

Prolonged Field Care Working Group Fluid Therapy Recommendations

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ABSTRACT

The Prolonged Field Care Working Group concurs that fresh whole blood (FWB) is the fluid of choice for patients in hemorrhagic shock, and the capability to transfuse FWB should be a basic skill set for Special Operations Forces (SOF) Medics. Prolonged field care (PFC) must also address resuscitative and maintenance fluid requirements in nonhemorrhagic conditions.

KEYWORDS: *prolonged field care; blood, fresh whole; shock, hemorrhagic; transfusion*

Introduction

The Prolonged Field Care Working Group (PFC WG) concurs that FWB is the fluid of choice for patients in hemorrhagic shock, and the capability to transfuse FWB should be a basic skill set for SOF Medics.¹ Additionally, PFC must address both resuscitative and maintenance fluid requirements in nonhemorrhagic conditions such as significant burns, dehydration, sepsis, and head injury. Our goal is to inform the community through recommendations for premission training and logistics and actual patient treatment in the PFC environment.

There has been great debate regarding the use of colloids versus crystalloids; both fluid classes have advantages and disadvantages.^{2,3} The best fluid, however, is *the one you have available*.

Urine output (UOP) is a very easy and extremely important monitoring tool to guide fluid resuscitation and fluid maintenance requirements. We recommend that PFC providers be trained and equipped to accurately measure UOP.

The type and amount of fluids given must be tailored to the specific patient being treated. These recommendations

are meant to serve as a general guide, but specific guidance, via telemedicine or calling for other medical consultation, may be required for complicated, critically ill patients with prolonged evacuation times.

Clinical Overview

Fluid is administered to patients for one of three reasons: as therapy, to correct pathologic fluid volume loss, and as nutrition. Resuscitation fluid is given as therapy to achieve either an end-organ function (e.g., increased UOP, improved mentation) or hemodynamic improvement in a patient experiencing a systemic inflammatory response or shock state. Organ dysfunction or hemodynamic compromise in these patients is due to a loss of effective circulating volume. Resuscitation fluid is given to restore adequate volume, generally in bolus increments, guided by clinical end points, although certain specific conditions, such as rhabdomyolysis and crush injuries, are resuscitated with high-rate continuous infusions.⁴

Replacement fluid is used to correct water and electrolyte deficits due to pathologic volume loss. Examples include plasma loss in burns, watery diarrhea in gastrointestinal illness, and diabetes insipidus in head trauma. Replacement fluid is generally given as a continuous intravascular, enteral, or per rectum (PR) infusion, or by strictly scheduled oral (PO) intake. These patients may not be in a systemic inflammatory or shock state, but they are at risk of deteriorating into these states if their fluid losses are not replaced.

Maintenance fluid is given as nutrition to provide water and electrolytes that are lost via ongoing physiologic sweat, respiratory, urine, and stool output, as well as glucose required chiefly for brain metabolism. The body's absolute requirement for fluid is approximately

500mL/day to clear toxic solutes through the kidneys, and another 500mL/day to replace sweat losses. Febrile patients may lose an additional 100–150mL/day for every degree over 38°C. Respiratory losses of approximately 500mL/day are generally offset by generation of water from oxidation, unless the patient is hyperventilating.⁵ Children are much more sensitive to fluid loss than adults, because of larger insensible loss per kilogram and decreased renal concentrating ability, so more thought needs to be put into the content and amount of maintenance fluid in children.

The route of fluid administration takes on additional importance in PFC because of resource limitations. For resuscitation and replacement, there is evidence that describes good outcomes with oral or enteral resuscitation of shock due to burns up to 40% total body surface area (TBSA), and dehydration from diarrheal illness.^{6–8} There are limited studies of successful resuscitation of hemorrhagic shock with fluids given PR.^{9,10} We recommend a trial of oral or enteral resuscitation be considered for burns less than 40% TBSA, and hypovolemic shock due to dehydration. These routes should be considered for patients with hemorrhagic and septic shock if blood or intravenous (IV) fluid are unavailable.

Providers in the PFC environment should be trained in the preparation (i.e., glucose and electrolyte content) and administration of oral, enteral, and PR fluids for resuscitation, replacement, and maintenance requirements. The PFC WG also recommends that oral or enteral routes for maintenance fluids be encouraged in PFC to conserve resources.

Fluid given for resuscitation comprises only half of the therapy needed to manage the critically ill or injured patient. The other aspect of therapy is treatment of the underlying cause (e.g., hemostasis for hemorrhagic shock, antimicrobials for septic shock). It is beyond the scope of this paper to discuss the details of treating and resuscitating the various shock states, but an overview of fluids in PFC would be remiss if it did not remind the practitioner that resuscitation must be accompanied by treatment for the critically ill or injured patient to have the best chance of survival and recovery.

Overview of Fluid Types

Colloids

Colloids refer to fluids that contain microscopic particles in suspension. The principal clinical effect of giving colloids is that they are less likely to cross membrane barriers, specifically blood vessels, and thus remain in the intravascular compartment longer than crystalloids. Whether this has clinical benefit is uncertain

despite extensive study and debate. In the operational environment, the main benefit of colloids is to provide resuscitative fluid in smaller and lighter volumes than crystalloids. This advantage makes colloids a more ideal “ruck” fluid. Examples of colloids include all blood products, freeze-dried plasma, albumin, and semisynthetic colloid solutions, such as hetastarch. Currently, only hetastarch is widely available to military medical providers in operational environments.

Hetastarch. Semisynthetic colloid solutions are made of large molecules that rarely cross capillary membranes. Giving 500mL of hetastarch to a patient will have the volume expansion effect of giving 2,000–2,500mL of normal saline (NS), and the effect will last longer, since only 20%–25% of crystalloids remain in the intravascular space at 1 hour compared with nearly 100% of colloids. Thus, a medic can carry 500mL of hetastarch, instead 1,500mL of NS. As the SOF medic transitions a PFC patient from the initial treatment and stabilization (ruck phase) to the “truck” or “house” phase, the weight advantage of starches becomes less important.

Starches, used in critically sick patients, can increase the incidence of kidney disease, contribute to coagulopathy, and worsen patient outcome. Because of these risks, they should be used for initial resuscitation or replacement fluids only. There is no role for their use as a maintenance fluid, since they contain none of the nutritional requirements (i.e., electrolyte and glucose) required.

In summary, the recommended use of semisynthetic colloids is as follows: (1) for initial volume expansion in hemorrhagic shock while provision of blood is being arranged and (2) initial resuscitation of perfusion to dysfunctional organs or unstable hemodynamics in nonhemorrhagic shock states until adequate volume of crystalloids is available.

Crystalloids

Fluids in this category include NS and buffered or “balanced” solutions, such as lactated Ringer’s (LR) and Plasma-Lyte A (Baxter; <http://www.baxter.com>). These electrolyte solutions expand intravascular volume; however, only 20%–25% of a volume of crystalloid infused remains in the intravascular space. Crystalloids, when given to improve organ perfusion or hemodynamics, should be given as large-volume boluses (500mL to 1L per bolus) to cause a physiologic effect on the organs and vascular system.

Crystalloids given as continuous infusions to critically ill patients are more likely to diffuse out of the intravascular space (“third space”) than when given as boluses. For this reason, any continuous infusion in the critically ill or injured patient should be the minimum necessary to

replace water and electrolytes lost through sweating and urine, unless the patient has a condition that specifically requires large-volume continuous infusion therapy (e.g., burns, crush injuries, rhabdomyolysis). Complications of large-volume crystalloid resuscitation include compartment syndromes, acute respiratory distress syndrome, and dilutional coagulopathy. In addition, NS can cause hyperchloremic acidosis in large-volume resuscitation.

Despite these cautions, crystalloids are not the enemy. They are first-line therapy in expanding plasma volume in septic shock. Also, in the initial response to a hypotensive trauma patient, a careful provision of crystalloids remains a first-line strategy to expand plasma volume, optimize organ perfusion, and reduce the risk for hypovolemic shock, compounding the inflammatory response to tissue injury.

The differences between crystalloids are as follows:

- NS is an unbalanced crystalloid with a supraphysiologic concentration of chloride, which can produce a hyperchloremic metabolic acidosis in larger infusions. Increasing evidence shows that this worsens inflammation and decreases kidney function.¹¹ One advantage of NS is its compatibility with many IV medications and blood transfusions.
- LR is a *slightly* hypotonic solution that has a minimal effect on pH. It is referred to as a balanced crystalloid because of the presence of organic anion (lactate) and lower chloride. The lactate component was once thought to be harmful, especially in critically ill patients with lactic acidosis. Research found that the D-isomer of lactate was proinflammatory, but that the L-isomer has beneficial immunomodulatory properties. The form of lactate currently used in LR is either L-lactate or a mixed L- and D-lactate form, both of which have less toxicity than D-lactate.¹² LR's mild hypotonicity makes it a less ideal fluid for patients with cerebral edema; in these cases, NS or Plasma-Lyte A would be recommended, if available.
- Plasma-Lyte A injection solution is an isotonic solution that can slightly raise a patient's pH in larger infusions. Plasma-Lyte A is compatible with blood transfusions and with many IV medications. Plasma-Lyte A costs approximately 1.7 times more than NS and is generally considered equivalent to LR as a resuscitation and maintenance fluid, though it is less prevalent in the US medical supply system.

Resuscitation Goals for Hemorrhagic Shock in a PFC Environment

Robust medical evacuation infrastructure in Operation Enduring Freedom allowed close adherence to the Golden Hour for damage control surgery. The permissive hypotension strategy for patients in hemorrhagic

shock with penetrating trauma to the chest and abdomen is appropriate with 1- to 2-hour evacuation times from point of injury to damage control hemostasis. In a PFC situation, evacuation may be delayed for hours to days. Maintaining a patient in a hypotensive state beyond the Golden Hour puts the patient at risk for end-organ injury, reperfusion injury, and a worsening shock state from compensated, to decompensated, to refractory. We recommend FWB as the fluid of choice for patients in hemorrhagic shock.

To mitigate these risks in the PFC environment, we recommend the provider aim for a “low-normal” perfusion state defined as any one *of* the following: mean arterial pressure (MAP) of 55–65mmHg,^{13–15} adequate urine output (0.5mL/kg/hr) or adequate mentation (though caution must be taken because mentation will be preserved at the expense of all other systems and vital organs). Although this recommendation is greater than the 40–60mmHg MAP referenced in discussions of hypotensive resuscitation, 55–65mmHg is still a low-normal target that will minimize clot disruption and coagulopathy in hemorrhagic shock while providing adequate tissue perfusion in all shock states.

Resuscitation goals are important because they prompt earlier provider responses, but beware of “chasing numbers” in patients who have normal mental status and adequate UOP. The goal of resuscitation is to treat the patient, not achieve a certain number. Patients may have adequate organ function and circulation below a MAP of 55mmHg. This “low normal” resuscitation strategy is for patients in hemorrhagic shock only. Do not apply this strategy to patients with other etiologies of shock.

Recommended Strategy for Fluid Therapy in PFC

The selection of maintenance or resuscitation (bolus) fluid should be guided by the patient's clinical condition. If the patient is unstable with inadequate intravascular volume, resuscitate with bolus fluid. If the patient is stable with adequate intravascular volume, provide maintenance fluid. A general target is to achieve a UOP of 0.5mL/kg/hr. Goals of UOP up to 1mL/kg/hr may be advised by telemedicine consultation for specific conditions such as significant crush injury.

Accurate measurement of UOP will most likely require Foley catheterization in critically ill patients. In complex cases such as burns, we recommend dumping the urine from the collection bag into a specimen cup or other receptacle every 60 minutes to accurately measure the hourly output. Simply estimating UOP in a large Foley catheter collection bag may not be precise enough, since the difference of 10mL may necessitate an increase or

decrease in the fluid rate. Trends of UOP over time are important to properly manage your patient and will help accurately communicate the overall status of your patient to higher medical authority.

Maintenance Fluids

Maintenance fluid should be provided orally in any patient who is capable of drinking. If the patient cannot drink because of diminished mental status, pharmacologic sedation, or abdominal wounds, fluid can be provided by IV or PR. For IV maintenance fluid, we recommend LR solution or another balanced solution, such as Plasma-Lyte A.

For adults, we recommend starting at a total daily replacement volume of 1.2L (50mL/hr). If the patient has inadequate UOP for more than two consecutive hours, bolus 250–500mL of crystalloid, increase the hourly rate by 25%, and continue to reassess.

For children, we recommend the “4-2-1” formula to derive the initial hourly maintenance fluid rate, based on the patient’s body weight, as follows:

$$(4\text{mL/kg for the first } 10\text{kg}) + (2\text{mL/kg for the next } 10\text{kg}) + (1\text{mL/kg for the remainder of the patient's weight}) = \text{hourly maintenance fluid rate}$$

For a child weighing 40kg, for example, the formula calculations would be as follows:

$$\begin{aligned} (4\text{mL/kg} \times 10\text{kg} = 40\text{mL}) &+ (2\text{mL/kg} \times 10\text{kg} = 20\text{mL}) \\ &+ (1\text{mL/kg} \times 20\text{kg} = 20\text{mL}). \\ 40\text{mL} + 20\text{mL} + 20\text{mL} &= 80\text{mL/hr is this patient's} \\ &\text{initial hourly maintenance requirement.} \end{aligned}$$

Resuscitation Strategy and Goals for Nonhemorrhage Scenarios

The following cases, in particular, require early call for telemedicine.

Burns

If a patient has large burns (>20% second degree or >10% third degree [%TBSA]), burns involving the airway, circumferential burns, or burns of critical areas (head, hands, feet, genitalia), early telemedicine consultation is critical. The greatest risk to the patient is hypotension due to intravascular fluid leak into the interstitial space. The goal of initial burn resuscitation is to maintain adequate blood pressure (MAP >55mmHg), heart rate <130, and appropriate level of consciousness. UOP between 30mL/hr and 50mL/hr is a good indicator of adequate perfusion, but hemodynamic stability is the most important goal.¹³

The %TBSA of second- or third-degree burns will drive the fluid resuscitation approach. In general:

- <15% TBSA: nonaggressive fluid resuscitation recommended, PO hydration may be sufficient
- 15%–40% TBSA: this is the patient population in PFC that requires our diligent management; morbidity is likely to be reduced in this group if proper resuscitation and attention are given
- >40% TBSA: this will require major resuscitation, likely airway management with cricothyrotomy or endotracheal intubation, and has an ominous prognosis

Burns require large amounts of resuscitation fluids. For this reason, LR or Plasma-Lyte A are recommended over NS. A recommended formula to estimate fluid requirements is the Rule of Tens (for burns): 10mL/hr × %TBSA of second- and third-degree burns.

- If the patient weighs 40–80kg, multiply the %TBSA by 10 to get the hourly infusion rate
- If the patient weighs >80kg, add 100mL/hr for each 10kg over 80kg

For example: For a 100kg patient with a 40% TBSA burn, the formula calculations would be as follows:

$$\begin{aligned} (40\% \text{ TBSA} \times 10 = 400\text{mL/hr [for the first } 80\text{kg]}) \\ + (100\text{mL} \times 2 = 200\text{mL/hr [for the remaining } 20\text{kg]}) \\ 400\text{mL} + 200\text{mL} = 600\text{mL/hr infusion rate} \\ \text{of LR or Plasma-Lyte A} \end{aligned}$$

If UOP is <30mL/hr, increase the hourly fluid rate by 20% for the next hour and reassess. If UOP is >50mL/hr, decrease the hourly fluid rate by 20% for the next hour and reassess.

Both over- and under-resuscitation with fluids can cause significant complications in burn patients (most importantly, hypovolemic shock in the former and compartment syndromes in the latter).

The key part of burn management is the need to monitor UOP and be as ready to decrease fluid rate for suprathreshold UOP as to increase it for suboptimal output. One cause of “fluid creep” that can lead to compartment syndrome may be that providers are less likely to decrease infusion rates when UOP is above goal than they are to increase rates when UOP is below goal.¹⁶

Colloid infusion, either plasma (including freeze-dried plasma) or albumin, has been shown to reduce fluid requirements in burns, as well as decrease the incidence of abdominal compartment syndrome. One approach is to change to a colloid infusion for patients whose 24-hour crystalloid requirements exceed 250mL/kg, the

volume at which the risk for abdominal compartment syndrome becomes significantly higher.^{13,17}

Finally, oral or enteral nutrition has been studied in burns up to 40% TBSA. Though not a primary solution, this technique could be very useful in a resource-limited PFC environment.

Sepsis

The recognition of sepsis may be difficult, especially early in the disease process. A patient should be considered septic if they have an infection (fever and/or clinical concern such as cough productive of purulent sputum, diarrhea, urinary tract infection, skin infection, or signs of systemic infection such as rigors) accompanied by an elevated heart rate and/or respiratory rate. *Severe sepsis* is defined as sepsis plus organ dysfunction (e.g., altered mental status, decreased UOP, respiratory compromise). *Septic shock* is severe sepsis accompanied by decreased blood pressure (BP) that is not responsive to initial volume resuscitation (1–2L fluid bolus).

Sepsis has a large fluid requirement because of capillary leak. Initial resuscitation (2–4L) can be attempted with NS, but we recommend changing fluids to LR or Plasma-Lyte A if more fluid is required.¹¹ The following are recommended protocols:

- Titrate total fluids to maintain systolic BP >90mmHg (ideal MAP goal: >60–65mmHg) and adequate UOP (0.5mL/kg/hr).
- Initiate early broad-spectrum antibiotic coverage (and source control, if applicable) early.
- A good starting point is an initial 2L bolus, then 500mL boluses until systolic BP is >90mmHg (MAP >60–65mmHg). Frequent rebolusing may be required in addition to maintenance fluid if the patient is unable to take oral fluids or nutrition.

Head Injury

The following are recommended¹⁸:

- 3% (hypertonic) saline solution (HTS) for signs of significant elevated intracranial pressure (ICP):
 - Progressively worsening mental status (decreased Glasgow coma score) or other signs, such as bradycardia, widening pulse pressure, and increased diameter of optic nerve sheath on ultrasound evaluation in a known head-injured patient with adequate BP and UOP. (Remember, lowered BP can lead to decreased mental status without head injury).
 - If giving HTS, a maintenance fluid is likely not necessary, since nearly 100% of 3% saline remains in the intravascular space (250mL is equivalent to >1L of crystalloid).

- NS, Plasma-Lyte A, or oral replacement for patients with head injury and no signs of elevated ICP.

The following is a strategy for HTS administration: 250mL bolus of 3% followed by 50mL/hr basal rate for an average 80kg patient. This is approximate and, ideally, serum sodium (Na) can be measured with point-of-care testing (POCT) systems, such as an i-Stat.

If POCT is available, the following steps are recommended:

1. Give 250mL 3% HTS bolus IV (children: 5mL/kg) over 10–15 minutes.
2. Follow bolus with infusion of 3% HTS at 50mL/hour (children: 1mL/hour).
3. If awaiting transport; check serum Na levels every hour and respond as follows:
 - a. If Na <150 mEq/L, rebolus 150mL over 1 hour, then resume previous rate
 - b. If Na = 150–154 mEq/L, increase 3% HTS infusion by 10mL/hr
 - c. If Na = 155–160 mEq/L, continue infusion at current rate
 - d. If Na > 160 mEq/L, hold infusion, then recheck in 1 hour
4. Once Na is within the goal range (155–160mEq/L), continue to follow the serum Na level every 6 hours.
5. After cessation of 3% HTS infusion, continue to monitor serum Na for 48 hours to watch for rebound hyponatremia.

Logistics (The Bottom Line on What to Pack)

The following are the basic recommendations for deployment:

- 3–4 FWB transfusion kits
- 3–4 500mL bags of Hextend (BioTime; <http://www.biotimeinc.com>) (if used as initial resuscitation per Tactical Combat Casualty Care [TCCC] guidelines)
- 1 case NS or the equivalent, with 6–8 250mL NS bags for reconstituting IV medications, and the balance being 1L bags
- 2–3 cases LR or Plasma-Lyte A to use for large resuscitations
- 6–8 bags (250mL or 500mL) of HTS
- 10–15 microdrip administration tubing sets (need for maintenance and sedation drips)

References

1. Ball J, Keenan S. Prolonged Field Care Working Group Position Paper: prolonged field care capabilities. *J Spec Oper Med.* 2015;15:76–77.
2. Winters M. IV fluid in resuscitation [audio podcast]. <http://emedhome.com>

3. Myburgh JA, Mythen MG. Resuscitation fluids. *N Engl J Med*. 2013;369:1243–1251.
4. Vincent JL, Weil MH. Fluid challenge revisited. *Crit Care Med*. 2006;34:1333–1337.
5. Brandis K. Fluid physiology, an on-line text. <http://www.anaesthesiamcq.com/FluidBook>
6. Kramer GC, Michell MW, Oliveria H, et al. Oral and enteral resuscitation of burn shock the historical record and implications for mass casualty care. *J Burns Wound Care*. 2003;2:458–474.
7. Milner SM, Green WB III, Asuku ME, et al. From cholera to burns: a role for oral rehydration therapy. *J Health Popul Nutr*. 2011;29:648–651.
8. Binder HJ, Brown I, Ramakrishna BS, et al. Oral rehydration therapy in the second decade of the twenty-first century. *Curr Gastroenterol Rep*. 2014;16:376–384.
9. Grocott MP, McCorkell S, Cox ML. Resuscitation from hemorrhagic shock using rectally administered fluids in a wilderness environment. *Wilderness and Environ Med*. 2005;16:209–211.
10. Girisgin AS, Acar F, Cander B, et al. Fluid replacement via the rectum for treatment of hypovolaemic shock in an animal model. *Emerg Med J*. 2006;23:862–864.
11. Rochweg B, Alhazzani W, Sindi A, et al. Fluid resuscitation in sepsis: a systematic review and network meta-analysis. *Ann Int Med*. 2014;61:347–355.
12. Delman K, Malek SK, Bundz S, et al. Resuscitation with lactated Ringer's solution after hemorrhage: lack of cardiac toxicity. *Shock*. 199;6:298–303.
13. US Army Institute of Surgical Research. Joint Theater Trauma System Clinical Practice Guideline—burn care. http://www.usa.isr.amedd.army.mil/cpgs/Burn_Care_13_Nov_13.pdf
14. Santry HP, Alam HB. Fluid resuscitation: past, present and the future. *Shock*. 2010;33:229–241.
15. Medby C. Is there a place for crystalloids and colloids in remote damage control resuscitation? *Shock*. 2014;41:S47–S50.
16. Saffle JR. The phenomenon of “fluid creep” in acute burn resuscitation. *J Burn Care Res*. 2007;28:382–395.
17. Chung KK, Blackbourne LH, Wolf SE, et al. Evolution of burn resuscitation in Operation Iraqi Freedom. *J Burn Care Res*. 2006;27:606–611.
18. US Army Institute of Surgical Research. Joint Theater Trauma System Clinical Practice Guideline—management of patients with severe head trauma. http://www.usa.isr.amedd.army.mil/cpgs/Mgmt_of_Patients_with_Severe_Head_Injury_16Jun2014.pdf

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