FLUID RESUSCITATION IN MAJOR BURNS

BISWADEV MITRA,* MARK FITZGERALD,*† PETER CAMERON*†‡ AND HEATHER CLELAND§

*The Alfred Emergency and Trauma Centre, †National Trauma Research Institute, ‡Department of Epidemiology and Preventive Medicine, Monash University, and §The Alfred Burns Unit, Melbourne, Victoria, Australia

Background: The Parkland formula is established as the ‘gold standard’ for initial fluid resuscitation for major burns. The purpose of this study was to review our fluid resuscitation practice for major burns to determine whether anecdotal observations of significant variations from the Parkland formula were widespread and whether any difference could be used as a basis for a revision of fluid resuscitation in major burns.

Methods: A retrospective review of 127 presentations to The Alfred Burns Unit with total body surface area (TBSA) affected ≥15% was conducted. A retrospective review of the resuscitation data from these patients was compared with the Parkland formula as well as other studies.

Results: A total of 49 patients with complete data on fluid administration and uncomplicated burns were included in the analysis. Significantly larger volumes of fluid (5.58 mL/kg per %TBSA) were given to these patients in the first 24 h than predicted by the Parkland formula. Mean arterial pressure, pulse rate and urine output were at satisfactory levels. Clinically evident complications from fluid administration were minimal. Mortality was similar to that in other centres.

Conclusion: Fluid resuscitation volumes significantly higher than those predicted by the Parkland formula were given, without adverse consequences. This retrospective review supports a prospective, multicentre, randomized, controlled study comparing this study with the Parkland formula, resulting in a better guide to initial fluid resuscitation in major burns.

Key words: burns, emergency, fluid, Parkland, resuscitation.

INTRODUCTION

Adequate fluid resuscitation has been recognized as an important contribution to outcome postburn injury. After injury, fluid accumulates rapidly in the burnt tissues, and to a lesser degree, in unburnt tissues. Without effective and rapid intervention, hypovolamic shock will develop if the burns involve more than 15–20% of the body surface area.¹ The Parkland formula has become the established ‘gold standard’ for initiation of fluid resuscitation in burns since its introduction by Baxter and Shires in 1968.²

We observed that despite the Parkland formula being the standard hospital protocol for fluid administration in burns, much higher rates of fluids were being given to the patients than estimated by the Parkland formula. The Parkland formula estimates a 24-hourly fluid volume of 4 mL/kg per %TBSA with half given in the first 8 h. This formula was devised after experiments by Baxter and Shires on rhesus monkeys using Ringer’s lactate in 1968.²

The aims of this study were to review our fluid resuscitation practice in major burns and compare it with historical and current studies to determine whether there was a significant difference and whether this difference could be used as a basis for a revision of fluid resuscitation in major burns.

METHOD

Setting

The Alfred Hospital is the sole adult burns service for the population of 5 million within the state of Victoria, Australia.

Patients

All patients with a body surface area burnt of greater than or equal to 15% and admitted to The Alfred Burns Unit between 1 July 2002 and 30 April 2004 were considered as major burns patient and were included in the study. Patients with associated injuries, for example, motor vehicle accidents, explosions, and those presenting more than 24 h postburns injury were excluded. Patients with other tissue conditions admitted under the Burns Unit such as chronic ulcers and toxic epidermal necrolysis were also excluded. Fluid administration in patients with incomplete information was not analysed. However, basic demographics and mortality rates were recorded to ensure that the study sample was not biased (Table 1).

Study design

A retrospective explicit chart review of patient records was conducted by a single operator. Patient demographics, burn type and extent, associated injuries, fluid management and outcomes were documented. The time to presentation to the Emergency and Trauma Centre was calculated from the ‘estimated time of incident’ according to Ambulance records. The weight was as estimated by the Emergency and Trauma Centre staff and the percentage of body surface area burnt was as estimated and documented by the admitting Burns Registrar. The total amount of...
fluid given was recorded, including ambulance and referring hospital fluids. Vital signs and urine outputs were as documented in the patient histories. Pathology tests and radiologist’s X-ray reports were used to determine renal failure and fluid status on chest X-ray. Inhalation burns were diagnosed by direct laryngoscopy and bronchoscopy.

Analysis

Data were stored and collated using Microsoft Excel, and Student’s t-test was used to calculate significance between different groups.

The study was approved by The Alfred Hospital Research and Ethics Committee.

RESULTS

A total of 127 histories of patients admitted to The Burns Unit with ≥15% of TBSA affected were reviewed.

There were six deaths. Of these, four patients were treated palliatively: three who suffered greater than 80% TBSA burnt and were deemed to have unsurvivable burn injuries, and one patient with severe alcoholic liver disease who had presented with multisystem organ failure. Another patient, an 86-year-old man with 35% TBSA burnt, had a troponin rise on presentation, died of acute myocardial infarction at day 10. It was felt that the palliative management and the diagnosis of myocardial infarction would have impacted on the amount of fluid given to these patients and its physiologic response. Fluids given to these patients were therefore excluded from further analysis. A 71-year-old woman with 20% TBSA burn died of septicaemia in intensive care unit (ICU), primarily secondary to bronchopneumonia on day 20 after admission. Fluid given to this patient was included. This left 49 of the 127 patients who were included in the study with one death in this group. Basic demographics and mortality rates in patients excluded because of incomplete data were collected to ensure that the study sample was not biased.

Of the 49 patients, there were 36 men and 13 women aged 37 ± 13. The average weight was 79.14 ± 16.10 kg, and the average percentage total body surface area (%TBSA) affected was 26.89 ± 13.45%. Figure 1 shows the age and percentage total body surface area distribution for the study group. There were 24 presentations to The Alfred, whereas the other 25 were transferred from other centres. The average time to presentation, including transfers, to the Emergency and Trauma Centre was 2.45 ± 1.99 h with the longest being 7 h. There were 10 patients with predominantly full-thickness burns.

There were 35 (72.9%) patients who had more fluids given than 4 mL/kg per %TBSA. The initial fluid rate given at 2 h was 7.67 ± 4.88 mL/kg per %TBSA, which exponentially decreased to a 24-hourly fluid rate of 5.58 ± 2.28 mL/kg per %TBSA. Figure 2 shows the cumulative volume of fluid given over 24 h contrasted with the Parkland formula. Of note is that almost double the amount is being given in the first 2 h.

There were 34 patients with no inhalation burns, and these patients were given 5.21 ± 2.67 mL/kg per %TBSA (P £ 0.55). Age distribution in these patients was 36 ± 12 years (P £ 1), with TBSA burnt of 24.4 ± 14.1% (£ 0.33). There were

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Table 1. Selection of patients

<table>
<thead>
<tr>
<th>Included patients</th>
<th>Excluded patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with ≥15% burns</td>
<td>49</td>
</tr>
<tr>
<td>Associated with other injuries</td>
<td>8</td>
</tr>
<tr>
<td>Incomplete data</td>
<td>34‡</td>
</tr>
<tr>
<td>Old burns representing</td>
<td>14</td>
</tr>
<tr>
<td>Other tissue conditions</td>
<td>10</td>
</tr>
<tr>
<td>Deaths</td>
<td>1</td>
</tr>
<tr>
<td>Sepsis†</td>
<td>1</td>
</tr>
<tr>
<td>Total included</td>
<td>49</td>
</tr>
<tr>
<td>Total excluded</td>
<td>78</td>
</tr>
<tr>
<td>Total patients: 127</td>
<td></td>
</tr>
</tbody>
</table>

†Included in study as sepsis was a delayed complication. ‡Included four deaths.

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Fig. 1. Age and %TBSA distribution in study group. %TBSA, percentage total body surface area.

Fig. 2. Fluid given in 24 h compared with the Parkland formula. —, Parkland; —, the Alfred.
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29 patients with no inhalation burns and no surgery in the first 24 h who were given 5.21 ± 2.89 mL/kg per %TBSA (P ≤ 0.58).

Age distribution in this group was 38 ± 11 years (P ≤ 0.49) with TBSA burn of 23.3 ± 14.0% (P ≤ 0.01).

Crystalloids (0.9% saline and compound sodium lactate) were used for 74.9% of the resuscitation volume in 24 h. Hypertonic saline was given to 19 of the 49 patients, accounting for 3% of their resuscitation volume in 24 h. The TBSA in these patients was 34.1 ± 15.8% (P ≤ 0.07 compared with the total study group), and they received 6.32 ± 2.34 mL/kg per %TBSA fluids in the first 24 h (P ≤ 0.24).

Urine output at 24 h was 2.05 ± 0.8 mL/kg per hour. Initial urine output at 2 h was 1.5 ± 1.87 mL/kg per hour. The mean arterial pressure was maintained above 80 over the first 24 h, with only two patients having a mean arterial pressure of less than 60 at any time in the first 24 h. The average mean arterial pressure at 24 h was 83.3 ± 14.1 mmHg. The mean pulse rate was above 89.4 ± 19.6 b.p.m. on presentation and went down to an average of 84.5 ± 14.5 b.p.m. at the end of 24 h. Of the 49 patients, 21 (42.9%) had a pulse rate of greater than 90 b.p.m. at 2 h as compared with 31.2% at 24 h.

There were two patients who went into acute renal failure. Neither required dialysis on discharge. Of these two patients, one had pre-existing renal impairment and suffered 60% TBSA burnt. He received 4.4 mL/kg per %TBSA in 24 h. His worst creatinine was 0.35 mmol/L. The other patient was a delayed transfer with 15% TBSA burnt who received 3.2 mL/kg per %TBSA over 24 h. His worst creatinine was 0.15 mmol/L.

There were 13 patients (27.1%) who had chest X-rays during their admission that displayed features of fluid overload. There were no records of pulmonary oedema requiring diuretic treatment in the first 24 h.

Overall mortality rate in the 88 patients presenting with new burns of 15% or greater TBSA affected was 11.4%, including 34 patients with incomplete data. For those presenting with new burns with complete data, 6 out of 54 died (11.1%). There were no cases of abdominal compartment syndrome or fasciotomy in uninjured limbs.

DISCUSSION

This study shows that significantly more fluid was given than predicted by the Parkland formula. For example, a 80-kg patient with 30% TBSA burnt would receive 3.8 L of fluid in the first 24 h in excess of what the Parkland formula would predict, with a majority (2.35 L or almost 50% more than estimated) in the first 8 h. This does not appear to be associated with any adverse clinical consequences from fluid overload. The rates of mortality, acute renal failure and multiorgan failure appeared low.

There have been multiple studies on fluid administration following burns injury. Four articles since the year 2000 analysing fluid administration in major burns were selected to compare our data. Table 2 compares the demographics and fluid administration of this study group with those of the recent studies. In comparison with recent studies, there was no significant difference between fluid administration rates in this study and those in the studies of Engrav et al. and Cartotto et al. We gave significantly less fluids than Friedrich et al. but significantly more than Cancio et al.

This phenomenon of increased fluid administration has been labelled as ‘fluid creep’. This is the first study which shows that this fluid creep phenomenon is more evident in the first 8 h. It has been noted in a recent study that although over the last 12 years there has been marked improvement in referral practice and initiation of management, there has been no improvement in the burns size estimation of referring hospitals. This may partially account for fluid creep.

The systemic capillary leak that causes the loss of fluids typically ‘seals off’ after 24 h if resuscitation has been successful. It is, therefore, vitaly important that the patient with major burns is resuscitated in the early hours after burns injury.

The Parkland formula of 4 mL/kg per %TBSA has been used as the ‘gold standard’ for the initiation of fluid resuscitation in major burns. Baxter clearly indicated that the formulae used for calculating burns resuscitation fluids are guidelines and that clinical signs determine the quantity actually given. Berger et al. noted that in this era of evidence-based medicine, this fundamental fluid resuscitation formula was published without peer review.

The dangers of fluid overresuscitation, which have been highlighted, include pulmonary oedema,10 the need for fasciotomy in uninjured limbs11 and the need for tracheostomy in patients with scald burns.12 Our patient group had no life-threatening pulmonary oedema, and findings of fluid overload on chest X-ray features also correlate poorly with clinical fluid overload. Traditional concerns that excessive crystalloid volumes precipitate cardiopulmonary overload have been rejected in studies using the double-dye dilution principle to monitor the water content of the lung.13,14 This may explain the findings of Herndon et al.15 that fluid accumulation in the lung may result from inadequate resuscitation and increased lung capillary permeability rather than from infusion of excessive fluid volumes. There were no cases of limb-threatening oedema in our sample group.

Mortality was lower than reported in other studies despite similar rates of fluid administration (Cartotto et al. reported 32% mortality, Cancio et al. reported 25.8%). Baxter had reported

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>%TBSA</th>
<th>Age (years)</th>
<th>Fluid administration (mL/kg per %TBSA)</th>
<th>Significance (fluid administration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baxter16</td>
<td>438</td>
<td>n/a</td>
<td>62</td>
<td>4.0 ± 0.3</td>
<td>P ≤ 0.01*</td>
</tr>
<tr>
<td>Cancio et al.6</td>
<td>89†</td>
<td>36.9 ± 1.8*</td>
<td>35.9 ± 2</td>
<td>4.7 ± 0.3</td>
<td>P ≤ 0.01*</td>
</tr>
<tr>
<td>Engrav et al.3</td>
<td>50</td>
<td>43 ± 21*</td>
<td>36 ± 15</td>
<td>5.2 ± 2.3</td>
<td>P ≤ 0.44</td>
</tr>
<tr>
<td>Alfred</td>
<td>49</td>
<td>26.9 ± 1.4</td>
<td>37 ± 13</td>
<td>5.6 ± 2.8</td>
<td></td>
</tr>
<tr>
<td>Cartotto et al.4</td>
<td>31‡</td>
<td>27 ± 10</td>
<td>51 ± 20</td>
<td>5.9 ± 2.3</td>
<td>P ≤ 0.62</td>
</tr>
<tr>
<td>Friedrich et al.5</td>
<td>11</td>
<td>48 ± 15*</td>
<td>33 ± 13</td>
<td>8.0 ± 2.5</td>
<td>P ≤ 0.01*</td>
</tr>
</tbody>
</table>

*Significantly different from the Alfred data. †Soldiers from combat, 66 survivors. ‡21 survivors. %TBSA, percentage total body surface area.

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a mortality rate of 11.4%, the same as our study. Importantly, in this study, no deaths appeared to be attributable to fluid administration overload or deficit.

Sheridan\textsuperscript{17} pointed out that after 18–24 h, capillary integrity generally returns if resuscitation has been successful. At this point, fluid requirements abruptly decrease, and it is important to decrease fluid administration appropriately at this point. Over-administering fluids at this time is associated with potential morbidity and mortality. This may contribute to higher mortality in other studies, as may other factors such as higher burns severity, wound care and intensive care.

Baxter\textsuperscript{18} had postulated that patients with inhalation burns would require additional fluid volume replacement over that calculated for the area of cutaneous burns. However, there was no significant difference in the amount of fluid given to these patients, when compared with the total study group.

A significant advance in burns care has been the practice of early escharectomy. It was felt that this practice may contribute to the increase in fluid volumes given. However, although the group of patients with no inhalation and no surgery in the first 24 h had significantly less TBSA burnt, the volume of fluid given adjusted for TBSA was not significantly different.

There is a dearth of evidence for the use of hypertonic saline.\textsuperscript{19,20} However, it continues to be used as part of the Alfred Intensive Care resuscitation protocol in the first 24 h. Although the indications of hypertonic saline resuscitation could not be determined, in this small cohort of patients, it did not appear to have any benefits in terms of reducing total fluid administration. Further clinical trials are needed to establish the routine use of hypertonic saline resuscitation in major burns.

This study is limited by the fact that it was retrospective and the factors contributing to increased fluid administration are unknown. A significant number of patient records were incomplete and had to be excluded. Ringer’s lactate, as used by Baxter, is not used in our institution.

Recent studies\textsuperscript{3–6,21} have reported using significantly higher amount of fluids than the Parkland formula. All of these studies have been retrospective reviews. Significantly, more fluids were given in 24 h than estimated by the Parkland formula in this study. A large proportion of this excess is given in the first 8 h. This fluid administration practice has not resulted in any documented adverse effects. Mortality and complication rates appear low. It is not possible from this retrospective review to recommend a change in practice. A multicentre, randomized, blinded, prospective study should be undertaken to determine whether resuscitation with i.v. fluids in the first 8 h given at a rate 50% higher than that predicted by the Parkland formula leads to an overall decrease in burns mortality.

REFERENCES