

DISCLAIMER: These guidelines were prepared by the Department of Surgical Education, Orlando Regional Medical Center. They are intended to serve as a general statement regarding appropriate patient care practices based upon the available medical literature and clinical expertise at the time of development. They should not be considered to be accepted protocol or policy, nor are intended to replace clinical judgment or dictate care of individual patients.

ACUTE BURN RESUSCITATION

SUMMARY

Acute major burns are serious life threatening conditions. The patient's optimal chance for survival and a meaningful recovery depends upon appropriate fluid resuscitation, airway management, and appropriate, timely burn care. This guideline provides a template for the initial resuscitation of patients with acute major burn injury encompassing 10% total body surface area (TBSA) or more.

RECOMMENDATIONS

- **Level 1**
 - None
- **Level 2**
 - Estimate initial fluid requirements with the Parkland formula (4 mL/kg/% TBSA burned).
 - Give ½ of the fluid volume calculated over the first 8 hours from the time of the burn
 - Give the remaining half of the fluid volume over the next 16 hours
 - For ≥ 30% TBSA burns, Vitamin C infusion should be considered. See the “Ascorbic Acid (Vitamin C) Infusion in the Resuscitation of Burn Patients” guideline.
 - Avoid the use of hypertonic saline.
- **Level 3**
 - Avoid oversedation. Consider non-narcotic analgesia such as ketorolac, ibuprofen, or ketamine.
 - In patients with burns ≥ 20% TBSA:
 - Insert a central venous catheter
 - Insert a urinary (Foley) catheter
 - Monitor intra-abdominal (bladder) pressure q 4 hours during the initial resuscitation
 - Consider invasive hemodynamic monitoring to guide resuscitation
 - Resuscitation endpoints in the first 24 hours post-burn injury:
 - Monitor arterial lactate q 4 hours until < 2 mMol/L
 - Maintain urine output at 30-50 ml/hr (50-100 ml/hr if receiving Vitamin C)
 - In electrical injury or rhabdomyolysis patients, serial creatinine kinase levels should be checked daily until < 2500 mcg/L
 - Monitor hemoglobin to ensure that it is not trending upward
 - If the patient requires ≥ 1.5 times the calculated Parkland formula volume (6 ml/kg/TBSA), consider colloid rescue:
 - 5% albumin at 1/3 Parkland rate + 2/3 Parkland rate of Lactated Ringers OR
 - 25% albumin at 1/15th the Parkland rate + 2/3 Parkland rate of Lactated Ringers
 - Fresh frozen plasma may be used as an efficacious alternative to albumin for colloid rescue
 - If the patient has received > 250 mL/kg of fluid resuscitation, intraocular pressure should be measured.

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

INTRODUCTION

The most commonly used formula to determine fluid resuscitation volume following burn injury was published in 1968 by Dr. Baxter from Parkland Hospital. It has become known as the "Parkland formula". This formula is based on the patient's weight and the percentage burn. The resuscitation fluid is always Ringer's Lactate. The formula is 4 ml/kg/% TBSA burned. The fluid administration is divided into two time intervals. The first half of the calculated fluid volume is given over the first 8 hours from the time of the injury and the second half of the fluid is given over the next 16 hours. The formula is designed to estimate fluid requirements for burns that are 20% TBSA or greater. The goal is to maintain adequate tissue perfusion to prevent shock and conversion of partial thickness burns to full thickness burns. The following evidence-based discussion addresses the options for fluid resuscitation requirements that exceed the normal calculated volume.

LITERATURE REVIEW

Fluid Choice

In 2000, Pruitt coined the term "fluid creep" suggesting that many patients are being over-resuscitated resulting in secondary complications. Chung et al. recommended "colloid rescue" for those patients who exceeded the Parkland formula calculation by more than 1.5 times or 6 ml/kg/%TBSA. Similar protocols were instituted at the University of Utah and by the US military. The colloid rescue formula is 1/3 of the Parkland volume given as albumin + 2/3 of the Parkland rate given as Lactated Ringer's solution (Cartotto et al 2012). This formula has been shown by multiple studies to decrease fluid requirements without any associated increase in mortality or renal failure. On the contrary, there is evidence that use of hypertonic saline in burn patients will lead to an increase in renal failure and mortality; as such it should not be used for resuscitation.

End Points of Resuscitation

There is no one clear parameter to evaluate the adequacy for fluid resuscitation. Many centers institute a multi-factorial approach looking at several different markers of resuscitation adequacy. These include urinary output (30-50 ml/hr) and serial lactate, base deficit, and creatinine kinase levels every 4 hours. The trend in these parameters over time helps ensure appropriate resuscitation and it is important to see that they are approaching normal values within the first 24 hours post-burn injury.

High Dose Vitamin C

Following thermal injury, mast cells activate releasing histamine. This causes an increase in xanthine oxidase activity and free radical production. Vitamin C serves as a free radical scavenger and stabilizes the cellular membranes reducing post-injury membrane lipid peroxidation. This decreases vascular permeability and reduces edema (Kahn et al 2011).

Tanaka et al and Kahn et al both demonstrated that Vitamin C at a dose of 66 mg/kg/hr started as soon as possible and before the burn was 10 hours old greatly reduced fluid resuscitation volume. Tanaka et al demonstrated that a Vitamin C protocol decreased the total fluid volume required from 5.5 ml/kg/%TBSA burn to 3.1 ml/kg/%TBSA.

There has been some controversy over the potential for Vitamin C to cause osmotic diuresis. This has been identified during clinical use of the Vitamin C protocol however neither study clearly demonstrated this side effect. Of note, there was no increase in mortality or incidence of acute renal failure in either study. Kahn et al did identify that point-of-care glucose tests may be erroneously elevated by the presence of high-dose Vitamin C and that confirmatory serum glucose analyses should be done.

Hemodynamic Monitoring

There is no perfect way to monitor and ensure adequate tissue perfusion and volume resuscitation. However, several principles should be applied and followed. Shock following burn injury is a combination of both hypovolemic and distributive shock. The emphasis in the last decade has been to avoid "fluid creep" or excessive fluid administration has over-resuscitation has been common. There appears to be a reluctance to decrease fluid administration rates even when urinary output exceeds 1 ml/kg/hr. There are many complications associated with over-resuscitation including abdominal compartment syndrome,

extremity compartment syndrome, and increased nosocomial infections. Chung et al demonstrated that patients receiving >250 ml/kg had significantly increased mortality compared to those who received less than 250 ml/kg. This has become known as the “Ivy Index”.

Patients with >20% TBSA burn injuries should have urinary (Foley) and central venous catheters placed (Azzopardi et al 2009). Given the risk for intra-abdominal hypertension and abdominal compartment syndrome, intra-abdominal (bladder) pressures should be monitored every 4 hours (Cheatham et al 2007). It is strongly recommended that a pulmonary artery catheter (or other appropriate hemodynamic monitoring technology) be inserted in patients with \geq 30% TBSA burn injury to allow monitoring of intravascular volume status, especially in patients who receive Vitamin C therapy or where fluid status cannot be determined with traditional markers of fluid resuscitation adequacy such as urinary output (i.e. acute renal failure). One of the current theories put forth on the “fluid creep” phenomenon is that there is now more liberal narcotic use. This narcotic use mitigates some of the catecholamine effects and causes vasodilation. While it is essential to control pain, it is also important to not oversedate patients (Endorf et al 2011). The goal of fluid resuscitation is to give “just enough” and more is not necessarily better. Nurse driven protocols and hourly communication between nursing staff and burn physicians have been shown to decrease fluid resuscitation volumes and lead to better outcomes. (Pham et al 2008).

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Surgical Critical Care Evidence-Based Medicine Guidelines Committee

Primary Author: Paul Wisniewski, DO; Howard G. Smith, MD
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Please direct any questions or concerns to: webmaster@surgicalcriticalcare.net