VANDERBILT UNIVERSITY MEDICAL CENTER

Guideline: Pediatric Burn Fluid Resuscitation

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I. Purpose

To guide the fluid resuscitation required to treat patients with partial and/or full thickness burns ≥15% TBSA.

II. Population and Injury Characteristics

This protocol applies to the pediatric patients with burn injuries seen in Monroe Carell Jr. Children's Hospital at Vanderbilt (Monroe Carell) with a total body surface area (TBSA) ≥15% of partial and/or full thickness burns. Superficial burns (first degree) are not included in this calculation.

Depth of Burn	
Superficial (1st Degree)	Erythema; skin intact
Partial Thickness (2nd Degree)	Wet, weepy, blisters
Full thickness (3rd Degree)	White, leathery, dry

III. Calculating TBSA

There are various methods used to estimate TBSA. For pediatric burn patients requiring resuscitation, the Lund and Browder chart is the preferred method to estimate TBSA.

Modified Lund and Browder [8]					
Area	**Birth-1yr**	**1-4yrs**	**5-9yrs**	**10-14yrs**	**15yrs**
Head	19	17	13	11	9
Neck	2	2	2	2	2
Anterior trunk	13	13	13	13	13
Posterior trunk	13	13	13	13	13
R buttock	2.5	2.5	2.5	2.5	2.5
L buttock	2.5	2.5	2.5	2.5	2.5
Genitalia	1	1	1	1	1
R upper arm	4	4	4	4	4
L upper arm	4	4	4	4	4
R lower arm	3	3	3	3	3
L lower arm	3	3	3	3	3
R hand	2.5	2.5	2.5	2.5	2.5
L hand	2.5	2.5	2.5	2.5	2.5
R thigh	5.5	6.5	8	8.5	9
L thigh	5.5	6.5	8	8.5	9
R leg	5	5	5.5	6	6.5
L leg	5	5	5.5	6	6.5
R foot	3.5	3.5	3.5	3.5	3.5
L foot	3.5	3.5	3.5	3.5	3.5

To calculate TBSA using the Lund and Browder chart, measure the affected surfaces for each body part. For example, if a 10-year-old presented with a burn to half of the left upper arm, the TBSA of burn would be 2%. The palmar method can also be use, 1% TBSA is the equivalent of one of the PATIENT'S palms (wrist crease

to tip of longest finger).

The Lund and Brower tab within the medical record must be completed by the attending Burn Surgeon or the Burn APP following initial debridement. The Lund and Browder should not be completed prior to initial debridement.

IV. Phase 1: Emergency Management

For complete guidance on ED management of pediatric patients with burns, please see the Pediatric ED Management of Burns guideline. The following is an outline of the management of burns ≥15% TBSA.

a. **STEP ONE**
Activate Level I Burn Alert

b. **STEP TWO**
Emergency Fluid Resuscitation
These patients require resuscitation and admission to the Pediatric Critical Care Unit under shared service between Pediatric Intensive Care and Burn Surgery – Pediatric Burn services. The ED management of pediatric burn patients requiring resuscitation is as follows:

i. **Age-Based Resuscitation Fluid**: The following fluid rates should be started during the primary survey:

Age/Weight of Child	Initial fluid rate & type (prior to burn size calculation)
<6 years old	125mL/hr of LR + maintenance rate D5LR*
6-12 years old	250mL/hr of LR
>12 years old	500mL/hr of LR

*Maintenance rate calculation using 4-2-1 rule

ii. **Fresh Frozen Plasma (FFP)**: Patients with a TBSA ≥15% require a second PIV for administration of FFP bolus(es). A type and screen and consent should be obtained by the ED and FFP bolus stared in the ED whenever possible. If a patient has a delayed presentation >8 hours post-burn, the FFP bolus may be omitted and FFP drip (see Phase 2) started immediately at the discretion of the Burn Attending.

TBSA	FFP Bolus
<15%	None
15-50%	1 weight-based unit (10mL/kg)
>50%	2 weight-based units (10mL/kg)

c. **Additional Interventions**

i. Labs: Initial labs should be obtained by the ED whenever possible:
1. Type & Screen
2. CBC
3. CMP
4. Magnesium
5. LFT
6. Lactate
7. Urine toxicology
8. Urine hCG for pubescent females

ii. Foley catheter: Patients require placement of a foley catheter which is ideally placed

during initial debridement if not already in place prior to arrival. Urine output should be closely monitored and documented (ideally hourly) whenever possible. *Notify the Burn Team should the patient's urine output be <1mL/kg/hr.*

iii. Nasogastric (NG) Feeding Tube: Patients will require NG feedings which will begin on admission to the PICU. To reduce discomfort, this should be placed and bridled during the initial, sedated debridement.

iv. Pain management: Patients require multimodal pain control to address the background, episodic, and neuropathic pain that burns cause. In the absence of contraindications, the burn team recommends that all burn patients be started on the following:
   1. Acetaminophen 15mg/kg (max 1000mg) PO/IV q6hr scheduled
   2. Ibuprofen 10mg/kg (max 600mg) PO q6hr scheduled
   3. Oxycodone 0.15mg/kg (max 10mg) PO q4hr PRN
   4. Hydromorphone 0.015mg/kg (max 0.2mg) IV q3hr PRN

   Patients in the emergency department may benefit from the use of fentanyl for quick onset pain control or other narcotic medications such as morphine. Pain management may be left to the discretion of the emergency medicine provider. For additional guidance on pain control, refer to the Pediatric Burn Pain Management Guideline.

v. Anxiety management:
   A Child Life Consult should be placed for all burn patients. While in the Emergency Department, intranasal or intravascular midazolam may be useful to reduce anxiety. Patients with a delayed transfer from MCJ ED to PICU should be started on the following:
   1. Gabapentin 5mg/kg (max 300mg) PO TID scheduled
   2. Clonidine should be considered when hemodynamically stable
      (a) 2-4yo: 0.005mg/kg (max 0.05mg) qHS scheduled
      (b) 5-10yo: 0.05mg PO qHS scheduled
      (c) >10yo: 0.1mg PO qHS scheduled

V. Phase 2: Titrated Burn Fluid Resuscitation

Once the patient has been debrided, TBSA determined, and arrives in the PICU, the titrated burn fluid resuscitation is started. The following are the calculations for burn fluid resuscitation:

a. **STEP ONE**

Initial Resuscitation Fluid Rate (LR)

Utilize the Modified Parkland Formula (below) to determine the initial rate of fluid (LR). If the patient has already received significant fluid volumes prior to arrival, it may be appropriate to subtract that volume from the 24-hour total and perform a second calculation — discuss with the Burn & PICU attendings.

1. (3 mL x ____ kg x ____ % Burn) = 24h Total ____
2. 24h Total (from above) ____ / 16 = Hourly starting rate ____ mL/hr

Maintenance IV Fluids (only ages <6 years) (D5LR) – Not Titrated

Patients ages <6 years old have increased dextrose requirements and are therefore started on maintenance rate D5LR in addition to the resuscitation fluid (LR). This rate is **not titrated** with urine output. It may be adjusted with the initiation of tube feeds and titrated with the tube feed rate. Once the tube feed goal is met, the maintenance IV fluids may be turned off. The **4-2-1 Rule** should be utilized for calculating MIVF rates, or per the PICU guidelines.

4 mL/kg/hr for the first 10 kg
2 mL/kg/hr for the second 10 kg

1 mL/kg/hr for any kg above 20 kg

Tube Feeds

Tube feeds should be initiated upon admission to PICU if feasible. Feeds should only be held for OR sedation per Monroe Carell existing policies. Any prolonged or unnecessary feeding interruption could potentiate stress ulcers and post-burn gastropathy, contribute to nutritional deficiencies, and impair recovery.

If a patient requires low doses of vasoactive medications to support blood pressure until resuscitation is adequate, consider tube feeds at a trophic rate (0.5 mL/kg/hr).

b. **STEP TWO**

Fresh Frozen Plasma (FFP)

FFP criteria: $TBSA_C \geq 15\%$ (Where $TBSA_C$ indicates cutaneous TBSA)

Do NOT include additional TBSA for electrical/inhalation injury.

There are two steps in FFP administration, the FFP bolus (see Phase 1) given on arrival and the FFP drip started 8 hours post burn injury. Whenever possible, the Type & Screen should be drawn by the ED and the FFP bolus started in the ED (see Phase 1). *If the FFP bolus is not started in the ED, it should be given as soon as possible in the PICU. In the case of delayed presentation where the FFP is being administered ≥ 8 hours post burn, the FFP bolus can be skipped and FFP gtt (see below) started immediately at the discretion of the Burn attending.*

i. **FFP Bolus – See Phase 1**

ii. **FFP Drip: Started 8 hours post burn injury**

Use the following formula for calculating the FFP rate

1. Total FFP Volume: 0.5mL x _____ (kg) x _____ ($\%TBSA_C$) =_____mL
2. FFP gtt Rate: _____ (Total FFP Volume) / 8 hrs = _____ mL/hr

c. **STEP THREE**

Calculate Minimum Resuscitation Rate (CMRR)

Calculate the minimum fluid requirement (insensible losses via burned tissue) for the patient to determine the lowest rate of titratable resuscitation fluids using the following formula:

i. Insensible Loss (IL) = MIVF + [(25 + $\%TBSA_T$) x BSA]

You will need the patient's height for the BSA in this formula. Utilize the BSA calculated in the EMR once data is entered for height and weight.

In STEP THREE of the resuscitation phase, the CMRR is inclusive of resuscitation fluid (LR) and FFP only.

ii. IF The initial resuscitation rate is less than the CMRR, use the lesser of the two rates as the minimum resuscitation rate. For example, if the initial resuscitation rate is 20 mL/hr and the CMRR is 30 mL/hr, utilize 20 mL/hr as the minimum rate (i.e. do not drop below 20 mL/hr until resuscitation is complete).

Fluid Titration

The following is a guide through titration of fluids. Once the CMRR is met, the fluids should be continued at this rate until stable and unchanged for 4 hours. Once met and stable, the foley catheter should be removed.

i. Identify Urine Output Goals

The urine output (UOP) goal is weight-based with ideal goals as follows:

1. <30kg: 0.9-1.1 mL/kg/hr
2. ≥30kg: 0.4-0.6 mL/kg/hr

3. **Myoglobinuria regardless of weight:** 1-2 mL/kg/hr
   Rounded to the nearest half number (i.e 3.4 rounded to 3.5, 2.1 rounded to 2).

ii. Titrate Resuscitation Fluid Rate Hourly

The resuscitation volume is titrated up or down based on UOP. Hourly volumes are titrated using resuscitation fluid only. Maintenance fluids and tube feeds should remain at the weight-based rate and are not titrated. When FFP is infusing, titrate LR so that the total infusion rate is inclusive of FFP (do no adjust the FFP infusion rate). **LR rate + FFP rate = Current resuscitation fluid rate**. Following completion of FFP drip, increase LR to equal the current resuscitation rate.

Resuscitation Fluid Titration	
UOP < Goal	Increase resuscitation fluid rate by 10 % of the current rate
UOP = Goal	Maintain current resuscitation fluid rate
UOP > Goal	Decrease resuscitation fluid rate by 10% of the current rate*

*Once the minimum calculated resuscitation rate has been met, do not decrease the rate. If UOP > goal at minimum resuscitation fluid rate, maintaining the minimum resuscitation fluid rate for 4 hours before reaching the Resuscitation Endpoint. At this point, Phase 3: Total Fluid Monitoring is started.

VI. Phase 3: Total Fluid Monitoring

a. Once the Resuscitation Endpoint is met, the patient's resuscitation is complete; however, close fluid balance must be monitored for hemodynamic stability. The patient is weaned from the total fluid goal as deemed clinically appropriate. The purpose of the total fluid goal is to maintain euvolemia following the fluid resuscitation and adjustments to the total fluid goal may differ from the initial calculated hourly volume. The following formula is used to calculate the total fluid volume for pediatric patients with burns:

b. Total Fluid Goal (TFG) = CMRR (see STEP THREE above)
However, in the transition to TFG monitoring, **the TGF is inclusive of all continuous IV infusions as well as tube feeds.**

The maintenance IVF rate is determined by the PICU, following their current guidelines and may deviate from the 4-2-1 Rule calculation particularly in heavier/older patients.

Note: Fluids should only rarely be completely stopped on a patient that has not had their full thickness burn excised as they will have an ongoing inflammatory responsethat will cause capillary leak and relative intravascular hypovolemia. In addition, fluid resuscitation may need to be restarted if urine output goals are not achieved, and the patient has not undergone full excision. UOP should continue to be monitored after removal of the foley and evaluated prior to each decrease in fluid rate. Should the average hourly UOP drop below goal, the Burn team should be notified to discuss appropriate fluid management.

VII. Labs

Whenever, possible, initial labs should be obtained by the ED:

a. Type & Screen
b. CBS

c. CMP
d. Magnesium
e. LFT
f. Lactate
g. Urine toxicology
h. Urine hCG (pubescent females)

Labs should be followed every 6 hours until the resuscitation is complete, then spaced at the discretion of the PICU/Burn attendings (typically at least daily until stable):
a. CBCd
b. CMP
c. Magnesium
d. Phosphorus
e. Calcium
f. LFT
g. Lactate
h. Others as indicated: coagulations studies, CK, ABG)

VIII. Considerations and Monitoring

a. Call the Burn attending for any of the following reasons:
i. Unable to wean resuscitation fluids for 4 hours
ii. Low UOP for 2 hours consecutively
iii. Hypotension
iv. Concern for compartment syndrome
v. Prior to initiation of: Pressors, diuretics, steroids, antibiotics

b. Output

Output should be strictly monitored in all patients. Foley catheters will be placed in those patients requiring resuscitation with hourly titrations. A foley catheter should be placed as soon as a burn ≥15% TBSA is confirmed. The initial output (urine that drains in the first 5 minutes after placement) should be recorded but it should not be counted as an hourly urine output, the first hour starts at time of foley placement, after initial output. *For those patients not undergoing fluid resuscitation, consideration should be given to foley placement if the patient is unable to spontaneously void ≥ 4 consecutive hours during the acute phase*.

c. **Hypotension**

Parameters for treating hypotension and threshold of minimum blood pressure must be based on norms for the patient's age. Vasopressors should be considered and discussed with the PICU attending for patients with hypotension below the age-based parameters. Fluid boluses should be avoided in patients with burns.

Age	Stable MAP (mmHg)	Age	Stable HR (BPM)
Birth-3mo	40	<12mo	100-160
3-6mo	45	1-5y	80-140
6mo-2y	50	6-12y	70-120
2-8y	55	>12y	60-110
8-14y	60		
>14y	65		

Identifying hypotension in a burn patient requires a comprehensive clinical assessment. Hypotension in the burn patient is not well correlated with low UOP and tachycardia. Noninvasive blood pressure measurements may also be inaccurate when tissue edema is present. Consideration should be given to arterial line placement in high volume resuscitations. True hypotension will usually correlate with decreased UOP. However, **fluid boluses are contraindicated** for the management of low UOP in the hemodynamically normal patient. Hourly titrations of resuscitation volume typically correct oliguria.

d. **Hypothermia**
Children have nearly three times the body surface area (BSA) to body mass ratio of adults. Fluid losses are proportionately higher in children than in adults.
Consequently, children have relatively greater fluid resuscitation requirements and more evaporative water loss than adults" [10]. The BSA to body mass ratio also predisposes children to rapid shifts in body temperature. Children should be monitored closely for hypothermia during the resuscitation. Interventions to maintain body temperature may include heat lamps, Bair Huggers, + warming blanket (cooling blanket but set to warm), purple gel heat packs from NICU, increased room temperature and/or fluid warmers.

e. **Stress Ulcers**
Patients with ≥15% TBSA are at risk for stress ulcers and should receive H2 blocker for routine prophylaxis beginning at admission. Early initiation of enteral feedings is also recommended. See Pediatric Burn Nutrition Protocol.

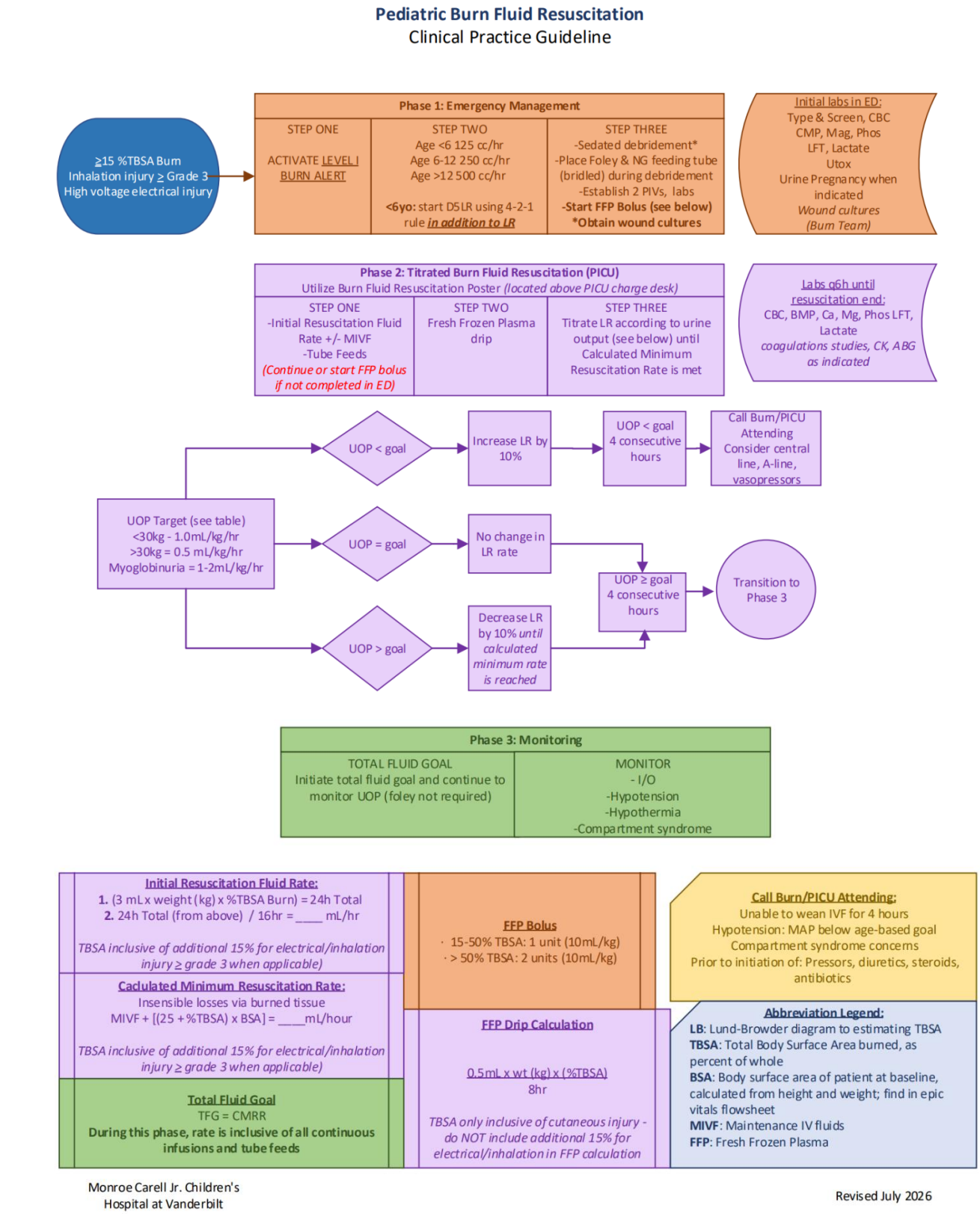
f. **Compartment Syndrome**
Those patients receiving high-volume resuscitations are at risk for developing abdominal, ocular, and extremity compartment syndrome. Hallmarks of abdominal compartment syndrome include increased pulmonary peak and plateau pressures, decreased UOP, hypotension not responsive to volume administration, and feeding intolerance. Clinical suspicion is critical in the diagnosis of this process as no one diagnostic test is predictive. If there is suspicion of abdominal compartment syndrome immediately contact the burn attending and discuss holding feeds, obtaining a bladder pressure, KUB, lactate and consulting pediatric surgery. Burn surgery and pediatric surgery will confer on the best next steps. Of note, a true bladder pressure reading is obtained while the patient is sedated and paralyzed.

Regarding extremity compartment syndrome, in patients requiring large volume resuscitation, extremities should be elevated at time of admission and a neurovascular exam of each extremity should be performed hourly. Tightness of the extremity +/- loss of pulse or decreased capillary refill should be relayed to the burn attending immediately.

Patients requiring formal volume resuscitation who are unable to communicate (either due to age or critical illness), need an ophthalmology consult at time of admission for serial measurement of intraocular pressures. Elevated pressures should prompt a lateral canthotomy to prevent long-term loss of vision.

Appendix I: Algorithms

[CPG] Pediatric Burn Fluid Resuscitation_7.2026.pdf



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