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# A Model for Validation of Parkland Formula for Resuscitation of Major Burn in Pediatrics

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## ABSTRACT

*Background:* Parkland formula is the standard formula used for resuscitation of pediatrics burn at our burn center. This formula depends on the percentage of the burn and the weight of the patient. It has been used for many years but it has never been validated before.

*Patients and Methods:* A retrospective cohort study between January 2016 and December 2020. Data collected from patient's records including patients' age, sex, type and percentage of burn, delay in start of resuscitation, weight on admission, hourly blood pressure, urine output, central venous pressure in the first 24 hours. Depending on specific resuscitation parameters, Patients were classified into 3 groups according to actual volume of fluid administrated as compared to the calculated Parkland then they were compared as regard incidence ratio of pulmonary edema, duration of hospital stay and mortality rate.

*Results:* 540 pediatric patients were admitted to our center during this period. Only 38 of them met our inclusion criteria. Groups are group I (patients received fluid volume more than that calculated by Parkland) 18 patients (47%), group II (patients received fluid volume less than that calculated by Parkland) 20 patients (53%), group III (patients received fluid volume equal to Parkland) zero. On comparing groups as regard end points of resuscitation in day 1, there was no statistical significance and as regard complications of resuscitation, no statistical significance was detected between the groups.

*Conclusion:* Although all patients had the same starting point for resuscitation calculated by Parkland but none of them was adherent to it and all of them needed tailoring of fluid administrated to reach target urine output 0.5-1ml/kg/hour.

*Recommendations:* This study is limited with the small number of patients. It could be a model for validation of Parkland formula but with larger number of patients and may be to be done in prospective manner.

***Key Words:*** *Pediatric resuscitation – Burn trauma – Fluid formulas.*

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## INTRODUCTION

Burn trauma is a major cause of death with 180000 deaths every year, which is more in low and middle income countries. Burn mortalities in pediatrics in these regions are seven times higher in the high income countries **[1,2].**

The crucial early step in burn management is resuscitation to avoid shock and to maintain organ perfusion. In pediatric population, it is even more serious as this group is more sensitive for complications due to defective glycogen storage with higher risk for hypoglycemia especially for those who weigh less than 30Kg. This makes it a must to add dextrose containing fluids to their resuscitation and inability to concentrate the urine so higher urine outputs are used as markers for resuscitation **[3,4].**

Multiple formulas have been expressed for pediatric resuscitation as Evans formula, Brooke and modified Brooke formula, Parkland formula, Shriner's Cincinnati formula and Galveston formula. The main differences between all these formulas are the type of fluid used and the target age group **[5].**

Parkland formula is used for pediatric resuscitation in our burn center as it is the most widely used formula for resuscitation. However, we noticed that fluid volume calculated is always modulated mainly by urine output to maintain perfusion. Therefore, this formula needs to be revised and validated.

## PATIENTS AND METHODS

This retrospective cohort study included all pediatric patients who presented with major burns

from January 2016 till December 2020 at burn center of Ain Shams University Hospitals, Cairo, Egypt. Approval of ethical committee of faculty of medicine, Ain Shams University was obtained by number (FAMSU M S 65/2021) as well as informed consents from the guardians to review patients' records and confidentiality was maintained.

We collected and revised all records of pediatric age group (≤16 years) with major burn (≥10% total burn surface area TBSA) secondary to thermal burn only and excluded patients presented with more than 6 hours delay in start of resuscitation. Also, we excluded patients with inhalational injury, concomitant trauma, associated medical illness e.g. diabetes, resuscitation volume exceeded 250ml/kg, incomplete records.

We analyzed patients' data as regard age, sex, co morbidities, type of burn, TBSA, weight on admission, distribution of burn, special habits of medical importance, estimated fluid according to Parkland formula, actual administrated volume per hour, hourly vital data, urine output (UOP) in the first 24 hours of resuscitation, incidence of lung injury through reviewing the need for intubation and $Pio_2/Fio_2$ (P/F ratio) immediate after intubation, duration of hospital stay and final outcome.

Calculated volume according to Parkland was compared to actual volume administrated to maintain UOP 0.5-1ml/kg/hr and this lead to classification of patients into three groups:

- Group I: Actual fluid infused was more than that calculated.
- Group II: Actual fluid infused less than that calculated.
- Group III: Actual fluid infused equal to that calculated.

The collected data were coded, tabulated and statistically analyzed using SPSS statistics (statistical package for social science).

## RESULTS

During study period, total number of pediatric patients admitted to our center was 540 patients. 71 patients (13%) met our inclusion criteria and 38 patients (7%) had complete records.

*Clinical data:*

Age of the study population ranged from 1-14 years with mean 4 years and male predominance (57.9%) and scalding being more common than flame burn (84.2%). Range of TBSA was 12-88% with mean 20% and weight on admission ranged from 9-88kg with mean 23. Average weight for group I was 15kg and 30kg for group II which was statistically significant. Study demography is shown in Table (1) and weight on admission for patients in Fig. (1).

Table (1): Demography of study population.

| | Total No. = 38 |
|---|---|
| *Age (years):* | |
| Mean | 4 |
| Range | 1-14 |
| *Type of burn:* | |
| SCALD | 32 (84.2%) |
| Flame | 6 (15.8%) |
| *TBSA%:* | |
| Median (IQR) | 20 (15-27) |
| Range | 12-88 |
| *Weight on admission (kg):* | |
| Mean | 23 |
| Range | 9-88 |

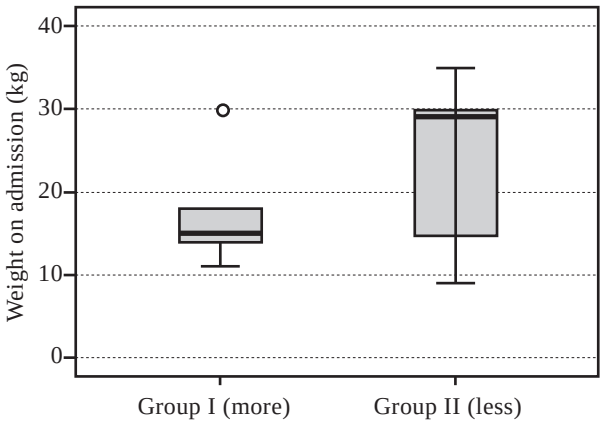


Fig. (1): Shows weight on admission for both groups. Group II had much higher weight.

As regard distribution of burn among study population anterior trunk was the most common site involved (78.9%) followed by right upper and lower limbs with percentage 68.4% and 63.2% respectively then left upper and lower limbs with percentage 47.4% and 57.9% respectively.

*Resuscitation:*

All patients had the same starting point of resuscitation according to Parkland which is 3.7-4.3ml lactated ringer/kg/TBSA% **[6]** and then resuscitation fluid is tailored according to patient vitals and urine output which was the main target to be maintained as 0.5-1ml/kg/hour. At the end of the study we classified the patients to meet one of the three groups: Group I 18 patients (received more than parkland), group II 22 patients (received

less than parkland) and group III (no patient received equal to parkland).

Events of day 1 resuscitation showed no statistical significance between both groups with median of IV crystalloid administration 120ml/hr and 135ml/hr for group I and group II respectively. Median of urine output was 1.39ml/hr/kg in group I and 1.25 ml/hr/kg in group II. Systolic and diastolic blood pressure were 107.22±10.32/60.56± 4.50 for group I and 118.50±13.58/70.20±6.35 for group II. Events of first day resuscitation are shown in Table (2).

Table (2): Events of day 1 resuscitation.

| | Relation to parkland | | Test value | *p*-value | Sig. |
|---|---|---|---|---|---|
| | Group I (more) No. = 18 | Group II (less) No.=20 | | | |
| *Volume of crystalloid ml/hr:* | | | | | |
| Median (IQR) | 120 (85-160) | 135 (60-200) | –0.177≠ | 0.860 | NS |
| Range | 60-280 | 40-800 | | | |
| *Systolic BP:* | | | | | |
| Mean ± SD | 107.22±10.32 | 118.50±13.58 | 0.723• | 0.476 | NS |
| Range | 90-125 | 100-150 | | | |
| *Diastolic BP:* | | | | | |
| Mean ± SD | 60.56±4.50 | 70.20±6.35 | 1.414• | 0.168 | NS |
| Range | 55-70 | 60-80 | | | |
| *UOP (ml)/HR/kg:* | | | | | |
| Median (IQR) | 1.39 (1-1.82) | 1.25 (1-2.27) | –0.059≠ | 0.953 | NS |
| Range | 0.67-9 | 0.67-4.29 | | | |
| *Total output:* | | | | | |
| Median (IQR) | 360 (200-960) | 752.5 (480-1135) | –1.818≠ | 0.069 | NS |
| Range | 144-1500 | 264-1440 | | | |

*p*-value >0.05: Non significant. *p*-value <0.05: Significant. *p*-value <0.01: Highly significant.
•: Independent *t*-test. ≠: Mann-Whitney test.

*Outcome:*

Incidence of lung injury among study population was 2 patients in group I representing 5% of the study population. These two patients were intubated on the second week after trauma with P/F ratio less than 200, raising the suspicion to incidence of ARDS. Average hospital stay was 18 days and 27 days for group I and group II respectively. Mortality rate was 15% in all studied patients represented in 4 patients in group I (10%) and 2 patients in group II (5%).

## DISCUSSION

Resuscitation of major burns in pediatric population still represents a challenging issue due to lack of standard protocols for fluid resuscitation of this age group and paucity of evidence on end points of resuscitation for pediatric population. Our study aimed to assess accuracy of parkland formula to predict actual IV fluids used for resuscitation in burn center of Ain Shams Hospitals.

In the current study; our participants' resuscitation started using parkland formula and 52.6% of cases needed to receive fluid volume less than that calculated by parkland compared to 47.4% received fluid volume more than that calculated in day1 resuscitation. Multiple studies showed that resuscitation of children always exceed what was expected. Sheridan and Schnitzer study in 2001 showed administration of total volume of fluid of 6.5±1.9ml/kg/% TBSA **[7]**. The amount of fluid administrated in the previously mentioned study could be attributed for its inclusion criteria which are presence of inhalational injury, TBSA>30% and age less than 48 months. Also in Napgal et al., although they started resuscitation of their cases using 3-4ml lactated ringer/kg/% TBSA but 56% of their patients received greater than 6ml/kg/ TBSA in first day resuscitation **[8]**. This could also be attributed to the inclusion criteria of the study as patients with inhalational injury were not excluded. Also body weight of the study participants was not mentioned as well as the timing of start of resuscitation.

In our cases we attribute the requirement of more fluid for resuscitation to the fact that parkland formula depends only on weight of the patient and TBSA% without taking into consideration that fluid loss in pediatrics is greater due to their small body weight to body surface area ratio which calls for the need of addition of maintenance fluid or usage of formulas that take this into consideration **[9]**.

On the other side group II was resuscitated with fluid volume less than that calculated by parkland which could be a result of their weight on admission that is significantly higher than group I. Heavier weights and obesity can result in prediction of higher fluid volume than actually administrated to reach target end points of resuscitation **[10]**.

We found incidence ratio of lung injury was 5.3% of total number of cases (2 patients) both were in group I. Although there is no statistical significance between both groups but this complication could be attributed to resuscitation especially that they had no inhalational injury and no concomitant trauma to thorax **[11]**. However, intubation occurred during the second week of injury. This raise the suspicion to Acute Respiratory Distress Syndrome (ARDS) which has several trigger factors of them tissue injury and infection **[12]**.

Average hospital stay for survivors was 18 days for group I and 27 days for group II meaning that every 1% TBSA needs one day or more hospital admission which is similar to what reported by the annual report of ABA in 2019 **[13]**.

With death of 15.8% of cases (4 patients in group I and 2 in group II) with no statistical significance between both groups and taking into consideration that death of all cases occurred during the first 7 days of injury, failure of resuscitation could be attributed for their death as well as lung injury and cardiogenic shock **[11,14]**.

*Conclusion*: Parkland formula is considered good starting point for pediatric resuscitation but need to be tailored according to vital data with urine output and to take body surface area and maintenance fluid into consideration.

*Limitations:* This is retrospective study limited by data availability and small number of patients.

*Recommendations:* We recommended conducting further studies on multicenter with higher sample size and our study could be used as a model for reviewing parkland formula taking into consideration more outcomes if it is done in prospective manner which are frequency of surgical intervention, condition of wound healing, duration of intubation for intubated patients, incidence of infection.

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## REFERENCES

1- Burns [Internet]. [cited 2021 Dec 28]. Available from: https://www.who.int/news-room/fact-sheets/detail/burns

2- Tsai S.Y., Lio C.F., Yao W.C., Liu C.P., Shih S.C., Wang T.Y.T., et al.: Cost-drivers of medical expenses in burn care management. Burns [Internet], 46 (4): 817-24, 2020. Available from: https://doi.org/10.1016/j.burns.2020.01.004.

3- Dries D.J.: Resuscitation Part 2: Trauma and Burn Injury. Air Med. J. [Internet], 38 (6): 400-3, 2019. Available from: https://doi.org/10.1016/j.amj.2019.05.012.

4- Pisano C., Fabia R., Shi J., Wheeler K., Giles S., Puett L., et al.: Variation in Acute Fluid Resuscitation Among Pediatric Burn Centers Courtney Pisano DO, M Sacute fluid resuscitation among pediatric burn centers. Burns, 2-7, 2020.

5- Leopoldo C. Cancio, Fredrick J. Bohanon and GCK: Burn resuscitation. In: total burn care. Elsevier, p. 77-86, 2018.

6- Blumetti J., Hunt J.L., Arnoldo B.D., Parks J.K. and Purdue G.F.: The Parkland formula under fire: Is the criticism justified? J. Burn Care Res., 29 (1): 180-6, 2008.

7- Sheridan R.L. and Schnitzer J.J.: Management of the high-risk pediatric burn patient. J. Pediatr. Surg., 36 (8): 1308-12, 2001.

8- Nagpal A., Clingenpeel M.M., Thakkar R.K., Fabia R. and Lutmer J.: Positive cumulative fluid balance at 72h is associated with adverse outcomes following acute pediatric thermal injury. Burns [Internet], 44 (5): 1308-16, 2018. Available from: https://doi.org/10.1016/j.burns.2018.01.018

9- Gibran EGB and NS: Evaluation of the Burn Wound: Management Decisions. In: Total Burn Care, p. 87-92, 2018.

10- Rosenthal J., Clark A., Campbell S., McMahon M., Arnoldo B., Wolf S.E., et al.: Effects of obesity on burn resuscitation. Burns [Internet], 44 (8): 1947-53, 2018. Available from: https://doi.org/10.1016/j.burns.2018.06.002.

11- Chung K.K., Wolf S.E., Cancio L.C., Alvarado R., Jones J.A., McCorcle J., et al.: Resuscitation of severely burned military casualties: Fluid begets more fluid. J. Trauma - Inj. Infect Crit. Care, 67 (2): 231-7, 2009.

12-Steinvall I., Bak Z. and Sjoberg F.: Acute respiratory distress syndrome is as important as inhalation injury for the development of respiratory dysfunction in major burns. Burns, 34 (4): 441-51, 2008.

13- Association A.B.: National Burn Repository 2019 Update, 60606 (312): 141, 2019.

14- Swanson J.W., Otto A.M., Gibran N.S., Klein M.B., Kramer C.B., Heimbach D.M., et al.: Trajectories to death in patients with burn injury. J. Trauma Acute Care Surg., 74 (1): 282-8, 2013.