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Revisiting the Baxter-Parkland Rescucitation Formula for Optimal Fluid Therapy in Haemodynamic Resuscitation for Burn Case in Resource-Limited Settings

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ABSTRACT

Background: Fluid resuscitation plays a crucial role in managing severe burn injuries, particularly in patients with burns covering more than 20% of their total body surface area (TBSA). The Baxter-Parkland formula remains the globally accepted standard for calculating fluid resuscitation, yet variations in its application have led to confusion, particularly in resource-limited settings.
Case Presentation: We present a case of a 28-year-old female who sustained second- and third-degree burns covering 52.5% of her TBSA following a gas explosion. Upon admission to the emergency department, she received fluid resuscitation based on the modified Baxter-Parkland formula at a rate of 2 mL/kg/%TBSA, with half of the calculated volume administered in the first 8 hours. Clinical assessments included airway management, oxygen supplementation, and burn wound care using silver sulfadiazine and wound dressing. Pain management and stress ulcer prophylaxis were initiated. Within the first hour, the patient demonstrated an adequate urine output indicating effective fluid resuscitation. The patient remained stable and was transferred to a specialized burn unit after nine hours.
Discussion: The Parkland formula recommends 2-4 mL/kg/%TBSA for fluid resuscitation; however, individualized modifications are often necessary to prevent complications such as over-resuscitation, which can lead to fluid overload and organ dysfunction. This case highlights the importance of adapting the formula based on clinical judgment and patient response. The study also emphasizes the necessity for burn centers to provide standardized protocols to minimize inconsistencies in fluid management.
Conclusion: Using a lower fluid volume may be a safer option for fluid therapy in primary care settings, as the risk of overhydration and lung edema practically requires more efforts and contributes worse prognosis than managing the risk of underhydration. Ultimately, we should keep in mind that a patient-centered, dynamically adjusted fluid resuscitation approach still offers the safest and most effective management for burn injuries.

Keywords: burn fluid resuscitation, Baxter-Parkland formula, burn shock, fluid creep, emergency burn management, individualized burn management, intravenous fluid therapy

INTRODUCTION

Fluid therapy is crucial for burn patients to prevent dehydration and hypovolemic shock, especially in those with burns covering 20% or more of their total body surface area (TBSA). Early intervention with appropriate fluid resuscitation is essential in the acute phase of major burns. Statistics indicate that up to 50% of burn patients require fluid resuscitation to prevent burn shock, a leading cause of early mortality in severe burns. The key interventions during this acute phase include "the 3 Fs" –Fluids, Feeding, and Fillet (emergency surgery), which have significantly reduced mortality rates. The primary objective of fluid resuscitation is to provide the minimum amount of fluid necessary to maintain adequate urine output while avoiding complications like under-perfusion or over-perfusion.[1-4]

Various formulas have been used for burn resuscitation, and the one that is globally accepted and utilized is the Baxter-Parkland formula. However, there is still ongoing debate between experts in the plastic surgery field about the most effective application of the Baxter-Parkland formula for optimal outcomes. In many scientific publications and textbooks, the Baxter-Parkland formula prescribes fluid resuscitation based on the calculation of 2-4 times the required volume substitution for fluid loss (2-4 milliliters isotonic solutions for each kilograms of body weight for each percent proportion of TBSA with full-thickness burn wound) in concern of massive extravasation to interstitial space during the acute phase of burn. This "2 to 4" variable often leads to confusion, particularly in smaller hospitals with no burn units and limited resources, such as our Kebayoran Baru Regional Hospital.[1-4]

We presented one case of burn patient with wound larger than 20% of total body surface area who received haemodynamic resuscitation and stabilization using the Baxter-Parkland formula before transferred to the burn unit, the variable range of 2 to 4 times the required substitution for fluid loss necessitates careful consideration and adjustment based on the specific context and available resources.

CASE ILLUSTRATION

A 28-year-old female sustained extensive burn injuries following a gas explosion in her workplace kitchen, and was taken as soon as possible to the emergency department. On assessment, she had second- and third-degree burns on her face, torso, arms, and legs, covering approximately 52.5% of her total body surface area (TBSA), as calculated using Wallace's Rule of Nines[5] (see **Table 1**). She further admitted no history of comorbidities, medication use, or allergies.

We began emergency trauma management immediately, evaluating and maintaining no possible harm in her airway, provided supplemental oxygen via a nasal cannula at 3 liters per minute, to maintain adequate breathing mechanism and cellular perfusion, then applied intravenous fluid resuscitation with the modified Parkland formula, using a rate of 2 milliliters for each kilogram of body weight for each percent proportion of TBSA; taking into consideration a previously calculated burn wound proportion of 52.5% and her body weight of for her 47 kilograms. The emergency team set half of the calculated fluid replacement volume to be given in the first 8 hours after the burn injury and the remaining half to be given in the slower rate during the next 16 hours.

We removed burned clothing adhering to her skin, treated the wounds meticulously with silver sulfadiazine cream except in facial region which received Moist Exposed Burn Ointment (MEBO®), then covered them with moist gauze with cool saline. We also administered intravenous ketorolac every 8 hour to relieve pain and intravenous ranitidine to anticipate Curling's ulcer and stress-induced gut mucosal injury. We also inserted urinary catheter to accurately monitor renal output

Table 1. Depth and percentage calculation of burn wound in ER

Body Part	Burn depth / degree	Description	Percentage calculation in ER
Face	2^{nd} degree	The facial burns involved superficial partial-thickness (second-degree), as evidenced by areas of epidermal and dermal loss. The right eyebrow is completely burned, indicating potential inhalation injury.	4.5%
Neck	2^{nd} degree	The neck showed superficial partial-thickness (second-degree) burn wound, displaying multiple intact bullae.	1%
Left Upper Limb	2^{nd} & 3^{rd} degree	The left hand displays superficial partial-thickness burns with widespread erythema and large, ruptured bullae. The lower left arm exhibits full-thickness burns, with the skin nearly detached and a white, insensate base, with no blanching response.	4%
right upper limb	2^{nd} degree	The right elbow is affected by deep partial-thickness burns, as evidenced by darkened skin, though capillary refill is preserved. Large bullae are also present on adjacent areas.	6.5%
posterior trunk	2^{nd} degree	The back demonstrates mixed superficial and deep partial-thickness burns, with multiple erythematous and dark red areas, accompanied by numerous bullae.	8%
Anterior trunk	2^{nd} degree	The chest and abdomen feature extensive superficial and deep partial-thickness burns, characterized by erythema, dark red discoloration, and multiple bullae.	12%
Buttock	2^{nd} degree	The buttocks present with superficial partial-thickness burns, indicated by small bullae and erythematous skin.	2.5%
left lower limb	2^{nd} degree	The left leg has superficial partial-thickness burns with erythematous skin and several bullae, some of which have ruptured, leading to epidermal loss.	9%
right lower limb	2^{nd} degree	The right leg shows superficial partial-thickness burns with erythema and bullae on the anterior surface.	5%
TOTAL			52.5%

Fig 1. Burn area on the right hemifacial.

Fig 2. Burn area on the left hemifacial with notable dermal loss.

Fig 3. Burn wound on the extensor side of the right upper arm and forearm.

Fig 4. Burn wound on the extensor side of the right forearm with notable blisters.

Fig 5. Burn wound on the posterior trunk with notable blisters

Fig 6. Burn wound on the extensor side of the left upper arm with notable blisters

Fig 4b. Burn wound on the volar side of the left forearm and left hand with notable skin detachment

RESULTS

We noted that within the first hour of resuscitation, urine output from our 47-kilogram patient reached 30 milliliters, suggesting clinical improvement and responsive resuscitation. Over the next few hours, urine

output remained within the target range of 0.5 to 1 milliliter for each kilogram of body weight in each hour, confirming effective fluid resuscitation.
Considering the severity of her burns, particularly the involvement of critical areas such as the face, hands, feet, and major joints, as well as concerns about inhalation injury, we confirmed she met the criteria for transfer to a hospital with a more specialized burn unit. After nine hours of resuscitation and stabilization in the emergency department, we referred and transported the patient to a burn unit in North Jakarta, located 21 kilometers away. Throughout the transfer, she remained in stable condition without signs of fluid overload like dyspnea or dehydration.
After the safe transfer to a hospital with a burn unit, the ER team invited our plastic surgeon author for retrospective analysis and discussion.

DISCUSSION

Burn injuries frequently present in emergency departments, especially in primary hospitals.[6] RSUD Kebayoran Baru, the only government-operated Type D hospital in the strategic "golden triangle" of South Jakarta serves as a primary healthcare facility for burn patients. Its wide catchment area, covering residential neighborhoods, offices, and commercial centers, contributes to a diverse patient demographic with a high incidence of burn injuries.
Our team use the Rule of Nines to assess the total body surface area (TBSA) involved in burn patients. The measurement of the initial burn surface area is important in estimating fluid resuscitation requirements, as patients with severe burns will have insensible fluid losses due to loss of the skin barrier. Moreover, an accurate assessment provides data that will assist in determining the eventual outcomes. Both inadequate estimates and overestimation have their own shortcomings, as under-resuscitation can lead to progressive shock and, ultimately, end-organ damage, and excessive resuscitation places the patient at risk for developing acute respiratory distress syndrome and abdominal compartment syndrome. The Rule of Nines was first discussed by Pulaski and Tennison in 1947 and later presented at the National Burns Research Council at a symposium[7]; in 1951, Wallace first published them in the Lancet, and ever since it has also been known as the Rule of Nines from Wallace.[5]
Fluid resuscitation is essential in burn trauma to replace fluid losses from capillary leakage due to inflammation.[1–3] Clinicians must administer resuscitation fluids for deep partial and full-thickness burns exceeding 20% TBSA while avoiding over-resuscitation.[1–4,6,7]
Several formulas are available for burn fluid resuscitation (**Table 2**).[1]

Table 2. List of commonly used fluid replacement formula for burn shock resuscitation with composition during the 1st and 2nd d ays.[1]

Formula	1st day			2nd day		
	Crystalloid	Colloid	Glucose in water	Crystalloid	Colloid	Glucose in water
Evans	1 mL NS solution / %TBSA / kg body weight	1 mL / %TBSA / kg body weight	2,000 mL	half of the 1st day required volume of crystalloid	half of the 1st day required volume of colloid	2,000 mL
Brooke	1.5 mL RL solution / kg	0.5 mL / kg body	2,000 mL	50 - 75% of the 1st day	50 - 75% of the 1st day	2,000 mL

	body weight / %TBSA	weight / %TBSA		required volume of crystalloid	required volume of colloid	
Baxter - Parkland (1968)	4 mL RL solution / kg body weight / %TBSA	-	-	-	20 - 60% of calculated plasma	Titrated to adjust UO
Modified Brooke	2 mL RL solution / kg body weight / %TBSA	-	-	-	0.3 - 0.5 mL / kg body weight / %TBSA	Titrated to maintain UO
Monaro	Na 250mEq/litre to maintain UO	-	-	Titrate to maintain UO with ½ normal saline	-	
Warden	RL + 50mEq $NaHCO_3$ for first 8 h to maintain UO at 30-50 cc/hr. After first 8 h RL to maintain UO at 30-50 cc/hr	-	-	-	-	
Demling (1987)	Dextran 40 in saline solution 2 mL / kg body weight / hour for the first 8 hours after trauma.	FFP 0.5 mL / kg body weight / hour for the next 18 hours after finishing Dextran 40 in the first 8 hours	-	RL solution at 30 mL / hour to maintain UO	-	

NS: normal saline, NaCl 0.9%
RL: Ringer's lactate
FFP: fresh frozen plasma
UO: urine output

Since the initial calculation of burn wound area in our patient at the time of admission covered larger than 20% of her total body surface area, our team agreed on the need for resuscitative fluid replacement therapy, using the most commonly used Parkland formula. The Parkland formula, also known as Baxter-Parkland since it was introduced in 1968 by doctors Charles Baxter and Tom Shires from the Parkland Memorial Hospital Texas, revolutionized burn care by providing a clear guideline for fluid administration during the critical early phase of burn injuries to prevent shock and multi-organ failure. The formula generally uses Ringer's Lactate as the primary resuscitation fluid, with half of the total calculated fluid volume being given within the first 8 hours and the remaining half within the next 16 hours.[1–4,6,8,9] Interestingly, medical reference varied about the Parkland formula and often created confusion, as many wrote the formula as 2 to 4 milliliters Ringer's Lactate for each kilograms of body weight for each percent proportion of TBSA with full-thickness burn wound.[2]

Principle of fluid replacement therapy is substituting the deficit of circulation volume with the exact amount of intravenously infused volume of fluid with the same characteristics. However, managing a burn shock is quite a challenge because it is very much different from managing a hypovolemic shock. Studies showed that during acute burn injuries, burn shocks happen due to activity of local and systemic mediators of inflammation creating endothelial leak to facilitate extravasation of white blood cells and blood plasma to the burned tissue. As the leakage outspreads, blood proteins also exits and sequestered in burned and non-burned tissue triggering fluid shifts from intracirculation, interstitial edema and more severe hypovolemia.

Looking back to understand the historical foundation of the formula is necessary to shed away confusion. Baxter and Shires conducted the study to learn the complex physiologic derangements of burn shock and the phenomenon of sodium-containing fluids translocation during the initial resuscitation with isotonic crystalloid solutions. During the study, they noticed that *the restoration and maintenance of the functional extracellular fluid with lactated Ringer's in experimental full-thickness burns required volumes exceeding those usually employed for total resuscitation*, thus, building a principle of fluid therapy in burn shock in which replacement of the circulation volume deficit *should have much larger amount of intravenously infused volume of fluid* with the same characteristics. Baxter and Shires observed that burn shock fluid resuscitation with an average of 3.5 milliliters Ringer's Lactate for each kilograms of body weight for each percent proportion of TBSA with full-thickness burn wound shows an acceptable early survival rate pointed that in selected patients with 30-85% full-thickness burns, then later wrote in the conclusion segment that fluid resuscitation treatment with 4 milliliters of Ringer's Lactate solution per each kilogram of body weight for each percent of total body surface with burn wound during the first 24-36 hour post-burn resulted in significant hemodynamic restoration, However, they added that rapid restoration and improvement of circulatory hemodynamics in burns only effective for patients with up to 65% full-thickness burn wound area.

We decided to apply a modified formula of 2 milliliters Ringer's Lactate for each kilograms of body weight for each percent proportion of TBSA with full-thickness burn wound while still adhering to the other principles. This decision was taken to account the risk of underestimating the burn area, which could result in over-resuscitation of the patient. According to the ATLS 10th edition guidelines, the American Burn Association also recommends using the Parkland formula for initial fluid calculations, which involves 2 ml of Ringer's Lactate multiplied by the patient's body weight in kilograms and the % total body surface area (TBSA) for cases with 2nd and 3rd degree burns.[8] Therefore, the patient required 4935cc of Ringer Lactate for a 24-hour period.

Our patient responded well to the initial fluid therapy, achieving clinical stabilization within the first hour. Vital signs improved, and hourly urine output, with a target of 0.5 milliliters/kilogram body weight/hour, was closely monitored and reached within 8 hours. This progress allowed for the patient's smooth transfer to a specialized burn unit for further care. In resource-limited settings, clinicians often adjust the traditional Parkland formula, as we did, by using 2 milliliters of Ringer's Lactate solution/kilogram body weight/%TBSA to minimize the risk of fluid overload.[5] This case shows the effectiveness of this modified approach, particularly when monitoring resources are limited. Although we were aware there was a potential overestimation of the burn area due to the subjective nature of %TBSA calculation, we selected the use of 2 milliliters of Ringer's Lactate solution/kilogram body weight/%TBSA to help avoiding risk of overhydration by reducing the total fluid volume.[7,9] It was our safeguard against "fluid creep" and over-resuscitation because we were aware the risk of overhydration and lung edema practically would require more efforts and contribute worse prognosis than the risk of underhydration.[1–3]
Based on the referral criteria outlined by *Advanced Trauma Life Support* (ATLS) and *Emergency management of Severe Burn* (EMSB), which adhere to the American Burn Association (ABA) guidelines (Table 3), our patient qualifies for referral to a burn center.[11,13–15] The patient presented with second- and third-degree burns involving more than 20% of total body surface area (TBSA), burns located over major joints, and facial burns with singed nasal hairs, suggestive of potential inhalation injury. These clinical findings meet the established criteria for specialized care, indicating the need for advanced burn management. Following an eight-hour waiting period in the emergency department, we transferred the patient to a Type B hospital with a dedicated Burn Unit in North Jakarta.

Table 3. Burn Center Referral Criteria from ABA[11,15]

• Partial thickness burns greater than 10% TBSA
• Burns that involve the face, hands, feet, genitalia, perineum or major joints
• Third-degree burns in any age-group
• Electrical burns, including lightning injury
• Chemical burns
• Inhalation Injury
• Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
• Any patient with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality.
• Burned children in hospitals without qualified personnel or equipment for the care of children
• Burn injury in patients who will require special social, emotional, or rehabilitative intervention

After the safe transfer to a hospital with a burn unit, the ER team contacted our plastic surgeon author for retrospective analysis and discussion. Further assessment from clinical photographs showed that the actual burn proportion was 20.5%, and the overly calculated burn size during the initial assessment happened due to lack of familiarity in clinical assessment of burn size that should exclude superficial burn wounds or 1st grade burn wound. The post-transfer assessment still justified the referral to the burn unit. We also predicted that the hemodynamic condition of our patient could still progress well as expected as our 2 milliliters solution/kilogram of body weight/%TBSA for 52.5% TBSA burn wound (4935 milliliters) we provided was not too much overhydrating compared to 4 milliliters solution/kilogram of body weight/%TBSA for 20.5% TBSA burn wound (3,854 milliliters) as long as the renal function was good as observed in patient's responsive urine output, and no signs of overhydration like dyspnea due to lung edema. The retrospective assessment also underlined that the best formula for burn initial resuscitation was an individualized fluid therapy that closely monitoring fluid input, clinical hemodynamic condition and urine output.

CONCLUSION

Accurate burn assessment is crucial to prevent miscalculations that could lead to either under- or over-resuscitation. This case underscores the importance of increasing familiarity with clinical burn assessment, particularly in primary care settings or in health facility with limited access to burn specialist expertise, to minimize errors in TBSA estimation. While standardized formulas like the Parkland formula provide a framework for initial resuscitation, historical context reveals that fluid therapy should be individualized rather than strictly formulaic. Given the risks associated with fluid overload and inadequate resuscitation, the most effective approach remains close monitoring of fluid input, hemodynamic stability, and urine output. In resource-limited settings, a modified fluid strategy of lesser volume —such as our utilization of 2cc/kg/%TBSA—can help prevent "fluid creep" while ensuring adequate resuscitation and clinical improvement. Using a lower fluid volume may be a safer option for fluid therapy in primary care settings, as the risk of overhydration and lung edema practically requires more efforts and contributes worse prognosis than managing the risk of underhydration. Ultimately, we should keep in mind that a patient-centered, dynamically adjusted fluid resuscitation approach still offers the safest and most effective management for burn injuries.

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