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Wound Care Management in Children with Extravasation Injury: A Case Study

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Abstract

Extravasation injury is a serious complication of intravenous therapy in children that may cause tissue damage, necrosis, and impaired limb function. The application of systematic wound management using the TIME (Tissue, Infection/Inflammation, Moisture, and Edge) framework may support optimal wound healing; however, evidence regarding its use in pediatric extravasation injuries remains limited. This study aimed to evaluate the effectiveness of TIME-based modern wound care using gel dressing compared with conventional silver sulfadiazine treatment in pediatric extravasation injury management. A descriptive case study was conducted on a 2-month-old infant with lower extremity extravasation injury at RSUD Kabupaten Bekasi, Indonesia. Data were collected through clinical observation, wound assessment, medical record review, and FLACC pain scale evaluation. The wound healing progress between gel-based dressing following TIME principles and silver sulfadiazine dressing was compared during a two-week observation period. Gel-based TIME wound care demonstrated faster necrotic tissue removal, improved granulation tissue formation, and better wound appearance compared with silver sulfadiazine treatment. The gel-treated area also showed lower procedural pain, with a FLACC score of 3 compared with 9 in the silver sulfadiazine-treated area. TIME-based wound care with gel dressing showed potential effectiveness in accelerating healing and reducing procedural pain in pediatric extravasation injuries. This approach may support evidence-based pediatric wound management, although further studies with larger samples are required.

INTRODUCTION

Extravasation is the leakage of intravenous fluids or medications into the subcutaneous tissue, which frequently occurs in neonates and children and carries the risk of tissue damage and necrosis (Cianci et al., 2023). Individual studies report extravasation incidence rates of 18–46% among neonates receiving intravenous therapy in intensive care settings, with severe complications such as necrosis and ulceration developing in 2.4–4% of cases; in the long term these complications can lead to contractures, deformity, and loss of limb function through unfavorable scar formation (Hackenberg et al., 2021). Neonates and infants are particularly vulnerable because of their small and fragile vessels, difficulty with cannula fixation, frequently prolonged intravenous therapy, and their limited ability to communicate pain or discomfort (Hackenberg et al., 2021).

Peripheral venous extravasation injury results from the inadvertent leakage of infuscate into the surrounding subcutaneous and soft tissue, and its severity is determined by the volume, osmolarity, pH, and vasoactive or cytotoxic properties of the infused solution, as well as by the duration of tissue exposure before the infiltration is recognized (Billingham & Mittal, 2022). In children, extravasation can progress rapidly from localized swelling and discoloration to compartment syndrome, full-thickness skin loss, and eschar formation that requires surgical debridement or escharotomy, as also illustrated in pediatric case reports of acute compartment syndrome following fluid extravasation (Cianci et al., 2023).

The wound healing process that follows an extravasation injury proceeds through three overlapping phases: the inflammatory phase, in which hemostasis is achieved and the wound bed is cleared of debris and bacteria; the proliferative phase, characterized by the formation of granulation tissue, angiogenesis, and re-epithelialization; and the remodeling phase, in which collagen is reorganized to restore tissue strength. When one or more of these phases is prolonged or dysregulated for example by persistent necrotic tissue, infection, or an unfavorable moisture balance the wound fails to progress toward closure, a condition described as an aberration of the normal wound healing process (Fernandez Guarino et al., 2024).

To prevent such aberrations, a systematic approach to wound bed preparation is required. The TIME framework Tissue, Infection/inflammation, Moisture balance, and Edge of the wound were developed to give clinicians a structured method for assessing and treating wounds that fail to heal spontaneously, guiding the selection of debridement techniques, infection control measures, and dressings suited to the wound's moisture requirements (Schultz et al., 2004). Although the TIME framework is widely adopted for chronic wounds in adults, evidence on its implementation shows that translating the framework into consistent bedside practice remains a persistent barrier for nursing services (Munro, 2021). In parallel, modern moisture-retentive dressings particularly hydrogel and gel-based dressings have increasingly been used alongside or in place of conventional antimicrobial dressings such as silver sulfadiazine, because they maintain a moist wound environment, absorb exudate, and support autolytic debridement (Arabpour et al., 2024).

However, the evidence base for TIME-guided and hydrogel-based wound care is drawn predominantly from adult populations with chronic wounds such as diabetic ulcers (Astuti et al., 2024), and a systematic review of extravasation injury management in neonates and children found no clinical trials and no consensus on treatment or wound staging, with the available evidence limited to case series and case reports (Dufficy et al., 2022). This gap is clinically significant because children's thinner skin, smaller vessel caliber, and inability to verbally report pain make them a distinct population whose response to wound care cannot simply be assumed to mirror that of adults (Hackenberg et al., 2021). A case study that documents a structured, TIME-based approach to a pediatric extravasation wound, evaluated against conventional silver sulfadiazine care, therefore contributes clinically relevant evidence to an area where high-quality data remain scarce.

In addition to systematic wound care, pain assessment should be performed to evaluate patient comfort during dressing changes, since unrecognized procedural pain can compound the physiological stress already experienced by a vulnerable infant. The Face, Legs, Activity, Cry, Consolability (FLACC) scale is a validated behavioral pain assessment tool for children aged 2 months to 7 years who are unable to verbally report pain, scoring five behavioral domains to produce a total score ranging from 0 (no pain) to 10 (severe pain) (Merkel et al., 1997). This case study aims to determine the effectiveness of modern wound care using the TIME method, compared with conventional silver sulfadiazine-based care, in accelerating granulation tissue formation and reducing procedural pain in an infant with an extravasation injury of the lower extremity (Li et al., 2025; Lin et al., 2025; McNamara et al., 2020).

One of the structured approaches developed to improve wound healing outcomes is the TIME framework, consisting of Tissue management, Infection/inflammation control, Moisture balance, and Edge advancement (Atkin et al., 2019). This framework provides healthcare professionals with a systematic method to evaluate wound conditions and determine appropriate interventions, including debridement strategies, infection prevention, and dressing selection. Although TIME has been widely adopted in chronic wound management, its application in pediatric extravasation injuries remains limited (Dufficy et al., 2022). Existing evidence has primarily focused on adult populations with chronic wounds, such as diabetic ulcers (Chen et al., 2024), rather than acute infusion-related injuries in children (Hackenberg et al., 2021). Furthermore, children cannot simply be considered equivalent to adults because differences in skin thickness, vascular characteristics, physiological responses, and pain communication ability may influence treatment outcomes (Stamatas et al., 2023). This limitation highlights the need for research specifically addressing TIME-based wound management among pediatric extravasation cases.

Previous studies have investigated various approaches for improving wound healing through advanced dressing technologies. Astuti et al. (2024) demonstrated that hydrogel-based dressings improved wound conditions and reduced wound scores among patients with diabetic ulcers, suggesting that moisture-retentive dressings may accelerate tissue recovery. Similarly, Arabpour et al. (2024) explained that hydrogel materials possess important characteristics, including biocompatibility, moisture retention capability, exudate absorption, and support for cellular migration and proliferation during wound healing. Hua et al. (2025) further highlighted that intelligent hydrogel dressings have potential therapeutic benefits because they can respond to wound microenvironments and optimize tissue regeneration. These studies indicate that hydrogel-based approaches provide promising alternatives for wound management; however, most available evidence remains concentrated on chronic wounds rather than pediatric extravasation injuries.

In contrast, conventional silver sulfadiazine treatment remains widely used in wound care because of its antimicrobial properties, particularly in burn and contaminated wounds. However, recent evidence has questioned its effectiveness in supporting optimal wound regeneration. Khansa et al. (2019) reported that silver sulfadiazine may negatively influence wound healing due to potential cytotoxic effects on keratinocytes and fibroblasts, which are essential cells for

epithelialization and granulation tissue formation. In the context of extravasation injuries, this limitation becomes important because successful wound recovery depends not only on infection prevention but also on effective removal of necrotic tissue and stimulation of tissue regeneration. The current clinical challenge is therefore determining whether modern moisture-based wound care approaches can provide better outcomes than conventional therapies in pediatric extravasation cases.

Despite increasing interest in modern wound care technologies, significant research gaps remain. A systematic review conducted by Dufficy et al. (2022) found that evidence regarding extravasation injury management in neonates and children remains limited, with no clinical trials and no established consensus regarding treatment protocols or wound staging. Most available evidence consists only of case reports and case series, limiting the ability to establish standardized pediatric wound care guidelines. Additionally, previous studies have rarely compared different wound care approaches within the same pediatric patient, making it difficult to distinguish treatment effects from patient-related factors. This evidence gap demonstrates the necessity of clinical studies documenting practical wound management approaches that can be applied in real healthcare settings, particularly in hospitals without specialized wound care units.

The urgency of this research is strengthened by the potential consequences of inadequate extravasation management. Untreated or poorly managed injuries may lead to prolonged wound healing, scar formation, contractures, deformities, and loss of limb function. Pediatric patients represent a particularly vulnerable population because delayed wound recovery may affect growth, mobility, and future quality of life. Furthermore, the absence of standardized pediatric extravasation management guidelines forces healthcare teams to rely on individual clinical judgment and experience. Therefore, generating clinical evidence regarding structured wound care strategies is important to support evidence-based nursing practice, improve patient safety, and reduce variations in pediatric wound management.

The novelty of this research lies in its application of the TIME framework combined with gel-based dressing management for pediatric extravasation injury through a within-patient comparative case study design. Unlike previous studies that primarily examined adult chronic wounds or separate patient comparisons, this study compares gel-based TIME-guided treatment and silver sulfadiazine treatment in the same infant under comparable clinical conditions. This approach provides a more controlled clinical observation by minimizing differences related to patient characteristics. Additionally, the study demonstrates the feasibility of implementing structured wound assessment and modern dressing techniques in a regional hospital setting in Indonesia using locally available materials. Thus, the research contributes new practical evidence regarding pediatric wound management in resource-limited healthcare environments.

Based on these considerations, this study aims to evaluate the effectiveness of modern wound care using the TIME principle with gel-based dressing compared with conventional silver sulfadiazine-based care in accelerating wound healing and reducing procedural pain among pediatric patients experiencing extravasation injury. The research specifically examines changes in wound condition, necrotic tissue removal, granulation tissue formation, and pain responses

during wound dressing procedures. The findings are expected to provide evidence supporting clinical decision-making among nurses, pediatricians, and wound care professionals when selecting appropriate interventions for pediatric extravasation injuries. Furthermore, this research contributes to the development of pediatric wound care protocols by demonstrating the practical application of systematic wound assessment and advanced dressing strategies.

The contribution of this research extends beyond individual patient management by providing valuable insights for healthcare institutions seeking to improve pediatric wound care quality. The findings may support the integration of TIME-based wound assessment, hydrogel dressing utilization, and FLACC pain monitoring into pediatric nursing protocols. Although the study is limited by its single-case design and short observation period, it provides an important foundation for future comparative or quasi-experimental research involving larger pediatric populations and longer follow-up periods. Ultimately, this research contributes to advancing evidence-based pediatric wound management by addressing an underexplored clinical problem and offering practical recommendations for improving healing outcomes, patient comfort, and healthcare quality.

METHOD

This report used a descriptive case study design to document the clinical course and wound care management of a pediatric patient who experienced a peripheral intravenous extravasation injury during hospitalization. The case was managed at the Pediatric Care Unit and Pediatric Intensive Care Unit (PICU) of RSUD Kabupaten Bekasi, Indonesia, involving a multidisciplinary team consisting of the treating pediatrician, a plastic surgeon, and wound care nurses.

This case study was conducted on An. A, aged 2 months with a diagnosis of Observation of convulsions and Mild to Moderate Acute Dehydration Diarrhea (DADRS), admitted through the Emergency Room, treated in the Pediatric Care Room receiving anticonvulsant therapy, IV fluids, antibiotics and Vitamin K1 (IM).

On January 18, 2025, phlebitis and extravasation occurred, and wound care was performed. On January 21, 2025, the wound became darker, and debridement and eschariotomy were performed by a plastic surgeon. The patient was apneic in the operating room. Intubation was performed, and the patient was transferred to the PICU. On January 22, 2025, the wound was treated using tulle and silver sulfadiazim, covered with gauze not too tightly (according to the plastic surgeon's advice). On January 23, 2025, the wound was treated with gel, but the plastic surgeon disagreed. On January 25, 2025, a Zoom meeting was held to discuss the patient's condition, including wound care. The plastic surgeon challenged the wound nurse to divide the wound care into two, using silver sulfadiazim and using gel. On January 27, 2025, the condition of the wound: with gel treatment, dead tissue was removed; while with silver sulfadiazim treatment, dead tissue had not been removed and appeared black.

Data were obtained through direct clinical observation, physical wound assessment, and the patient’s medical record. Wound assessment covered anatomical location, wound bed tissue type and base color, wound grade and depth, exudate amount, odor, wound edge condition, and the

condition of the periwound skin, consistent with the parameters emphasized in the TIME framework (Schultz et al., 2004). Procedural pain during wound care was assessed using the FLACC behavioral pain scale, which is appropriate for infants who cannot verbally report pain (Merkel et al., 1997).

Data were analyzed descriptively by comparing the wound assessment findings and FLACC pain scores obtained from the two wound care approaches applied to the same patient modern wound care using gel-based dressings following TIME principles, and conventional care using silver sulfadiazine over the two-week observation period, and by narratively comparing these findings with results reported in the existing wound care literature.

Patient data are reported using initials in accordance with case study reporting ethics, and clinical images were used solely for wound assessment and documentation purposes.

RESULTS AND DISCUSSION

At the beginning of the wound care procedure, a wound assessment was performed and the following results were obtained: location of the lower left extremity; base color of the wound is necrotic/yellow/slough tissue; grade 2 wound with deep partial thickness ; minimal exudate; no odor; thick wound edges; pain during wound care (using silver sulfadiazim pain scale 9, using gel pain scale 3); the area around the wound appears reddish and purplish indicating inflammation and possible local ischemia. The goal of wound care to be achieved is to remove dead tissue and prevent infection. Wound care actions carried out include: washing using 0.9% NaCl; debridement technique: Conservative Sharp Wound Debridement (CSWD); dressing selection: comparison of mid to lower wounds: Gel + gauze + transparent dressing; Mid to upper wounds: Silver sulfadiazim + tulle + gauze + Hipafix as well as collaboration for antibiotic administration. After 2 weeks of wound care with CSWD followed by topical gel showed significant tissue granulation.

The wound was staged as a grade 2 injury with deep partial-thickness involvement. Because adult-oriented staging systems such as the Millam scale have limited applicability in children, pediatric-specific classification approaches instead grade extravasation injuries by criteria such as the number of joints involved and the proportion of limb circumference affected, reflecting the fact that a similarly sized injury is proportionally more severe in a small infant limb than in an adult limb (Amjad et al., 2011). Applying this pediatric perspective to the present case reinforces why the injury despite covering a relatively small absolute area carried a meaningful risk of functional impairment and warranted an aggressive, systematic wound care response.

Table 1 summarizes the initial wound assessment findings mapped onto the four components of the TIME framework, which subsequently guided the selection of wound care interventions described above.

Table 1. Wound Assessment Findings Mapped to the TIME Framework

TIME Component	Clinical Assessment Finding	Clinical Significance
Tissue (T)	Necrotic, yellow, slough tissue; grade 2 wound with deep partial thickness (Amjad et al., 2011)	Indicates a substantial nonviable tissue burden that must be debrided before granulation can proceed

Infection/Inflammation (I)	No malodor; periwound skin reddish and purplish, consistent with inflammation and possible local ischemia	No clinical sign of active infection identified; inflammatory response localized to the injury site
Moisture (M)	Minimal wound exudate	Relatively dry wound bed, favoring a moisture-retentive dressing to support autolytic debridement
Edge (E)	Thick, non-advancing wound edges	Suggests epithelial migration was impeded prior to intervention

This case adds to the literature in two respects. First, it is, to the authors' knowledge, among the few documented applications of the TIME framework to an extravasation injury in an infant outside a specialized wound care unit, at a regional referral hospital in Indonesia, illustrating that structured wound bed preparation principles developed largely in high-resource settings can be implemented with locally available materials such as hydrogel sheets, gauze, and transparent film. Second, the within-patient, split-wound comparison design offers a more controlled observation than a typical single-treatment case report, since both wound care approaches were applied concurrently to the same infant under comparable general health conditions, reducing some of the confounding that would arise from comparing separate patients.

For Indonesian pediatric nursing practice specifically, these findings are consistent with locally reported evidence that gel-based dressings improve wound outcomes and reduce wound scores compared with conventional care (Astuti et al., 2024), suggesting that the results observed in this case are not an isolated finding but align with a broader, if still limited, body of regional evidence. Wider adoption of TIME-guided, hydrogel-based wound care for pediatric extravasation injuries in Indonesian hospitals would likely require institutional wound care protocols, staff training on TIME-based assessment, and reliable local supply of moisture-retentive dressings, echoing the implementation barriers previously reported for district nursing services elsewhere (Munro, 2021). Embedding FLACC-based pain monitoring into routine nursing documentation, as applied in this case, would additionally support more consistent evaluation of procedural pain during dressing changes across wards that do not have access to a dedicated wound care team.

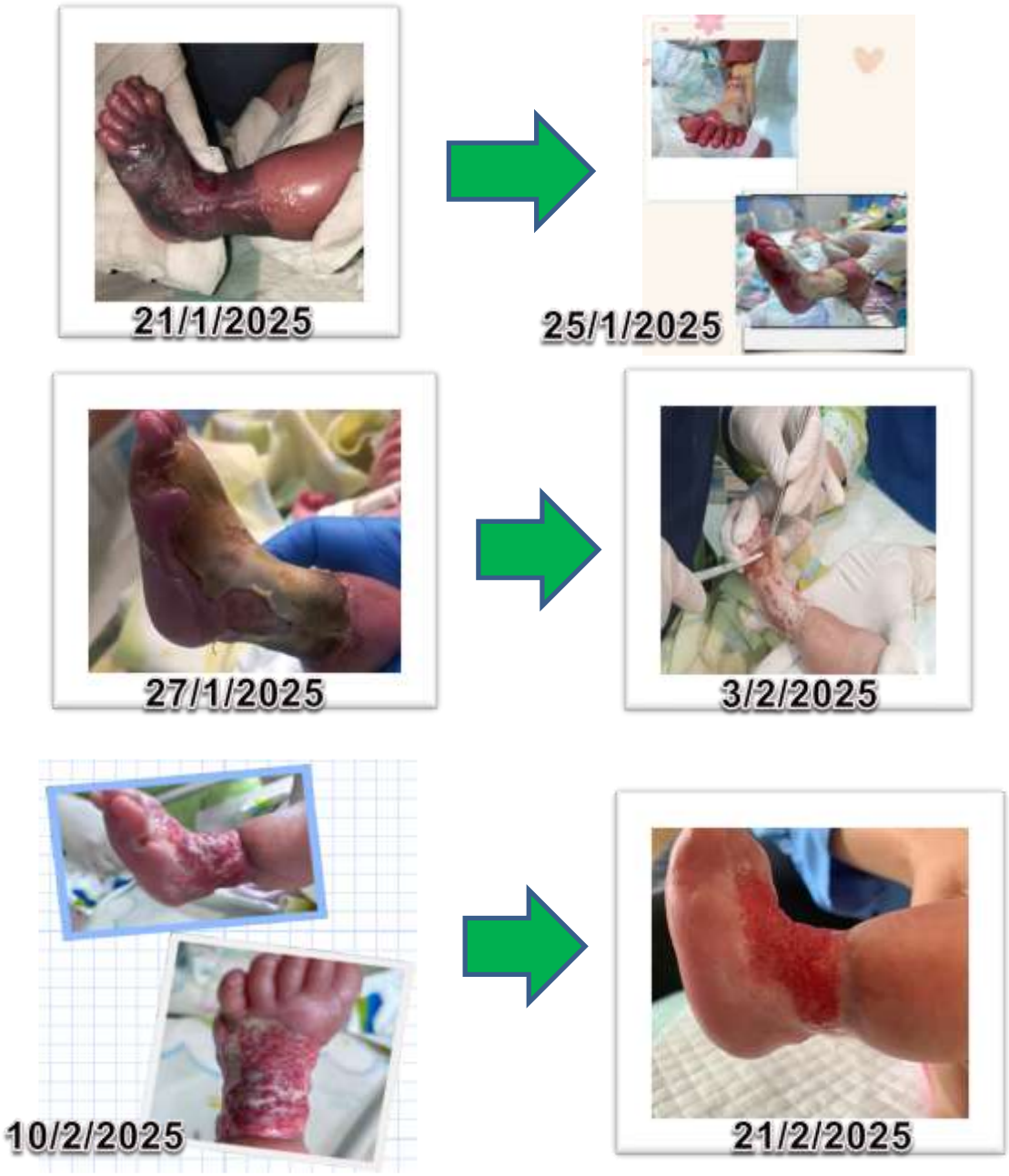

Figure 1. Comparison of wound condition over the two-week observation period between the area treated with gel-based dressing and the area treated with silver sulfadiazine dressing.

Table 2 compares the two wound care approaches applied within this case silver sulfadiazine-based care and gel-based care following TIME principles across the parameters documented during the two-week observation period.

Table 2. Comparison of Wound Care Approaches Applied in This Case

Parameter	Silver Sulfadiazine-Based Care	Gel-Based Care (TIME Principle)
Dressing composition	Silver sulfadiazine, tulle, gauze, Hipafix	Hydrogel-based gel, gauze, transparent dressing
Debridement approach	Passive, dependent on scheduled dressing changes	Conservative Sharp Wound Debridement (CSWD) combined with autolytic debridement
FLACC pain score during dressing change	9 (severe pain)	3 (mild pain)
Necrotic tissue status (27 January 2025)	Dead tissue not removed; wound appeared black	Dead tissue removed
Systemic antibiotic coverage	Given, per collaborative order	Given, per collaborative order

The results of this case study are in line with research conducted by Astuti, Hidayah & Puspasari (2024) which proves that the use of gel-based dressings can maximize the wound healing process and reduce wound scores in patients with diabetic ulcers. Another study proves that gel-based dressings can be used for wound care for the upper gastrointestinal tract (Ma et al., 2026). Meanwhile, Hua et al. (2025) conveyed that hydrogel dressings are intelligent self-healing as a new design strategy that is able to detect and respond to changes in the wound microenvironment, showing significant potential in the treatment of diabetic wounds. In the self - healing process , hydrogels ensure continuous wound closure and protection, reduce the risk of infection, and optimize the healing environment.

The results of this case study indicate that the use of hydrogel accelerates wound healing because hydrogel is a three-dimensional polymer network with hydrophilic properties, capable of holding large amounts of water within its structure while maintaining its shape. This hydrogel is biocompatible, biodegradable, and exhibits beneficial properties. These properties include elasticity similar to natural tissue; maintenance of a moist environment; absorption of wound exudate; and a porous structure that facilitates gas exchange, acts as a barrier against bacterial infection, and creates a conducive environment for enhancing cellular functions such as migration and proliferation. In addition, hydrogel helps with wound hydration, promoting a moist environment that supports the removal of wound debris through autolysis (Arabpour et al., 2024).

The comparatively slower clearance of necrotic tissue observed with silver sulfadiazine in this case is also consistent with a broader body of evidence questioning its wound-healing profile. Although silver sulfadiazine remains a widely used topical antimicrobial for burns and infected wounds, a comprehensive review of the silver wound-care literature concluded that silver sulfadiazine specifically impairs wound healing and should not be used for burns, largely because of its cytotoxic effect on keratinocytes and fibroblasts, the very cells responsible for re-epithelialization and granulation tissue formation (Khansa et al., 2019). This mechanism offers a plausible explanation for why the silver sulfadiazine-treated portion of the wound in this case retained black, non-viable tissue for longer than the gel-treated portion, even though both areas received comparable washing and debridement technique.

The clinical course of this case also illustrates how the absence of pediatric-specific extravasation management guidelines translates into practice. Because no single evidence-based protocol was available, the treating team resolved disagreement between the plastic surgeon and the wound care nurse by pragmatically dividing the wound into two treatment areas and directly comparing outcomes at the bedside, a process formalized through a multidisciplinary discussion involving the wound nurse and the plastic surgeon. This ad hoc, within-patient comparison mirrors, on a small scale, the broader evidence gap identified in the literature: because no clinical trials or consensus guidelines exist for pediatric extravasation wound management, individual clinical teams are often left to generate their own comparative evidence at the point of care (Dufficy et al., 2022; Hackenberg et al., 2021). While this approach allowed the team to reach a locally meaningful conclusion, it also underscores the urgency of the further research called for above, so that future clinicians are not required to improvise similar comparisons for every child who presents with a comparable injury.

Beyond the wound itself, the extended hospitalization of an infant who progressed from the Emergency Room to the Pediatric Care Room and ultimately to the PICU carries implications for the family that are worth acknowledging in wound care planning. Systematic review evidence on family-centered care in neonatal and pediatric intensive care shows that structured parental involvement in an infant's care is associated with improved parent satisfaction and mental health, alongside better infant feeding and shorter length of stay, without any evidence of worsened infant outcomes (Hodgson et al., 2025). Extending this principle to wound care, explaining the rationale for the TIME-based approach to the family, preparing them for the appearance of the wound at each dressing change, and involving them in simple comforting measures during procedures may help reduce parental distress during a prolonged and visually difficult treatment course, alongside the direct clinical benefits already discussed. For pediatric nursing practice, this suggests that TIME-guided wound protocols and FLACC-based pain monitoring, discussed earlier as recommended additions to local wound care protocols, should be paired with routine, structured communication with the family rather than implemented as a purely technical intervention.

These findings are consistent with the underlying goal of the proliferative phase of wound healing described earlier: hydrogel dressings maintain the moist, protected environment needed for granulation tissue and re-epithelialization to progress, whereas silver sulfadiazine-based dressings, although effective as a topical antimicrobial agent, tend to dry the wound bed and can slow autolytic debridement of necrotic tissue (Fernandez Guarino et al., 2024). The markedly lower FLACC pain score recorded during gel-based dressing changes compared with silver sulfadiazine dressing changes further suggests that gel dressings reduce trauma to the wound bed during removal, which is clinically important in infants who cannot verbally communicate pain (Merkel et al., 1997). For pediatric nursing practice, these results support incorporating TIME-guided, moisture-retentive dressing selection into local wound care protocols for extravasation injuries, alongside routine FLACC-based pain monitoring during dressing changes.

This case study has several limitations. As a single-case report, the findings cannot be generalized to the broader pediatric population, and the comparison between the gel-based and

silver sulfadiazine approaches was drawn from two anatomically distinct regions of the same wound rather than from a randomized or controlled comparison. The observation period was limited to two weeks, so longer-term outcomes such as complete wound closure, scar quality, and limb function were not evaluated. FLACC pain scoring was also performed by the treating clinical team without a second independent rater, which may introduce observer bias.

Given that current evidence on extravasation wound management in children remains limited mainly to case series and case reports, with no clinical trials to date (Dufficy et al., 2022), further research using comparative or quasi-experimental designs with larger pediatric samples and longer follow-up periods is needed to confirm the effectiveness and safety of TIME-based hydrogel wound care for extravasation injuries in neonates and children.

CONCLUSION

This case study showed that modern wound care applying the TIME principle, using gel-based dressings, resulted in faster granulation tissue formation and lower procedural pain scores than conventional care with silver sulfadiazine in an infant with an extravasation injury of the lower extremity, without any resulting impairment of limb function. The evaluation results showed that the gel was more effective in removing necrotic tissue than silver sulfadiazine in this wound, indicating that the choice of dressing significantly influences the speed of debridement, autolysis, and granulation stimulation. In this case, the gel may be a superior alternative to accelerate the wound cleansing process, while silver sulfadiazine remains beneficial as an antimicrobial agent under certain conditions. These findings support the integration of TIME-guided wound assessment and moisture-retentive dressings, together with routine behavioral pain monitoring, into pediatric wound care protocols, particularly in settings where extravasation injuries are managed outside specialized wound care units.

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