

Original Article

The impact of resuscitation strategies on burn patient outcomes: Parkland vs. modified Brooke's

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Abstract: Objectives: Over-resuscitation is a formidable complication of burn resuscitation and increased morbidity and mortality. Currently, the Advanced Trauma Life Support recommends using a modified Brooke's formula to minimise its incidence; however, supporting evidence is very limited. We aimed to compare the resuscitative and clinical outcomes between the Parkland and modified Brooke's formulas in patients with burn trauma. Methods: A retrospective cohort study was conducted through a chart review of patients admitted to the burn unit. The patients were divided into two groups: Group 1 (2017-2019) was resuscitated using Parkland's formula and Group 2 (2020-2022) with modified Brooke's formula. The main outcome measures were mortality rate, length of stay, complication rate exceeding the Ivy index (250 mL/kg) in the first 24 h, and overall fluid administered in the first 24 h. Results: We included 125 patients, of whom fifty-five were resuscitated using Parkland's formula and seventy using the modified Brooke's formula. Patients in group 1 had higher resuscitation volume (5.04 vs. 3.37 mL/kg/total body surface area, $P < 0.0001$) and were more likely to exceed the Ivy index (250 mL/kg) (32.73% vs. 12.86%, $P = 0.0074$) in the first 24 h compared to those in group 2. There were no significant differences in clinical outcomes between the two groups. Conclusions: The modified Brooke's formula resulted in lower resuscitative volumes in the first 24 h than Parkland's formula, with no differences in complication rates. Our findings are consistent with currently recommended guidelines.

Keywords: Burn, resuscitation, fluid, parkland formula, modified Brooke formula

Introduction

Early and adequate fluid resuscitation in severely burned patients is a determining factor for survival [1]. The primary aim of fluid resuscitation in patients with burns is to sustain adequate perfusion and avoid end-organ damage using the least amount of fluid needed to avoid over-resuscitation [2]. Despite the existence of several formulae for the prediction of fluid demands in patients with burn injury, the Parkland formula has long been considered the standard of care to estimate fluid needs during the initial 24 h after burn injury. A 2009 global survey of burn care experts revealed that 70% incorporated the Parkland Formula into their resuscitation strategies [3]. However, in recent years, the formula has been questioned regarding whether it accurately estimates fluid needs

or contributes to over-resuscitation - a contribution that has been theorised to be related to the early extravasation of intravascular fluid and resultant oedema formation [4, 5]. Consequently, over-resuscitation in burn patients has been linked to many complications, such as abdominal compartment syndrome (ACS), ocular compartment syndrome (OCS), acute respiratory distress syndrome (ARDS), bacteraemia, mortality, and acute kidney injury (AKI) [2, 6-9].

While the range for Parkland's formula as proposed by Dr. Baxter is 3.7-4.3 mL/Total body surface area (TBSA)/kg for the first 24 h, these certainly are not the actual numbers that burn patients receive nowadays; patients now receive 5-8 mL/TBSA/kg in the first 24 h, which reflects a certain degree of over-resuscitation [4, 5, 10]. In 2009, Chung et al. compared

the outcomes of patients who were resuscitated using Parkland's formula to those who were resuscitated using Modified Brooke's formula and found that Parkland's group received much more fluid in the first 24 h with no significant difference in the complication rate [11]. Consequently, the Advanced Trauma Life Support (ATLS) and American Burn Association (ABA) have updated their guidelines to recommend the use of the modified Brooke's formula for thermally injured adult patients [12, 13]. However, the existing evidence supporting the use of the modified Brooke's formula over Parkland's formula is not well-defined. Therefore, we investigated the benefits and risks associated with the application of these recommendations.

Materials and methods

Aim of the study and outcomes

The primary outcome of our study was to compare the incidence rates of mortality, over-resuscitation, ARDS, AKI, mean ICU LOS, and resuscitative volumes in the first 24 h between the Parkland's formula resuscitation group and modified Brooke's formula resuscitation group. The secondary objective was to investigate the predictors of in-hospital mortality among admitted patients.

Study design

This study received approval from the institutional review board (IRB) of King Saud Medical City (KSMC), Riyadh, in April 2023. Subsequently, a retrospective observational cohort study was conducted by reviewing the charts of patients admitted to the burn intensive care unit (ICU) at KSMC from 1 January 2017 to 31 December 2022. The data were collected by the authors of this study.

Data collection

Patients were divided into two groups based on the formula used. Group 1 was resuscitated using Parkland's formula (4 mL/TBSA/kg) data from 2017-2019 the patient who received fluid resuscitation based on four multiplied by the total body surface area which got burn second degree and more multiplied by the weight of patient by kilogram. Group 2 was resuscitated using a modified Brooke's formula (2 mL/TBSA/kg) data from 2020-2022 the patient

who received fluid resuscitation based on two multiplied by the total body surface area which got burn second degree and more multiplied by the weight of patient by kilogram.

We extracted information about patient demographics, such as sex, age, and weight, from the recorded charts. Burn characteristics such as TBSA were calculated using the Lund and Browder chart, and the presence of inhalational injury was confirmed by direct visualisation with bronchoscopy. Clinical and resuscitative indicators of over-resuscitation or under-resuscitation, such as mortality, ICU length of stay (LOS), cumulative 24 h volumes, ARDS, and AKI developed during admission to our burn ICU, were recorded.

Inclusion and exclusion criteria

Our inclusion criteria were thermal burn victims of both sexes aged ≥ 16 years, with a TBSA of $> 15\%$, and a time lapse between emergency room admission and burn unit admission of ≤ 12 h, unless referral sheets contained detailed fluid infusion rates. Patients who had electrical burns, chemical burns, or died within 24 h were excluded from this study. Charts with missing or incomplete data that could jeopardise the study, such as records of continuous resuscitative volumes, body weight, length of hospital stay, and TBSA documentation, were excluded.

Data cleansing

The Berlin criteria were used for the diagnosis of ARDS [14]. AKI was defined by any of the following: Increase in serum creatinine (Cr) by ≥ 0.3 mg/dL within 48 h, increase in serum Cr to ≥ 1.5 times the baseline level if known within 7 days, or decrease in urine output (UO) below 0.5 mL/kg/h for > 6 h [15]. Over-resuscitation was defined as exceeding the Ivy index which is (250 mL/kg) during the first 24 h, that mean if the total fluid resuscitation for the first 24 hours which was received by the patient exceed 250 mL/kg will considered as over-resuscitation. This index is formally used to predict the likelihood of developing intra-abdominal hypertension, which is another complication of over-resuscitation [16].

Statistical analysis

Data were analysed using the JMP Pro software version 15 (IMP Statistical Discovery

Table 1. Baseline characteristics of the included patients based on the two formulae

Variables	Total (n = 125)	Parkland's (n = 55)	Brooke's (n = 70)	p-value
Age in years, mean (SD)	33.17 (10.86)	32.05 (10.61)	34.05 (11.06)	0.3061
Sex, n (%)				0.6025
Male	102 (81.60)	46 (83.64)	56 (80.00)	
Female	23 (18.40)	9 (16.36)	14 (20.00)	
Total body surface area, mean (SD)	43.40 (19.16)	44 (19.73)	42.92 (18.83)	0.7591
Presence of inhalation injury, n (%)	69 (55.20)	30 (54.55)	39 (55.71)	0.8962

SD: standard deviation.

Table 2. Resuscitation details of included patients based on the two formulae

Variables	Total (n = 125)	Parkland's (n = 55)	Brooke's (n = 70)	p-value
Total colloid given in the first 24 h in (mL), mean (SD)	379.73 (530.33)	444.07 (594.28)	329.17 (472.39)	0.2439
Presence of over-resuscitation in the first 24 h, n (%)	27 (21.60)	18 (32.73)	9 (12.86)	0.0074
Resuscitation volume in the first 24 h in (mL/TBSA/kg), mean (SD)	4.11 (1.88)	5.04 (1.70)	3.37 (1.69)	< 0.0001

SD: standard deviation; TBSA: total body surface area.

LLC, Cary, North Carolina, United States). For descriptive analysis, categorical variables were presented as frequencies and percentages, and numerical variables were presented as means and standard deviations. An independent t-test was used for quantitative and qualitative data analysis. The chi-square test was used for qualitative-qualitative variable analysis. Multiple logistic regression analysis was conducted to assess the effects of age, sex, TBSA, weight, presence of inhalation injury, formula type, and total colloids administered in the first 24 h in predicting over-resuscitation in the first 24 h. A second multiple logistic regression analysis was conducted to assess the effects of age, sex, TBSA, presence of inhalation injury, formula type, presence of over-resuscitation in the first 24 h, and total colloids administered in the first 24 h in predicting mortality. Statistical significance was set at $P < 0.05$, and the corresponding 95% confidence intervals (CIs) were set.

Results

Study population

A total of 125 patients with burns were included in this study, of whom 55 (44.00%) were resuscitated using Parkland's formula and 70 (56.00%) were resuscitated using the modified Brooke's formula. The mean (and standard deviation) age of the patients was 33.17 ± 10.86 years, and 102 (81.60%) were males.

Demographic data

There were no significant differences between the two groups in terms of age, sex, TBSA, or presence of inhalation injury (**Table 1**).

Parkland vs. modified Brooke's

The patients who were resuscitated using Parkland's formula had a significantly higher mean resuscitation volume in the first 24 h (5.04 ± 1.70 vs. 3.37 ± 1.69) mL/kg/TBSA, $P < 0.0001$) and were significantly more likely to have over-resuscitation in the first 24 h (32.73% vs. 12.86%, $P = 0.0074$) than those who were resuscitated using the modified Brooke's formula. However, no significant difference was observed between the two groups in the amount of colloid administered in the first 24 h (**Table 2**).

Of all patients, 27 (21.60%) developed AKI, while 22 (17.60%) developed acute respiratory distress syndrome. The LOS was 17.04 ± 14.24 days, and 30 patients (24.00%) died. There were no significant differences between the two groups in terms of complications, ICU LOS, or mortality (**Table 3**).

The results of the first multiple logistic regression showed that a unit increase in TBSA (odds ratio [OR]: 1.1349, CI: 1.0842-1.2086, $P < 0.0001$), presence of inhalation injury (OR: 11.7478, CI: 2.0619-66.9336, $P = 0.0055$), and Parkland's formula (OR: 18.9204, CI:

Resuscitation on burn patient

Table 3. Complications and outcomes of the included patients based on the two formulae

Variables	Total (n = 125)	Parkland's (n = 55)	Brooke's (n = 70)	p-value
Acute kidney injury, n (%)	27 (21.60)	13 (23.64)	14 (20.00)	0.6238
Acute respiratory distress syndrome, n (%)	22 (17.60)	12 (21.82)	10 (14.29)	0.2723
Length of stay in days, mean (SD)	17.04 (14.24)	18.76 (14.73)	15.70 (13.79)	0.2379
Mortality in total, n (%)	30 (24.00)	14 (25.45)	16 (22.86)	0.7357

SD: standard deviation.

Table 4. Prediction of over-resuscitation in the included patients

Variables	Odds ratio	Lower confidence interval	Upper confidence interval	p-value
Age	0.9917	0.9235	1.0588	0.8086
Sex				
Male	Reference	Reference	Reference	Reference
Female	3.8746	0.6085	24.6689	0.1515
Total body surface area	1.1349	1.0842	1.2086	< 0.0001
Weight	0.9765	0.9319	1.0165	0.2769
Presence of inhalation injury	11.7478	2.0619	66.9336	0.0055
Formula type				
Brooke's	Reference	Reference	Reference	Reference
Parkland's	18.9204	3.0351	117.9456	0.0016
Total colloids given in the first 24 h	1.0003	0.9990	1.0014	0.5852

Table 5. Prediction of mortality in the included patients

	Odds ratio	Lower confidence interval	Upper confidence interval	p-value
Age	1.0839	1.0256	1.1547	0.0067
Sex				
Male	Reference	Reference	Reference	Reference
Female	1.5656	0.3462	7.0802	0.5604
Total body surface area	1.0437	1.0087	1.0873	0.0176
Presence of inhalation injury	19.6181	3.5714	107.7629	0.0006
Formula type				
Brooke's	Reference	Reference	Reference	Reference
Parkland's	1.1339	0.3036	4.2344	0.8517
Presence of over-resuscitation	3.9189	0.7584	20.2485	0.1031
Total colloids given in the first 24 h	1.0004	0.9994	1.0013	0.3248

3.0351-117.9456, $P = 0.0016$) were positive predictors of over-resuscitation (**Table 4**).

The results of the second multiple logistic regression analysis showed that a unit increase in age (OR: 1.0839, CI: 1.0256-1.1547, $P = 0.0067$), a unit increase in TBSA (OR: 1.0437, CI: 1.0087-1.0873, $P = 0.0176$), and the presence of inhalation injury (OR: 19.6181, CI: 3.5714-107.7629, $P = 0.0006$) were positive predictors of mortality (**Table 5**).

Discussion

Over the past few years, fluid resuscitation in patients with burns has swung back and forth between over- and under-resuscitation [2, 17]. Despite the rise of interest in over-resuscitation, only a few studies in the burn literature have discussed the implications of such a trend. Mason et al. found that patients who received fluid volumes lower than 4 mL/TBSA/kg in the first 24 h had higher rates of AKI,

emphasising the implications of under-resuscitation [2]. Nonetheless, this highlights one of the pillars of our study, which we believe successfully transitioned to a more restrictive strategy without compromising the efficacy of our resuscitation efforts.

In our study, we did not find significant differences in the rates of complications, such as mortality, ICU LOS, ARDS, and AKI, between the two groups, which is consistent with findings from the literature [11, 18]. Despite that, we found that patients resuscitated using Parkland's formula received much more fluid volumes in the first 24 h: 5 mL/TBSA/kg vs modified Brooke's formula 3.37 mL/TBSA/kg ($P < 0.0001$), which reiterates the notion of fluid creep and its relevance to the current resuscitative practices in burn care. Multiple studies have shown similar results where patients resuscitated using Parkland's formula received much more fluids than the volume recommended by Dr. Baxter (3.7-4.3 mL/TBSA/kg) [11, 19, 20]. Additionally, patients resuscitated using Parkland's formula exceeded the Ivy index much more frequently: 33% vs modified Brooke's formula 13% ($P < 0.05$), indicating that our findings replicate the results of Chung et al. In their study, the Parkland's group received 5.9 mL/TBSA/kg, while the modified Brooke's group received 3.8 mL/TBSA/kg and had higher rates of exceeding the Ivy index [11]. Both findings demonstrated that a higher initial fluid flow rate resulted in a higher total infused volume in the first 24 h.

Furthermore, in our first multivariate analysis, we found that higher TBSA, presence of inhalation injury, and use of Parkland's formula were predictive of exceeding the Ivy index. This is also consistent with the findings of Chung et al., who found that the formula type and higher TBSA were predictive of exceeding the Ivy index [11]. While it is recognised that severe burns with larger, deeper burn surface areas and inhalation injuries often require more fluid to achieve adequate UO because of increased widespread vascular permeability, our study showed that along with the severity of the underlying injury, the formula type also played a role in the development of over-resuscitation, which underscores the relevance of the initial fluid rate [21]. In the second multivariate analysis, we found that higher TBSA and the presence of inhalation injury were predictive of mor-

tality. Exceeding the Ivy index, albeit increasing the OR, was not a statistically significant predictor of mortality. This is in contrast with Chung et al., who found that exceeding the Ivy index was predictive of both mortality and ACS [11].

While it is true that neither the modified Brooke nor the Parkland formulae could predict the physiological fluid needs in the first 24 h after injury, these formulae are only meant to serve as a tool to guide the initial fluid rate in resuscitation [22]. Mitchell et al. reported the results of adherence to a low-fluid titration protocol in a retrospective study. They also found that their patients received 7.4 mL/TBSA/kg in the first 24 h, thus, it is possible that sub-optimal adherence in fluid titration protocols could play a role in the development of over-resuscitation [23].

In our opinion, the solution to the problem of over-resuscitation or under-resuscitation cannot be simply made by changing the type of formula used in resuscitation, as there are many intricate details regarding how the human body responds to the burn injury itself and to fluid resuscitation. Also, the type of fluids that patient will receive [24, 25].

Continuous clinical assessments of UO, physiological response, and vital signs should guide further fluid administration. What is more important than the type of formula used in resuscitation is probably the strict fluid titration to achieve a UO between 0.5-1 mL/kg/h. However, at least in our burn centre, we found that changing the protocol helped us achieve, albeit minimally, better overall results.

Further prospective, randomised, multi-institutional studies are required to investigate the efficacy and safety of substituting Parkland's formula with the modified Brooke's formula for burn resuscitation.

Our study had certain limitations. First, this was a retrospective chart review, and provider-to-provider variability in the use of colloids might have occurred during the study period. Therefore, we believe that further prospective studies with stricter methodologies are needed. Second, we had a noticeable number of missing files; in total, we had fifty-three missing files, most of which were patients from the Parkland's formula period. However, we could not determine whether these files could have

been included in our inclusion criteria because we could not retrieve any data from these charts. Third, the sample size of our study was small, and we cannot exclude the possibility that a type 2 error might have occurred when looking for differences in complication rates between the groups. However, to the best of our knowledge, this is the largest cohort study to compare clinical outcomes between the two groups, and our results are supportive of the evidence in the literature, which aligns with the rationale behind the ATLS and ABA guidelines that support more restrictive and mindful resuscitation of burn victims. In addition, our data can be used in meta-analyses for further investigation.

Conclusion

In this study, we found that the use of the modified Brooke's formula instead of Parkland's formula for predicting fluid demand in patients with thermal burn injuries resulted in lower fluid infusion volumes in the first 24 h of admission. No significant differences were noted in the complication rates between the two groups.

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Disclosure of conflict of interest

None.

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References

- [1] Klein MB, Hayden D, Elson C, Nathens AB, Gamelli RL, Gibran NS, Herndon DN, Arnoldo B, Silver G, Schoenfeld D and Tompkins RG. The association between fluid administration and outcome following major burn: a multicenter study. *Ann Surg* 2007; 245: 622-8.
- [2] Mason SA, Nathens AB, Finnerty CC, Gamelli RL, Gibran NS, Arnoldo BD, Tompkins RG, Herndon DN and Jeschke MG; Inflammation and The Host Response To Injury Collaborative Research Program. Hold the pendulum: rates of acute kidney injury are increased in patients who receive resuscitation volumes less than predicted by the parkland equation. *Ann Surg* 2016; 264: 1142-7.
- [3] Greenhalgh DG. Burn resuscitation: the results of the ISBI/ABA survey. *Burns* 2010; 36: 176-82.
- [4] Friedrich JB, Sullivan SR, Engrav LH, Round KA, Blayney CB, Carrougier GJ, Heimbach DM, Honari S, Klein MB and Gibran NS. Is supra-Baxter resuscitation in burn patients a new phenomenon? *Burns* 2004; 30: 464-6.
- [5] Saffle JL. The phenomenon of "fluid creep" in acute burn resuscitation. *J Burn Care Res* 2007; 28: 382-95.
- [6] Strang SG, Van Lieshout EM, Breederveld RS and Van Waes OJ. A systematic review on intra-abdominal pressure in severely burned patients. *Burns* 2014; 40: 9-16.
- [7] Vrouwe SQ, Zuo KJ, Grotzki CH, Tredget EE, Chew HF and Cartotto R. Orbital compartment syndrome following major burn resuscitation: a case series and survey of practice patterns. *J Burn Care Res* 2021; 42: 193-9.
- [8] Kumar AB, Andrews W, Shi Y, Shotwell MS, Dennis S, Wanderer J and Summitt B. Fluid resuscitation mediates the association between inhalational burn injury and acute kidney injury in the major burn population. *J Crit Care* 2017; 38: 62-7.
- [9] Daniels M, Fuchs PC, Lefering R, Grigutsch D, Seyhan H and Limper U; The German Burn Registry; Schiefer JL. Is the Parkland formula still the best method for determining the fluid resuscitation volume in adults for the first 24 hours after injury? - A retrospective analysis of burn patients in Germany. *Burns* 2021; 47: 914-21.
- [10] Shah A, Pedraza I, Mitchell C and Kramer GC. Fluid volumes infused during burn resuscitation 1980-2015: a quantitative review. *Burns* 2020; 46: 52-7.
- [11] Chung KK, Wolf SE, Cancio LC, Alvarado R, Jones JA, McCordle J, King BT, Barillo DJ, Renz EM and Blackburne LH. Resuscitation of severely burned military casualties: fluid begets more fluid. *J Trauma* 2009; 67: 231-7; discussion 7.
- [12] Cartotto R, Johnson LS, Savetamal A, Greenhalgh D, Kubasiak JC, Pham TN, Rizzo JA, Sen S and Main E. American burn association clinical practice guidelines on burn shock resuscitation. *J Burn Care Res* 2024; 45: 565-89.

- [13] Galvagno SM Jr, Nahmias JT and Young DA. Advanced trauma life support((R)) update 2019: management and applications for adults and special populations. *Anesthesiol Clin* 2019; 37: 13-32.
- [14] ARDS Definition Task Force; Ranieri VM, Rubenfeld GD, Thompson BT, Ferguson ND, Caldwell E, Fan E, Camporota L and Slutsky AS. Acute respiratory distress syndrome: the Berlin definition. *JAMA* 2012; 307: 2526-33.
- [15] Khwaja A. KDIGO clinical practice guidelines for acute kidney injury. *Nephron Clin Pract* 2012; 120: c179-84.
- [16] Ivy ME, Atweh NA, Palmer J, Possenti PP, Pineau M and D'Aiuto M. Intra-abdominal hypertension and abdominal compartment syndrome in burn patients. *J Trauma* 2000; 49:3 87-91.
- [17] Pruitt BA Jr. Protection from excessive resuscitation: "pushing the pendulum back". *J Trauma* 2000; 49: 567-8.
- [18] Dahl R, Galet C, Lilienthal M, Dwars B and Wibbenmeyer L. Regional burn review: neither Parkland nor brooke formulas reach 85% accuracy mark for burn resuscitation. *J Burn Care Res* 2023; 44: 1452-9.
- [19] Cartotto RC, Innes M, Musgrave MA, Gomez M and Cooper AB. How well does the Parkland formula estimate actual fluid resuscitation volumes? *J Burn Care Rehabil* 2002; 23: 258-65.
- [20] Blumetti J, Hunt JL, Arnoldo BD, Parks JK and Purdue GF. The Parkland formula under fire: is the criticism justified? *J Burn Care Res* 2008; 29: 180-6.
- [21] Faraklas I, Cochran A and Saffle J. Review of a fluid resuscitation protocol: "fluid creep" is not due to nursing error. *J Burn Care Res* 2012; 33: 74-83.
- [22] Tejiram S, Tranchina SP, Travis TE and Shupp JW. The first 24 hours: burn shock resuscitation and early complications. *Surg Clin North Am* 2023; 103: 403-13.
- [23] Mitchell KB, Khalil E, Brennan A, Shao H, Rabbits A, Leahy NE, Yurt RW and Gallagher JJ. New management strategy for fluid resuscitation: quantifying volume in the first 48 hours after burn injury. *J Burn Care Res* 2013; 34: 196-202.
- [24] Greenhalgh DG, Cartotto R, Taylor SL, Fine JR, Lewis GM, Smith DJ Jr, Marano MA, Gibson A, Wibbenmeyer LA, Holmes JH, Rizzo JA, Foster KN, Khandelwal A, Fischer S, Hemmilla MR, Hill D, Aballay AM, Tredget EE, Goverman J, Phelan H, Jimenez CJ, Baldea A and Sood R. Burn resuscitation practices in North America: results of the acute burn resuscitation multicenter prospective trial (ABRUPT). *Ann Surg* 2023; 277: 512-9.
- [25] Greenhalgh DG. Current thoughts on burn resuscitation. *Adv Surg* 2024; 58: 1-17.