JURNAL REKONSTRUKSI DAN ESTETIK

TREATMENT OF PRESSURE ULCERS OF THE SCALP IN DECOMPENSATED HYDROCEPHALY: A CLINICAL CHALLENGE

Letitia Bellavesta Kale[a*], Elric Brahm Malelak[b], Robertus Arian Datusanantyo[a], Wajahat Ullah[d], Ahmed Mohamed Ahmed Ali[e], Dhyey Thumar[f], Kundan Kumar[g]

[a] Department of Surgery, Prof. Dr. W. Z. Johannes General Hospital, Kupang, East Nusa Tenggara, Indonesia
[b] Neurosurgeon, Department of Surgery, Faculty of Medicine and Veterinary Medicine Universitas Nusa Cendana / Prof. Dr. W. Z. Johannes General Hospital, Kupang, East Nusa Tenggara, Indonesia
[c] Plastic Surgeon, Department of Surgery, Faculty of Medicine and Veterinary Medicine Universitas Nusa Cendana / Prof. Dr. W. Z. Johannes General Hospital, Kupang, East Nusa Tenggara, Indonesia
[d] Faculty of Clinical Science, Saidu Medical College in Swat, Pakistan
[e] Faculty of Medicine, Alzaiem Alazhari University, Khartoum North, Sudan
[f] Narsinhmeta University, GMERS Medical College Junagadh, India
[g] Dow University of Health Science, Dow International Medical College, Pakistan

ARTICLE INFO

Keywords: Pressure injury, hydrocephalus, staging system, good health and well-being

***Corresponding author**:
Letitia Bellavesta Kale
Email address:
bella.kale@yahoo.com

History:
Received: September 21, 2023
Revised: October 30, 2023
Accepted: November 27, 2023
Published: December 1, 2023

JRE : Jurnal Rekonstruksi dan Estetik
e-ISSN:2774-6062; p-ISSN: 2301-7937
DOI: 10.20473/jre.v8i2.49972
Open access :

Available at:
https://e-journal.unair.ac.id/JRE/

How to cite: Kale, L. B., Malelak, E. B. ., Datusanantyo, R. A. ., Ullah, W. ., Ali, A. M. A. ., Thumar, D. ., & Kumar, K. TREATMENT OF PRESSURE ULCERS OF THE SCALP IN DECOMPENSATED HYDROCEPHALY: A CLINICAL CHALLENGE. Jurnal Rekonstruksi Dan Estetik,2023.8(2):73–84.

ABSTRACT

Introduction: A pressure injury is a localized injury to the skin and/or underlying tissue usually over a bony prominence, that caused by compression. Multiple studies have demonstrated that age, moisture, immobility, and friction/shear are key risk factors. We report a challenging case of multiple pressure injuries over the scalp in hydrocephalus patients. In order to treat and accelerate the recovery of these severe skin disorders, the study recommends using the TIME principles.
Case Illustration: Three toddlers with Hydrocephalus was consulted due to multiple Pressure Injury over the scalp in the bilateral temporoparietal and occipital region. After ventriculoperitoneal shunting (VP-shunt), the wounds were managed in accordance with TIMERS guidelines.
Discussion: Pediatric tissues are more susceptible to deformation injuries. Severe skull deformity and macrocephaly are serious problems that may lead to difficulties in head control and child positioning increases the risk of pressure injury. After VP-shunt, wound care is even more challenging since the surgical wound is closely related to pressure injuries. Shunt exposure can occur in these patients. According to both examination and intervention of TIMERS, guidelines are essential as well as controlling risk factors of pressure injury development.
Conclusion: Surgeons should be aware that children with hydrocephalus may experience scalp injuries and changes to their body composition, which challenge the diagnosis and care process.

Highlights:

1. Children with hydrocephalus may face challenges related to scalp injuries and changes in body composition, which can complicate diagnosis and care.
2. Inserting a shunt in infants or young children with hydrocephalus as a preventive measure against pressure ulcers.
3. Surgeons should be aware of these factors and consider comprehensive approaches to treatment.

INTRODUCTION

Hydrocephalus is a condition characterized by an excessive accumulation of cerebrospinal fluid in the central nervous system due to disruptions in its secretion, flow, or absorption. Worldwide, the prevalence of hydrocephalus has reached 85 cases per 100,000 individuals, and in Indonesia specifically, it affects around 10 in 1,000 individuals annually. The classification of communicative hydrocephalus that occurs in an acquired and acute manner necessitates surgical intervention, such as the placement of a VP shunt, to facilitate the drainage of cerebrospinal fluid (CSF). Nevertheless, postoperative infection complications remain notably high.[1]

The development of macrocephaly resulting from disruptions in cerebrospinal fluid circulation can lead to progressive hydrocephalus. This condition can result in severe mental retardation or neurological impairments, rendering the affected child incapable of sitting or walking, unable to balance their heavy head, and restricting them to a lying position in bed. Additionally, the inability to eat or drink without assistance can easily lead to malnutrition, increasing the risk of pressure injuries.

It is estimated that pressure injuries affect between 1 to 3 million individuals annually in the United States. Nevertheless, in Indonesian hospitals, pressure injuries represent a concealed healthcare issue. The incidence of pressure injuries remains remarkably elevated within the ICU setting. There are only four published studies on pressure injuries in Indonesia, indicating a pressing need for increased awareness regarding this problem.[2–4]

Numerous studies have demonstrated that age, moisture, immobility, and friction/shear are significant risk factors for pressure injuries. Factors such as pressure, friction, chronic illnesses, and skin conditions can cause pressure injuries. Age, nutrition, and oxygen supply are also intrinsic factors that can contribute.[5] Sick or immobile children are at a higher risk of developing pressure injuries and deep tissue injuries. Furthermore, the type of injury and potential causes differ between adults and children. Pediatric patients' most common locations for pressure injuries are the ears and the back of the head.[6–8] When infants and toddlers are lying supine, there is high pressure on the back of their heads.[9]

Individuals suffering from hydrocephalus experience limited mobility due to the weight of their heads, and their notably fragile skin can result in scalp pressure injuries if proper monitoring is not in place. Skin damage and the ensuing infections pose risks for shunt infections in patients and could potentially lead to fatal outcomes unless caregivers are meticulous in averting these issues by consistently altering the head's positioning and furnishing head and neck support, which could include the use of cushions.[10]

This report is a concise case series involving multiple pressure injuries in individuals with hydrocephalus. It is worth noting that there is a scarcity of publications addressing pressure injuries in hydrocephalus patients. Within this series, we have identified the difficulties encountered in the diagnosis and staging of pressure injuries and the potential for complications in individuals with hydrocephalus.

CASE ILLUSTRATION

Case 1

A one-year-old male with severe hydrocephalus and multiple pressure injuries on the bilateral temporoparietal and occipital regions was referred from a lower-level general hospital located on another island within the same province, approximately 527.[3] kilometers away, to our provincial-level general hospital. Upon physical examination, his head circumference measured 101 cm, his height was 79 cm, he weighed 13 kg, and his upper arm circumference was 10.5 cm, which falls below the normal range for a one-year-old male (normal range: 12.5 - 17.1 cm).

The wound on the left temporoparietal region measured 10 x 7.5 cm and exhibited dry necrotic tissue, some slough, and an obscured wound base (Figure 1A). On the right temporoparietal region, there were two wounds, measuring 7 x 6 cm and 2 x 5 cm, both with necrotic tissue at the wound base. The edges of these wounds were flat and well-defined (Figure 1B). In the occipital region, there was a 14 x 8 cm wound with a well-defined margin, signs of bleeding, and the wound base consisted of a portion of the galea (Figure 1C).

Laboratory results revealed hypoalbuminemia, with an albumin level of 1.17 g/dL, and a multislice computed tomography (MSCT) without contrast indicated diastasis of cranial sutures. Following ventriculoperitoneal shunting (VP-shunt), the wounds were managed according to the TIMERS guideline.

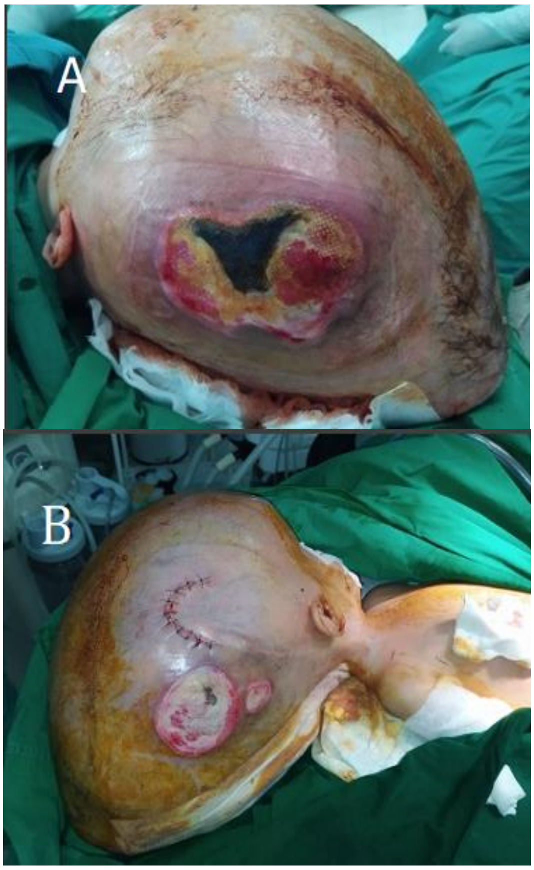

Figure 1. The Wound is on The Left Temporoparietal Region (A), The Right Temporoparietal Region (B), The Occipital Region (C).

Case 2

A six-month-old female with hydrocephalus, who had undergone ventriculoperitoneal shunting (VP shunt) and temporoparietal and occipital regions before the surgery, was referred from a lower-level general hospital located in another regency on a different island within the same province, approximately 604 kilometers away, to our provincial-level general hospital. Upon physical examination, her head circumference measured 67 cm, her height was 64 cm, she weighed 8.1 kg, and her upper arm circumference was 12 cm, which fell below the normal range for a six-month-old female (normal range: 11.7-16.3 cm).

The wound on the left temporoparietal region measured 10 x 5 cm and exhibited dry necrotic tissue with an obscured wound base (Figure 2A). In the occipital region, there were multiple wounds, measuring 3 x 2 cm superiorly, 4 x 2 cm inferiorly, and 5 x 3 cm on the left side, all with well-defined margins and obscured wound beds (Figure 2A). On the right side of the temporoparietal region, there were two wounds situated next to the VP shunt wound sutures, each measuring 6 x 5 cm. These wounds displayed dry necrotic tissue and obscured wound bases. Additionally, there was another wound positioned medially, measuring 3 x 2 cm, which presented with slough. The boundaries of these wounds appeared flat and distinct (Figure 2B).

Her laboratory results indicated anemia (hemoglobin=7.6 g/dL), a neutrophil count of 11,240/µL, and a leukocyte count of 20,320/µL. The wounds were addressed in accordance with the TIMERS guidelines. We provided treatment for the wounds at the outpatient department every two or three days for roughly 2.5 months before her hospitalization. Regrettably, the wounds worsened, and she encountered shunt exposure because her parents did not follow the care schedule. She unfortunately succumbed to a shunt-related complication ten days after her hospitalization.

Figure 2. The Wound on The Left Temporo-Parietal Region (A), The Right Temporo-Parietal Region (B).

Figure 3. Picture of The Shunt is Extruded from The Thin Skin of The Patient.

Case 3

A seven-month-old female with hydrocephalus, who had previously undergone a ventriculoperitoneal (VP) shunt surgery and had multiple pressure injuries on the right temporo-parietal and occipital region even before the surgery, was referred from a lower-level general hospital located in a regency approximately 33.6 kilometers away to our provincial-level general hospital.

During the physical examination, her head circumference was measured at 64 cm, and her height was 64 cm, with a weight of 9 kg. Her upper arm circumference was 13.5 cm, which was slightly below the median range for her age (normal range: 13.9 cm; 11.8 - 16.5 cm).

The wound on the right temporo-parietal region measured 3 x 2 cm, with a granulated wound bed and signs of epithelialization on the wound's edges (Figure 4A). In the occipital region, there was a wound measuring 5.5 x 5 cm with a well-defined margins and necrotic tissue, and the wound bed was part of the galea (Figure 4B).

Her laboratory results showed a hemoglobin level of 11.5 g/dL, an increasing level of C-reactive protein at 1.78 mg/dL, and a random blood sugar level of 71.50 mg/dL. The wounds were managed according to the TIMERS guidelines, and we provided treatment twice a week at the outpatient clinic for approximately 3 weeks before she was hospitalized.

Figure 4. The Wound on The Right Temporo-Parietal Region (A), Occipital Region (B).

DISCUSSION

The National Pressure Ulcer Advisory Panel (NPUAP) provides a definition for pressure injuries as localized harm to the skin and the tissues underneath, typically occurring on bony areas due to extended and/or intense pressure of shear and friction. The terms pressure ulcer, decubitus ulcer, pressure ulcer, and pressure injury are commonly utilized interchangeably. However, the preferred term is pressure injury, as it encompasses cases where not all damage results in a complete breakdown or ulceration of the skin.[6]

Documentation and reporting regarding pressure injuries in hydrocephalus patients in developed countries are insufficient, primarily because cases of significantly enlarged head circumferences are infrequently documented. There is a scarcity of published studies on pressure injuries in Indonesia, highlighting the urgent need for increased awareness of this issue. According to a previous study, the incidence of pressure injuries in immobilized patients in the surgical treatment room at Public Hospital Kupang in April and May 2009 was alarmingly high, reaching 60.7%.[11] Another study conducted in 2007 reported a pressure injury incidence of 33.4% in an ICU unit in an Indonesian public hospital.[4] During the period from January to June 1999, a 15-bed intensive care unit (ICU) at Pontianak Public Hospital in Kalimantan Barat Province recorded a 29% occurrence rate for pressure injuries. It is worth noting that pressure injuries are more commonly observed among hospital inpatients (ranging from 4% to 30%) when compared to residents of long-term care facilities (2.4% to 23%) and patients receiving home care (4%).[12]

Previous research reported the cases of nine children with severe hydrocephalus, whose head circumferences ranged from 56 to 94 cm, with an average of 67 cm. Within this group, three cases involved skin injuries on the side opposite to the surgery site, which were attributed to the weight of the head. These injuries occurred within a period of 2 weeks to 6 months post-operation. Additionally, four patients experienced shunt infections, with two cases resulting from gram-negative bacteria (*Escherichia coli, Pseudomonas, and Klebsiella*), while the cause of infection in one patient remained undetermined. Tragically, three patients passed away during the follow-up period, primarily due to shunt infections and sepsis.[10]

In developing and underdeveloped countries, the management of hydrocephalus is often accompanied by economic challenges, resulting in treatment delays. Recognizing the financial burdens, parents frequently find themselves compelled to forgo essential medical care. Conversely, many patients experiencing pressure injuries have specific mental or physical conditions that restrict their mobility.[10]

Research on pediatric pressure injuries is notably insufficient in comparison to studies focusing on adults. Nevertheless, healthcare practitioners must account for the disparities in pressure injuries between adult and pediatric populations when treating children with complex medical conditions. Given the substantial anatomical and physiological distinctions between children and adults, findings derived from adult studies cannot be universally applied to pediatric patients.[6]

During the course of pediatric growth and development, there are rapid changes in body composition, which distinguish it from that of adults. Typically, toddlers have a higher proportion of fat and a lower proportion of muscle compared to adults. This results in their subcutaneous tissue being softer and more susceptible to deformation when subjected to similar forces.[8] Simultaneously, their skin is less flexible in comparison to that of adults.

The composition of adipose tissue changes significantly with age, despite the fact that the majority of it consists of fat stored in adipocytes. In newborns, approximately 35.5% of adipose tissue is composed of lipids, while 56.5% is water. In adults, the corresponding figures are 26.3% lipids and 71.7% water. As a result, fat tissue in babies and infants is inherently softer and more pliable.[13] During early development, there are also substantial changes in muscle composition. In infants and children, the endomysium (connective tissue within muscles) is thinner, making their relaxed skeletal muscles considerably softer than those of adults.[14] Toddlers and the elderly are more susceptible to mechanical stress and deformation due to their less flexible, non-extendable skin tissues. Age also influences the coefficient of friction in human skin. However, in the early years of life, it is so low that it doesn't seem to pose an additional biomechanical risk for the pediatric population.[15]

Moreover, the comorbidities present in medically complex individuals affect their body composition. In contrast to children with minimal functional impairment, those with significant functional limitations exhibit reduced lean body mass and higher percentages of body fat.[16] This, coupled with difficulties in head control and positioning arising from severe skull deformities and macrocephaly, puts hydrocephalus infants and children at constant risk of pressure injuries to the scalp.[10,17]

In our cases, the patients are entirely reliant on their parents for care. The occurrence of pressure injuries in the occipital region led parents to position the head in a sideways manner without alternating, resulting in pressure injuries in both the occipital and bilateral temporoparietal regions. The authors encountered several challenging issues when diagnosing these patients with pressure injuries alongside hydrocephalus.

First and foremost, it is crucial to take into account the anatomical location when assessing the type of tissue involved in the wound.[18,19] A Stage 3 pressure injury is defined in the staging system as full-thickness tissue loss. While subcutaneous fat may still be visible, the fascia should remain intact and cover any exposed bone, tendon, or muscle. Although slough may be present, it cannot obscure the extent of tissue loss. In some anatomical areas, like the occiput, subcutaneous tissue is virtually absent, making it impossible to diagnose Stage III pressure injuries in these areas.[19]

The second challenge involves healthcare providers who care for children with complex medical conditions needing to consider the distinct characteristics of pressure injuries in children when compared to adults. Children with hydrocephalus may encounter scalp injuries and experience alterations in their body composition. This can make the diagnosis of stage III pressure injuries challenging, especially if subcutaneous tissue is absent. Malnutrition plays a significant role in promoting the development of pressure injuries.[12]

In our cases, the patients exhibited clinical signs of malnutrition based on upper arm circumference and hypoalbuminemia, both of which serve as indicators of surgical or ICU outcomes. Notably, albumin provides insights into the nutritional status over an extended period.[20] Another concern is the impact of sweating and excess moisture, both of which can contribute to skin breakdown. To address chronic wounds in children, surgeons are advised to adhere to the TIMERS guidelines, as they are another essential factor in the development of pressure injuries.[12]

The TIME guidelines outline a comprehensive framework for the management of wound bed preparation, providing healthcare professionals with a structured approach for treating chronic wounds. The TIME framework is further elaborated in Table 1, illustrating how clinical evaluation can be correlated with the underlying pathophysiology.

This framework is centered around four key components. "T" stands for Tissue, focusing on the assessment of non-viable or deficient tissue. "I" represents Infection or inflammation. "M" addresses issues related to Moisture imbalance, and "E" pertains to the evaluation of the wound's Edge, specifically whether it is non-advancing or undermined.

Table 1. TIME Principles [21]

Wound Bed Preparation				
Clinical Observations	**Proposed Pathophysiology**	**Wound Bed Preparation Clinical Actions**	**Effect of Wound Bed Preparation Actions**	**Clinical Outcome**
Tissue	Defective matrix and cell debris impair healing	Debridement (episodic or continuous), autolytic, sharp, surgical, enzymatic, mechanical or biological agents	Restoration of wound base and functional extracellular matrix proteins	Viable wound base
Infection or inflammation	High bacterial counts or prolonged inflammation. Increased inflammatory cytokines. Increased protease activity. Decreased growth factor activity	Remove infected foci. Topical or systemic antimicrobials, anti-inflammatories, protease inhibitors	Low bacterial counts or controlled inflammation. Decreased inflammatory cytokines. Decreased protease activity. Increased growth factor activity	Bacterial balance and reduced inflammation
Moisture imbalance	Desiccation slows epithelial cell migration. Excessive fluid causes maceration of the wound margin	Apply moisture-balancing dressings. Compression, negative pressure or other methods of removing fluid	Restored epithelial cell migration, desiccation avoided. Oedema, excessive fluid controlled, maceration avoided	Moisture balance
Edge of wound	Desiccation slows epithelial cell migration. Excessive fluid causes maceration of wound margin	Reassess cause or consider corrective therapies: debridement, skin grafts, biological agents, adjunctive therapies	Migrating keratinocytes and responsive wound cells. Restoration of appropriate protease profile	Advancing edge of wound

The "T" in TIME pertains to the external appearance of the wound bed and specifies the type of tissue that is present, which can include granulation, slough, epithelialization, or necrotic tissue.[21] All of these tissue types indicate challenges in the healing process, necessitating appropriate interventions. Various debridement techniques are available, with the most commonly used method in clinical practice being the use of different dressing materials to facilitate autolytic debridement.[21] It is crucial to regularly reassess the wound's condition and the chosen treatment as debridement progresses. However, in cases where the root cause of necrosis, such as insufficient blood supply, remains unaddressed, necrosis may reoccur. Many chronic wounds, including pressure ulcers, leg ulcers, or diabetic foot ulcers, may require periodic debridement.[21]

This aspect of the TIME guideline recognizes that wounds may contain non-viable or deficient tissues that impede the healing process due to an imperfect extracellular matrix and the presence of cell debris. Clinical intervention for this issue typically involves debridement, which can be either episodic or continuous. There are several methods for removing debris, including autolytic, sharp, surgical, enzymatic, mechanical, or biological debridement.

Surgical debridement is a procedure performed by surgeons that involves the removal of non-viable tissues, often requiring anesthesia. Sharp debridement, on the other hand, entails the use of scalpels or scissors to remove dead tissues. Autolytic debridement is the most commonly employed approach in clinical practice. It involves the use of a range of products that create local optimal conditions for the body's endogenous enzymes, such as matrix metalloproteinases (MMPs), to break down non-viable tissues. Maintaining a moist environment is crucial for autolytic debridement, and commonly used materials for this purpose include hydrogels and hydrocolloids, which provide fluid to the wound.

Enzymatic debridement involves the application of exogenous enzymes, such as streptokinase and streptodornase (available in the UK), to enhance enzymatic activity in the wound. These enzymes work to break down fibrin and fibrinogen. Bio-surgical debridement, on the other hand, employs sterile maggots or larvae to remove debris from the wound. The larvae of the greenbottle fly, Lucilia sericata, are commonly used for this purpose. They have several effects on the wound: (a) their movement helps loosen surface debris, (b) they secrete enzymes onto the wound's surface, which liquefy dead tissue, and (c) their secretions alter the wound's pH. The larvae remain in place on the wound for about three days and are then removed.

The TIME framework takes into account the influence of infection and inflammation on wounds and recommends the removal of infected areas because elevated bacterial counts or prolonged inflammation can lead to an increase in inflammatory cytokines, heightened protease activity, and a decrease in growth factor activity. Clinical intervention includes the removal of infected areas, as well as the application of topical and systemic antimicrobial agents and anti-inflammatories, in addition to the use of protease inhibitors.

For wounds experiencing moisture imbalances, which can result from either desiccation (slowing epithelial cell migration) or excessive fluid (causing wound maceration), the TIME guidelines recommend the utilization of moisture-retaining dressings, compression, negative pressure, or other methods to address fluid accumulation.

According to the TIME guideline, when the wound's edge does not progress as anticipated due to factors such as non-migrating keratinocytes, unresponsive wound cells, or abnormalities in the extracellular matrix or abnormal proteases, clinical interventions such as debridement, skin grafting, biological agents, and adjunctive therapies should be considered.[21]

Most open wounds harbor a variety of bacterial species, but whether or not a wound becomes infected depends on the patient's response to these microbes. Patients' overall health, immune system, pharmacological treatments, nutritional status, and the presence of underlying medical conditions all play a role in determining their ability to combat bacterial intrusion. It's not always the case that the presence of bacteria in a wound leads to infection. Early detection of symptoms allows for the use of local topical treatments and can prevent the undesirable side effects often associated with systemic therapy. Following the principle of moist wound healing, maintaining the right balance of moisture is crucial. The formation of a dry scab can hinder the healing process and lead to less favorable outcomes because dehydrated tissues impede the movement of epithelial cells. The majority of wounds contain some level of exudate, which typically supports the healing of acute wounds. Chronic wound exudate tends to have a higher concentration of proteolytic enzymes than normal.[21]

One of the most difficult clinical challenges is managing exudate. Recognizing the causes of elevated fluid levels is crucial for clinicians because managing them is a practical concern. The proliferation of keratinocytes, fibroblasts, and endothelial cells can be slowed or prevented in chronic wounds when there is an excessive amount of fluid present. In order to improve clinical outcomes for patients, wound assessment and review as well as the establishment of reasonable and achievable goals are essential.[21]

It is obvious that the wound is not healing if epidermal cells are unable to migrate across the wound bed. This deficiency could be brought on by clinical infection, critical colonization, or non-responsive keratinocytes and fibroblasts. Excessive inflammatory response, increased proteolytic activity, or dehydration of the wound surface are other factors that could also delay epithelialization.[21]

Any practitioner can use TIME to evaluate wounds in clinical practice. The model's simplicity makes it adaptable for use in a variety of settings, which encourages clinicians to clearly and consistently record their assessments.[21]

The TIMERS framework (Tissue, Inflammation and/or Infection, Moisture, Epithelial, Repair and Regeneration, Social and Individual) is indispensable for surgeons when addressing chronic wounds.[22] A targeted approach to wound care prioritizes debridement, maintaining bacterial balance, and moisture management, with treatment strategies closely aligned with the root cause of the wound.

Hypoalbuminemia, which is a condition characterized by low levels of serum albumin, serves as an indicator for assessing long-term nutritional status, providing insights into an individual's nutritional status over an extended period. A previous study has suggested a link between having a serum albumin level below 3.3 g/dl and the development of pressure injuries. It has been demonstrated that the administration of albumin can significantly reduce the incidence of pressure injuries in ICU patients.[20]

Thirdly, the hot and humid climate in our region contributes to this issue. The combination of elevated temperatures and increased perspiration, along with additional moisture from wound exudate, can result in maceration and exacerbate skin deterioration. This, in turn, can prolong the development of pressure injuries.[17]

Implantation of a shunt in newborns and young children with hydrocephalus is a common and effective medical procedure. Hydrocephalus is a condition characterized by the accumulation of cerebrospinal fluid in the brain, leading to increased intracranial pressure. This can cause various symptoms and complications, including head enlargement, developmental issues, and the risk of pressure ulcers.

The implantation process typically involves surgically placing a shunt system that includes a tube, valve, and reservoir. The valve regulates the flow of cerebrospinal fluid, and the tube directs it away from the brain. Shunt implantation can help manage intracranial pressure, prevent further brain damage, and improve the child's quality of life.

The study suggests that the most effective way to prevent pressure ulcers in newborns and young children with hydrocephalus is the timely implantation of a shunt. Shunt implantation is a vital and highly effective treatment for hydrocephalus, but it should be acknowledged that it does not directly act as a preventative measure for pressure ulcers. The prevention of pressure ulcers in children with hydrocephalus involves additional measures such as proper positioning, skincare, and addressing risk factors like malnutrition and immobility. Healthcare professionals caring for children with hydrocephalus should implement a comprehensive care plan that includes both shunt management and pressure ulcer prevention strategies.

The study's strength lies in its detailed examination of the difficulties and complications associated with pressure injuries in hydrocephalus patients, encompassing factors like wound location, alterations in body composition, and the impact of socioeconomic conditions in developing nations. The introduction of the TIMERS framework and the emphasis on clinical assessment and intervention guidelines offer practical guidance for healthcare providers in effectively managing pressure injuries. It highlights the intricacies and challenges of dealing with pressure injuries in pediatric hydrocephalus patients, although its limitations include a restricted scope for generalization due to the small sample size. Studies of pressure injury in hydrocephalus patient are very limited.

The novelty of this study is found in its thorough examination and the application of clinical guidelines to tackle this issue, providing valuable guidance for healthcare professionals confronting such cases. Overall, the study imparts valuable insights into the complexities of pressure injuries in hydrocephalus patients, but it could benefit from improved organization, enhanced clarity, and a more concise presentation of information. The study takes into consideration a variety of factors contributing to pressure injuries in pediatric hydrocephalus patients, encompassing differences in anatomy and physiology, changes in body composition, infection, inflammation, and nutritional status. This comprehensive approach offers a more holistic understanding of the problem.

CONCLUSION

Healthcare professionals caring for children with complex medical conditions need to take into account the distinct characteristics of pressure injuries in children, particularly in cases of hydrocephalus, as they can present challenges in the diagnostic process. Children with hydrocephalus might encounter scalp injuries and alterations in their body composition, which can complicate the identification of pressure injuries. Factors such as malnutrition, perspiration, and excessive moisture can individually or in combination contribute to skin breakdown. Furthermore, the prompt implementation of a shunt in newborns and young children with hydrocephalus is considered the most effective approach to prevent the occurrence of pressure ulcers. Additionally, surgeons are advised to adhere to the TIMERS guidelines when managing chronic wounds in pediatric patients.

ACKNOWLEDGMENTS

We thank the Surgery Department, Faculty of Medicine and Veterinary Medicine Universitas Nusa Cendana/ Prof. Dr. W.Z Johannes General Hospital, Kupang, East Nusa Tenggara, Indonesia. We also thank our patients' families who consented to us to report these cases in our paper, without whom this work will not be accomplished.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this article.

FUNDING DISCLOSURE

This research has no financial interest or affiliation concerning material.

AUTHOR CONTRIBUTION

The cases in this paper are patients treated together between EBM and RAD. RAD and EBM conceptualized, proposed the main idea, supervised, and revised the final paper. LBK contributed with data acquiring, manuscript preparation writing, revising, and data analyzing. WU was responsible for content revision, AMAA played a role in data analysis, as well as content and grammar revision, and DT and KK were involved in content revision.

REFERENCES

1. Yowantono A. *Karakteristik Pasien Hidrosefalus Di RSUP Dr. Wahidin Sudirohusodo Makassar Tahun 2018–2019*. Universitas Hasanuddin, 2021.
2. Mervis JS PT. Pressure ulcers: Pathophysiology, epidemiology, risk factors, and presentation. *J Am Acad Dermatology* 2019; 81: 881–890.
3. Sanada H, et al. Risk factors in the development of pressure ulcers in an intensive care unit in Pontianak, Indonesia. *Int Wound J*; 4.
4. Amir Y, et al. Pressure ulcer prevalence and quality of care in stroke patients in an Indonesian hospital. *J Wound Care* 2013; 22: 254–260.
5. Shahin ESM, et al. The relationship between malnutrition parameters and pressure ulcers in hospitals and nursing homes. *Nutrition* 2010; 26: 886–889.
6. Delmore B, et al. Pressure Injuries in the Pediatric Population: A National Pressure Ulcer Advisory Panel White Paper. *Adv Ski Wound Care* 2019; 32: 394–408.
7. Pascal E SA. Posterior scalp pressure injury among pediatric head and neck surgical patients. *Int J Pediatr Otorhinolaryngol* 2020; 132.
8. Levy A, Kopplin K GA. Adjustability and Adaptability Are Critical Characteristics of Pediatric Support Surfaces. *Adv Wound Care (New Rochelle)* 2015; 4: 615–622.
9. K F. Pressure injuries in medically complex children: A review. *Child MDPI*; 4.
10. Faghih Jouibari M, et al Huge hydrocephalus: Definition, management, and complications. *Huge Hydroceph Defin Manag Complicat* 2011; 27: 95–100.
11. Kale ED, Nurachmah E PH. The Use of Braden Scale Proven Effective in Predicting the Incident of Pressure Ulcer. *J Keperawatan Indones* 2014; 17: 95–100.
12. Shuk-Fan T, et al. Pressure Ulcer Wound Care for Elderly in Home: A Case Report. *J Dermatology Res Ther*; 2.
13. B F-H. Body composition during growth. In vivo measurements and biochemical data correlated to differential anatomical growth. *Pediatrics* 1971; 47: Suppl 2:264+.
14. Debernard L, et al. Analysis of thigh muscle stiffness from childhood to adulthood using magnetic resonance elastography (MRE) technique. *Clin Biomech (Bristol, Avon)* 2011; 26: 836–840.
15. Zhu YH, Song SP, Luo W, Elias PM MM. Characterization of skin friction coefficient, and relationship to stratum

corneum hydration in a normal Chinese population. *Ski Pharmacol Physiol* 2011; 24: 81–86.
16. Finbråten AK, et al. Assessment of body composition in children with cerebral palsy: A cross-sectional study in Norway. *Dev Med Child Neurol* 2015; 57: 858–64.
17. Bhattacharya S MR. Pressure ulcers: Current understanding and newer modalities of treatment. *Indian J Plast Surgery Medknow Publ* 2015; 48: 4–16.
18. Black J, et al. National Pressure Ulcer Advisory Panel's updated pressure ulcer staging system. *Dermatology nursing/Dermatology Nurses' Assoc*; 19.
19. Edsberg LE, et al. Revised National Pressure Ulcer Advisory Panel Pressure Injury Staging System. *J Wound, Ostomy, Cont Nurs* 2016; 43: 585–97.
20. Serra R, et al. Albumin administration prevents the onset of pressure ulcers in intensive care unit patients. *Int Wound J* 2015; 12: 432–5.
21. Fletcher J. Wound bed preparation and the TIME principles. *Nurs Stand* 2005; 20: 57–65.
22. Caroline D EA. TIME principles of chronic wound bed preparation and treatment. *Br J Nurs Treat* 2004; 13: 16–23.