VANDERBILT UNIVERSITY

MEDICAL CENTER

Protocol: Adult Burn Fluid Resuscitation

Category	Clinical Practice
Approval Date	1/20/2021
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I. Population:

Adult (≥16 year old and ≥30kg) burn patients requiring acute intravenous burn resuscitation.

II. Indications:

Adults requiring more than maintenance intravenous resuscitation will be admitted to the BICU. The goal of fluid resuscitation after a severe burn injury is to reach and maintain appropriate organ and tissue perfusion. Insufficient resuscitation leads to organ failure and death while excessive resuscitation also causes increased morbidity and mortality.(1) For this reason, an appropriate early resuscitation is the most critical intervention in optimizing burn patient outcomes. A standardized algorithm is used to best match a continuous fluid infusion with the patient's needs, which are proportional to the size of the patient and the burn size.

Please use the following guidelines to determine appropriate disposition and resuscitation:

Appropriate Unit	
<10% TBSA	Admit to: burn step down Resuscitation: Oral
10-19% TBSA	Admit to: burn step down Resuscitation: Oral + MIVF
≥20% TBSA	Admit to: BICU Resuscitation: Resuscitation Protocol

III. Definitions:

Depth of Burn

Estimated percent of total body surface area (%TBSA) of partial and full thickness burns is needed to calculate fluid requirements.
Superficial burns (1^{st} degree) are <u>not included</u> in this calculation.

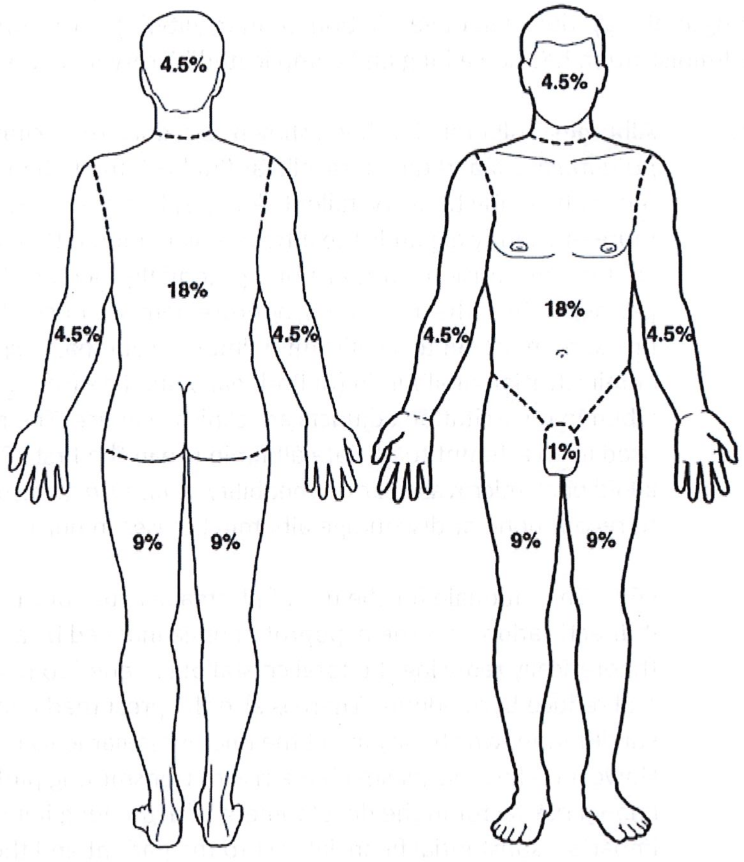
Depth of Burn	
Superficial (1^{st} Degree)	Erythema; skin intact ("sunburn")
Partial Thickness (2^{nd} Degree)	Wet, weepy, blisters, pink, blanching
Full thickness (3^{rd} Degree)	White, brown, red, black, leathery, dry

Calculating TBSA

There are various methods used to estimate TBSA. The Rule of Nines(2) and/or the Palmar Method(3) are the easiest and fastest way to estimate burn size. As humans grow and their body proportions change, there are some slight changes to the Rule of Nines. The adult diagram is below. If the burn does not encompass the entire area referenced in the rule, the %TBSA is counted as a proportion of the size noted in the diagram.

For example, if half of the posterior torso is burned that is 9% TBSA, not 18%.

The palmar method is 1% TBSA= the palm of the patient from wrist crease to tip of longest finger.



IV. Resuscitation Fluids

A. Crystalloid

Lactated ringers (LR) solution is the mainstay of burn resuscitation and has been so since the 1960s. As an isotonic solution, it has been used to expand the extracellular fluid volume in the critical first 48 hours post burn. This is complicated by burn induced inflammatory and vasoactive mediators that lead to local and systemic vascular changes promoting substantial fluid loss and fluid shifts, as well as reduced cardiac output.(4) However, it remains the standard for resuscitation.

B. Oral resuscitation (in isolation) is primarily used in smaller burns. Larger burns with more substantial fluid requirements naturally limit oral volume delivery and may lead to emesis if attempted.

C. **Colloid**

Plasma proteins exert an oncotic pressure, which balances against the hydrostatic pressure in normal homeostasis. Burn injury causes increased vascular permeability and changes the balance of plasma and interstitial oncotic pressures, driving proteins into the interstitium. This is exacerbated by increased interstitial compliance through local tissue destruction and plasma dilution through high volume crystalloid resuscitation.(5) While colloid administration may maintain the osmotic gradient in *unburned* skin and reduce resuscitation volumes while restoring cardiac output, it is not clear that there is an effect on multi-organ failure rates, length of stay, duration of ventilation, or mortality.(1) In response, colloid administration has had a long and complicated history in acute burn care.

1. **Albumin** – Albumin has been shown to reduce resuscitation volumes and *potentially* expand the extracellular fluid volume (when given along with LR) more efficiently than crystalloid alone.(1) It is not clear, however, that it more efficiently expands the intravascular volume than any other continuous infusion. Furthermore, potentially increased microvascular permeability in the lung and hypoproteinemia-induced loss of osmotic pressure may lead to significant pulmonary edema, in spite of the administration of albumin.(6) Both early and late (or "rescue strategy") albumin resuscitation adjuncts are clinically in use. The rescue strategy is used in an attempt to obviate albumin use in the first 12 hours post burn to avoid peak microvascular permeability of *unburned* tissue. There is no data to recommend or discourage albumin boluses in burn.

2. **FFP** – The rationale for the use of plasma in acute burn resuscitation is that it directly addresses the hypoproteinemia induced by a large burn, theoretically reducing the total crystalloid needed to restore cardiac preload and reduce burn edema. There is also the presumed benefit of endothelial stabilization, which may avoid the microvascular leakage seen in albumin. However, allogenic plasma has a risk of transmitting pathogens and is a known risk factor in the development of acute lung injury (ALI). It also imparts a substantial financial cost to the patient and the healthcare system.(7)

V. **Resuscitation Endpoints:**

A. **Hourly Urine Output**

1. While crude, urine output is the best and least invasive endpoint of resuscitation at our disposal. Maintenance of an hourly urine output between 30-50mL/hr (or approximately 0.5 -1 ml/kg/hr) remains the standard in adult burn resuscitation.(4) As such, urine output should be strictly monitored in all patients. Foley catheters will be placed in those patients requiring intravenous fluid resuscitation.

2. For those patients not undergoing intravenous fluid resuscitation (which should be the minority and *only* after discussion with the burn surgeon and

BICU attending), consideration should be given to bladder scanning, possible Foley catheter placement, and alternative fluid management if the patient is unable to spontaneously void ≥ 4 consecutive hours during the acute phase.

3. Crystalloid boluses are **not** indicated for the management of oliguria in the hemodynamically normal patient. Hourly titrations of resuscitationvolume typically correct the issue.(4)

4. Oliguria in a burn patient is mostly likely to be due to hypovolemia, but it still requires a comprehensive clinical evaluation to assess all possible etiologies. Evaluation of the Foley catheter placement, a bladder scan, and, in the appropriate population, measurement of bladder pressures should be considered.

B. Blood Pressure

1. Parameters for treating burn shock and threshold of minimum blood pressure must be individualized. In the previously healthy patient, a MAP≥60 and a heart rate below 140 are considered adequate, but age and comorbidities will require reconsideration of these metrics.
Patients over 65 should have a MAP≥65 and HR ≤130.

2. Isotonic crystalloid fluid boluses (500mL), administered rapidly, are the preferred method of management for hypotension in the resuscitation phase. The fluid resuscitation rate should be increased at the same time as the bolus is being given, as hypotension is a sign of inadequate volume resuscitation in most acute burn resuscitations. Giving a bolus without increasing the continuous rate will not prevent additional hypotension.

3. Hypotension in a burn patient requires a comprehensive clinical evaluation to assess all possible etiologies. Noninvasive blood pressure measurements may also be inaccurate when tissue edema or thick, leathery burns are present. Consideration should be given to arterial line placement early in the resuscitation and it is expected in the setting of hemodynamic difficulties.

4. Recurrent hypotension should lead to investigation of potential heart failure. Administration of vasopressors during the resuscitation phase is *discouraged* as most vasopressors cause cutaneous vasoconstriction and can extend the depth of the burn injury. However, in refractory hypotension causing resuscitation failure, they may be unavoidable.

5. As abdominal compartment syndrome can cause both hypotension and decreased urine output, and further fluid administration will only exacerbate this etiology, it is important that *every* resuscitation that is failing include an assessment for intra-abdominal hypertension.

C. **Lactate**

1. Lactate makes a poor independent metric of resuscitation compared to urine output. However, both the initial lactate and the ability to clear it have been shown to prognosticate mortality in burn resuscitations. (8, 9)Lactate clearance at 24 hours has been shown to predict improved mortality. As such, any persistent lactemia mandates comprehensive clinical evaluation to assess all possible etiologies.

2. Serum lactate reflects a balance of production and (10)hepatic clearance, and may ultimately represent a complication separate from resuscitation, such as liver failure, mesenteric ischemia, compartment syndrome, and etc.; as such, other causes of elevated lactate should be ruled out before using this as an independent metric of the trajectory of a burn resuscitation.(11)

D. **Other Endpoints**

1. Various invasive and non-invasive endpoints of resuscitation have been studied since the 1960s with inconsistent or unimpressive results. Central venous pressures and pulmonary artery catheter pressures provide more information, but have not been shown to improve mortality and may lead to greater over-resuscitation than urine output alone. Ventricular–arterial coupling measurements, pulse contour analysis, tissue perfusion monitors, and other measures of cardiac output and perfusion are similarly of questionable use at this time and should primarily be used as adjuncts when patient factors, such as renal failure or cardiomyopathy, make urine output unreliable.

E. **Resuscitation Failure**

1. Causes of resuscitation failure include incorrect burn size estimation, incorrect evaluation of burn depth, compression syndrome from eschar, electrical injury mechanism, concomitant trauma or inhalation injury, significant comorbidities (especially those that make UOP an unreliable metric of resuscitation). Patients at extremes of age and those with prior dehydration or delayed start of resuscitation are at particular risk of a failed resuscitation.(12, 13) Absence of a strict fluid titration protocol is another risk factor.

2. Defining burn resuscitation failure is difficult, especially in its early stages. Any evidence of inadequate end-organ oxygen delivery despite reaching or exceeding predicted fluid resuscitation volumes may be considered evidence of resuscitation failure. Irreversible burn shock is the primary contributor to burn mortality.(14)
   Signs of failure include:
   - Persistent oliguria despite escalation of fluid resuscitation up to 6ml /kg/%TBSA and inclusion of colloid
   - Persistent hypotension (MAP<60) despite boluses of crystalloid and colloid
   - Persistent elevation of lactate over 2.5(8, 9)

   Note: any of these could be present in isolation or together to be *considered potential resuscitation failure, though each of these in isolation would require elimination of other causes.*

3. Mitigation: A single instance of hypotension or decreased urine output does not define failure, but steps must be taken to correct the trajectory of the resuscitation. Oliguria must be treated with an increase in basal resuscitation fluid rate per protocol, including colloid. Hypotension and/or lactemia should be managed with boluses of crystalloid as well escalation of resuscitation rate. However, some portion of the population will have a poor outcome from resuscitation, even with rescue efforts embedded in the algorithm. In these cases, other possible methods of mitigation include:
   - boluses of colloid – used to expand intravascular volume, reduce total resuscitation volume, decrease edema in *unburned* tissue, and other potential effects that are less well understood (stabilization of endothelium, cardiac output restoration, etc.)(6),
   - hemofiltration (reduces inflammatory burden and manages renal failure) ,
   - vasoactives (15-17),
   - high dose vitamin C (antioxidant effect)(10, 18),
   - early burn excision – within 24-72 hours (reduce inflammation)(19, 20), and
   - plasma exchange/plasmapheresis (reduces inflammatory burden)(21, 22)

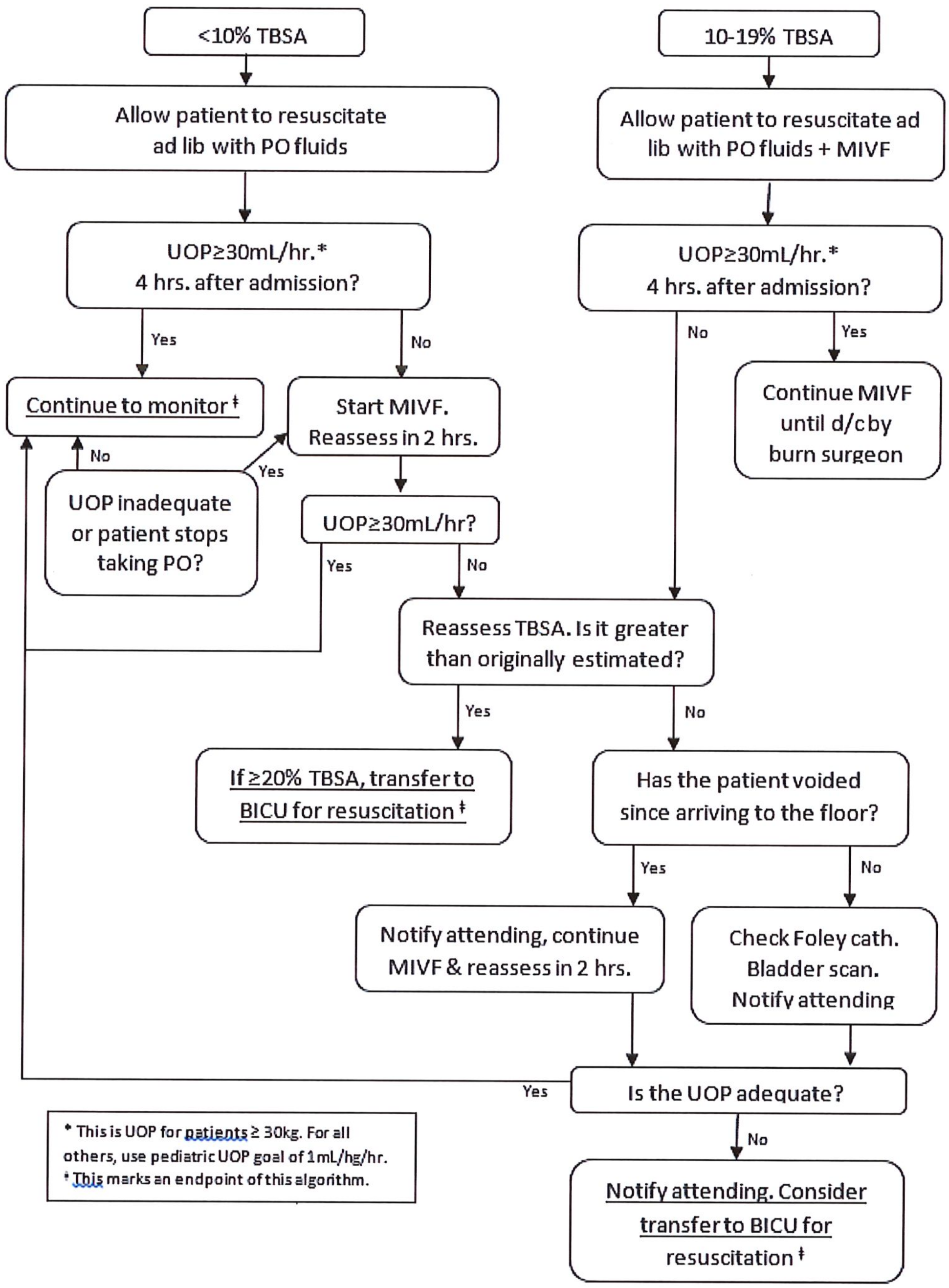
VI. Intervention/Treatment:

Labs at admission

CBC with differential, CMP, serum lactate, Magnesium, Phosphorous, Calcium, and coagulation labs should be drawn upon admission. CBC with differential, CMP, and serum lactate should be drawn at hours 4, 8, 12, 18, and 24 thereafter.

FLUID MANAGEMENT

TBSA <20%



RESUSCITATION – TBSA ≥20%

Preparation

Ideally, 2 large bore (18 gauge or larger) IVs would be placed in unburned skin for resuscitation and a Foley catheter would be placed. The patients TBSA, Baux score, and expected mortality should be documented on the resuscitation table and should also be discussed with the burn surgeon, BICU attending, bedside nurse, and charge nurse

FLUID MANGEMENT

Fluid Requirements

STEP One: Calculate the starting rate

The Consenscus formula is used during resuscitation and Lactated Ringers is used as the resuscitation fluid. Resuscitation starts at 2ml/kg/%TBSA.

Filling out the table below at the start of resuscitation will give you all of the values that you will need throughout the resuscitation. At VUMC, our fluid titration during resuscitation is nurse-driven and the resident is responsible for knowing how the resuscitation is progressing, identifying potential signs of resuscitation failure, and communicating with the burn surgeon and the BICU attending.

Necessary Calculations	
Starting Rate	Typical starting rate of resuscitation 2ml x ____kg x ____ %TBSA=______ml/16=_____ml/hr
Albumin Start	Consider starting albumin per protocol when resuscitation is ≥ this rate 4ml x ____kg x ____ %TBSA=______ml/16=_____ml/hr
Albumin Stop	Discontinue albumin protocol when fluids return to this rate 3ml x ____kg x ____ %TBSA=______ml/16=_____ml/hr
MIVF Rate	4-2-1 Rule *For 0-10kg:* +4ml/Kg/hr, *For 10-20kg:* +2ml/kg/hr, *For >20kg:* +1ml/kg/hr

STEP Two: Titrate Resuscitation Volume Hourly

Resuscitation volume is titrated ↑ or ↓ hourly by 10-20% based on UOP if the heart rate is <140 and MAP >60 (see resuscitation failure section if otherwise). See below for guidance:

Standard Titration of Resuscitation					
UOP	≤19	20-29	30-39	40-49	≥50
LR ml/hr.	↑20%	↑10%	-	↓10%	↓20%

Monitoring Resuscitation

Vital Sign Monitoring & Interventions for Hemodynamic Abnormalities

Heart rate and blood pressure are monitored throughout the resuscitation. At 4 hours of inpatient protocolized resuscitation, admission labs should be repeated. The trajectory of the resuscitation (changes over last 4 hours and boluses) and the MAP should be reviewed between the charge nurse and the resident. Both parties, as well as either the NP on service or charge nurse will also sign off their satisfaction (or lack thereof) with the resuscitation. This information should be conveyed to the burn surgeon and the burn attending and documented on the flowsheet and in the patient's chart. This should occur even if the resuscitation is going well.

After the first 4 hours, any 2 consecutive hours with UOP≤30 or shock require re-evaluation by the resident and the nurse, review of the labs and hemodynamics, and a call to the providers. Labs (CBC, CMP, and lactate) will be redrawn at hours 8, 12, 18, and 24 of resuscitation.
If at any point, either the bedside nurse or the resident feel that the trajectory of the resuscitation is poor, they **MUST** let the burn surgeon and BICU attending know that the patient is exhibiting signs of a potentially failing burn resuscitation. This must be documented.

Albumin Rescue Strategy

Patients require albumin if they have reached a rate of *double* the starting fluid rate (BFR 4) or they have developed complications related to edema. While the use of albumin in the first 8-12 hours after injury is discouraged due to capillary leak, it may be unavoidable. Infusion should be 5% albumin at 1/3 the current hourly rate while continuing LR at 2/3rds of the current rate(23). Titration of both the albumin and LR should follow the standard titration guidelines by UOP. Discussion with the burn surgeon and BICU attending is required prior to starting albumin.

Other Considerations When Starting Albumin

When albumin has been started then this should be an indicator that the patient is at risk for secondary complications from resuscitation including abdominal compartment syndrome. Consideration should be given to the following:

- Placement of central access and arterial line if not already done
- Assessment of cardiac function by either non-invasive or invasive means (ie. PAC, Imacor, etc.)
- Monitoring of abdominal compartment pressures q4 hours with serial bladder pressures and peak inspiratory pressures (PIPs) on the ventilator

Albumin Stop

When the total rate of hourly fluid administration returns to 3ml/kg/%TBSA, albumin administration should be discontinued. Albumin should continue ideally <u>no longer than 24 hours</u>, unless decided by the BICU attending or burn surgeon. When albumin is discontinued, the volume is replaced with crystalloid fluid and continues to be titrated to UOP.

Example: UOP=40cc/hr

- Current resuscitation volume= 150ml/hr. 100ml LR (2/3 crystalloid)
  <u>+50ml</u> albumin (1/3 colloid)
  150ml (total resuscitation volume)
- Stop albumin and decrease resuscitation by 10% 150 ml (Current total volume)
  <u>– 15ml</u> (10% of current volume)
  135ml (Next hour fluid rate of LR)

Cessation of Resuscitation

Once resuscitation volume is at calculated weight based MIVF rate for 4 consecutive hours, the burn fluid resuscitation has ended. Switch to a maintenance fluid with a glucose source and continued at the maintenance rate until enteral intake is adequate to maintain adequate UOP. At the end of each resuscitation, the patient will have documentation of their total volume (including boluses) of crystalloid and colloid. Crystalloid will further be broken up by mL/kg/hr.
Use caution when discontinuing IV fluids in patients who still have the inflammatory drive and insensible losses of the burn injury.

VII. Failing Resuscitations

A. **Tachycardia** is frequently multifactorial in large burns, but if the patient develops a sustained heartrate of >140 bpm, please contact the BICU attending and burn surgeon. Pain and anxiety should be addressed first. Intoxication should be considered if UOP is adequate and pain/anxiety have been addressed. If tachycardia is accompanied by **hypotension** (defined as a MAP of <60), the most likely diagnosis is burn shock due to inadequacy of resuscitation and the patient the patient is to be bolused 500 mL of LR along with a simultaneous increase in the hourly infusion of LR by 20%. If a bolus is given, the BICU attending and burn surgeon must be notified. Persistent hypotension after a second bolus of 500mL (also done after discussion with BICU attending and burn surgeon) *or* hypotension that persists for 4 hours should lead to consideration of a bolus of 50mL of 25% albumin and other strategies to mitigate a failing burn resuscitation.

B. **Oliguria** (UOP <30mL/hr): If oliguria persists despite 4 hours of escalation on the protocol, consider starting albumin rescue protocol, even if the patient has not yet reached BFR4. You should also consider a bolus of 50mL of 25% albumin. The burn surgeon and BICU attending must be notified in any of these cases. A discussion must be had about other strategies to mitigate a failing burn resuscitation at this time.

C. **Lactemia**: If elevated lactate, defined here as a serum lactate persistently above 2.5 and up-trending, persists after 4 hours of inpatient, protocolized resuscitation, the patient is to be bolused 500 mL of LR along with a simultaneous increase in the hourly infusion of LR by 20%. If a bolus is given, the BICU attending and burn surgeon must be notified and a discussion must be had regarding other strategies to mitigate a failing burn resuscitation.

VIII. Mitigation of Failure

Consideration of Causes: Patients who are failing their resuscitation should have a comprehensive physical examination and evaluation of all of their potential risk factors for failure, as described above. This should be done when it is identified, irrespective of previous evaluations. Labs, including CBC with differential, CMP, serum lactate, and coagulation labs, should be repeated at this time. The evaluation should also include evaluation of cardiac function, such as point of care ultrasound or echocardiogram. Results of this evaluation should be discussed with the burn surgeon and BICU attending in case any of them can be intervened upon without significant alteration to the resuscitation protocol. In all others, and only with the agreement of the burn surgeon and BICU attending, consider the following:

A. **Further Fluid Administration**

Patients who are failing their resuscitation are likely to have already had significant escalation in their resuscitation and potentially have boluses of both crystalloid and colloid. It is very likely that these patients are no longer fluid responsive and further escalation would increase the risk of excessive resuscitation and increase mortality. Any further escalation in resuscitation should be done with this in mind and should only be done under the direction of the burn surgeon and BICU attending.

1. Ideal population: intravascular deplete (US, echocardiogram, PAC, pulse

pressure variation, and etc.) and fluid responsive (leg raise, US, and etc.). Consider in patient dehydrated at admission.

2. Avoid in: patients with anasarca and evidence of worsening intra-abdominal hypertension or abdominal compartment syndrome.

B. **Hemofiltration**

Continuous renal replacement therapy may play a role in mitigating failing burn resuscitation through removal of inflammatory mediators. It is known that CVVH can reasonably filter out many small, water-soluble immune mediators efficiently and may improve mortality in that way.(24) Furthermore, in patient with acute renal injury, this may mitigate the risk of excessive resuscitation. This requires evidence of adequate intravascular resuscitation and placement of an appropriate vascular catheter, along with consultation of the nephrology service.

1. Ideal population: Patients who present with renal failure or those who have isolated oliguria and worsening renal function. Patients must be close to euvolemic and <u>will</u> continue to require resuscitation. Unclear stopping point, but cessation should be considered at 24 hours and should not need to go for more than 48, except in patients with pre-existing or worsening renal failure.
2. Avoid in: Under-resuscitated patients.

C. **Very Early Burn Excision** (within 48 hours)

The decision to excise a patient before they are finished with their resuscitation is a difficult one and needs to be based on clinician judgment. Very early excision has been shown to decrease pro-inflammatory cytokines and improve mortality. While there are real limitations on very early excision, including the difficulty in trying to continue resuscitation in the OR and a higher blood transfusion requirement, it is a reasonable rescue measure.

1. Ideal population: Failure of other mitigation efforts.
2. Avoid in: The vast majority of patients should be through their resuscitation and through the diuretic phase of resuscitation before an operation.

D. **Vasoactive medications**

There are no prospective, randomized control trials regarding the use of vasopressors in burn. The rare, descriptive studies and protocols using vasopressors tend to agree that they may have a role in patient with sustained hypotension and *potentially* in sustained oliguria.

1. Ideal Population: Sustained MAP ≤60, despite fluid resuscitation by protocol.
2. Avoid in: Under-resuscitated patients.
3. Potential medications (starting doses):
   a. Norepinephrine at 5mcg/kg/min
   b. Vasopressin at 0.04u/min,
   c. Dobutamine at 2.5g/kg/min
   d. Each should be titrated to effect

E. **High Dose Vitamin C**

Ascorbic acid is an oxygen-free radical scavenger that has shown a reduction in resuscitation volumes in the animal model and in humans.(25-27) However, a higher incidence of renal failure (potentially through a diuretic effect or oxalate nephropathy) and questionable effect on mortality have made the use of high dose vitamin C controversial.(18) Some studies have failed to recreate even the volume sparing effect otherwise noted.(10)

1. Ideal Population: Patients with oliguria despite escalation of resuscitation
2. Avoid in: Potentially in patients with renal failure at presentation
3. Dosing: Ascorbic acid at 66mg/kg/hr

F. **Plasma Exchange/Plasmapheresis**

Plasma exchange (PlEx)and plasmapheresis are extracorporeal blood purification methods that fractionates whole blood and returns components free of, in this case, inflammatory mediators, to the patient. PlEx has been shown to decrease fluid requirements to reach goal UOP in difficult burn resuscitations, as well as improve base deficit, lactate, and hematocrit.(28)

1. Ideal Population: Patients with large, survivable burn wounds exhibiting oliguria despite escalation of resuscitation. Especially in patients at greater than BFR 4.
2. Avoid in: The vast majority of patients are unlikely to need this.

IX: Complications/Comorbidities

A. **Heart Failure**

Burn induced inflammatory mediators case a reduction in cardiac output and an increase in systemic and pulmonary vascular resistance. Patients who already have heart failure, and thus exhibit increased sympathetic tone and a stimulated neuroendocrine state, can quickly exhaust their cardiac reserve in the setting of a large burn. These patients may benefit from more formalized metrics of resuscitation, including a pulmonary artery catheter (PAC) or echocardiogram, for example.

1. PAC is only useful in the hands of a skilled and experienced provider who is able to reliably place the catheter, analyze the date, and act on it in the setting of heart failure. Target cardiac output (CO), peripheral vascular resistance (PVR), and mixed venous oxygen saturation (S_vO^2) to be decided by the BICU attending.
2. CVVH may be indicated for patients who need resuscitation but cannot tolerate the volumes required due to heart failure.
3. Medications to consider in this population include the following:
   a. ACE inhibitor – offload cardiac stress, with expected increase in creatinine
   b. Dobutamine started at 2.5g/kg/min and titrated to effect
   c. Milrinone infused at 0.375 to 0.75g/kg/
   d. Other: β-1 agonist and a phosphodiesterase inhibitor

B. **Renal failure**

In patients with renal failure, whether acute or chronic, decisions must be made regarding an alternative metric of resuscitation and management of renal failure. Alternative metrics of resuscitation in these patients include hemodynamics, mental status, labs indicating acid-base status and oxygen availability, and invasive monitors, such as PAC.

1. In patients who meet criteria for renal replacement, or those on outpatient dialysis, CVVH should be used for the acute resuscitation to minimize hemodynamic perturbations of hemodialysis.
2. BMP should be regularly evaluated to evaluate BUN and K^+. EKG should be obtained to make sure and other signs of

C. Hypothermia

Significant hypothermia is common in burn patients. If severe, it can cause alterations in oxygenation and electrolytes. Interventions include:

Hypothermia Management

<35°	• Heat Lamps • Plastic Covering • Thermal Surgical Cap • Fluid Warmer
35-36°	• Heat Lamps • Plastic Covering • Fluid Warmer
>36°	• Continuous Monitoring • Fluid Warmer

D. Stress Ulcers

Patients with >20% TBSA are at risk for stress ulcers and should receive routine prophylaxis beginning at admission.(29) Early enteral feedings is recommended.

E. **Compartment Syndrome**

Patients receiving high-volume resuscitations are at risk for developing ocular, abdominal, and extremity compartment syndrome. Any patient who cannot communicate vision changes should have an ophthalmology consult to measure intraocular pressures and intervene if elevated. If there is suspicion of abdominal or extremity compartment syndrome, notify burn and BICU attendings immediately. All patients with circumferential full thickness burn on an extremity should receive hourly neurovascular assessments until discontinued by the burn surgeon.

F. **Electrical Injury and (concomitant) Inhalation Injury**

These mechanisms have practice management guidelines, but from a resuscitation standpoint, it is important to remember that the %TBSA will <u>underestimate</u> the fluid requirements in these patients as the underlying tissue damage is greater than what is visible on presentation.

Electrical Injury patients are also at a greater risk of compartment syndrome and acute renal injury due to underlying muscle damage. This may require supra-normal urine output targets for the resuscitation and a lower threshold for compartment decompression.

Inhalation injury increases fluid requirements relative to %TBSA estimate alone in patients with burns over 25% TBSA. As such, the %TBSA alone would be an inadequate metric to estimate to total requirement. (29)

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