Pediatric Trauma Six Years of Experience in a Swiss Trauma Center

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Six Years of Experience in a Swiss Trauma Center

THESE

préparée sous la direction du Professeur Patrick Schoettker
(avec la co-direction du Docteur Mirko Dolci)
(avec la collaboration du Docteure Catherine Heim)

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par

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Monsieur le Professeur John Prior
Vice-Directeur de l'Ecole doctorale

Résumé en français

Trauma pédiatrique

Expérience d'un trauma centre Suisse sur une période de 6 ans

L'objectif de notre étude était de fournir une vue d'ensemble du trauma pédiatrique des enfants admis au déchoquage de pédiatrie au sein du Centre Hospitalier Universitaire Vaudois et d'améliorer ainsi la prise en charge des enfants polytraumatisés.

Nous avons analysé les données de tous les enfants de moins de 16 ans souffrant de polytrauma ayant été admis au déchoquage de pédiatrie sur une période allant de 2011 à 2016. Les admissions au déchoquage de pédiatrie faisaient suite à un triage pré-hospitalier. Les données ont été analysées par le biais de statistique descriptive.

Les données analysées provenaient de notre trauma registre qui a été débuté en janvier 2011. Celui-ci est conforme aux recommandations internationales, permettant ainsi de confronter nos données à celles des autres traumas centres Européens. Les variables recueillies étaient les suivantes: données épidémiologiques, signes vitaux, Injury Severity Score (ISS), le mécanisme du trauma, Abbreviated Injury Scale (AIS), Glasgow Coma Scale (GCS), type de transport, mesure thérapeutique, résultat d'imagerie, valeurs de laboratoire, intervention immédiate, unité de transfert suivant la prise en charge du déchoquage, durée de séjour, mortalité intra-hospitalière, ainsi que le Trauma and Injury Severity Score (TRISS) des non-survivants.

Nous avons inclus 327 enfants, 63% d'entre eux étaient de sexe masculin, l'âge médian était de 8 ans. 97 enfants ont souffert de trauma sévère (ISS > 15). Le mécanisme principal des blessures étaient les chutes (45%), les accidents de la voie publique (29%) et les brûlures (14%). Les zones corporelles les plus fréquemment lésées étaient la tête et les zones externes. Les admissions aux soins intensifs pédiatriques s'élevaient à 27%. 22% des enfants ont nécessité une intervention chirurgicale immédiate (majoritairement des débridements de plaie, des interventions neurochirurgicales et orthopédiques). La mortalité globale était de 5.5% pour un ISS médian de 9. La mortalité des traumas sévères était de 17.5% pour un ISS médian de 22. La moitié des enfants sont décédés dans les 6h suivant leur admission. Les causes principales de mortalité étaient les chutes de plus de 5 mètres et les accidents de la voie publique en tant que piéton.

Ce que nous avons observé est que la démographie et les types de blessures décrites dans notre étude sont identiques à ceux des autres traumas centre européens, mais la mortalité et la sévérité des blessures est varable. (Royaume-Unis 3.7 %-ISS médian 9 ; Danemark 7.3% - ISS médian 9 ; Allemagne 13.4%-ISS médian 25). Le taux élevé de mortalité précoce suggère que les phases initiales de la prise en charge pourraient jouer un rôle dans la diminution du taux de mortalité (phase pré-hospitalière, orientation - via le triage - vers un trauma centre pédiatrique, soins à l'admission au déchoquage pédiatrique).

Pediatric Trauma
Six Years of Experience in a Swiss Trauma Center

Julianna Svantner, MD, Mirko Dolci, MD, MER, Catherine Heim, MD, MSc, and Patrick Schoettker, MD

Objectives: The purpose of this study was to provide an internationally comparable overview of pediatric trauma of the University Hospital of Lausanne to improve the care of children.

Methods: We analyzed the data from all injured children (<16 years of age) listed in our trauma registry from 2011 to 2016. These children were admitted to the resuscitation room after prehospital triage. Our data were analyzed using descriptive statistics.

Results: We included 327 children. Sixty-three percent were male, and the median age was 8 years. Severe trauma (Injury Severity Score (ISS), >15) occurred in 97 children. The principal mechanisms of injury were falls (45%), traffic accidents (29%), and burns (14%). The most frequently affected areas were the head and external body regions. Intensive care admissions amounted to 27%. Twenty percent of patients underwent immediate surgery (wound care, neurosurgery, and orthopedic surgery). The overall mortality rate was 5.5%, with a median ISS of 9. The mortality of severe trauma was 17.5%, with a median ISS of 22. Half of the children died within 6 hours. The main causes of death were falls from greater than 5 m and traffic accidents as pedestrians.

Conclusions: The demographics and patterns of injury in the pediatric trauma population are similar to other European pediatric trauma centers, but the mortality and the severity of injuries can vary (United Kingdom, 3.7%, median ISS of 9; Denmark, 7.3%, median ISS of 9; and Germany, 13.4%, median ISS of 25). The elevated early mortality rate suggests that improvements in prehospital care and early resuscitation could decrease mortality.

Key Words: pediatric trauma, trauma registry, trauma center, injury severity score

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Pediatric trauma accounts for an important proportion of childhood mortality. At the University Hospital of Lausanne (CHUV), the mortality rate is 9% for pediatric patients with medical emergencies and up to 4.9% for children suffering from trauma.[1] In European countries, the morality rates of pediatric patients who experienced trauma range from 0.5% to 30%.[2–13] The establishment of pediatric trauma centers improves survival,[14,15] and analysis of data from these centers helps assess the effectiveness and quality of care.

In western Switzerland, the CHUV is a referral hospital for a population of over 1 million, of which 80,000 are children.[1] The CHUV serves as a tertiary and level 1 trauma center for adult and pediatric populations. It is also one of the 2 major national burn centers, which explains its role as a referral center for the treatment of burn injuries. Its trauma registry started on January 1, 2011.

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According to our health system, the emergency team, which includes a physician, provides first aid, triage, and transfer from the site of the trauma to the resuscitation room of the designated hospital. The purpose of triage is to determine the pediatric patient's destination based on the pattern of injury, clinical status, and geographical factors. The patient is transferred by ambulance or helicopter. In the CHUV, the pediatric resuscitation room admits all children younger than 16 years who are suffering from potentially life-threatening medical or surgical emergencies. The number of life-threatening emergencies from various causes is approximately 150 per year[1]; of those cases, one thirds are trauma emergencies. Care is provided according to Pediatric Advanced Life Support recommendations.

The Lausanne University Trauma Registry was developed to facilitate international comparisons. It was elaborated according to the Utstein Template for the Uniform Reporting of Data following Major Trauma.[16] The construction is similar to the British (Trauma Audit and Research Network [TARN]) and German (Deutsche Gesellschaft für Unfallchirurgie) registries, as well as to the American National Trauma Data Bank.

Epidemiological studies and the identification of specific high-risk injury patterns have the potential to improve care and outcomes. One study has previously described life-threatening pediatric emergencies.[1] It included life-threatening pediatric emergencies of all etiologies over a period of 2 years. Two hundred seventy-seven children were included. Medical problems were identified in 155 children and included refractory epilepsy, respiratory insufficiency, and cardiopulmonary arrest. Surgical problems were diagnosed in 122 children who mainly suffered from traumatic brain injury (TBI) and polytrauma. We focused our study on this second population.

The purpose of this retrospective study was to provide a comprehensive and internationally comparable overview of 6 years of data from pediatric patients who experienced trauma and were admitted to our center. Therefore, we analyzed our pediatric trauma registry covering the years from 2011 to 2016.

METHODS

Study Design

We performed a retrospective cohort analysis of the Lausanne University Trauma Registry. The registry collected the data from injured children who were admitted to the resuscitation room. The data were recorded prospectively and consecutively. We analyzed the pediatric population over the first 6-year period (up to December 31, 2016). We compared our data with publications from some European pediatric trauma centers.

The Human Research Ethics Committee of Canton of Vaud allowed data to be collected from the trauma registry (number of approval, 66/13). Because no prospective intervention was performed, new approval for this study was not required.[17]

Data Collection and Processing

The registry contains data collected from pediatric patients' hospital files: epidemiological data, vital signs, Injury Severity

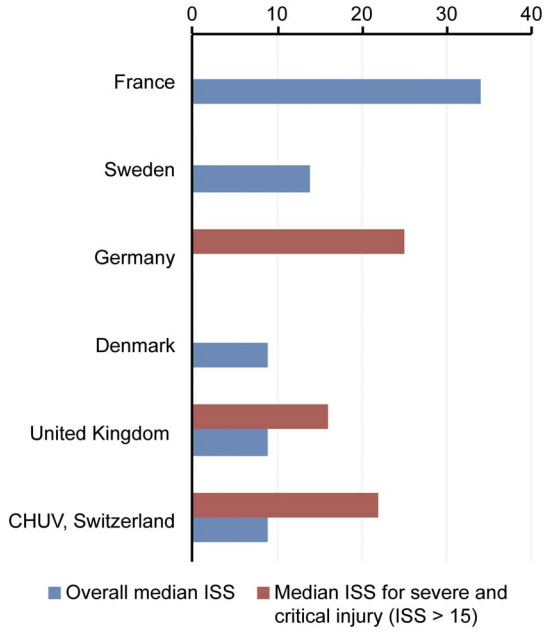

FIGURE 1. The distribution of the median ISS (*y* axis) compared with other European pediatric trauma centers.

Score (ISS), mechanism of injury, Abbreviated Injury Scale (AIS), Glasgow coma scale, mode of transportation, therapeutic measures, imaging results, laboratory values, emergency interventions, transfer unit location, length of stay (LOS), in-hospital mortality, and Trauma and Injury Severity Score (TRISS) of nonsurvivors.

According to the international trauma scoring system, the ISS is the sum of the squares of the highest AIS code for each of the 3 most severely injured body regions. It is classified as follows: minor injury (ISS, 1–9), moderate injury (ISS, 10–15), severe injury (ISS, 16–24), and critical injury (ISS, ≥25). The AIS is an anatomically based severity scoring system that classifies each injury by body region according to its relative importance on a 6-point scale.[18]

Calculations and Statistical Analysis

In the descriptive analysis of the study cohort, data are presented as mean values (and SDs) or median values (and interquartile ranges, IQRs) whenever appropriate. Student *t* test was used to compare means between 2 independent groups. Data were analyzed with JMP 10.0.0 (SAS Institute Inc, Cary, NC) and Stata 14.2 (Statacorp, College Station, TX) statistical software.

RESULTS

Over this 6-year period, 327 children were admitted to the resuscitation room for trauma emergencies. Two hundred five boys (63%) and 123 girls (37%) aged from 37 days to 16 years (median age, 8.1 [IQR, 3.4–12.7]; mean age, 8.1 [SD, 4.1]) were admitted. Of all these children, 26 were aged less than 1 year. The distribution according to age was as follows: 1 to 2 years, 46 patients (14%); 3 to 5 years, 53 patients (16%); 6 to 9 years, 65 patients (20%); 10 to 12 years, 66 patients (20%); and 13 to 16 years, 71 patients (21%). Only small differences in the age at admission were observed between European countries: the mean and median ages ranged from 6.5 to 9.5 years.[4–7,9–11] In Spain, the predominant age group was 12 to 15 years.[8]

The median ISS was 9 (IQR, 4–16). Minor trauma occurred in 201 children (61%), and moderate trauma occurred in 29 children (9%). Overall, 97 children (30%) presented with an ISS of greater than 15. In our study, severe trauma occurred in 51 children (16%), and critical trauma occurred in 46 children (14%). The median ISS for patients with severe and critical injuries was 22 (IQR, 17–25). The distribution of ISS compared with other European pediatric trauma centers is illustrated in Figure 1.[2,4,6,7,9–11,19] In Finland, the mean ISS was 21.3.[5]

The distribution of the principal mechanisms of injury and their comparison with European pediatric trauma centers is shown in Figure 2.[4–8,10,12] In our center, among falls, 40% occurred from less than 1 m, 50% from 1 to 5 m, and 10% from greater than 5 m. Pedestrians (38%) were most frequently involved in road injuries, followed by cyclists (32%) and individuals in 4-wheel vehicles (27%) and motorbikes (3%). Thirty-two percent of admitted children were involved in accidents at home. Home accidents involved mainly falls (48/104) and burns (41/104). Our trauma registry reported 15 other types of home accidents: shaken baby syndrome (1×), drowning (2×), cut-pierce injury (4×), firearm injury (1×), and unknown (4×). Sports injuries accounted for the injuries of 28% of admitted children, and one thirds of these injuries were winter sport injuries. Winter sport injuries included skiing, snowboarding, and snow sledging. Other sports-related injuries involved horse riding, bicycle motocross bikes, kid scooters, etc.

The distribution of the prevalent areas of injury based on the AIS and their comparison with other European pediatric trauma centers are shown in Figure 3.[4,5,7,8,10,12] In our study, severely injured areas (AIS, ≥3) were the abdomen (37/50 abdominal injuries; 74%), followed by the chest (38/64 chest injuries; 59%) and the head and neck area (94/205 head and neck injuries; 46%).

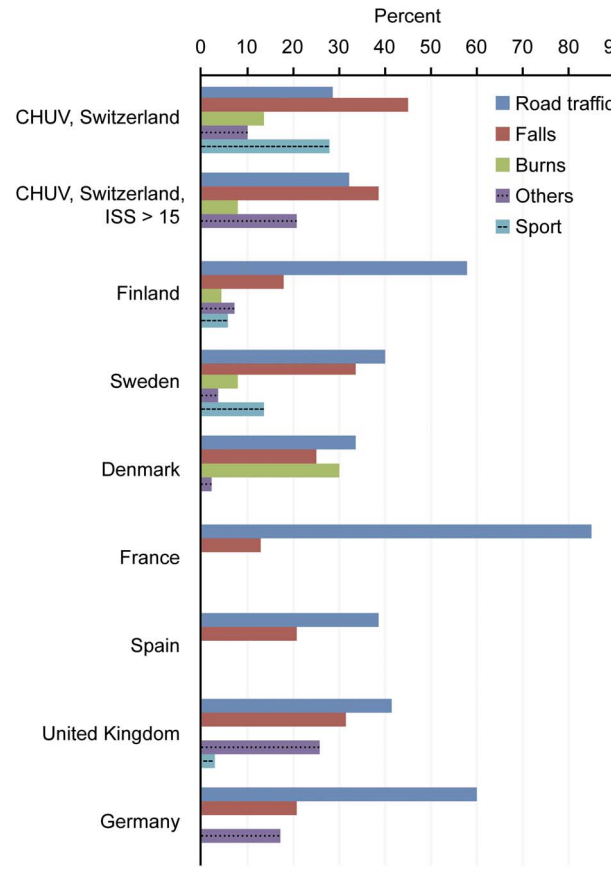

FIGURE 2. The distribution of the principal mechanisms of injury compared with other European pediatric trauma centers.

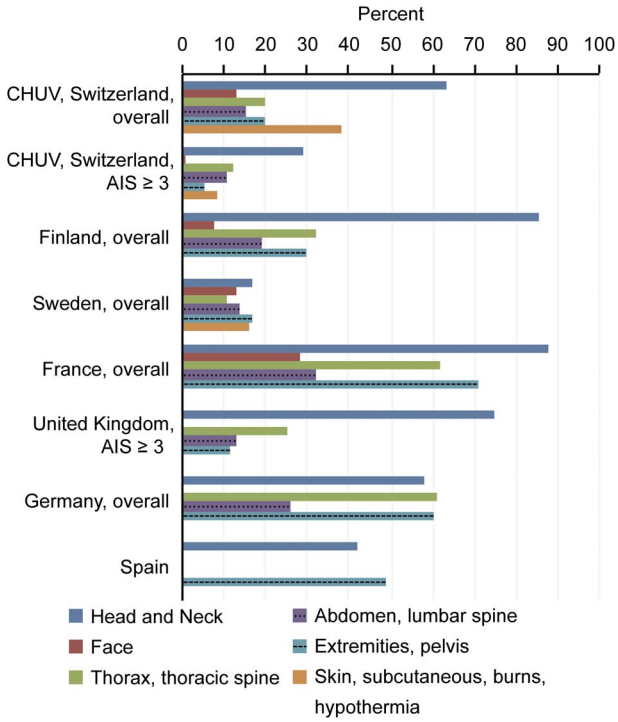

FIGURE 3. The distribution of the prevalent areas of injury based on the AIS and a comparison with other European pediatric trauma centers.

The distribution of TBIs is illustrated in Figure 4.

Home accidents were more frequent in children younger than 5 years, with a majority of 1- to 2-year-olds experiencing this type of injury (33/104; 31%, 18/33 were burn injuries). Children above the age of 5 years represent the majority of victims of sports injuries (37/93; 40%) and traffic accidents (49/129; 38%). In our cohort, no difference in the distribution of mortality was observed across age groups. In Denmark, burns were the leading cause of trauma in children aged less than 1 year, whereas burns and blunt traumas in 1- to 5-year-old children and children older than 6 years were more often implicated in road traffic accidents and falls.[6] In Germany, children less than 5 years of age mainly suffered from falls (19.8%), and children aged 6 to 15 years mainly suffered from traffic accidents as pedestrians. The age group of 16 to 17 years suffered from road traffic injuries involving car accidents.[12] In the United Kingdom, head injury was the leading cause

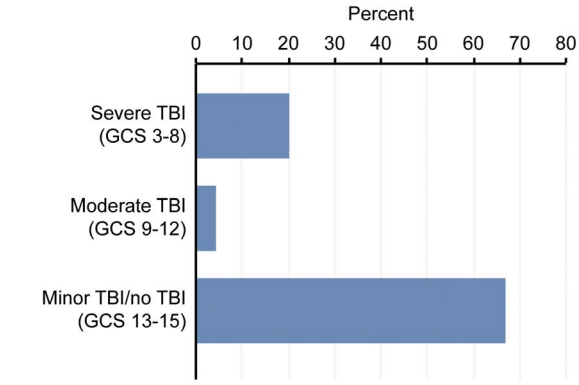

FIGURE 4. Distribution of TBIs.

of trauma in infants; with increasing age, limb injuries became more prevalent and head injuries became less prevalent.[11]

Among all the admitted children, 323 (98%) suffered blunt injuries and 6 (2%) suffered penetrating injuries (1 was due to a firearm, and other lesions were caused by sharp or perforating objects). Our results are similar to other European pediatric trauma centers.[4–7,10]

The majority of children, 195 (60%), were directly transferred from the site of the trauma to the resuscitation room, and the remaining 40% (132 children; minor trauma, 75/132; moderate trauma, 10/132; severe and critical trauma, 47/132; falls, 64/132; burns, 25/132; and traffic accidents, 30/132) were admitted after an interhospital transfer. Prehospital transport was provided by a physician-staffed helicopter (59%), physician-staffed ambulance (19%), paramedic ambulance (15%), or private transport (2%). In Sweden and the United Kingdom, the most common mode of transportation was an ambulance.[4,10]

Eighty-four of the children required intubation for various reasons, representing an overall intubation rate of 25%; the rate of intubation in patients with minor trauma was 24 (12%) of 201, 9 (31%) of 29 in patients with moderate trauma, 14 (27%) of 51 in patients with severe trauma, 36 (78%) of 46 in patients with critical trauma, and 50 (51%) of 98 in patients with an ISS of greater than 15. The majority (57/327; 17%) were intubated on the scene, and the remaining (27/327; 8%) were intubated upon admission to the resuscitation room. One child needed a tube exchange. Children aged from 1 to 2 years (15/47) and 10 to 12 years (21/66) required the highest rate of intubation.

Interventions provided in the resuscitation room upon admission are presented in Figure 5. All 24 intraosseous devices were placed during prehospital care, and no intraosseous device was placed in the resuscitation room. In our center, computed tomography scans were performed on 55% of admitted patients, x-ray examinations on 22%, and focused assessment with sonography on 2.4% of admitted patients.

The majority of the pediatric patients were transferred from the resuscitation room to a standard bed in the emergency department (142; 43%). A pediatric intensive care unit transfer was necessary for 87 children (27%), and intermediate care transfer was

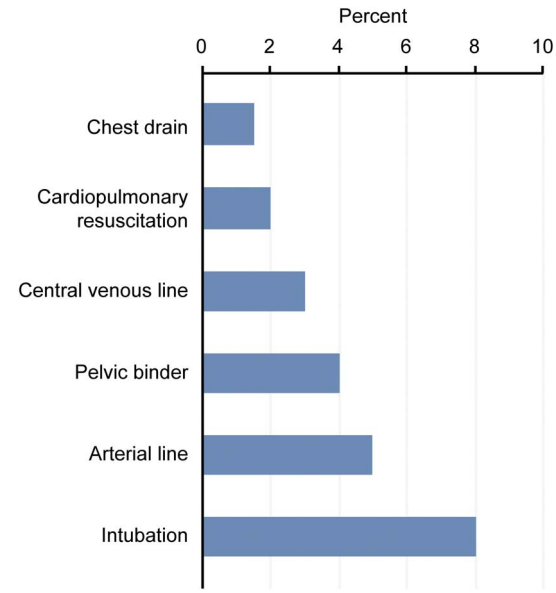

FIGURE 5. Interventions provided in the resuscitation room upon admission.

required for 28 (8%). Only 3 children (0.9%) were directly transferred to the ward. Overall, 65 children (20%) were transferred to the operation theater or to the angiographic facility. The following specialties were involved in patient care: burn surgery (20), neurosurgery (19), orthopedic surgery (12), surgical wound care (7), abdominal surgery (3), thoracic surgery (1), vascular surgery (1), and interventional radiology (1). In European pediatric trauma centers, the incidence of emergency surgery varies (Spain, 56.5%[8]; Sweden, 44%[4]; Finland, 35.1%[5]; France, 22%[7]; United Kingdom, 15%[10]; and Germany, 75% in nonsurvivors and 30.9% in survivors[9]); orthopedic surgery and neurosurgery were the most frequent specialties involved in patient care in all these countries.

The average LOS in the intensive care unit was 3.1 days (SD, 7.6; median, 0; IQR, 0–2). The average overall in-hospital LOS was 9.5 days (SD, 19.2; median, 3; IQR, 1–10). If we only considered survivors, the average LOS was 9.9 days (SD, 19.6; median, 3; IQR, 1–10). For nonsurvivors, the average LOS was 2.2 days (SD, 3.8; median, 0; IQR, 0–4). Pediatric patients suffering from burn injuries were at higher risk of being hospitalized longer than 10 days (odds ratio, 3.19 (1.53–6.68); $P = 0.002$). Pediatric patients suffering from fall injuries were at lower risk of staying in the hospital for more than 10 days (odds ratio, 0.38 (0.20–0.73); $P = 0.003$). The LOS represents an additional outcome measure, although it is affected by the local hospital network. In other European pediatric centers, the LOS in the intensive care unit ranged from 0 to 9 days, and the overall LOS ranged from 6 to 22.6 days.[2,4–6,8,10,11]

The overall mortality rate was 5.5% (18/327). One child had a high probability of survival (TRISS, 95.5%), and he died from a critical injury after a fall from more than 5 m (ISS, 34). The probability of survival of the other children was low (mean TRISS of approximately 20%). Children with an ISS of greater than 15 had a mortality rate of 17.5% (18/97). The median ISS of nonsurvivors was 25 (IQR, 25–34), and the mean was 29.8 (SD, 14.7). Nonsurvivors' ISS in the Danish study was 25,[6] and in Germany, it was 38.[9] In our study, 9 children (50%) died within 6 hours, 6 died during the first hour, and 3 died between the first and the sixth hours. Two children (11%) died between the sixth and 24th hours, 2 (11%) died between the first and second days, and 5 (27%) died after 48 hours. Of the 18 children who died, 11 were admitted after direct transfer, and 7 were admitted after secondary transfer.

The mortality rates and their comparisons with other pediatric trauma centers are presented in Figure 6.[4,6,7,9–11,19,20] In Spain, the overall mortality rate was 0.5% (7/1500), and for patients with an ISS of greater than or equal to 15, the mortality rate was 14% (7/50).[8] In Finland, the mortality rate was 30% for patients with a mean ISS of 21.3.[5]

Based on our results, the early mortality rate is high at our center: half of the deceased children died within 6 hours. In Sweden, the trend seems to be similar: 77.1% of the deceased children died within 6 hours after the incident. The majority of traumatic deaths occurred immediately at the scene or within the first 6 hours of the accident.[5] In Denmark, a similar trend was observed, with 16 of 24 deaths occurring within 24 hours after admission.[6] A German study showed the same trend, in which death occurred shortly after arrival at the hospital.[9]

In our study, the main causes of death were falls from more than 5 m and traffic accidents as pedestrians. The deaths most frequently involved head (12/18) and thoracic injuries (7/18). In European pediatric trauma centers, the results were similar: head injuries were the main cause of death, followed by thoracic injuries.[4–7,9–11,20] In our trauma centers, the main causes of death were brain edema and massive hemorrhage. Two children died after drowning, 2 children fell from several floors, and 1 child died after an avalanche. Two children committed suicide by hanging. Two children died after homicide: one after an injury by a firearm and the second after a stabbing injury. The other children died after road traffic accidents or falls.

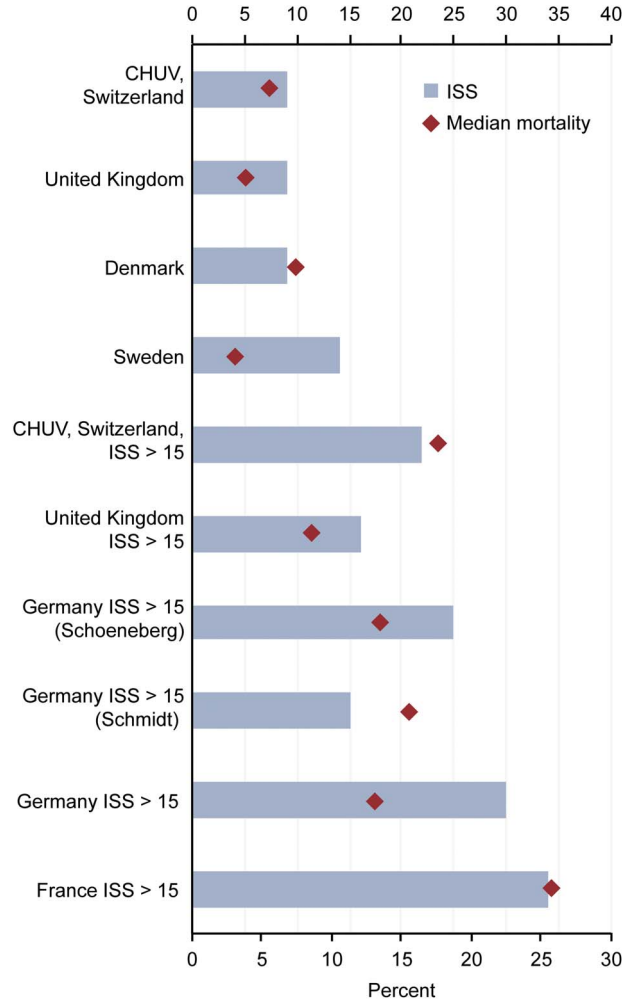

FIGURE 6. The mortality rates and their comparisons to other pediatric trauma centers.

DISCUSSION

The first registry-based analysis of 6 years of pediatric trauma care in the University Hospital of Lausanne revealed that 55 children were treated annually. The demographic findings were similar to other European countries, with pediatric trauma patients being mainly males[2–8,19] and school-age children. The severity of injuries and mortality varied (Fig. 6) among European countries, although the main patterns of injury (Fig. 2) were somewhat similar. Our findings on injury patterns reveal that the majority of our pediatric patients with trauma presented with head and neck injuries, and the main mechanisms of injury were falls and traffic accidents. As a consequence of the high rate of sports injuries and home accidents, falls were more frequent in our study than road traffic accidents. Even if sport and home injuries were regrouped as mainly minor traumas, falls remained more frequent than road traffic accidents in children suffering severe trauma. This observation seems to be specific to our pediatric trauma center. In our

region, home accidents related to falls were secondary to falls on stairs from 1 or more floors, chairs, bunk beds, windows, etc. The epidemiology of falls in our region is very similar to that in France.[21] In other European studies, the trend was the opposite: road traffic accidents were more frequent than falls. In our center and in other European trauma centers, children suffering from road traffic accidents and falls with head and thoracic injuries had the highest mortality rate.[2,5,6,9–12,19,22] In our study, the highest mortality rate occurred in pediatric patients who were injured from falls more than 5 m and traffic accidents involving pedestrians. Notably, external body area injuries, which correspond mainly to burn injuries, were frequent in our registry. Similar to the pediatric trauma center of Copenhagen,[6] our trauma center serves as a referral hospital for burn injuries. No mortality was associated with burn injuries.

The analysis of causes of death showed that the causes were explained by the severity of trauma. One child had a high probability of survival, and his death was owing to an unexpected massive hemorrhage 24 hours after admission. Based on our results, early mortality was high: half of the deceased children died within 6 hours. Early mortality in pediatric trauma patients has been described in various studies. Some studies have even reported that death after pediatric trauma seems to follow a bimodal distribution.[3,5,6,23] The first peak describes children dying immediately after the trauma owing to untreatable injuries. The second peak seems shortly after the trauma. The amplitude of this second curve depends on early resuscitation (prehospital care, triage to the appropriate trauma center, and the care provided at the trauma facility).[6] This dependency suggests that improving early resuscitation has the potential to decrease mortality.[23] This model was unable to be validated in our study because of the small number of nonsurvivors.

Some children probably died immediately on the scene or at the local hospital, thereby bypassing the resuscitation room and were not included in our study.

The TRISS method is used to calculate the probability of survival (Ps) in trauma patients. We calculated the probability of survival of nonsurvivors to identify the unexpected outcomes. The TRISS score is a weighted combination of the Revised Trauma Score, the ISS, the type of injury (blunt or penetrating), and patient age. Given the lack of data, such as the respiratory rate or systolic blood pressure, we were unable to calculate the exact TRISS for all nonsurvivors. In the future, the TARN model could be used as an alternative to the TRISS method. The TARN model uses the Glasgow coma scale instead of the Revised Trauma Score, thereby enabling the inclusion of patients who would be excluded by the TRISS based on inclusion criteria. Furthermore, the predictive performance seems to be better.[24]

The comparison of nonsurvivors' ISS might reveal the reasons for higher mortality, but these data are rarely available in other studies. A lower median ISS of nonsurvivors than observed in other pediatric trauma centers should prompt us to reflect on the quality of care. Therefore, a higher ISS of nonsurvivors would reflect a greater severity of injuries, which is directly related to a poor prognosis.

Prevention strategies are part of pediatric trauma care. Successful prevention measures, such as education, legislation, and environmental changes, help to decrease childhood injury and their severity. Engineering measures, reducing speed, safe routes to school, safety equipment, and safe play areas helped to reduce injuries.[13,25]

Our institution provides a deliberate overtriage[15,22] to guarantee children's security. This approach accounts for 43% of the admitted children who did not require any intensive emergency care. Because of their lower need for treatment, children are redirected from the resuscitation room to a standard bed in the emergency department.

Similar to the European triage system, severely injured children were directly transferred to designated competence centers, bypassing local hospitals. Secondary transfers from local hospitals occurred in 40% of the cases, and 7 of 18 deceased children were transferred from a local hospital. This rate of transfer shows how the identification of the correct orientation can be challenging. Direct transfers should be encouraged because this process provides the timely intervention that reduces mortality and morbidity and improves the outcome.[14,15,26] Children with cervical spine injuries benefit from an outcome advantage of being primarily evaluated at pediatric trauma centers. Furthermore, undertriage to a regional hospital with fewer resources may result in greater morbidity and mortality or a greater cost burden if a secondary transport is required.[27] Transport to nontrauma hospitals delays definitive pediatric trauma care. This could be prevented by the provision of uniform triage and guidelines across regional hospitals in western Switzerland. Improvement of the current interfacility pediatric trauma transfer system, including triage, could reduce our secondary transfer rate.

Pediatric trauma patients require specific care. Given their anatomy and pathophysiology, these children require physicians with specific knowledge and treatment to guarantee the best quality of care.

The efficiency of pediatric transfer directly to pediatric trauma centers via helicopter medical emergency services for children with major trauma improves their outcome[28,29]; this mode of transport is encouraged in our region.

In the future, outcome measures should include long-term functional outcomes, such as the Glasgow outcome scale, and take into account quality of life, morbidity, and disability.

The diversity of study designs makes comparisons among European pediatric trauma centers difficult. At our pediatric trauma center and at other European pediatric trauma centers, the demographics and patterns of injury are similar. However, mortality and the severity of injury vary. It is difficult to explain these differences because the published data for European pediatric trauma centers do not describe their trauma management systems. The differences in the type of injuries can be explained by life conditions, discrepancies in trauma prevention, and geographic and socioeconomic characteristics. There are many potential causes of variable mortality: nonuniform local trauma management, such as mode of transportation, triage criteria, geographic conditions, distances to hospitals that offer specialized pediatric trauma services, local resources, prehospital and trauma team experience and coordination, standards for decision-making, and nonuniform availability of equipment.

Limitations of the Study

First, this study is limited by its retrospective design, although the data were collected prospectively. Second, the data are limited by variable accuracy provided by the children's files. Third, this study was conducted at a single center that may not reflect the actual conditions of other pediatric trauma centers in Switzerland. Fourth, our analyses are limited because of the small number of pediatric patients and because we lack data on prehospital care.

CONCLUSIONS

Our study demonstrates that demographics and patterns of injury are similar among European pediatric trauma centers; however, mortality and the severity of injury vary. Similar to other European pediatric trauma centers, falls and road traffic

injuries, such as injuries to pedestrians, are the main mechanisms of injury in our pediatric trauma population. What is specific to our study is that falls caused by home accidents and sport injuries are more common. Therefore, prevention should focus on pedestrian safety, avoiding home accidents and protection from head injuries and falls. The elevated early mortality rate suggests that improvements in prehospital care, triage, and early resuscitation are likely to decrease mortality rates. The optimal management of head and thoracic injuries, as well as hemorrhaging, is considered a key to the survival of the pediatric population.

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