

Lesions requiring wound management in a central tertiary neonatal intensive care unit

Angéla Meszes, Gyula Tálosi, Krisztina Máder, Hajnalka Orvos, Lajos Kemény, Zsanett Renáta Csoma

Szeged, Hungary

Background: Most of the skin disorders that occur in neonatal intensive care units are due in part to the immaturity and vulnerability of the neonatal skin. Various iatrogenic diagnostic and therapeutic procedures are also conducive to iatrogenic damage. This study was to review the neonates admitted to our neonatal intensive care unit who needed wound management, and to assess the most common skin injuries and wounds, and their aetiology.

Methods: Data were extracted from medical records of neonates who needed wound management in our Neonatal Intensive Care Unit between January 31, 2012 and January 31, 2013. Information about gestational age, sex, birth weight, area of involvement, wound aetiology, and therapy were collected.

Results: Among the 211 neonates observed, wound management was required in 10 cases of diaper dermatitis, 7 epidermal stripping, 6 extravasation injuries, 5 pressure ulcers, 1 surgical wound and infection, 1 thermal burn, and 5 other lesions.

Conclusions: International guidelines in neonatal wound care practice are not available, and further research concerns are clearly needed. Dressings and antiseptic agents should be chosen with great care for application to neonates, with particular attention to the prevention of adverse events in this sensitive population. Team work among dermatologists, neonatologists and nurses is crucial for the successful treatment of neonates.

World J Pediatr 2017;13(2):165-172

Author Affiliations: Department of Dermatology and Allergology, University of Szeged, Szeged, Hungary (Meszes A, Kemény L, Csoma ZR); Department of Pediatrics, University of Szeged, Szeged, Hungary (Tálosi G, Máder K); Department of Obstetrics and Gynecology, University of Szeged, Szeged, Hungary (Orvos H); MTA-SZTE Dermatological Research Group, Szeged, Hungary (Kemény L)

Corresponding Author: Angéla Meszes, H-6720 Szeged, Korányi fasor 6, Hungary (Tel: +36-30-3733275; Fax: +36-62-545954; Email: meszesangela@gmail.com)

doi: 10.1007/s12519-016-0070-6

Online First, November 2016

©Children's Hospital, Zhejiang University School of Medicine, China and Springer-Verlag Berlin Heidelberg 2016. All rights reserved.

Key words: epidermal stripping; extravasation injury; neonatal intensive care unit; surgical wound; wound care in neonates

Introduction

With the increase in the survival rate of premature neonates in recent years, the skin care and wound management in this special patient group poses an ever greater challenge to practitioners. Skin and wound complications remain a significant source of morbidity and mortality in these vulnerable infants. The basic structural differences between preterm neonate, term neonate and adult skin play a considerable role in clinical practice.^[1-7] The immaturity of the stratum corneum, and hence of the epidermal barrier function of preterms results in a number of clinical consequences, including a high epidermal water loss, which may lead to a fluid and electrolyte imbalance, instability of the core temperature and a high potential for evaporative heat loss. Furthermore, the compromised skin barrier, coupled with a high body surface area to weight ratio, significantly increases the risk of the percutaneous absorption of applied chemicals and potential systemic adverse events. Preterm infants are more susceptible to infection, and septic complications are a relatively frequent cause of mortality.^[2-5,7-12] The dermoepidermal junction is flat, but ridged, anchoring fibrils, anchoring filaments and hemidesmosomes are fewer and smaller in premature infants, which results in a decreased resistance to shear forces. The skin is therefore fragile and prone to be affected by inadvertent cutaneous injury. The dermis is also thinner, less collagenized and more gelatinous and this gives to an increased risk of edema, resulting in the risk of an ischemic injury. Moreover, due to the thin layer of subcutaneous fat and the immature eccrine glands, premature infants have a compromised thermoregulatory capability.^[1-4,8,13-15]

The above-mentioned anatomical and functional

characteristics appreciably increase the possibility of the development of skin injuries and wounds, and also significantly influence the wound healing processes in premature and severely ill term neonates. There are many additional factors that affect the formation of wounds and wound healing, such as congenital disorders and accompanying conditions (protein-calorie malnutrition, hypotension requiring inotropic therapy, edema, and physiological instability that prevents the safe redistribution of pressure). It is important to consider that the current diagnostic and therapeutic procedures have reduced the morbidity and mortality in this special patient group on one hand, but also pose a significant risk of iatrogenic skin injuries and can delay the healing of an already extant wound.^[1-3,10,16-18]

To date, there have been no publications on lesions requiring wound management in a neonatal intensive care unit (NICU) during an exact and comparatively long-term study period. The purpose of our study was to conduct regular dermatological examinations in our NICU, in order to review the preterm and term neonates who needed wound management, and to assess the most common skin injuries and wounds, and their etiology. This article presents our results and the therapeutic methods we apply.

Methods

Patients

The study was carried out at NICU of the Department of Pediatrics in the University of Szeged between January 31, 2012 and January 31, 2013, after approval and permission had been obtained from the Institutional Review Board of Albert Szent-Györgyi Medical Center. NICU of the Department of Pediatrics is a 17-bed tertiary center, which annually admits 200-270 neonates in severe perinatal conditions from the south-eastern region of Hungary (with a population of almost 1.5 million). All skin wounds were referred to the dermatologists who conducted dermatological examinations twice a week, with additional unscheduled visits if necessary. All infants hospitalized in the NICU during the 1-year study period were included in the study, undergoing whole-body skin examinations, always carried out by the same two experienced dermatologists. The gestational age, sex, birth weight, area of involvement, etiology of the wound, causative factors, diagnosis at admission and comorbidities were recorded, together with the nature of the management (dressings, ointments and surgical interventions).

Therapeutic methods

All wound care objectives, management plans and

wound assessment details were documented precisely, including the etiology, the type (acute or chronic) and exact location of the wound, the wound dimensions (width, length and depth) in centimeters, the nature of the wound bed, the status of the surrounding skin, the exudate characteristics (amount, color, consistency and odor), and the presence of infection.

During the different steps and stages of the wound management, modern wound care methods were used, with close regard to the anatomical and physiological characteristics of neonates. The wound management included both conventional and modern dressings. The frequency of dressing changes was always determined individually, depending on the wound type and base, the amount of wound exudate, signs of infection and the type of dressing. Swabs were always taken from wound exudates for microbiology, and parenteral antibiotics were commenced in accordance with the bacterial sensitivity if the laboratory findings or skin signs were indicative of systemic infection. Photodocumentation was made at every, or every second examination. Follow-up visits occurred 1, 3 and 6 months after wound healing.

Results

During the 1-year study period, a total of 211 neonates were admitted to the ward [mean birth weight: 2353.6±981.6 (SD) g, mean gestational age: 34.5±4.3 (SD) weeks, range: 23-41 weeks, gender: 125 male and 86 female neonates]. As regards the birth weight: 7 patients were born with high birth weight (HBW, >4000 g), 86 with normal birth weight (NBW, 2500-4000 g), 66 with low birth weight (LBW, 1500-2500 g), 52 newborns weighted less than 1500g: 32 had very low birth weight (VLBW, 1000-1500 g) and 20 had extremely low birth weight (ELBW, <1000 g), 5 of whom weighted less than 750 g.

Totally 32 [17%; 17 males (53.1%)] of the 211 infants admitted to the NICU required special therapy for at least 1 wound; and 3 of the 32 suffering 2 wounds, i.e. a total of 35 wounds were detected and treated. The gestational age of these 32 neonates varied from 23 and 41 gestational weeks (mean±SD: 33.02±4.9). One of the 32 was born with HBW (3.1%), 10 (31.2%) with NBW, 8 (25.0%) with LBW, 4 (12.5%) with VLBW, and 8 (25.0%) with ELBW. The mean birth weight was 2037±1055 (SD) g.

The 35 wounds were grouped on the basis of the causative factors: epidermal stripping (ES) in consequence of the removal of adhesive dressings, extravasation injuries (EIs), surgical wounds and infections, burns due to thermal or chemical agents,

excoriation in the diaper area, pressure ulcers (PUs) and others. Erosions due to ES were observed in 7 neonates (20.0%), in whom injuries developed after the removal of a tape used for cannula fixation (Fig. 1). Extravasation wounds were also frequent (6 cases, 17.1%) after paravasation of parenteral feeding solutions such as amino acid, glucose and fatty acid infusions or inotropic drugs such as dobutamine and adrenaline (Fig. 2). PUs were staged on the basis of the National Pressure Ulcer Advisory Panel Staging Guidelines: two were in stage I, and three were in stage II. We observed one neonate with a deep surgical wound (2.8%) in the lumbo-sacral region, which developed after a closing operation for myelomeningocele, and one neonate with a thermal burn (2.8%) caused by a pulse oxymeter. There were 5 other iatrogenic lesions

(14.3%), which could not be classified into the previous groups: 4 cases of maceration in folds (12.5%), and one suffusion (2.8%).

A lower gestational age and a lower birth weight proved to be factors predisposing to ES (5/7, 71.4%) and diaper dermatitis (DD) (6/10, 60%). Data on all patients and wounds are presented in Table 1. The diagnoses at admission and comorbidities of these patients in the NICU are presented in Fig. 3.

Discussion

Most of the skin disorders that occur in NICUs develop as a consequence of the immaturity and vulnerability of the neonatal skin. Despite the novel techniques utilized in neonatal care leading to a significant reduction in



Fig. 1. A&B: Epidermal stripping around the umbilicus in twins as a result of tape removal; C&D: After epithelizing local treatment with a cooling ointment.



Fig. 2. A: Extravasation injury in the left gluteal region as a consequence of dobutamine infusion; B: After surgical necrectomy; C: After 72 days of treatment, a functionally non-disturbing scar in the left gluteal region.

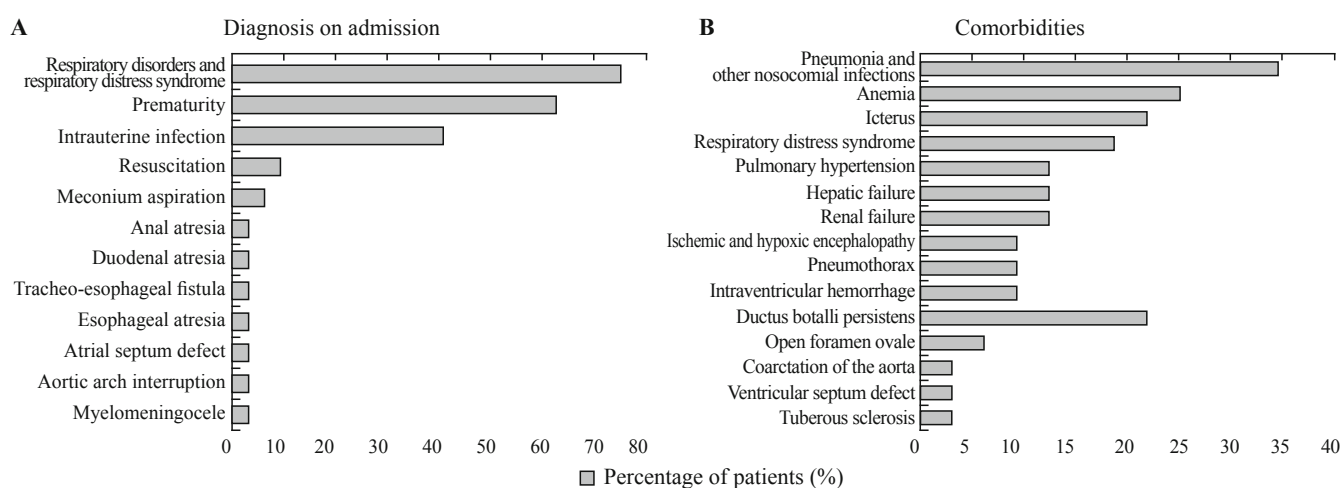


Fig. 3. A: Diagnoses at the time of admission to NICU for patients requiring wound management; B: Comorbidities of patients requiring wound management.

neonatal mortality, especially in premature infants, the various iatrogenic diagnostic and therapeutic procedures may also be conducive to iatrogenic damage, skin traumas and wounds.^[19-22] This is the first assessment of the etiology and frequency of iatrogenic skin injuries and lesions that needed wound management in preterm and term neonates during an exact and relatively long study period.

Thirty-two of the 211 neonates (17%) observed in the NICU required wound care for at least 1 wound, but 3 of the 32 neonates suffered 2 wounds during hospitalization; i.e. a total of 35 wounds were noticed and cured. Data on the overall prevalence of iatrogenic skin injuries in hospitalized neonates are lacking. In an observational, prospective study, Ligi et al^[21] assessed the incidence, nature, preventability and severity of iatrogenic events in a tertiary neonatal centre in France. A total of 388 neonates were enrolled in the study, with a total of 10 436 patient-days. A total of 267 iatrogenic events were recorded in 116 neonates, with an iatrogenic event incidence of 25.6 per 1000 patient-days. Cutaneous events were most common, with a prevalence of 24% in the study population.^[21] In contrast, our study indicated a much lower rate of iatrogenic injuries, 32 per 211 neonates (15%) in the NICU, i.e. a prevalence of 150 per 1000 infants hospitalized.

In order to gain an overall picture of the dermatologic disorders in preterm and severely ill full-term infants, we additionally recorded the neonatal skin disorders observed in the same study population. Overall, 89 different dermatologic cases were detected, 35 of whom needed some form of wound management. In conclusion, a great majority (39.3%) of the dermatologic disorders observed in the NICU proved to be various iatrogenic skin injuries requiring special wound care.^[23]

The most common acquired wound types in NICUs

have been demonstrated to be ES, EIs, surgical wounds, thermal and chemical burn injuries, DD and PUs.^[5,16,20,24] DD is one of the most common dermatological conditions in infants and children, with a prevalence of 14%-42%.^[6] We found skin breakdown caused in the gluteal region by urinal or fecal irritation to be the most common skin lesions in our NICU (10/211, 4.73%). The prevention of DD includes maintenance of a dry skin surface with frequent diaper changes and gentle skin cleansing with warm water. Wipes are not recommended because they contain unnecessary chemicals. The use of zinc-oxide paste, hydrocolloid paste or diaper creams provides a good barrier on the skin. Mild corticosteroids can be applied if inflammation is significant. Fungal and bacterial superinfections can be resolved with local antifungal or antibacterial products.^[3-5] It is also relevant to protect skin folds, e.g. the inguinal, axillar or neck regions, which are prone to maceration and erosion.

ES developing as a consequence of the removal of adhesive tapes and dressings used to secure life support and monitoring devices was earlier determined to be the most common cause of skin breakdown in hospitalized neonates,^[25] especially in neonates born before a gestational age of 27 weeks.^[9] However, the prevalence data on ES in pediatric care cases are somewhat controversial, varying from 8% to 17%.^[6] In our NICU, 7 of 211 infants (3.3%) suffered ES. For the prevention of ES, the use of adhesive tapes should be minimized, preference being given to non-bonding skin dressings, such as silicone dressings, film dressings, hydrogels and hydrocolloids. Moreover, adhesives should be removed slowly and carefully after at least 24 hours of use, with a warm water-soaked cotton ball in a horizontal plane.^[3-6,8,9,16,26]

It is noteworthy that premature neonates have smaller, thinner and hence vulnerable vessels, and the lack of subcutaneous tissue support can inevitably lead to EIs,

Table. Wounds occurring in the Neonatal Intensive Care Unit, and relevant data on the patients

Wound type	Etiology	Number of cases	Gender (M/F)	Gestational age, median (range), wk	Birthweight, median (range), g	Lesions (n)	Localization (n)	Causative factor (n)	Therapy (n)	Length of stay, median (range), d	Outcome (n)	Occurrence of wound, day of treatment, median (range)
Superficial skin injury	Diaper dermatitis	10	7/3	35 (27-41)	2102.5 (910-4340)	Erythema (10), erosion (9), papules (1)	Gluteal region (10)	Irritation (10)	Barrier creams liquid barrier film dressing (10)	43 (11-66)	TSNICU (4), home (6)	5.5 (2-11)
	Epidermal stripping	7	3/4	28 (23-38)	955 (530-3600)	Erosion (7)	Unilateral (3), right cheek (2), left cheek (1), left nipple (1), right foot (1)	Removal of a tape (7)	Epithelizing cream, foam dressing (7)	47 (11-49)	TSNICU (4), home (1), exitus (1)	1 (1-53)
	Maceration, suffusion	5	2/3	31 (26-37)	1650 (1300-1805)	Erosion (4), suffusion (1)	Neck folds (4), right foot (1), inguinal region (1)	Mechanic irritation (4), grabbing the arm (1)	Epithelizing ointment (4), observation (1)	12 (10-20)	TSNICU (5)	3 (2-10)
Lesions with extended damage of the dermis and subcutis	Extravasation injury	6	3/3	36 (31-36)	2042.5 (1225-2990)	Haematoma (2), superficial ulcer (4), deep ulcer (2), bulla (2)	Right wrist (3), left hand (1), left upper arm (1), left gluteal region (1)	Fatty acid, lipid and amino acid infusion (4), glucose (1), dobutamine (1)	Epithelizing ointment (3), hydrogels (2), surgical necrectomy (1), observation (1)	26 (18-41)	TSNICU (4), home (1), surgery (1)	8.5 (1-23)
	Pressure ulcers	5	2/3	38 (26-40)	3440 (700-3980)	Erythema (2), haemorrhagic erosion with crust (3)	Occipital region (4), nasal orifice (1)	Pressure (5)	Herb containing gel (2), epithelizing ointment (2), hydrogels (1)	47 (28-103)	TSNICU (4), exitus (1)	10 (2-47)
	Thermal Burns	1	0/1	32	1650	Ulcer	Forearm	Pulse oximeter	Epithelizing ointment	12	TSNICU	11
	Surgical wounds	1	0/1	39	3250	Ulcer	Lumbo-sacral region	Postoperative wound infection	Hydrofiber dressing, gelling foam dressing	25	TSNICU	6

TSNICU: transfer to secondary neonatal intensive care unit; M: male; F: female.

in spite of the most careful preventive action.^[27] Quick recognition and action to minimize further injury are essential, as is regular observation of the intravenous (iv) cannula site and the surrounding skin, which can be easily visualized with transparent film dressings.^[5,10,11,16,24,26] The reported incidence of EIs varies significantly. Wilkins and Emmerson^[28] estimated the prevalence of such injuries to be 38 per 1000 infants, and 70% of the injuries recorded developed in neonates born at 26 gestational weeks or less. Similarly, we observed 6 EIs (2.9%), 2 of which were severe, and the other 4 only moderate. It is well known that EIs are mostly caused by inadvertent leakage from vessels to the surrounding tissue of iv administered glucose (>10%), calcium gluconate or total parenteral nutrition, particularly when this is supplied through a peripheral line. Additionally, hypertonic solutions, ionic or alkaline solutions, or inotropic drugs (dopamine, dobutamine or adrenaline), which lead to vasoconstriction, can also cause skin damage.^[5,29,30] We observed 1 case of the extravasation of dobutamine, and 1 with glucose- and 4 with lipid and amino acid infusion-induced EIs. There is no general agreement as to the best practice for the treatment of EIs in preterm infants. There have been various publications on the successful management of EIs, which can be divided into operative and non-operative groups,^[27] or expectant, topical care and extravasant removal types.^[30] Observation alone until the total area involved is demarcated can be an option, and this is the most common practice in injuries without any obvious skin damage. A number of different topical agents have been applied with good results, including antiseptic creams with silver sulfadiazine, with or without 0.2% chlorhexidine, nitroglycerine or enzymatic debridement with an ointment containing fibrinolysin and deoxyribonuclease^[27,30] or even herbal mixtures.^[31] Additionally, film dressings, hydrocolloids and hydrogels can be used in occlusive dressings, and hydrogels even in a sterile polythene bag.^[8,28] Operative solutions involve removal of the extravasant by saline flushing, liposuction or skin puncturing and saline infiltration either alone or in some areas combined with hyaluronidase.^[27,28,30]

PU present a problem in neonatal care; particularly sedated, paralyzed or immobilized neonates are at high risk. Besides a low peripheral blood flow, as a consequence of the low amount of dermal collagen and elastic fibers, there is a high water content in the immature neonatal dermis. This edema can reduce the blood flow, and increases the risk of ischemic, pressure-related injuries.^[8,32] A Japanese study found that neonates nursed in incubators are at a special risk of the development of PU, because of the high temperature and humidity in incubators and specific intrinsic factors

such as the size, physical shape and skin immaturity of premature infants.^[33] The prevalence of PU has been reported to be 27% in pediatric intensive care units and 23% in NICUs.^[16] These wounds mostly occur in the occipital region or on the ear, nose or even the knees if the neonate is nursed prone, but medical devices can also cause PUs.^[22] In a multisite prospective cohort study, Fujii et al^[33] observed that the cumulative incidence rate of PUs in NICUs was 16%. The most frequent site of pressure sores was the nose (50%), the explanation of which was presumed to be that continuous positive airway pressure or nasal directional positive airway pressure was applied in most cases, these being risk factors for the development of nasal deformations and PUs.^[34] Our survey revealed 5 patients (2.37%) with PUs, 4 of which occurred in the occipital region, and all in critically ill neonates. Despite the frequent use of monitoring or therapeutic devices, we noted only one device-related PU, obviously thanks to the good nursing care. To prevent PUs, patients should be repositioned and turned at least once every 2 hours, medical equipment (cuff, saturation probes, tubes, etc) should be checked and replaced frequently, and the use of special weight-relieving gel pillows and foam mattresses for infants is recommended. Even if these rules are carefully observed, skin damage can easily develop in very preterm and unstable infants.^[5,8,26]

Burn injuries fortunately occur only rarely in NICUs; they usually develop following the use of pulse oxymeters, ultraviolet light or infrared heating lamps, various electrodes, fiber optic cold light, alcohol-based skin cleansers or warming bottles.^[5,13,35] Our survey detected only 1 neonate with a mild thermal burn injury caused by a pulse oximeter. Through the use of aqueous skin preparations and disinfectant products, and the rinsing of alcohol-based ones with saline water immediately after use, chemical burns can be prevented. Close control during the application of heating lamps or monitoring devices is indispensable for averting thermal burns. To prevent surgical wounds, sutures should be observed for signs and symptoms of infection by applying transparent dressings.^[5,16]

For the early recognition of wound infection, swabs were always taken from wound exudates for microbiology, and we carefully examined for laboratory and clinical skin signs indicative of systemic infections. All microbiological cultures from wound exudates were negative, with no need for antibiotics, with the exception of one case of postoperative infection after myelomeningocele closing surgery, when systemic inflammatory symptoms appeared on the day after surgery, the sutures opened and a purulent and necrotic ulcer with inflamed surroundings developed in the lumbo-sacral region. ESBL-producing

Klebsiella pneumoniae was cultured, and with regard to the antibiogram, systemic antibiotic therapy was introduced. Finally, together with the antiseptic wound care, the combinational therapy resulted in the inflammation ceasing within a few days.

Most skin injuries observed in our NICU proved to be erosions or superficial ulcers, and healed in a short time without any complications or sequels following the use of local epithelising ointments or non-adhesive silicone, foam or hydrogel dressings. Fortunately, we did not detect any progression in wound healing, even in the more severe cases. Besides the use of modern wound dressings suitable for wound stages, the good efficacy of wound healing in neonates is also a factor contributing to a good prognosis. Naturally, the relatively small number of neonates involved is one limitation of our study.

Epidermal stripping, erosive diaper dermatitis or erosions in skin folds usually heal without scarring as a consequence of the epidermal damage being only superficial. However, all other types of wounds with extensive damage of the dermis, subcutis or deeper layers leave scars with lifetime duration and even cosmetically or functionally disturbing scar can sometimes remain. In 100 consecutive children at 16-29 months of age, Cartlidge et al^[36] investigated the prevalence of scars attributable to intensive therapeutic procedures performed during the newborn period. Surprisingly, scars (needle marks, extravasation injuries, heelprick marks, adhesive tape damage, or lesions related to the application of central venous catheters or chest drains) were present in every child, and in 11 lesions were cosmetically or functionally significant. In our study, 24 of the 35 (68.6%) skin injuries detected (epidermal stripping, diaper dermatitis, erosions and first-degree pressure ulcers) healed without scar formation; 11 wounds (31.4%) were accompanied by scars, 9 (25.7%) of which proved to be small and visible, but cosmetically and functionally non-disturbing. One extravasation injury with a deep necrotic ulcer in the left gluteal region that resulted from a malpositioned umbilical arterial catheter left a cosmetically significant scar, as did a surgical wound that developed in the lumbo-sacral region as a consequence of postoperative wound infection after myelomeningocele closing surgery. To reduce the high rate of scar formation, points of particular importance to be stressed are the prevention of iatrogenic injuries with special care during medical procedures, the identification of risk factors, the early recognition of iatrogenic events and modern wound care strategies (use of non-adhesive dressings, alcohol-free antiseptic solutions, and weight-relieving anti-decubitus mattresses).

The average length of hospital stay of the infants suffering from wounds was 34 days, in contrast with the infants without wounds, who spent an average of 16 days in the NICU. However, most of the wounds observed in our NICU were fortunately minor, with the exception of two extravasation injuries and one surgical wound with extensive soft tissue damage and subsequently a longer wound healing time. Moreover, the longer time an infant needs to be hospitalized as a result of prematurity or a severely ill status, the greater the possibility of iatrogenic injuries developing due to various diagnostic or therapeutic interventions. In conclusion, the hospitalization time is significantly longer in the case of infants with iatrogenic cutaneous injuries, as the wound management of severe iatrogenic wounds may be accompanied by a longer hospital stay.

Previous studies demonstrated that the lower the gestational age at birth and the lower the birth weight, the higher was the risk of occurrence of iatrogenic events.^[17,21] More than half of the infants with wounds in our study population (59%) were born prematurely, most often between gestational weeks 28 and 31. A lower gestational age and lower birth weight were factors predisposing to ES (71.4%) and DD (60%).

Skin care and wound management in term and preterm neonates are complicated, and pose a great challenge to practitioners during neonatal care. Most of the injuries suffered by neonates are iatrogenic, and a recent study concluded that the majority (83%) of such iatrogenic events are preventable.^[17] It is important to emphasize the roles of preventive skin care and the adequate treatment of dermatological conditions during neonatal intensive care, since the integrity of the skin is essential for the stabilization of severely ill or preterm newborns. To maintain skin integrity, at least daily skin assessment is advised, using valid and objective score systems.^[25,26] Identification of risk factors for skin injury and regular skin care are also important as concerns the smallest infants. Furthermore, we aim to carry out a comparative interventional study in the future in order to investigate the prevalence of iatrogenic cutaneous injuries requiring wound management after the introduction of modern wound care principles and different preventive strategies in the NICU.

In conclusion, the prevalence of wounds occurring in the premature and ill neonate population is quite high, and can pose appreciable problems. The clinical practice of wound care in adults cannot be applied directly to neonates due to the anatomical and physiological differences of their skin. Evidence-based guidance for neonatal wound care practice is severely limited, in part because of the ethical problems of conducting clinical studies on this population. International guidelines are not available; mainly

regional customs and recommendations are to be found. For the safe use of suitable dressings, drugs and adjunctive treatments in neonates, further investigations and research studies on wound management are necessary in order to gain evidence-based data and to establish reliable practical guidelines. More clinical studies must be performed to obtain exact data on the prevalence of wounds and on the different wound management modalities in this special patient group.

Severe skin injuries were rather rare in our study, thanks to the appropriate daily skin care routine, involving careful observation and prevention. It is important to emphasize that team work and cooperation among dermatologists, neonatologists and the NICU nurses are crucial for the prevention of injuries and for the successful treatment of preterm and term neonates.

Funding: Zsanett Renáta Csoma is a recipient of the János Bolyai Research Scholarship from the Hungarian Academy of Sciences.

Ethical approval: Written informed consent was obtained from the patient for publication of this report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Competing interest: The authors declare that they have no competing interest.

Contributors: Meszes A contributed to the acquisition, analysis and interpretation of data, design of the study, and drafting of the article. Tálosi G performed the acquisition of data, design of the study, and revision of the article for important content. Máder K contributed to the acquisition of data, and revision of the article. Orvos H and Kemény L took part in the design of the study and revision of the article. Csoma Z was responsible for the design and concept of the study, acquisition of the data, and revision of the article for important content. All authors contributed to the final approval of the version to be published.

References

- 1 Rolfe KJ, Grobelaar AO. A review of fetal scarless healing. *ISRN Dermatol* 2012;2012:698034.
- 2 Costa S, De Carolis MP, Fusco FP, Savarese I, Tesfagabir MG, Romagnoli C. Skin ulceration in a preterm infant: a warning sign of a percutaneous long line complication. *Arch Dermatol* 2011; 147:512-514.
- 3 Darmstadt GL, Dinulos JG. Neonatal skin care. *Pediatr Clin North Am* 2000;47:757-782.
- 4 Lund C, Kuller J, Lane A, Lott JW, Raines DA. Neonatal skin care: the scientific basis for practice. *J Obstet Gynecol Neonatal Nurs* 1999;28:241-254.
- 5 Irving V, Bethell E, Burton F, on behalf of a Neonatal Advisory Group. Neonatal wound care: minimising trauma and pain. *Wound* 2006;2:33-41.
- 6 Noonan C, Quigley S, Curley MA. Skin integrity in hospitalized

- infants and children: a prevalence survey. *J Pediatr Nurs* 2006; 21:445-453.
- 7 Lyon VB. Approach to procedures in neonates. *Dermatol Ther* 2005;18:117-123.
 - 8 Irving V. Skin problems in the pre-term infant: avoiding ritualistic practice. *Prof Nurse* 2001;17:63-66.
 - 9 Afsar FS. Skin care for preterm and term neonates. *Clin Exp Dermatol* 2009;34:855-858.
 - 10 Tobin C. Managing an extravasation wound in a premature infant. *Wounds International* 2007;3:90-91.
 - 11 Liverpool Womens NHS Foundation Trust, 2011. www.liverpoolwomens.nhs.uk/Library/about_us/Quality_Account_20112012.pdf (accessed January 1, 2013).
 - 12 Rutter N. The immature skin. *Eur J Pediatr* 1996;155 Suppl 2: S18-S20.
 - 13 Hardwicke J, Richards H, Jagadeesan J, Jones T, Lester R. Topical negative pressure for the treatment of neonatal post-sternotomy wound dehiscence. *Ann R Coll Surg Engl* 2012;94: e33-e35.
 - 14 Rutter N. The dermis. *Semin Neonatol* 2000;5:297-302.
 - 15 LeFevre A, Shillcutt SD, Saha SK, Ahmed AS, Ahmed S, Chowdhury MA, et al. Cost-effectiveness of skin-barrier-enhancing emollients among preterm infants in Bangladesh. *Bull World Health Organ* 2010;88:104-112.
 - 16 Baharestani MM. An overview of neonatal and pediatric wound care knowledge and considerations. *Ostomy Wound Manage* 2007;53:34-6, 38, 40, passim.
 - 17 Kugelman A, Inbar-Sanado E, Shinwell ES, Makhoul IR, Leshem M, Zangen S, et al. Iatrogenesis in neonatal intensive care units: observational and interventional, prospective, multicenter study. *Pediatrics* 2008;122:550-555.
 - 18 Metzker A, Brenner S, Merlob P. Iatrogenic cutaneous injuries in the neonate. *Arch Dermatol* 1999;135:697-703.
 - 19 Sekar KC. Iatrogenic complications in the neonatal intensive care unit. *J Perinatol* 2010;30 Suppl:S51-S56.
 - 20 Sardesai SR, Kornacka MK, Walas W, Ramanathan R. Iatrogenic skin injury in the neonatal intensive care unit. *J Matern Fetal Neonatal Med* 2011;24:197-203.
 - 21 Ligi I, Arnaud F, Jouve E, Tardieu S, Sambuc R, Simeoni U. Iatrogenic events in admitted neonates: a prospective cohort study. *Lancet* 2008;371:404-410.
 - 22 Hogeling M, Fardin SR, Frieden IJ, Wargon O. Forehead pressure necrosis in neonates following continuous positive airway pressure. *Pediatr Dermatol* 2012;29:45-48.
 - 23 Csoma Z, Meszes A, Mader K, Kemeny L, Talosi G. Overview of dermatologic disorders of neonates in a central regional intensive care unit in Hungary. *Pediatr Dermatol* 2015;32:201-207.
 - 24 Irving V. Wound care for preterm neonates. *J Neonat Nursing* 2006;2:102-106.
 - 25 Lund CH, Osborne JW, Kuller J, Lane AT, Lott JW, Raines DA. Neonatal skin care: clinical outcomes of the AWHONN/NANN evidence-based clinical practice guideline. Association of Women's Health, Obstetric and Neonatal Nurses and the National Association of Neonatal Nurses. *J Obstet Gynecol Neonatal Nurs* 2001;30:41-51.
 - 26 National Guideline Clearinghouse (NGC). Neonatal skin care, second edition. Evidence-based clinical practice guideline. Association of Women's Health, Obstetric and Neonatal Nurses AWHONN, 2007. Rockville MD: Agency for Healthcare Research and Quality (AHRQ). 2007.
 - 27 Kumar RJ, Pegg SP, Kimble RM. Management of extravasation injuries. *ANZ J Surg* 2001;71:285-289.
 - 28 Wilkins CE, Emmerson AJ. Extravasation injuries on regional neonatal units. *Arch Dis Child Fetal Neonatal Ed* 2004;89: F274-F275.
 - 29 Tiraboschi IC, Niveyro C, Mandarano AM, Messer SA, Bogdanowicz E, Kurlat I, et al. Congenital candidiasis: confirmation of mother-neonate transmission using molecular analysis techniques. *Med Mycol* 2010;48:177-181.
 - 30 Reynolds BC. Neonatal extravasation injury: case report. *Infant* 2007;3:230-232.
 - 31 Cho KY, Lee SJ, Burm JS, Park EA. Successful combined treatment with total parenteral nutrition fluid extravasation injuries in preterm infants. *J Korean Med Sci* 2007;22:588-594.
 - 32 Hirsch B, Grunbaum M, Wagner F, Bi Y, Lucka L, Du MQ, et al. A novel A20 (TNFAIP3) antibody (Ber-A20) can be used to detect unmutated A20 by immunohistology. *Histopathology* 2012;60:E19-E27.
 - 33 Fujii K, Sugama J, Okuwa M, Sanada H, Mizokami Y. Incidence and risk factors of pressure ulcers in seven neonatal intensive care units in Japan: a multisite prospective cohort study. *Int Wound J* 2010;7:323-328.
 - 34 Fischer C, Bertelle V, Hohlfeld J, Forcada-Guex M, Stadelmann-Diaw C, Tolsa JF. Nasal trauma due to continuous positive airway pressure in neonates. *Arch Dis Child Fetal Neonatal Ed* 2010;95:F447-F451.
 - 35 Rimdeika R, Bagdonas R. Major full thickness skin burn injuries in premature neonate twins. *Burns* 2005;31:76-84.
 - 36 Cartlidge PH, Fox PE, Rutter N. The scars of newborn intensive care. *Early Hum Dev* 1990;21:1-10.

Received March 3, 2015

Accepted after revision June 22, 2015