# Obravnava otroških opeklin v terciarnem centru v SV Sloveniji

# Management of pediatric burn injuries in a tertiary center in North-East Slovenia

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## Izvleček

***Namen:*** *Opekline so hude poškodbe, ki povzročajo trajne funkcionalne, estetske in psihosocialne posledice. Namen študije je bil raziskati incidenco opeklin pri otrocih, ki potrebujejo hospitalizacijo, načine in uspeh zdravljenja.*

***Metode:*** *V retrospektivno opazovalno študijo smo vključili 28 otrok z opeklinami (19 dečkov in 9 deklic) v obdobju od leta 2014 do 2018. Spremljali smo incidenco opeklin, načine in rezultate zdravljenja. V študijo so bili vključeni otroci, ki so bili zdravljeni na Enoti za intenzivno nego in terapijo Klinike za pediatrijo ter na Oddelku za plastično in rekonstruktivno kirurgijo Klinike za kirurgijo Univerzitetnega kliničnega centra Maribor.*

***Rezultati:*** *Z analizo smo potrdili, da so oparine (68 %) najpogostejši vzrok za opekline pri otrocih. Najpogosteje so bili prizadeti otroci, mlajši od 5 let (75 %). Povprečen odstotek opečene celotne povr-*

## Abstract

***Purpose:*** *Burns are serious injuries that cause permanent functional, aesthetic, and psychosocial consequences. This study aimed to examine the incidence of pediatric burns requiring hospitalization, and different treatment modalities and outcomes.*

***Methods:*** *In this retrospective observational study, 28 children with burns (19 boys and nine girls) were admitted between 2014 and 2018 for treatment. We monitored the incidence of burns and analyzed different treatment modalities and treatment outcomes. Children in this study were treated at the Pediatric Intensive Care Unit and the Department of Plastic and Reconstructive Surgery of the University Medical Centre Maribor.*

***Results:*** *Scalds were found to be the most common type of burns in children (68%). Children younger than 5 years of age were the most affected (75%). The*



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*šine telesa je pri nas znašal 9 %. Kirurško zdravljenje je potrebovalo 89 % otrok. Hospitalizacija je v povprečju trajala 14,6 dneva, popolna zacelitev pa je pri 72 % otrok bila v 4 tednih.* ***Zaključek:*** *Raziskava je pokazala, da je za opekline, ki potrebujejo hospitalizacijo, najbolj ranljiva skupina otrok med 1. in 2. letom starosti, najpogostejše pa so oparine. Iz tega izhaja, da je za zmanjševanje teh poškodb bistvena preventiva, natančneje izobraževanje staršev najmlajših otrok. Tako bi se incidenca opeklin pri otrocih lahko še zmanjšala.*

*average burned total body surface area was 9%. Furthermore, 89% of children needed surgical treatment. The hospitalization lasted for an average of 14.6 days, with complete healing occurring in 72% of children within 4 weeks.*

***Conclusions:*** *This study showed that the most vulnerable age group of children with severe burns who required hospitalization was between 1 and 2 years and that the most common type of burn was scalding. We suggested educating parents about burns and burn injuries and how such serious incidence could be prevented, especially among the youngest children.*

## INTRODUCTION

Burns are serious injuries that cause permanent functional, aesthetic, and psychosocial consequences. Children with extensive burns are classified among the most difficult surgical patients. The treatment of these children in highly specialized centers, where a multidisciplinary team approach is enabled, has changed the prognosis of these injuries, and is now considered to be exceptionally good. A major contribution to a better prognosis or to greater survival of children with extensive deep dermal and subdermal burns are innovations in burns surgery, such as the Meek modification of skin micrografting and the cultivation of keratinocytes as well as new dermal regeneration templates (1).

According to the National Institute of Public Health of the Republic of Slovenia, 9,500–17,500 patients with burn wounds visited doctors annually for the primary level of care in the last 10 years. Of these patients, 1,800–3,500 were children. The proportion of children requiring emergency care and hospitalization was relatively small compared with the number of patients inflicted with burn injuries.

The most common type of burn among children in the age group of 1–4 years was scalding (70%) due to their proximity with hot fluids. Chemical and electrical burns were more common among children in the age of 5–14 years because of their inquisitive nature, while contact burns, mostly with flames, were most common among adolescents. Furthermore, 25%–50% of burns also provoked inhalation damage to the respiratory system caused by inhalation of hot air, burning particles, and toxic gases (carbon monoxide and cyanide). About 5%–10% of burns induced other additional injuries (1).

In the case of burn injury victims, it is necessary to clarify the cause and the mechanism of burning, and later assess the surface and depth of the burn. It is necessary to exclude inhalation damage and assess the hemodynamic state. Serious accidents include electrical damage, where electrocardiographic monitoring is required to evaluate associated damage (myocardial ischemia) and arrhythmias. According to the guidelines of the European Association for Burns (2), a patient should be referred to the center for treatment of burns according to the following criteria:

Basic criteria:

- A total of 5% of the total body surface area (TBSA) was affected by burns in children below 2 years of age.
- A total of 10% of the TBSA was affected in children 3–10 years of age.
- A total of 15% of the TBSA was affected in children 10–15 years of age.
- A total of 20% of the TBSA was affected in the age group of 15 years.

Additional criteria:

- Treatment of shock due to burns

- Burns to the face, hands, genitals, and large joints
- Deep dermal or subcutaneous burns in all age groups
- Burns that cover the full range of body parts
- Patients with an associated injury or illness that could lead to treatment complexity, prolonged rehabilitation, or mortality
- Suspected inhalation damage
- Patients with doubtful state of care and treatment
- Major injury due to electrical current
- Suspected child abuse

In Slovenia, the following anatomical classification of the depth of burns suggested by Prof. Derganc is in use (1):

- Epidermal burn (in American literature, Stage 1)
- Superficial dermal burn (in American literature, superficial Stage 2)
- Deep dermal burn (in American literature, deep Stage 2)
- Subcutaneous burn (in American literature, Stage 3)

The depth of the burn was assessed in terms of appearance (color), sensitivity of burned skin, and blood discharge. This assessment can be demanding, especially in children in whom, due to poor cooperation and limited clinical examination, the assessment was more subjective. A final assessment of the depth of burns was possible only after 48 h due to the possibility of further deepening of the burn wound. The wound should not be lubricated with ointments until the final determination of the depth of burns. In the assessment of the depth of burns, methods such as a pinprick test, thermography, and ultrasound could also be used, but they have limitations (3).

### Fluid replacement

The initial fluid replacement included the application of 20–60 mL/kg crystalloids (Ringer's lactate solution, 0.9% NaCl) in the case of a burn shock. The fluid therapy at the hospital continued in this manner, considering the basal needs and additional burn needs based on the burn area. The calculation of the fluid was based on the Galveston formula: 5,000 mL/m2 burned surface area as a resuscitation fluid + 2000 mL/m2 total burned surface area as a maintenance fluid. Half of the calculated fluid was administered in the first 8 h, and the rest in the next 16 h, using Ringer's lactate plus 12.5 g albumin per liter. The following day, 1,500 mL/m2 fluid is administered, and the maintenance of fluid was carried out based on the 3,000–3,500 mL/m2 burned area with a replacement fluid for treating burns. The adequacy of fluid therapy was monitored with hourly diuresis and monitoring other vital functions (4).

### Inhalation damage

In the case of suspected inhalation damage, a bronchoscopy using a flexible bronchoscope was required in the first 24 h to confirm the diagnosis and estimate the extent of the inhalation burn. The bronchoscopy also had a therapeutic effect as the lavage could be performed, and a sample for microbiological analysis could be obtained. The decision for intubation and artificial ventilation was taken more promptly due to the danger of complete closure of the respiratory tract. The use of inhalation bronchodilators was recommended, and inhalations using racemic adrenaline, heparin, or acetylcysteine (3) may be considered for reducing respiratory inflammations (5).

### Food and nutrition

In children with extensive burns, nutritional support was needed for the loss of plasma and electrolytes through the burn area due to the so-called burning hyperthyroidism caused by stress hormones, glucose metabolism, increased lipolysis, and increased protein requirements. Care must be taken to ensure enough caloric intake and protein intake. Children with burns had 20% higher nutritional needed 6 months after the treatment. The energy needs were calculated according to the Curreri formula (6):

60 kcal/kg + 35 kcal/% of burned TBSA

Caloric intake should be designed in the following way: 45%–60% carbohydrates, 15%–25% fats, and 20%–25% proteins. The enteral nutrition may be oral in children with less than 20% of burned area; however, many patients with burns may require a nasogastric or nasojejunal feeding tube placement. Parenteral nutrition was needed in children with extensive burns

(more than 60% of burned area) and in children with associated illnesses and complications (6).

### Pain treatment

A good analgesic is important for children with burn injuries. For intubated and artificially ventilated children, morphine was used as an analgesic, and more rarely, fentanyl. For children not admitted to intensive care, tramadol or ketamine could be administered by continuous infusion, and midazolam for sedation (5).

### Surgery of burns

The gold standard treatment of deep dermal and subcutaneous burns remained tangential excision of damaged tissue and coverage of the resulting defects using an Ollier-Thiersch split-thickness skin graft (7). The surgical excision of burn wounds was usually executed after 48 h and up to the fifth day after the burn injury, when the depth of the entire burn area could be assessed with certainty. In the meantime, the area of stasis could become normally perfused or it could necrotize and the decision on conservative or operative treatment depending on these changes (8). Most of the changes, modifications, and innovations in therapy happen mainly in the phase that followed necrectomy for covering the resulting defects (9). Split-thickness skin grafts were performed using various techniques such as mesh, Meek micrografting, and other modifications (10). In subdermal burns, dermal regeneration templates could be used, which were later covered with very thin split-thickness skin grafts (11). In the most severe burns, a culture of keratinocytes could be cultivated from a small sample of patient's skin because of limited access to the skin, but it was very time-consuming and expensive, and the uptake of grafts obtained in such a way was less reliable (12). In the case of large-scale burns, an exact plan of necrectomies, split-thickness skin graft coverings, dermal regeneration templates, or temporary artificial skin substitutes had to be in tune with the general condition of the child. Hence, effective coordination between the surgeon, pediatric intensivist, and anesthetist was of paramount importance.

## METHODS

The study represented a retrospective analysis of clinical data collected from electronic medical records of 28 pediatric burn patients treated from 2014 to 2018 at the Pediatric Intensive Care Unit (PICU) and Department of Plastic and Reconstructive Surgery of the University Medical Centre Maribor. We collected data for determining the burn incidence, TBSA burned in every child, treatment modalities (whether conservative with dressing changes or surgical treatment with necrectomy with or without using split-thickness skin transplants), duration of hospitalization, and treatment outcomes.

## RESULTS

During the observation period from 2014 to 2018, 28 children with burn injuries were treated at the University Medical Centre Maribor. They were aged 6 months to 9.5 years (mean age, 2.8 years) (Fig. 1).

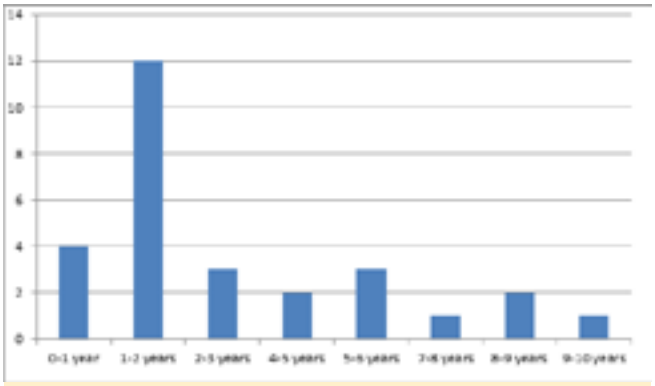

***Figure 1.*** *Number of children with burn injuries by age*

Scalds were found to be the most common type of burns, occurring in 19 (68%) children. In four patients, the cause was fire, four cases were due to contact burns, and one patient had a burn with a pyrotechnic agent. The burned TBSA ranged from 0.5% to 38%. The average burned TBSA regardless of depth was 9.3%. In children who suffered from deep dermal to subdermal burns, the average burned TBSA was 6.4% (Fig. 2).

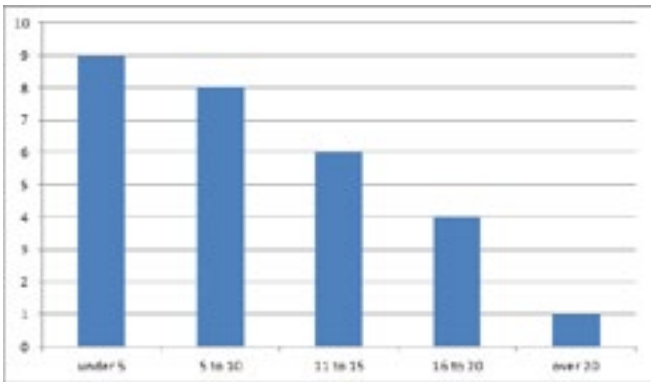


***Figure 2.*** *TBSA involvement in children with burns.*

In most cases the burn was at least partially deep dermal to subdermal, and only two patients (ages 6 months and 13 months, respectively) incurred a completely superficial dermal burn.

Of the 28 hospitalized children, 25 were treated surgically (89%). The remaining three children who presented with superficial dermal burns (two children) and a smaller-extent deep dermal burn (one child) were not treated surgically and underwent regular dressing changes for their burn wounds. Most of the operated children needed necrectomy once (84%), two children needed it twice, one child needed thrice, and one needed five times. Moreover, only one split-thickness skin graft was used to cover the burn wounds in most of the children (84%), two children needed such grafts twice, and one child needed it five times. In three cases, skin transplant was not required as only a very superficial burned skin surgical debridement was performed and the wound areas were covered with a temporal artificial skin substitute or a specific dressing. The first necrectomy was performed between days 2 and 10 after the burn injury. Only in one case where we witnessed prolonged healing of a minor deeper dermal burn, the burn was treated surgically after 25 days of unsuccessful conservative treatment. Nine children were treated with necrectomy on the fifth day (on average 5.8 days) after the burn.

A total of 18 children suffered burns on several parts of the body, and 10 of them had burn injuries in one region. In all the burn cases, either the upper or lower limbs were involved. The most common burned region was the upper limb (23 children), followed by the chest (18 children), the lower limb (9 children), the back and neck (7 children), the head (5 children), the gluteal region (2 children), and the genitalia (1 child) (Fig. 3).

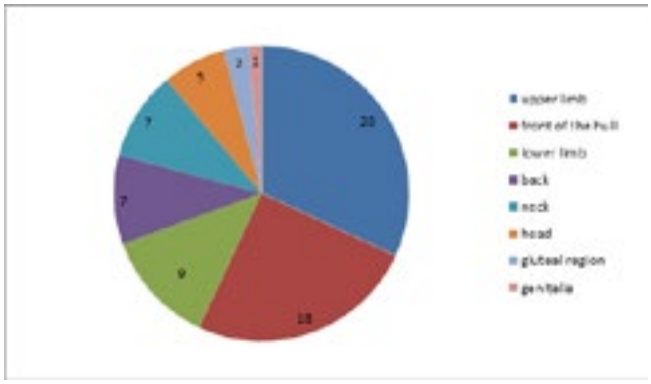


***Figure 3.*** *Most commonly burned anatomical regions in children.*

Although all 28 children were treated at the Department of Plastic and Reconstructive Surgery, 5 of them were initially at the PICU. The children admitted for intensive care had larger burned TBSA (5%–40%), and one of them was also treated for respiratory tract burns. The hospitalization of all children lasted from 2 to 55 days (on average 14.6 days), which included intensive care for 8 to 33 days (on average 15.2 days) (Fig. 4).

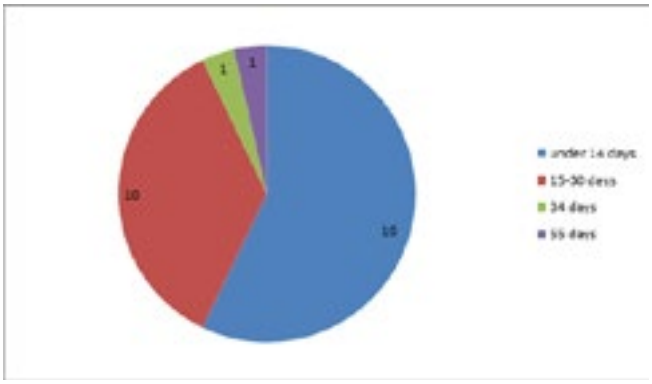


***Figure 4.*** *Duration of hospitalization in children with burns.*

The children who were also treated under intensive care had an overall longer hospitalization period (from 8 to 33 days). The burn wounds were completely healed in 10 days to 3 months (Fig. 5).

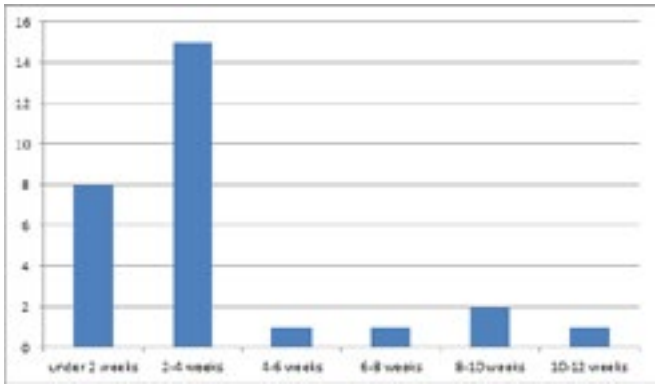

***Figure 5.*** *Duration of healing of burn injuries.*

Four children in this study underwent repeat surgery, two children once and two children twice. In the first surgery, necrectomy was performed on the small unhealed hypergranulated area on the scalp and a minor defect at the edge of the skin transplant was fixed with direct skin stitches. One child underwent correction surgery on fingers, and a local flap and a skin graft were applied in the process. One child had hypertrophic scars removed partly with an excision and primary closure of the affected area via an intralesional application of a corticosteroid. In the case of the second repeat surgery, one child underwent an aesthetic surgical procedure for hypertrophic scarring on the face via an excision of the scar and primary skin closure, and repositioning of one ear was also performed. In another second repeat surgery, the child was readministered a corticosteroid into a hypertrophic scar.

## DISCUSSION

The present study confirmed a well-known epidemiological constant: the most common cause of burns in children is scald (68%). Even in distant China, a large-scale study by Haisheng Li et al. during the same period found scalds to be the primary cause of burns, affecting 79% of children. Despite significant socioeconomic differences between the two countries, this study found the identical average age of children suffering from burn injuries as 2.9 years (13). A recent study by Barcot et al. in a burn referral center in Zagreb, Croatia, however, showed a higher average age of children with burn injuries (6.2 years) (14). In the present study, 75% of children affected with burn injuries were younger than 5 years of age, which was 85% in the study by Haisheng Li et al. Boys were more affected than girls in all studies: 68% in the present study, 65% in the study by Haisheng Li', and 58% in the study of Barcot et al. The percentage of burns caused by the fire was 14% in this study, which was the same as reported by Haisheng Li'. In 70% of cases in the studies by Haisheng et al. and Barcot et al., burns affected the limbs of children, but in this study the percentage was even higher, 89%. The average burned TBSA was 9% in this study and in the study by Barcot et al. (due to scalds and direct fire), but was 11.6% in the study of Haisheng Li et al. The average hospitalization lasted 14 days in this study, which was similar to Zagreb where the hospitalization time was also about 2 weeks for a comparable group of children. The time to final healing was difficult to determine, as in the case of extensive burns it did not usually mean the final healing of all burn wounds. The results of this study were consistent with the two aforementioned studies. In 82% of cases, patients recovered from burn injuries within 4 weeks. This was, to a large extent, due to a relatively lower average TBSA in those patients. No concomitant injuries were noted in any child during the study period, which also significantly improved the outcome and influenced the time of hospitalization. Moreover, no mortality incidence was reported during the whole study period. Furthermore, detailed information about the surface area of burns, treatment modalities, duration of hospitalization, and so forth was not available at the time of the study because of the absence of treatment protocols. Hence, these results helped us to develop protocols for pediatric patients with burns, which might help facilitate the management of patients with burn injuries and develop treatment plans.

## CONCLUSIONS

The present study showed that in North-East Slovenia, the most vulnerable age group of children who suffered from severe burns and required hospitalization was between 1 and 2 years. Considering that most burns are preventable, it is important to raise awareness among

parents, especially of young children. The parents need to set and control the home environment in an effective and timely manner in the course of their child's growth and development, especially in the early childhood days. This will decrease the incidence of the most common burns in this most vulnerable group of children. Future studies need to focus on upgrading the surgical treatment by combining and optimizing therapy at the PICU to improve the treatment outcomes and shorten the length of hospital stay. It will help children start normal daily lives as quickly and as successfully as possible after horrific episodes of severe burn injuries.

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