Care of Burns in Scotland
National Managed Clinical Network

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Paediatric guideline: Fluid resuscitation

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NOTE
This guideline is not intended to be construed or to serve as a standard of care. Standards of care are determined based on all clinical data available for an individual case and are subject to change as scientific knowledge and technology advance and patterns of care evolve. Adherence to guideline recommendations will not ensure a successful outcome in every case, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgement must be made by the appropriate healthcare professional(s) responsible for clinical decisions regarding a particular clinical procedure or treatment plan. This judgement should only be arrived at following discussion of the options with the patient, covering the diagnostic and treatment choices available. It is advised, however, that significant departures from the national guideline or any local guidelines derived from it should be fully documented in the patient's case notes at the time the relevant decision is taken.

Contents

When is fluid resuscitation needed?

Initial accurate assessment of the burn is vital for calculation of %TBSA. A unified Lund and Browder chart should be used (note that different versions of this chart are available, the version with **13% allocated to the chest** should be used). Once accurate estimation of the % TBSA burned is calculated, fluid resuscitation using a formula should start.

Consider starting intravenous fluid resuscitation if a child has a burn injury greater than or equal to 10% TBSA. It **must** be administered for paediatric burns over 15%.

The recommended formula is detailed in the Calculations section of this guideline (page 4). Hypertonic solutions are not recommended.

Other considerations

- Patients with large areas of full thickness burns, high voltage electrical injury, associated trauma, delay in resuscitation and inhalational injury may require additional fluid.
- Each child needs to be treated as an individual and clinical observations need to be assessed regularly to evaluate the effectiveness of the fluid replacement.
- The amount of fluid administered should be clearly recorded along with physiological parameters.

Steps for fluid resuscitation with paediatric burns:

1. Weigh the child on arrival in the emergency department.
2. Assess and document the percentage Total Burn Surface Area (%TBSA) on a Lund & Browder chart (simple erythema should not be included)
3. Obtain intravenous access. Limit attempts, early involvement of anaesthetics team for difficult cases. Consideration should be taken for early intraosseous or central venous access.
4. The initial resuscitation period is 24 hours from the time of burn injury, split into two periods of 8 then 16 hours. Plasma-Lyte148 is the recommended fluids used for the initial resuscitation period across Scotland. If unavailable, equivalent balanced salt solutions can be considered.
5. In the second resuscitation period a human albumin solution (HAS) is used in lower concentrations (4%, 4.5% and 5%). If this isn't available, use the Parkland formula for Plasma-Lyte or alternative balanced salt solution.

Calculations

First period (8 hours): Modified **Parkland** formula

<u>Total volume</u> of Plasma-Lyte 148 = %TBSA x weight (in kg) x 1.5

i.e. Total volume over 8hr - Lag time from burn injury to presentation

This is on top of full intravenous fluid maintenance calculated for the patient's body weight- see next section.

It is a clinical decision whether to include bolus volumes in the total amount.

Second period (16 hours): Further fluid given as **Human Albumin Solution (HAS)**

<u>Hourly rate</u> of HAS = %TBSA x weight (in kg) x 0.1mls/hr

This is on top of full intravenous fluid maintenance calculated for the patient's body weight- see next section.

Remember to add maintenance fluids

Maintenance fluids should contain sodium in sufficient quantity to avoid hyponatraemia and hyperchloraemia and should contain glucose.

Suitable initial fluids would be Plasma-Lyte148 and Glucose 5%, or equivalent balanced salt solution with 5% Glucose. Maintenance fluid content should be adjusted according to urea and electrolytes as per local protocols with the addition of potassium as necessary.

The rate of maintenance fluid is calculated as follows:

100ml/kg/day for the first 10kg body weight

Plus 50 ml/kg/day over 10kg and less than 20 kg body weight

Plus 20ml/kg/day for each kg over 20kg body weight.

Remember that oral fluids should be subtracted from maintenance fluids ml for ml.

For further detail on oral or enteral fluids or feeds please refer to the COBIS Paediatric Guideline on Nutrition in Thermal Injuries (found on the COBIS website under Clinical Guidelines).

Suggested patient observations

Always remember that the aforementioned formulae are a starting point for fluid resuscitation.

Fluid requirements should be altered according to clinical changes, in particular the following patient observations:

- Heart rate
- Urine output (this should match the hourly maintenance fluid rate)
- Blood pressure
- Capillary refill
- Skin-core temperature gap
- Acid base balance
- Central venous pressure (if available and indicated)
- Conscious level
- Electrolytes
- Haematocrit

Please refer to an age-appropriate PEWS chart for the above observations.

Appendix 1: Prospective burn Fluid Resuscitation Chart

CHI No: ____________________ **D.O.B:**_______________

Referring hospital: __________________ **Burns centre:** ____________________

INJURY DETAILS

Date of injury: ___/___/____ **Time of Injury:** ____:____

Date of arrival: ___/___/____ **Time of Arrival:** ____:____ **LAG TIME:** ___:___ **hrs**

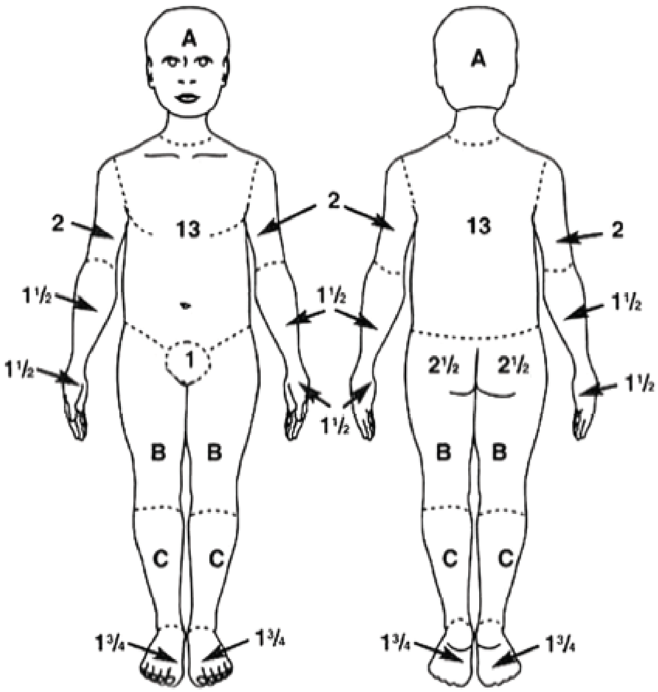
TYPE OF BURN:

Flame/ hot object ☐ **Scald** ☐ **Chemical** ☐ **Electrical** ☐

Suspected inhalation? **Yes** ☐ **No** ☐

Fluid bolus given? **Yes** ☐ **No** ☐

Weight	**kg**
TBSA	**%**



Partial Thickness	
Full Thickness	

REGION	%
Head	
Neck	
Ant Trunk	
Post Trunk	
Right Arm	
Left Arm	
Buttocks	
Genitalia	
Right Leg	
Left Leg	
Total Burn	

AREA	AGE 0	1	5	10	15	Adult
A - $\frac{1}{2}$ of Head	$9\frac{1}{2}$	$8\frac{1}{2}$	$6\frac{1}{2}$	$5\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$
B - $\frac{1}{2}$ of one thigh	$2\frac{3}{4}$	$3\frac{1}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$
C - $\frac{1}{2}$ of one leg	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$

Appendix 2: Calculation sheet

First period: 8 hours post-injury (minus lag)

Total volume of Plasma-Lyte 148 = %TBSA x weight (in kg) x 1.5

Volume	**mls**
8hrs - lag time	**hrs**
Rate	**mls/hr**

REMEMBER MAINTENANCE FLUIDS

Second period: 16 hours post-injury

Hourly rate of HAS = %TBSA x weight (in kg) x 0.1mls/hr

Rate	**mls/hr**

REMEMBER MAINTENANCE FLUIDS

Time from injury (hrs)	**Total crystalloid volume** (include boluses)	**Total HAS volume**	**Hourly IV fluids**	**Target urine output (ml)-** refer to age appropriate Pews chart
8				
24				
48				

Appendix 3: Worked examples

Patient A

Age	6 months
Weight	7.5kg
TBSA	24%

Background:
No fluids at home, pre-hospital or on ED before assessment and management.
Presented within the hour of injury and IV access obtained **immediately**.

Maintenance fluids (Plasma-Lyte 148 and Glucose 5%)

100ml/kg/day for the first 10kg body weight

100ml x 7.5kg per day = 750ml per day = 31.25mls/hr (**31mls/hr** for practical purposes)

First period (8 hours): Modified **Parkland** formula

<u>Total volume</u> of Plasma-Lyte 148 = %TBSA x weight (in kg) x 1.5

24% x 7.5kg x 1.5 = **270mls over 8hrs** (no lag time as seen within hour of injury)

Broken down to 33.75mls/hr (**34mls/hr** for practical purposes)

Second period (16 hours): Further fluid given as **Human Albumin Solution (HAS)**

<u>Hourly rate</u> of HAS = %TBSA x weight (in kg) x 0.1mls/hr

24% x 7.5kg x 0.1 = **18ml/hr for 16 hours**

The patient will have 2 infusions running.

Summary

Maintenance fluids (Plasma-Lyte 148 and Glucose 5%) running at 31mls/hr and:

- Plain **isotonic balanced** electrolyte solution (Plasma-Lyte 148 or equivalent) at 34mls/hr for the first 8 hours
- Then changed to 5% human albumin solution running at 18mls/hr for the next 16hrs.

An illustrative table of fluid administered and infusion rates:

	Hour								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9-24**
Maintenance	31	31	31	31	31	31	31	31	31
Fluid resus (first period/ 8 hrs)	34	34	34	34	34	34	34	34	Off
Fluid resus (second period/ 16 hrs)									18
Fluid boluses									

Patient B

Age	12 months
Weight	11kg
TBSA	34%

Background

Presents from rural GP via 999 and SAS, **2 hours** post injury. There is a further **1 hour** delay in obtaining vascular access and the child is hypotensive (shocked). They need 20mls/kg fluid bolus after access is gained (total of 220ml). After the fluid bolus the patient is no longer shocked.

Maintenance fluids (Plasma-Lyte 148 and Glucose 5%)

100ml/kg/day for the first 10kg body weight

Plus 50 ml/kg/day over 10kg and less than 20kg body weight

(100ml x 10kg) + (50ml x 1kg) = 1050ml/day = 43.75mls/hr (**44ml/hr** for practical purposes)

First period (8 hours): Modified **Parkland** formula

Total volume of Plasma-Lyte 148 = %TBSA x weight (in kg) x 1.5

34% x 11kg x 1.5 = **561ml**

The patient initially 20mls/kg fluid resuscitation. Delivered as 220mls of 0.9% sodium chloride (though Plasma-Lyte 148 could have been used for fluid boluses safely).

The patient is no longer hypotensive / shocked. Decision is made to **include this initial fluid bolus** in the first period fluid resuscitation, so it is subtracted from the calculated total:

561mls for first period – initial 220mls = 341mls

There was a 2 hour delay in presentation and 1 further hour delay obtaining vascular access. So, the remainder of the first period for fluid resuscitation is 5 hours.

The 341ml needs administered during the remaining time:

341ml / 5hrs = 68.2mls/hr (**68mls/hr for practical purposes**)

Second period (16 hours): Further fluid given as **Human Albumin Solution (5%)**

<u>Hourly rate</u> of HAS = %TBSA x weight (in kg) x 0.1mls/hr

34% x 11kg x 0.1 = **37.4ml/hr for 16 hours (37ml/hr for practical purposes)**

The patient will have 2 infusions running.

Summary

Maintenance solution with glucose (Plasma-Lyte 148 and Glucose 5%) running at 44mls/hr and:

- Plain **isotonic balanced** electrolyte solution (Plasma-Lyte 148 or equivalent) at 68mls/hr for 5 hours
- Then changed to 5% human albumin solution running at 37mls/hr for 16hrs.

An illustrative table of fluid administered and infusion rates:

	Hour								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9-24**
Maintenance	44	44	44	44	44	44	44	44	44
Fluid resus (first period/ 8 hrs)	NIL	NIL	NIL	68	68	68	68	68	Off
Fluid resus (second period/ 16 hrs)									37
Fluid boluses				220					

Patient C

Age	9 years old
Weight	35kg
TBSA	46%

Background

Presents to DGH from house fire. It took **1.5 hours** to rescue them from the ruins. There is another **30 minute** delay in obtaining vascular access due to extensive burns and need for intubation due to airway burns and the child is hypotensive (shocked) and needs 40mls/kg fluid bolus after access is gained (total of 1400mls). After the fluid bolus the patient remains shocked.

The patient is transferred to specialist paediatric burns centre and the affected surface area is recalculated.

Maintenance fluids (Plasma-Lyte 148 and Glucose 5%)

100ml/kg/day for the first 10kg body weight

Plus 50 ml/kg/day over 10kg and less than 20kg body weight

Plus 20ml/kg/day for each kg over 20kg body weight.

[(100ml x 10kg) + (50ml x 10kg) + (20ml x 15kg)] = 1800mls/day = **75mls/hr**

First period (8 hours): Modified **Parkland** formula

<u>Total volume</u> of Plasma-Lyte 148 = %TBSA x weight (in kg) x 1.5

46% x 35kg x 1.5 = **2415mls over 8 hours**

The patient initially had 40mls/kg fluid resuscitation. Delivered as **1400mls** of Plasma-Lyte 148.

As the patient remains shocked the decision is made to include this **ON TOP OF** the first period fluid resuscitation.

There was a 1 hour 30 minute delay to rescue the patient from the housefire and a further 30 minute delay to obtain access and secure the airway. This is a 2 hour delay.

The 2415mls is therefore administered over 6 hours (due to the 2 hrs delay).

Broken down to 402.5mls/hr (**403mls/hr for practical purposes**).
Second period (16 hours): Further fluid given as **Human Albumin Solution (5%)**

<u>Hourly rate</u> of HAS = %TBSA x weight (in kg) x 0.1mls/hr

46% x 35kg x 0.1 = **161ml/hr for 16 hours**

On transfer to the paediatric burns centre the plastics/burns team reevaluates the burn and the surface area is now calculated as 52%.

The patient is still hypotensive and receives a further 10mls/kg fluid bolus (350mls of Plasma-Lyte) 6 hours into the first period of fluid resuscitation. The calculation is adjusted to take this into account:

Adjusted first period calculation:	52% x 35kg x 1.5 = 2730mls over 6 hours = 455mls/hr

The patient will now have 455mls/hr fluid resuscitation running for the **remaining 2 hours** in the first period. The second period fluid resuscitation will be recalculated as well:

52% x 35kg x 0.1 = **182mls/hr**

An illustrative table of fluid administered and infusion rates:

	Hour								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9-24**
Maintenance	75	75	75	75	75	75	75	75	75
Fluid resus (first period/ 8 hrs)	NIL	NIL	403	403	403	403	455	455	Off
Fluid resus (second period/ 16 hrs)									182
Fluid boluses			1400			350			

Summary

In the first 24hrs the patient had:

- **75mls/hr maintenance solution** with glucose (Plasma-Lyte 148 and Glucose 5%) running for the whole 24 hours
- **1400mls fluid resuscitation** once vascular access was obtained
- **403mls/hr** plain ISOTONIC BALANCED electrolyte solution (Plasma-Lyte 148 or equivalent) running for 4 hours
- **350mls** fluid bolus when surface area was recalculated
- 455mls/hr plain ISOTONIC BALANCED electrolyte solution (Plasma-Lyte 148 or equivalent) running for the last 2 hours of first period
- **182mls/hr** 5% human albumin solution running at for 16hrs.

Appendix 4: Theoretical background

This is to promote a unified approach to fluid resuscitation of children with burn injuries in Scotland, including the immediate resuscitation in the Emergency Department and further fluid management in specialist units providing ongoing care.

1. Background

Thermal injuries affecting more than 20% of the total body surface area (TBSA) in adults and 10% TBSA in children can result in Burn Shock as a result of a combination of electrolyte shifts [Baxter 1968, Moyer 1965, Moylan 1973, Arturson 1979], inflammatory response [Gibran 2000, Scott 2005] and evaporative losses. This sequence of events leads to intravascular hypovolaemia and haemoconcentration that are maximal 12 hours post-injury [Moore 1970].

The clinical sequelae of reduced cardiac output are the combined result of decreased plasma volume, increased afterload, and decreased myocardial contractility. Recent clinical evidence suggests that fluid administration alone is not effective in restoring preload or cardiac output in the first 24 hours post-injury [Holm 2004] which confirms earlier animal based observations [Baxter 1968].

Under resuscitation may lead to decreased perfusion, acute renal failure, and death although since the adoption of formulas for resuscitation based on weight and injury size, multiple organ dysfunction caused by inadequate resuscitation has become uncommon [Pham 2008]. Instead, administration of excessive fluid volumes have been reported [Cancio 2004, Engrav 2000, Pruitt 2000] which can lead to worsening oedema formation, elevated compartment pressures, acute respiratory distress syndrome (ARDS), and multiple organ dysfunction [Klein 2007, Sheridan 1994, Sullivan 2006]. In October 2006, the American Burn Association conducted a meeting to determine a research agenda for the next decade. Participants highlighted over resuscitation as a common, but potentially avoidable phenomenon in today's burn units [Greenhalgh 2007].

2. Fluid regimes in the UK

In the UK, burns fluid resuscitation practice has undergone considerable change over the recent decades. In 1997, a questionnaire study presented at the European Burns Association annual conference, demonstrated that the majority of centres utilised the albumin based Muir & Barclay regime [Webb 2002] contrary to guidelines promoted during ATLS and EMSB courses that favoured the crystalloid based Parkland Formula. The following year saw the publication of the Cochrane Injuries Group report that questioned the appropriateness of using albumin in critically ill patients, particularly those with burn injuries [Cochrane Injuries Group Albumin Reviewers 1998]. In 2001, a similar questionnaire demonstrated that over 50% of centres managing paediatric burns continued to use the Muir and Barclay formula [Wharton 2001], but by 2007 most had changed to the Parkland formula [Baker 2007].

Most fluid regimes are governed by the percentage total body surface area affected by the burn injury (%TBSA) and the patient's weight, although some rely on more accurate assessments of surface area. It would be impractical to suggest that surface area is calculated by all units at initial presentation but an accurate weight should be documented rather than relying on an estimated weight. A unified Lund and Browder chart will be distributed to determine the %TBSA affected, with the stipulation that simple erythema is not included in the calculation [Lund 1944].

3. Albumin versus Crystalloid Debate

There are no level I or II publications to guide the choice of resuscitation fluid in the burned patient. The 1978 National Institutes of Health workshop on fluid resuscitation did not reach a consensus on the specific formula nor the type of fluid to be administered. At that time two principles were agreed; a) that the least amount of fluid necessary to maintain adequate organ perfusion should be given, and b) that the volume infused should be continually titrated to avoid both under and over resuscitation [Shires 1979].

As mentioned above, there is growing concern that excessive amounts of fluid are now being administered in the acute resuscitation period following burn injury. Baxter's first description of the "Parkland formula" was based on experimental and clinical research where volumes of 3.7 – 4.3 ml/kg/%TBSA appeared adequate to achieve set end-points [Baxter 1968]. When this was introduced it represented much higher volumes of fluid than had previously been used. Recently reported series demonstrate that volumes administered in crystalloid-based formula are often in excess of that predicted by the formula [Blumetti 2008, Cartotto 2002].

Administration of large volumes of crystalloid during burn resuscitation decreases plasma protein concentration and further promotes extravascular egress of fluid and oedema formation. Replenishment of plasma protein using colloids (either with albumin or plasma) would theoretically mitigate this effect although there is a lack of evidence to support this. Experimental evidence would suggest that the rate of oedema formation was maximal at 8 to 12 hours after burn injury [Demling 2005] and that any fluid given before this time is susceptible to tissue egress. After this time, nonburn tissues appear to regain the ability to sieve plasma proteins. Virtually all studies using large macromolecules to augment oncotic pressure have documented reduced oedema formation in non-burn tissue, but not in the burn wound itself [Guha 1996, Demling 1984].

A recently reported double-blind randomised controlled trial of albumin administration demonstrated the safety of albumin use and observed that the saline group received 40% more fluid than the albumin group [The SAFE Study Investigators 2004]. Further meta-analysis of published literature has concluded that albumin administration significantly reduces morbidity in ill hospitalised patients, including patients with burn injury [Vincent J-L 2004]. Follow-up reports from the Cochrane Injuries Group have failed to support the earlier claims that albumin administration increases mortality [Alderson 2004].

Many burns centres have now moved to using formulas where crystalloid is given for the first 8-12 hours, when capillary leak may be most pronounced, followed by colloid administration thereafter.

4. Monitoring of resuscitation

Traditional dogma suggests that titration of fluids to maintain renal perfusion to obtain a urinary output of 30-50 ml/hr is considered adequate for adults, whereas a urinary output of 0.5-1 ml/kg/hr is an appropriate target for young paediatric patients. The age (or weight) of child where this parameter changes to "adult" values is arbitrary, although 30kg in weight has been recommended [Warden 2006]. Other physiological signs should be regularly assessed and recorded including heart rate, blood pressure, respiratory rate in addition to other signs of end-organ perfusion such as capillary refill time, core-peripheral temperature gap and conscious level. Blood tests such as acid-base balance, lactate and haematocrit may give further useful information although regular testing out with an intensive care environment is not routinely recommended.

Clearly, in the intensive care setting, there are more sophisticated monitoring devices with variable invasiveness, leading some to suggest that resuscitation volumes can be targeted towards normalising cardiac pre-load. A recent prospective randomized trial did not confirm the benefits of this approach whereby neither restoration of intrathoracic blood volume nor cardiac index were attained by an additional 68% of fluid administered in the preload- driven strategy. Based on these results, a preload- driven strategy for burn resuscitation is not advisable. Invasive monitoring with central venous catheters or pulmonary artery catheters may still be occasionally indicated in patients who display an inadequate response to standard treatment [Reynolds 1995].

5. Maintenance Fluids

Until enteral feeding is established, maintenance intravenous fluids should be administered as governed by local guidelines. This should be administered in addition to resuscitation fluids.

6. Oral / Enteral Fluids

Oral fluids should be introduced as early as possible following admission as detailed in the accompanying nutritional guidelines. Volumes of enteral feeds or fluids should replace maintenance fluids rather than resuscitation fluids. Enteral fluids should constitute either milk formulas as governed by local guidelines or balanced salt-solutions rather than water to avoid the risk of hyponatraemia.

7. Process of review and resulting recommendation

The paediatric subgroup of COBIS in 2009 was made up of representatives from all the Scottish centres involved in the care of the child with a burn injury. Discussion of a unified fluid resuscitation guideline formed part of the larger process aiming to construct a series of management guidelines. Contact was made, in 2009, with various other burns centres to determine other established guidelines including St Andrews Centre in Chelmsford, Birmingham Children's Hospital, Booth Hall Children's Hospital in Manchester and the Shriners Burns Institute (Galveston, Texas). All regimes were compared and presented along with available evidence. All fluid regimes were considered, along with another hybrid regime which comprised of a Muir and Barclay type formula that substituted crystalloid for colloid in the first 12 hours.

The subgroup concluded that, in the absence of a clear gold standard, the recommended regime should be the one currently used by Birmingham Children's Hospital. The main advantage was the use of colloid in the latter part of the resuscitation period which was considered, on current evidence, to represent best practice. The fact that the formula had been in use for a number of years was considered to afford a degree of validation.

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