of data on the preclinical phase was made using the record files from emergency physicians structured according to the recommendations of the German Interdisciplinary Union of Intensive and Trauma Care (DIVI) (version 2.5) [10]. Data were analysed using descriptive statistics. During a five-year period (1995-1999) over 200,000 record files were analysed using a computer programme (Teuton) written specially for this purpose. The programme was based on MS-DOS and used a four-line ASCII file for each data set. The data were later transferred to a Microsoft Access databank. The final statistical evaluation was made on 220,221 data sets using the programme "MEDAS"; descriptive data being written using Microsoft Word 2000.
Not all data were available for each case, so that the number of data analysed per field varied, which led to a variation in the predictive value of the results obtained.

Results

Category of causes of accidents including cases with TBI

Figures 1 and 2 summarise the data. The reason for the rescue operation was given in 171,172 from 200,221 records (85.5%). In 20,817 cases (12.2%) a traffic accident was the initiator. Acute illness was the main cause of the emergency (117,499 cases = 68.6%). The other reasons for emergency rescue were: accidents at work (3,354 = 2.0%), diverse accidents (13,277 = 7.8%) as well as other injuries (25,385 = 14.8%) (Figure 1). Children and adolescents up to the age of 14 accounted for 8.7% of cases in the traffic accident data.

7,890 persons involved in traffic accidents (37.9%) developed a TBI, of whom 6,072 were older than 14 years. 1,578 children and adolescents aged 14 years and younger were involved in traffic accidents, of whom 721 (45.8% of this group; 9.1% of all traffic accidents) sustained a TBI (Figure 2).

Time-course of rescue operations

The data are given in Figures 3 and 4. The frequency of rescue operations correlated strongly with the time of year, a marked increase being seen in the summer months which include the summer holidays in Bavaria (July-September). During these 3 months, 34.3% of all traffic-related accidents occurred (Figure 3).

Figure 4 shows the distribution of accidents according to the time of day, with a maximum between 16.00 and 18.00 (23.7%). The second most frequent accident period was between 12.00 and 16.00, which coincided with the end of the school day.

Time between alarm and arrival of the emergency team at the site of the accident

The mean time between receiving the alarm and arrival at the scene of the accident was 8.8 ± 3.1 min in Bavaria (compared with the data from 1996-1997 for the whole of the German Federal Republic of 9.8 min [11]) and is a critical point in the preclinical treatment period. In 82.5% of all cases in Bavaria, the emergency team arrived within 12 minutes of having been alarmed, the 95th centile was 18 minutes, the 99.5th centile at 30 minutes - see Figure 5.

The treatment time (at the site of the accident) was the time between arrival of the emergency services and the start of the transportation to the hospital and represented 19.3 ± 5.8 minutes for children and adolescents with TBI (Figure 6). The 95th centile was 43 minutes, i.e. in 95% of all cases the treatment at the site of the accident was less than three-quarters of an hour. The transport time from the site of the accident to the hospital was 16 ± 5.6 min, the 95th centile being 35 min. The average time of the whole rescue operation was 44.2 ± 5.8 min with a 95th centile value of 80 min.

Age and sex of the children and adolescent patients

The data are summarised in Figure 7. The incidence of accidents in children increased with age and reached a maximum in the age groups 7-10 and 11-14 years. In these groups the frequency was identical (30.8%). Boys (n = 433; 63.6%) were involved in accidents on average almost twice as often as girls (n = 248; 36.4%). The average age of the boys was 8.0 ± 1.9 years and for girls 7.7 ± 2.0 years.

Clinical results

The results are shown in Tables 1-3.

Nervous System. In 36.8% of all 707 children studied, no pathological disorder was found. Neurological disorders are classified according to changes in the state of awareness and conspicuous movements of the extremities. Difference in pupil size or meningism played a minor role.

In 92.8% of all cases a definite GCS score could be determined. In this group, 193 children (28.9%) had a GCS score less than 15 which meant that 514 (71.1%) children showed no obvious neurological disorder. 14.2% of the children showed slight neurological disorders (GCS score of 13-14). 4.4% had a GCS score of 9-12, i.e. moderate neurological disorders, 4.0% had a GCS score of 6-8, representing severe neurological disorder and 6.3% had a GCS score of 3-5 reflecting a most severe neurological disorder. For full details see Table 1. Around 10% of the children suffered severe TBI (GCS score <9). TBI was observed more in younger children up to the age of 10 years.

Circulation. Table 2 shows the circulatory disorders according to age group. The data from 653 children were examined, representing 90.3% of the total. The data had to be adjusted for age-dependent reference ranges. A reduced blood pressure was seldom observed (3.4%). In contrast hypertension was seen in around half the children (54.5%). Bradycardia was found more in younger children, tachycardia more in older children. The typical constellation of shock is therefore only recognised as such in a few cases (1.1% in the age group 7-10 years; 3.3% in the age group 11-14 years). Table 3 shows the blood pressure values seen at the first examination.
Figure 1: Category of emergency according to the records of the emergency physician (multiple selections were possible)

Figure 2: Distribution of the age of persons involved in traffic accidents in general (n=20817) and in traffic accidents with patients sustaining traumatic brain injury (n=7890)

Figure 3: Distribution of accidents resulting in traumatic brain injuries in children during the course of the year
Figure 4: Distribution of accidents resulting in traumatic brain injury in children according to the time of the day.

Figure 5: Time till arrival of the emergency physician at the site of the accident (p95: 95% of all sites of accident are reached within this period).

Figure 6: "Treatment time" of the injured child at the site of the accident (p95: 95% of all treatments were completed within this period).
Table 1: Children with traumatic brain injury (TBI): Glasgow Coma Scale and severity of cerebral injuries

| GCS   | Neurological findings                      | Grade of severity                        | N=669 | %  |
|-------|--------------------------------------------|------------------------------------------|-------|----|
| 15    | Inconspicuous neurology                    | Conscious                                | 476   | 71.1|
| 13 to 14 | Mild neurological disorder                 | Cerebral commotion e.g. TBI grade 1    | 95    | 14.2|
| 9 to 12 | Moderate neurological disorder             | Clouded awareness, cerebral contusion, e.g. TBI grade 1-2 | 29    | 4.4 |
| 6 to 8 | Severe neurological disorder               | Clouded awareness to unconsciousness, e.g. TBI grade 2-3 | 27    | 4.0 |
| 3 to 5 | Most severe neurological disorder          | Unconscious, coma e.g. TBI grade 3       | 42    | 6.3 |

Table 2: Children with traumatic brain injury: circulatory disorders according to age group

| Age group       | Hypotension | Hypertension | Bradycardia | Tachycardia |
|-----------------|-------------|--------------|-------------|-------------|
| Up to 3 years   | 2.6% (1)    | 72.2% (28)   | 39.3% (22)  | 5.3% (3)    |
| (n=39)          |             |              |             |             |
| 4 to 6 years    | 1.0% (1)    | 62.0% (67)   | 17.7% (22)  | 7.3% (9)    |
| (n=108)         |             |              |             |             |
| 7 to 10 years   | 3.8% (7)    | 48.7% (90)   | 19.3% (35)  | 17.1% (31)  |
| (n=185)         |             |              |             |             |
| 11 to 14 years  | 6.3% (10)   | 35.3% (67)   | 11.5% (21)  | 30.2% (55)  |
| (n=190)         |             |              |             |             |
Table 3: Children with traumatic brain injury: blood pressure values at the first examination according to age group

| Age Group        | Total Number | Blood Pressure |
|------------------|--------------|----------------|
| **Up to 3 years**|              |                |
| Total number     | 39           | 100%           |
| Between 75 and 95 mmHg | 10           | 25.6%          |
| Below 75 mmHg    | 1            | 2.6%           |
| Over 95 mmHg     | 28           | 72.2%          |
| **4 to 6 years** |              |                |
| Total number     | 108          | 100%           |
| Between 80 and 100 mmHg | 40           | 37.0%          |
| Below 80 mmHg    | 1            | 1.0%           |
| Over 100 mmHg    | 67           | 62.0%          |
| **7 to 10 years**|              |                |
| Total number     | 185          | 100%           |
| Between 90 and 110 mmHg | 88           | 47.6%          |
| Below 90 mmHg    | 7            | 3.8%           |
| Over 110 mmHg    | 90           | 48.7%          |
| **11 to 14 years**|              |                |
| Total number     | 190          | 100%           |
| Between 100 and 120 mmHg | 113       | 59.5%          |
| Below 100 mmHg   | 10           | 6.3%           |
| Over 120 mmHg    | 67           | 35.3%          |

**Blood Oxygen Saturation.** The measurement of blood oxygen saturation was only performed in 311 children (47.8% of the total). In 192 children (61.7%), no obvious changes were seen, in 26.1% (81 children) the saturation was 94-96% and in 38 children (12.2%) the oxygen saturation was below 94%.

**Respiratory system.** The respiratory function was documented in 79.3% of all children. In this group in 85.5% respiration was normal, in 3.8% dyspnoea was seen and 2.6% were in respiratory arrest. There was no correlation between GCS score and respiratory function. In the children with GCS score <9, only 36.5% had a normal respiratory function.

**Medical intervention by the emergency physician**

Therapeutic measures were documented in 97.1% of all cases.

**Circulatory system.** Measures involving the circulatory system were taken in 51.6% (n = 361) of the children with TBI. A venous catheter was inserted in 49.6% of cases, other measures - for example CVC (central venous catheter) - being seldom (1.9%). The insertion of a venous catheter was age dependent, in older children, 64.4%, in children under 3 years of age, 20.2% (Figure 8). The most common infusion was of crystalloid solutions (45.3%), independent of whether an immediate emergency was present. Colloidal solutions were infused in only 6.1% of the cases. Therapy due to respiratory disorders was carried out by the emergency physician in 26.9% of the cases, the most common single measure being oxygen inhalation (20.0%). Tracheal intubation was only necessary in 8.6% and ventilation with peak end-expiratory pressure (PEEP) in 2% of the children. Oxygen inhalation was age dependent, older children receiving this therapy form more often than younger children. Tracheal intubation was related to the GCS score as expected. In the children with a GCS score <9, 65.2% were intubated, in the children with a GCS score 9-14, 5.6%. Anaesthesia was induced in 35 children (5%). Figure 9 shows the incidence of oxygen inhalation and tracheal intubation.

**Medication given.** Table 4 shows the medication given according to age. Analgesics were given in 117 cases (16.7%). Analgesics were given more frequently to older children, in the age group 11-14 years the frequency being 23%, compared to only 7.1% in children under the age of 3 years. 11.4% of the children received sedatives, 1.3% catecholamines.

**National Advisory Committee for Aeronautics - NACA scale**

Table 5 shows the allocation of 642 cases (89.3%) to the NACA scale. The NACA scale is used to indicate the overall severity of an emergency. The scale can be used to determine the need for intervention by the emergency physician (a NACA scale above III). NACA I (minimal disorder) was seen in only 3.7% of the children. Around 25% were classified as NACA IV - VI, i.e. as acute cases.

**Condition at the transfer to hospital care**

In 37.7% of cases, improvement between the scene of accident and the hospital was seen; in 1.5% of the children the condition had worsened. In the majority of children, their condition remained stable during the preclinical phase.

The course of TBI could only be followed by GCS documentation at the time of handing over the patient. This was only done in 26.2% of the rescue operations. From these data, in 84.7% of the patients the GCS score was unchanged, 2.2% showed an improvement to a GCS score of 15 and 3.3% a worsening of the GCS score. The administration of sedatives or anaesthesia may have been responsible for the latter. A difference between subjective assessment (37% of the children had improved) and GCS score (12% an increase) was observed.
Figure 8: Medical interventions by the emergency physician: insertion of a peripheral venous catheter according to the age of the children with traumatic brain injury ($n_{\text{total}}=700$)

Figure 9: Medical Interventions by the emergency physician: insufflation of oxygen and tracheal intubation according to the age of the children with traumatic brain injury ($n_{\text{total}}=700$)

Table 4: Medical interventions by the emergency physician: medication given according to age group

| Age in years | Ø       | Analgesic | Narcotic | Crystalloid solutions | Colloid solutions |
|--------------|---------|-----------|----------|-----------------------|------------------|
| Up to 3 (n=109) | 76.8%   | 7.1%      | 2.0%     | 12.1%                 | 1.0%             |
| 4 to 6 (n=161)  | 54%     | 12.4%     | 4.3%     | 44.1%                 | 3.7%             |
| 7 to 10 (n=214) | 44.6%   | 15.8%     | 5.4%     | 48.2%                 | 8.1%             |
| 11 to 14 (n=216) | 37.8%   | 23.4%     | 5.4%     | 53.1%                 | 8.1%             |
| Average         | 43.4%   | 16.3%     | 4.6%     | 45.3%                 | 6.1%             |
Discussion

Despite the continual reduction of traffic accidents, the proportion of emergency rescue operations in Bavaria was 12.2%, compared with 9% for the German Federal Republic as a whole [11]. Traffic accidents are the most common form of injury in children and adolescents, for children under the age of 15, amounting to 8.7% of the total number of traffic accidents. 45.8% of all children involved in a traffic accident suffer from TBI, which agrees with the data from Albrech et al. [12]. The high proportion of TBI in children may be due to the anatomy, children having a higher centre of gravity than adults due to the relatively larger head size and less stable cervical spine, resulting in a higher risk of injury. According to Ward [6], the negative combination of the anatomy explains that 25% of death due to trauma in childhood can be attributed to TBI. In Bavaria this was not seen, only 1.3% of children requiring resuscitative measures, 1.6% of children dying at the scene of the accident. The intervention of the emergency service physician can lead to a better outcome. This study is of interest because of the limited amount of data for children involved in traffic accidents. The German Federal Office for Statistics (Statistisches Bundesamt) [13] documented a nearly linear increase in the number of children involved in traffic accidents during the period of this investigation. In Bavaria, an increase was only seen in children up to 6 years of age, above this the figures remained constant. The implementation of safety measures (courses in road safety in schools and nurseries, wearing of helmets on bicycles and seat belts in cars) may have had a positive effect here.

There was an increase in the number of accidents outside of school time. The German Federal Office for Statistics found that 73% of traffic accidents involving 6-year old cyclists occurred between April and October, with a peak in May (20). Albrech and co-workers found a similar distribution, with a maximum in the afternoon [12]. In 56% of traffic injuries in children under 6 years of age in 1998, the child was a car passenger [13].

The use of the GCS score for evaluating the negative effects of TBI is relatively coarse and must be adapted to the physiological and pathophysiological characteristics of the child. The pathophysiological course of TBI in children is markedly different than that in adults. 50% of children who died as a result of TBI were conscious at the time of hospital admission [14]. Children may respond to mild or middle-severe cases of TBI with a foudroyant swelling of the brain [15]. Humphreys et al. [14] reported a transient responsiveness in children with TBI, which may however be followed by a dramatic worsening and death.

The goal of the Glasgow Coma Scale is the assessment of individual damage in a simple, standardised and quantifiable way using the state of consciousness as a marker. Therapeutical measures can be partially derived from the GCS score - for example tracheal intubation if the GCS score is less than 9. The GCS is recommended by neurological and anaesthesiological societies and is reflected in the "Guidelines to primary care of patients with traumatic brain injury" [16]. Their adaption to children is however still not generally accepted [17], [18], [19] and is not to be found in the DIVI-form.

An essential for successful therapy is an early and professional application. The emergency rescue service in Bavaria can be classed as good, with reduced time between alarm and arrival at the scene of accident (in Munich on average 8.2 minutes, compared with 8.8 minutes nationally) [4]. In the air rescue services, this was also seen, with a time of 15 minutes for starting therapy in 77% of cases [12].

As already mentioned, children present different problems, especially in communication, at the site of the accident. The topical signs of injury (lacerations, contusions and haematomas) therefore play a more important role in children than in adults. In both groups, the main symptom remains the change in awareness. In around 10% of all children with TBI, the GCS score was less than 9. The NACA scale is more subjective. It was possible to compare GCS and NACA systems in this study because 82.8% of all records had both assessment values. In the NACA classification I - III (slight injury) 85.5% of the children had a GCS score above 15. A discrepancy of 1.9% between both scales was seen if the GCS-score was less than 9. Conversely, 30% of children assessed as NACA IV - VI had been ascribed a GCS score of 15. It is still un-

Table 5: Children with traumatic brain injury: allocation to the NACA (National Advisory Committee for Aeronautics) scale

| NACA | Description                                      | Number | n=642 |
|------|--------------------------------------------------|--------|-------|
| I    | Minimal disorder                                 | 24     | 3.7%  |
| II   | Outpatient clarification                         | 170    | 26.5% |
| III  | Inpatient clarification                          | 278    | 43.3% |
| IV   | Unable to exclude acute danger of life           | 116    | 18.1% |
| V    | Acute danger of life                             | 36     | 5.6%  |
| VI   | Resuscitation                                    | 8      | 1.3%  |
| VII  | Death                                            | 10     | 1.6%  |
|      |                                                  | 642    | 100%  |

NACA IV to VII (serious injury) 170 26.5%
clear as to the role which concomitant injuries play in subjective assessment (Figure 10). 54.5% of the children with TBI were hypertensive, 3.4% hypotensive. Hypotension and hypoxaemia tend to worsen the prognosis of TBI via secondary neurological damage as was confirmed in a prospective evaluation of the data [20]. In 12.2% of cases, oxygen therapy was required on admission to hospital. Although the preclinical care is not the only factor in the treatment of TBI, it plays an important role as has been shown recently on analysis of larger groups of patients [21]. Here hypoxia and hypotension were shown to affect morbidity and mortality negatively. Administration of oxygen requires little skill, whereas the laying of an intravenous port and tracheal intubation require specific skills which must be learnt. This may reflect the somewhat conservative or reserved approach in children who had a GCS score less than 9. Hypertension is not only explained by TBI, but is also a result of pain and concomitant injuries sustained, as well as the rescue operation itself. The administration of analgesics in children with clouded awareness is justified, as the latter reduce the pain-induced intracranial pressure [22]. As a result, pain should be alleviated as soon as possible to reduce the possibility of increased trauma [23].

In this study, only 16.3% of children received narcotic or analgesic agents; in children under 4 years of age the proportion was only 7.1%. The restraint shown by the emergency physicians in administering analgesics, laying an intravenous port or tracheal intubation may be reflect-
ed in the limited improvement rate between the site of the accident and admission to hospital. Despite these reservations, only 1.5% of all cases worsened on the way to hospital. Albrech and co-workers [12] were able to report a full recovery in 85% of cases between the source of accident and admission to hospital. They showed an absence of permanent disability, as well as a lethal outcome in 5.7% of all cases, although 34% of those injured were primarily graded as being in a life-threatening condition.

**Conclusions**

The aim for primary care of children with traumatic brain injury is to move the intensive care period to the site of the accident, i.e. into the operational area of the emergency rescue services. Guidelines exist [16], which have to be individually adapted to the physiology of the child and which may lead to a complete recovery from TBI, with low levels of mortality and absence of permanent disability [12].

The main problem is the lack of typical symptoms in children, which may result in misjudgement of the situation and exclude the necessary immediate action. Restraint in taking primary action may be the result of insufficient training of physicians involved in the rescue services, especially in the field of paediatric emergencies. Further intensive training of such personnel may result in improvement of the therapy success rates in traffic

---

**Figure 10:** Children with traumatic brain injury: assessment according to the NACA (National Advisory Committee for Aeronautics) scale in relation to the initial assessment with Glasgow Coma Scale (GCS).
accidents involving children. This in turn can lead to a reduction of the follow-up costs, which occur in cases of permanent disability requiring life-long treatment.

References

1. Helm M, Haucke J, Frey W, Lampl L. Der pädiatrische Traumapatient im Luftrettungsdienst: altersspezifische Besonderheiten. Notfall Rettungsmed. 1999;2(3):150–7.

2. Maier-Hauf K, Gatzounis G, Borschel M. Das kindliche Schädel-Hirn-Trauma. Besonderheiten, Therapie und Prognose. Unfallchirurg. 1993;96(11):604-8.

3. Schulte FJ, Springer J. Unfälle im Kindesalter. In: Schulte FJ, ed. Lehrbuch der Kinderheilkunde. 27. Aufl. Stuttgart: Fischer; 1993. p. 905 – 12.

4. Scheingraber S, Reulen HJ. Praxis präklinischer Versorgung Schädel-Hirn-Traumatisierter. Notfall Rettungsmed. 1999;2(2):84–91.

5. Hall SC. Pediatric trauma in the 90s: an overview. Int Anesthesiol Clin. 1994;32(1):1-9.

6. Ward JD. Pediatric issues in head trauma. New Horiz. 1995;3(3):539-45.

7. Jantzen JP, Piek J, Buchardi H. SHT – Manual, Primärversorgung des Patienten mit schwerem Schädel-Hirn-Trauma. Lünen: Systemed; 1998.

8. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet. 1974;2(7872):81-4.

9. Lackner CK, Ruppert M, Lazarovici M, Stolpe E. Anwenderperformanz und –variabilität der Glasgow-Koma-Skala. Notfall Rettungsmed. 2002;5(3):173–85.

10. Das bundeseinheitliche Notarzteinsatzprotokoll der Deutschen Interdisziplinären Vereinigung für Intensiv- und Notfallmedizin (DIVI). Notarzt. 1989;5:91 – 3.

11. Bundesministerium für Verkehr. Sicherheit im Straßenverkehr. Bericht über Maßnahmen auf dem Gebiet der Unfallverhütung im Straßenverkehr und Übersicht Rettungswesen 1996 und 1997. Bundestagsdrucksache 13/11252 v. 03.07.1998.

12. Albrech M, Berner J, Attemayer KH. Kinderunfälle im Luftrettungsdienst. Eine retrospektive Qualitätsanalyse der präklinischen Versorgung, des klinischen Verlaufs und des Outcome. Notfall Rettungsmed. 2000;3(3):156–69.

13. Statistisches Bundesamt. Straßenverkehrsunfälle, Kinderunfälle im Straßenverkehr 1998. Auszug aus der Fachserie 8, Reihe 7. Stuttgart: Metzler Poeschel; 1999.

14. Humphreys RP, Hendrick EB, Hoffman HJ. The head-injured child who "talks and dies". A report of 4 cases. Childs Nerv Syst. 1990;6(3):139-42.

15. Schöchl H, Ziegler B, Hofmann N. Das schädel-hirn-traumatisierte Kind im Rettungsdienst. Rettungsdienst. 1997;20(7):30–3.

16. Jantzen JP, Piek J. Leitlinien zur Primärversorgung von Patienten mit Schädel-Hirm-Trauma. Anaesthesiol Intensivmed. 1997;38(2):89–93.

17. James HE, Tranner DA. The Glasgow – Coma Scale. In: James HE, Anas AG, Perkin RM, eds. Brain insults in infant and children. Orlando: Grune & Stratton; 1985. p.179–82.

18. Raimondi AJ, Hirschauer J. Head injury in the infant and toddler. Coma scoring and outcome scale. Childs Brain. 1984;11(1):12-35.

19. Rapp S, Schädel-Hirm-Trauma im Kindesalter. Notfall Rettungsmed. 1998;1(6):367 – 70.

20. Hennes HJ. Der Notfallpatient mit Schädel-Hirm-Trauma. Notfallmed. 1992;18:422 – 7.

21. Thomas A, Berlinghof HG, Bock KH, Lampl L. Outcome-Faktoren des schweren Schädel-Hirm-Traumas. Eine retrospektive Analyse von 228 (161) Patienten, Anaesthesiol Intensivmed Notfallmed Schmerzther. 2000;35(2):91-7.

22. Schüttler J, Schmitz B, Bartsch AC, Fischer M. Untersuchungen zur Effizienz de notärztlichen Therapie bei Patienten mit Schädel-Hirm-bzw. Polytrauma. Ein Beitrag zur Qualitätssicherung in der Notfallmedizin. Anaesthesist. 1995;44(12):850-8.

23. Illers G, Dick W. Wie entstehen Fehler und Gefahren bei der Behandlung Polytraumatisierter? Notfallmed. 1985;11:30–43.

Corresponding author:
Prof. Dr. med. Peter Sefrin
Klinik und Poliklinik für Anästhesiologie, Sektion für Präklinische Notfallmedizin, Josef-Schneider-Straße 2, 97080 Würzburg, Germany
Sefrin_P@klinik.uni-wuerzburg.de

Please cite as
Sefrin P, Brandt M, Krede M. Preclinical care of children with traumatic brain injury (TBI). Ger Med Sci. 2004;2:Doc02.

This article is freely available from http://www.egms.de/en/gms/2004-2/000012.shtml

Received: 2004-01-08
Published: 2004-03-10

Copyright
©2004 Sefrin et al. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en). You are free: to Share — to copy, distribute and transmit the work, provided the original author and source are credited.