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Characteristics of severely injured children admitted to a Danish trauma centre

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ABSTRACT

INTRODUCTION: The epidemiology of children admitted to Scandinavian trauma centres remains largely unknown. This study aimed to describe the characteristics of severe injuries in children admitted to a Danish university-level trauma centre.

METHODS: A descriptive study of all severely injured (Injury Severity Score ≥ 16) children aged 0-15 years who were admitted to the university level trauma centre at Odense University Hospital, Denmark, in the 2002-2018 period. Data were extracted from the South Danish Register and from medical records.

RESULTS: A total of 152 children were included. The median age was 11 (range: 0-15) years. Boys accounted for 57% of the cases. Accidents accounted for 99% of the cases. In the youngest age group (0-4 years), the majority of injuries occurred in domestic areas, in the daytime, in the summer and around the weekends. In the oldest age group (11-15 years), most injuries occurred in traffic areas, in the autumn, on weekdays and in the afternoon. In all age groups, the majority of lesions were sustained to the head/face/neck, limbs and thorax. The overall median number of days in hospital was six. Overall, 39 (26%) children died. Almost half of the injuries were traffic related and this proportion increased with increasing age group. One-third of the traffic injured children died.

CONCLUSIONS: Based on a regional trauma register, we described the characteristics of severely injured children. The study included several aspects regarding injury pattern and severity, which may be useful for risk identification, prevention of accidents and for hospital resource planning.

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Injuries are the main reason for death in children in the industrial countries [1]. However, children in Denmark generally live a safe life and severe injuries and death from injuries are relatively uncommon. From 2002 to 2016, the number of deaths from injuries in Denmark in the 0-14-year age group has shown a declining trend from 33 to 10, corresponding to 8% and 4% of all deaths in the age group, respectively [2].

However, the epidemiology of severely injured children admitted to Danish trauma centres remains largely unknown. To our knowledge, only two Danish studies have described paediatric trauma patients [3, 4]. A previous study from Odense University Hospital studied both children and adolescents 0-17 years admitted to the trauma centre from 2002 to 2014 [3]. In the Odense study, 61% were boys, most injuries occurred in the afternoon and in the summer. Overall, 59% were traffic-related injuries and the overall mortality was 5.2%. However, the study examined all children and adolescents admitted without conducting any analyses of the important group of severely injured children [3]. In a study from Aarhus University Hospital comprising all children from 0 to 15

years admitted to the level-1 trauma centre from January 2004 to May 2014, the majority of injured children were boys, most injuries occurred in the afternoon and in the summer, 48% were traffic-related injuries, and the overall mortality was 2.7% [4]. Two-thirds of all fatalities were related to injuries caused by traffic accidents [4].

No previous Danish study has focused on the characteristics of the important group of severely injured in children admitted to a trauma centre. The clinical implication of having access to this information is improved preparedness owing to enhanced knowledge about the types of injuries and impacts that may be expected by receiving traumatologists, and thus how specialist competence may be organised for treatment of acute trauma patients.

Therefore, this study aimed to describe the characteristics of severe injuries in children admitted to a Danish university level trauma centre.

METHODS

This is a register study based on the South Danish Trauma Register. From the trauma register, we extracted data about all severely injured children aged from 0 to 15 years admitted to the university level trauma centre at Odense University Hospital (OUH), Denmark, in the 2002-2018 period. Severe injuries were defined as Injury Severity Score (ISS) ≥ 16. Included were children primarily admitted to the trauma centre and children transferred from other hospitals within 24 hours after the trauma. Excluded according to the UTSTEIN criteria were children who were declared dead at the place of injury, who were strangled, drowned or seriously burned [5]. Children who died during transportation to the hospital were included [5].

The Trauma Centre at OUH provides services for the entire Region of Southern Denmark with a population of approximately 1,000,000 and is located in the city centre of Odense with a population of approximately 200,000 inhabitants. In addition to the university level trauma centre, four regional trauma centres provide services for the region. Occasionally, the trauma centre at OUH receives trauma patients from other parts of Denmark.

Since 1996, all trauma patients admitted to the trauma centre at OUH have been uniformly registered in the South Danish Trauma Register. The register contains detailed information about demography, the circumstances leading to injury, the place of injury, diagnoses, treatment and outcome. Trauma patients are registered prospectively and consecutively on admission to the trauma centre. The trauma register includes self-reported information from the patient, information from the police/paramedics and information from the medical records. The trained staff do all registrations and trained physicians determine the diagnoses according to the International Classification of Diseases – tenth version (ICD-10) – with a maximum of ten diagnoses for each patient. For those patients who die, diagnoses are obtained from the autopsy reports. All trauma patient autopsies are made at the Institute of Forensic Medicine, University of Southern Denmark. The injury severity is coded using the Abbreviated Injury Scale (AIS) according to which the ISS is calculated [6].

From the trauma register, we extracted data about age, gender, time of injury, place of injury, diagnoses, treatment, days is hospital, injury severity (ISS) and mortality. The data were analysed following stratification of the children into three age groups according to psychosocial and physiological steps in children's development: 0-4 years (infants), 5-10 years (small children) and 11-15 years (older children). Non-parametric statistics with Stata 15 were used in all statistical analyses and a $p < 0.05$ was considered statistically significant.

Trial registration: not relevant.

RESULTS

In the study period, 1,035 children aged 0-15 years were admitted to the trauma centre at OUH for examination and treatment by a trauma team. Among these, 152 (15%) were severely injured with an ISS ≥ 16, corresponding to nine cases annually. No significant change was observed in the annual proportion of severely injured children in the study period (trend test, p = 0.362).

Ninety-four (62%) children were primarily admitted to the trauma centre and 58 (38%) were transferred after initial treatment at another hospital. Eighty-seven (57%) children were boys. The gender distribution did not vary between the different age groups (**Table 1**). The median age was 11 years (0-15 years) with no difference between boys and girls (Mann-Whitney, p = 0.22). Accidents (not intended injuries) accounted for 99% of the cases. In two cases, the injuries were inflicted by violence.

TABLE 1 The distribution of gender and injury characteristics stratified by age groups. The values are n (%).

	Age group			
	0-4 yrs	5-10 yrs	11-15 rs	Total
Gender				
Boys	22 (60)	18 (55)	47 (57)	87 (57)
Girls	15 (40)	15 (45)	35 (43)	65 (43)
Place of injury				
Home	19 (52)	8 (24)	9 (11)	36 (24)
School/institution/recreation	9 (24)	6 (18)	16 (19)	31 (20)
Traffic area	9 (24)	19 (58)	57 (70)	85 (56)
Season				
Spring: Mar-May	11 (30)	10 (30)	22 (27)	43 (28)
Summer: Jun-Aug	18 (49)	12 (36)	29 (35)	59 (39)
Autumn: Sep-Nov	5 (14)	6 (18)	22 (27)	33 (22)
Winter: Dec-Feb	3 (8)	5 (15)	9 (11)	17 (11)
Weekday				
Monday-Thursday	15 (41)	18 (55)	49 (60)	82 (54)
Friday-Sunday	22 (59)	15 (45)	33 (40)	70 (46)
Time of day				
08.00-15.59	20 (54)	18 (55)	28 (34)	66 (43)
16.00-23.59	14 (38)	13 (39)	32 (39)	59 (39)
24.00-07.59	3 (8)	2 (6)	22 (27)	27 (18)
Total	37 (100)	33 (100)	82 (100)	152 (100)

The injury characteristics varied with age groups (Table 1). In the youngest group, the majority of injuries occurred in domestic areas, in the daytime, in the summer and around weekends. In the oldest age group, most injuries occurred in traffic areas, in the summer, on weekdays and in the afternoon.

Overall, 90% of the children suffered from lesions to the head/face/neck, 36% to the thorax, 34% to the lower limbs, 25% to the abdomen, 24% to the upper limbs and 10% to the spine. The 152 children had 560 lesions recorded, corresponding to 3.7 lesions per child. The majority of lesions were to the head/face/neck, limbs and

thorax in all age groups (**Table 2**). The overall median days in hospital was six days (0-54 days with no difference between the age groups (Kruskal-Wallis, p = 0.051). The overall median ISS was 25 (16-75) with no difference between age groups (Kruskal-Wallis, p = 0.316). Overall 39 (26%) children died. The proportion did not change in the study period (trend test, p = 0.967). All deceased children suffered from severe injuries in the head/face/neck and/or trunk.

TABLE 2 Overview of the injuries in different body regions, the Injury Severity Score (ISS), the number of days in hospital, and the mortality stratified by age group.

	Age group			
	0-4 yrs	5-10 yrs	11-15 rs	Total
Body region, n (%)				
Head/face/neck	70 (52)	71 (54)	120 (38 %)	261 (47)
Thorax	24 (18)	18 (14)	44 (14 %)	86 (15)
Abdomen	11 (8)	11 (8)	34 (11 %)	56 (10)
Spine	2 (1)	7 (5)	14 (5)	23 (4)
Upper limb	12 (9)	9 (7)	47 (15)	47 (8)
Lower limb	11 (8)	16 (12)	45 (14)	72 (13)
Unspecified	5 (4)	0	10 (3)	15 (3)
Subtotal	135 (100)	132 (100)	314 (100)	560 (100)
Time in hospital				
1-7 days, n (%)	27 (73)	15 (46)	51 (62)	93 (61)
8-14 days, n (%)	6 (16)	8 (24)	14 (17)	28 (18)
> 14 days, n (%)	4 (11)	10 (30)	17 (21)	31 (21)
Days, median (range)	6 (0-54)	9 (0-51)	5 (0-133)	6 (0-133)
ISS				
16-30, n (%)	26 (70)	27 (82)	59 (72)	112 (74)
31-45, n (%)	5 (14)	4 (12)	13 (16)	22 (14)
> 45, n (%)	6 (16)	2 (6)	10 (12)	18 (12)
Score, median (range)	25 (16-75)	22 (16-75)	25 (16-75)	25 (16-75)
Mortality, n (%)				
Survived	28 (76)	28 (85)	57 (70)	113 (74)
Died	9 (24)	5 (15)	25 (30)	39 (26)

Almost half (48%) of the injuries were traffic related. The proportion of traffic-related injuries increased with increasing age group (11%, 24% and 65%). The youngest age group was most frequently (50%) injured as passengers in four-wheeled vehicles, whereas the two oldest age groups were most frequently injures sustained while riding a bicycle (**Table 3**). Overall, 310 lesions were registered in the 74 children with traffic-related injuries corresponding to 4.2 lesions per child. The head/face/neck, lower limbs and thorax were the most common injury sites in all age groups. The median days in hospital was five days (0-133 days). The median number of days was six (2-60 days) in the youngest age group, ten (1-27 days) in the middle age group and four (0-133 days) in the oldest age group. Overall, 24 (32%) children died from their traffic-related injuries.

TABLE 3 Traffic-related injuries: gender, role of traffic, Injury Severity Score (ISS), and mortality stratified by age group.

	Age group			
	0-4 yrs	5-10 yrs	11-15 rs	Total
Role of traffic, n (%)				
Pedestrian	3 (38)	3 (17)	6 (12)	12 (16)
Bicycle	1 (12)	7 (39)	22 (46)	30 (41)
Moped	0	2 (11)	9 (19)	11 (15)
Vehicle ≥ 4 wheels	4 (50)	6 (33)	11 (23)	21 (28)
Body region, n (%)				
Head/face/neck	17 (46)	47 (59)	68 (35)	132 (43)
Thorax	6 (16)	10 (12)	32 (17)	48 (15)
Abdomen	2 (6)	8 (10)	23 (12)	32 (10)
Spine	3 (8)	0	14 (7)	17 (6)
Upper limb	3 (8)	4 (5)	20 (10)	27 (9)
Lower limb	6 (16)	11 (14)	29 (15)	46 (15)
Unspecified	0	0	7 (4)	7 (2)
Subtotal	37 (100)	80 (100)	193 (100)	310 (100)
ISS				
16-30, n (%)	5 (63)	13 (72)	28 (58)	46 (62)
31-45, n (%)	0	3 (16)	11 (23)	14 (19)
> 45, n (%)	3 (37)	2 (12)	9 (18)	14 (19)
Score, median (range)	26 (16-56)	16 (16-75)	16 (16-75)	16 (16-75)
Mortality, n (%)				
Survied	6 (75)	15 (83)	29 (60)	50 (68)
Died	2 (25)	3 (17)	19 (40)	24 (32)

DISCUSSION

Drawing on data from a regional trauma register, the present study describes the characteristics and severity of severely injured children admitted to a Danish university level trauma centre. The study covers the longest study period published from Denmark. The age and gender distributions were similar to those reported in previous Danish and international studies [3, 4, 7-15). In the youngest age group, most injuries occurred in domestic areas. With increasing age, traffic-related injuries became the predominant site of injury, which corresponds to findings in other studies [3, 9]. The overall proportion of traffic-related injuries in our study was 48%, which corresponds to previous Danish studies from Aarhus and Odense, and to a study from the UK [3, 4, 9]. However, the proportion is lower than that reported in studies from Sweden, Germany and Austria, which fall in the 64-81% range [8, 12, 16]. Studies from Canada and the US have reported proportions of traffic-related injuries ranging from 31% to 39% [10, 13]. Cultural differences may explain the difference, i.e. school transportation. Only one-fifth of the injuries occurred at school/institutional/recreational areas. This is a relatively small proportion compared with the amount of time children spend within these areas. However, this finding

corresponds to those reported by most other studies [3, 9, 10]. The highest injury frequency occurred in the summer time, during weekends (Friday-Sunday), and in the afternoon, which corresponds to the findings reported by other studies [3, 4, 9]. The distribution by injured body regions found in our study corresponds to previous studies with head/face/neck, lower limbs and thorax being the most frequently injured body regions [3, 8, 15, 17, 18]. The proportion of head/face/neck injuries decreased, and limb injuries increased with increasing age. A similar pattern was described by Bayreuther et al. [17].

The overall mortality among severely injured children in our study did not change during the study period. The high overall mortality in our study is explained by the inclusion of severely injured children only (ISS ≥ 15). The mortality in previous Danish studies including all children received by a trauma team showed mortality rates of 2.7% and 5.2% [3, 4]. Similarly low mortality rates between 2.4% and 8% were found in international studies including all children received by trauma teams [8, 17, 18, 19]. Studies including severely injured children only have shown different mortality rates. In a UK study including only severely injured children (ISS ≥ 16), the overall hospital mortality was 6.6% [9]. A similar German study found hospital mortality rates in different age groups of 13.7-22.6% [11]. These studies only included children who were alive upon arrival to the trauma centre. In our study, we included both children who died during the transport from the trauma scene to the trauma centre and those who died in the trauma centre or hospital. This may explain the higher mortality in our study.

In the group with traffic-related injuries, most children were injured as bicyclists and as passengers in vehicles. The traffic mode varied with age group. Similar distributions were found in other studies [10, 15]. The mortality and the median ISS were higher among children who had become injured in traffic than among children sustaining non-traffic-related injuries. This is explained by the expected high proportion of high-energy traumas in traffic accidents.

One of the strengths of the study was that data were collected during a long period producing a relatively large study population. The data were collected prospectively in a uniform manner, and the number of unknown variables was relatively limited. The AIS measurements were based on anatomical regions in accordance with the AIS criteria. This approach carries some limitations. The AIS weighs all anatomical regions equally. An AIS score for a head lesion may be more severe than a lesion in the upper extremities receiving the same score. Patients may therefore have the same ISS but a different risk of death. In addition, calculation of ISS includes only three injuries, one for each of the three most severely injured anatomical regions. Therefore, the ISS may be underestimated in patients with more than one serious injury within the same body region. Despite these limitations, the AIS/ISS remains the most reliable and valid tool for measuring the immediate severity of injuries.

Biases may have influenced the results. In 2009, the Trauma Registry started organising its contents in accordance with the Utstein criteria [20]. Thus, minor changes in exclusion criteria and definitions may have caused bias. However, we believe that the extent of this bias is limited. Secondly, the triage criteria used to decide whether an incoming trauma triggers trauma reception may have resulted in under-triage as some severely injured patients may not be received by a trauma team. We consider the bias from under-triage to be very limited.

Knowledge of the causes, gender, age group distribution and lesion patterns play a pivotal role in the prevention of injuries. The large proportion of head injuries in our study is concerning. However, these potentially life-threatening lesions are preventable. The correct use of protection equipment such as bicycle helmets can prevent some of the severe head injuries. Furthermore, separate bicycle lanes, safer cars, speed reduction where pedestrian and bicyclists/mopeds mix with cars play important roles. At home, prevention of falls from heights are important among the youngest.

Focusing on severely injured children, the study provided important clinical information. The clinical

implication of this information may be improved preparedness for the types of injuries that a trauma team may meet when treating an incoming trauma child. Especially, the high proportion of head injuries and the high mortality in all age groups should lead to increased awareness. Furthermore, the study supports the importance of a multidisciplinary trauma team including different specialists (neurosurgeons, etc.)

CONCLUSIONS

Based on the South Danish Trauma Register, we described the characteristics of severely injured children admitted to a Danish university level trauma centre. The study comprised several aspects of injury pattern and severity, which may be useful for risk identification, prevention of accidents and for hospital resource planning.

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