

## Case Report

# A case study demonstrating tolerance of the gut to large volumes of enteral fluids as a complement to IV fluid resuscitation in burn shock

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**Abstract:** Appropriate intravenous fluid resuscitation has improved early post burn outcomes. However, clinical and pre-clinical evidence suggests that enteral or oral resuscitation may complement intravenous fluid administration. While this strategy is often discussed in the context of resource-limited settings, its implementation could reduce overall IV fluid requirements and simplify management during routine care. Conversely, concerns about this strategy have been raised over impaired gut perfusion and function leading to adverse effects. We present a case of an 82-year-old man with a total burn size of 14% who was encouraged to ingest the oral rehydration solution Drip Drop® starting 7 hours post-burn. In the ensuing 17 hours he consumed over 5 L of oral rehydration solution, which was nearly 1 L more than the total amount of IV fluids he received. There were no adverse gastrointestinal side effects. This demonstrates tolerance of a significant volume of voluntary oral fluids in combination with IV resuscitation. Clinical trials are warranted.

**Keywords:** Burn, resuscitation, fluids, gut, enteral

## Introduction

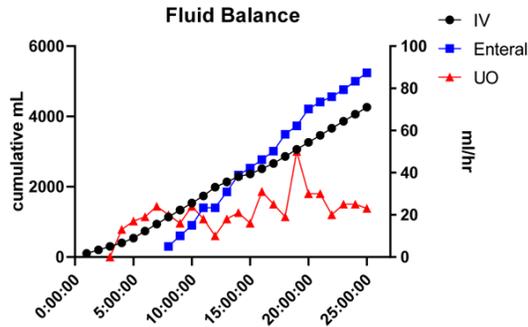
Initial management of severely burned patients requires aggressive fluid resuscitation in order to prevent under-perfusion of organs because of global fluid shifts within damaged and non-damaged tissues [1]. While current clinical practice guidelines emphasize the use of intravenous (IV) fluids, utilizing the enteral/oral route of administration has been described. In fact, in 1950, the growing threat of a nuclear war prompted the United States Surgeon General to adopt the use of oral saline as the treatment of burn shock and burn injuries in the event of a disaster with a large number of civilian or military casualties [2]. This propelled both pre-clinical and clinical research, although these ideas were eventually shelved--not because of a lack of efficacy or feasibility--but because the introduction of plastic IV catheters dominated the more basic oral/enteral fluid approach [3].

The concept of enteral or oral resuscitation has since reemerged as a practice for burn treat-

ment in resource-limited situations such as during military operations in austere environments. Oral rehydration solutions defined by the World Health Organization (WHO) have proven life-saving for treating dehydration from severe diarrhea in conditions like cholera in third world countries [4]. They have since been recommended for treatments for burns in resource-limited environments. Multiple studies have shown that enteral fluids can reduce IV requirements and also reduce the increased burden of managing IV fluids [5]. In the military context specifically, concerns over multi-domain operations or mass casualty scenarios and a limited supply of IV fluids have resulted in the creation of prolonged field care (PFC) guidelines that specifically address oral resuscitation [6, 7].

Growing preclinical evidence has mounted to show reasonable absorption and efficacy of enteral resuscitation in the face of extensive burns [8, 9], with differential effects on the immune response [10]. Moreover, a recent randomized clinical trial also suggested that oral

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**Figure 1.** Cumulative oral (blue boxes) and IV (black circles) fluid resuscitation plotted with urine output (UO; red triangles) in the first 24 hours for an 82-year-old man with 14% TBSA mixed superficial and partial thickness injury.

resuscitation resulted in equivalent hemodynamics and improved urine output compared to IV fluids [4]. Despite this, the argument for this route of administration has largely been limited to resource-poor settings [3, 11, 12]. Anecdotal examples of paralytic ileus in the face of reduced splanchnic perfusion during burn shock have been cited as reasons to discourage enteral fluid resuscitation. However, this strategy was recently underscored during the IV fluid shortage of 2017 when Hurricane Maria disrupted IV fluid production in Puerto Rico. This shortage prompted development of recommendations and criteria utilizing oral and enteral resuscitation for conditions causing dehydration [13].

Much of the previous research on enteral fluid (such as the randomized controlled trial mentioned above) have examined the performance of enteral fluids alone in comparison to IV fluids alone. However, some have suggested a place for this strategy even during IV fluid infusion [6]. Here we describe experience with an older male patient that presented to the burn center with a Baux score of 96. During his resuscitation, he voluntarily consumed a large volume of a commercially available oral rehydration solution (ORS; Drip-Drop®), demonstrating proof-of-concept evidence that the gut can tolerate substantial enteral fluids as a complement to IV fluid resuscitation without adverse consequences in the setting of burn shock.

### Case presentation

The patient is an 82-year-old male, who presented with 14% total body surface area (TBSA)

burns sustained from a vehicle fire. The burns were superficial to partial thickness on his posterior back (9%), neck (2%), head and left ear (3%), without evidence of ocular or oral mucosal involvement. The patient was able to extinguish the fire and was subsequently transported to the burn center via ambulance. The patient was never intubated, but had a history remarkable for hypertension, coronary artery disease and prostate cancer. Since care of this patient was within the scope of clinical practice, consent was not necessary.

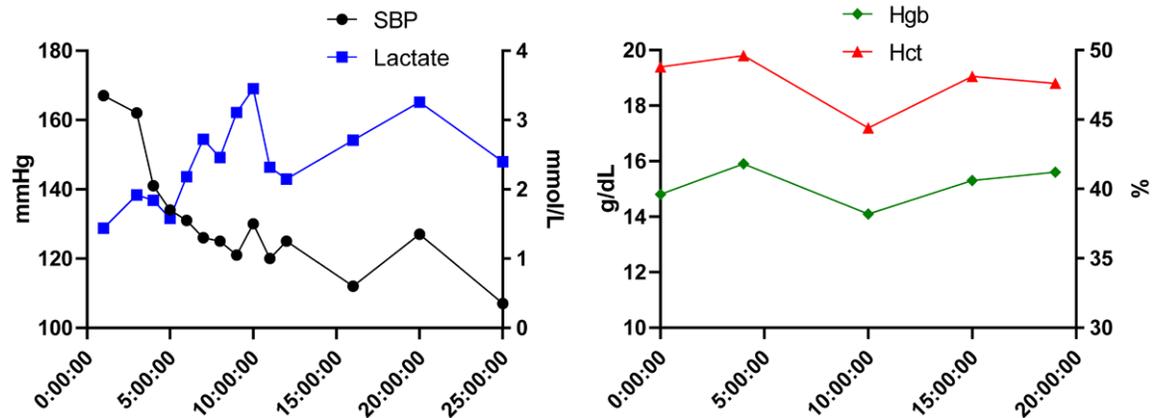
Cumulative fluid inputs, as well as hourly urine output are shown in **Figure 1**, while selected biochemical data are shown in **Figure 2**. Fluid resuscitation with IV lactated Ringer's (LR) solution was initiated within 30 minutes of arrival to the hospital. Throughout the resuscitation of this patient, fluid levels were monitored continuously with recommendations by the Burn Navigator [14]. In the subsequent 6 hours, IV fluid rate increased to 200 mL/hour, while the patient's lactate also increased to 2.70 mmol/L with a base deficit of -4.1 mEq/L. At this point oral consumption was first encouraged. Lactate remained elevated (apex of 3.45 mmol/L) for the next 3 hours, during which the patient consumed nearly 1 L of the ORS Drip-Drop® (<https://dripdrop.com/>). Subsequently his lactate began to decrease, while urine output began to increase (**Figure 1**). Throughout this resuscitation period, he remained hemodynamically stable with a systolic blood pressure (SBP) above 107 mmHg, and hemoglobin and hematocrit remained within normal limits without evidence of hemoconcentration (**Figure 2**).

Altogether, he received 9542 mL of total fluid that included 4302 mL of LR and 5420 mL of Drip-Drop®. Additionally, there were no physical exam findings consistent with paralytic ileus or delayed gastric emptying throughout the patient's resuscitation. Moreover, no gastrointestinal (GI) complaints or vomiting occurred, and the patient had two bowel movements within the first 24 hours. Unfortunately, this patient was lost to follow-up after an uneventful discharge.

### Discussion

Burn shock is caused by a handful of pathophysiologic perturbations, including a cascade of endotheliopathy, sympathetic activation,

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**Figure 2.** Systolic blood pressure (left, black circles) remained within normal levels, while lactate levels (blues boxes) began to decrease starting around hour 10 post-burn. Both hemoglobin (Hgb, green diamonds) and hematocrit (Hct, red triangles) remained within normal levels throughout the resuscitation period.

metabolic dysfunction, inflammation and vascular leak leading to edema. These changes and associated hypovolemia, in turn, lead to under-perfused tissues and organs, which all result in burn shock [15]. Moreover, recent animal studies suggest that trauma-induced pathophysiology is exacerbated or ameliorated by the resuscitation strategy [16, 17], to include in burns [18]. Treatment of burn shock requires a balanced fluid resuscitation that provides enough volume to enable tissue and organ perfusion without causing edema-related comorbidities such as compartment syndromes [19]. In this case, an older patient with large burns was able to voluntarily consume and tolerate more than 5 L of ORS within a 24 hour period in the setting of elevated lactate without evidence of gut impairment. This example suggests that oral consumption of fluids as a complement to IV fluid resuscitation is feasible.

A large number of research studies have focused on the fluid rates/volume of fluid administered to treat burn shock, which has led to an extensive body of clinical evidence and consensus recommendations to guide practice [20]. While volumes and types of fluids employed have been hotly debated for some time, this discussion almost exclusively revolves around intravenous (IV) infusion, with much less consideration for other potential routes of fluid administration. On the other hand, in the 1950s (and earlier) the concept of using a combination of oral and IV saline for burn shock resuscitation was examined [21]. Since then, many advances in the efficacy of different ORS have occurred.

In a conscious patient, success of enteral resuscitation depends on several key factors such as palatability, electrolyte balance and appropriate osmolality. In certain clinical scenarios, such as this one presented, our burn center encourages the voluntary consumption of Drip-Drop® secondary to its palatability and osmolality [6]. However, in situations where a nasogastric (NG) or orogastric (OG) tube has been placed, palatability considerations do not take precedent; therefore, less expensive (and less palatable) ORS from the WHO are feasible and suitable. Our burn center is currently exploring both the voluntary consumption of solutions such as the one used in this study as performance improvement, as well as assessing the ability of WHO-ORS infusion through an NG/OG tube to reduce overall IV fluid requirements.

Still, solutions other than these may prove to be optimally effective. For example, rehydration drinks exist that utilize rice-based carbohydrates instead of glucose, which is purported to encourage absorption along the length of the intestine by means of the varying lengths of the carbohydrate chains present. In this way, there is more utilization of the sodium glucose co-transporter (SGLT1) throughout the intestine. An example of this ORS is CeraLyte®, which has been successfully used in burn patients and shown to decrease IV fluid requirements. In three patients with 20-40% TBSA burns, a mean of 65.2% and a maximum of 77.5% of the calculated Parkland-formula fluid needs were replaced with CeraLyte®, with appropriate urine output and no evidence of electrolyte abnormalities [5].

While urine output remains the main driver of the IV fluid rate, lactate is often considered during a patient's resuscitation. Lactate is thought of as a global hypoperfusion marker, and the lactate of 3.45 mmol/L, as seen in this patient, could signify impaired perfusion of vital organs (to include the gut). Still, the gut demonstrated the ability to handle a large volume of fluid without adverse effects. In this regard, an alternative explanation has been posited to explain increases in lactate, wherein a sustained sympathetic response is the cause of increased lactate level [22]. Specifically, it has been suggested that, in sepsis, beta-2 adrenergic stimulation results in increased aerobic glycolysis, which causes increases in lactate [23]. Thus, the interpretation of an elevated lactate level as precluding enteral resuscitation may be problematic, and further investigation is required in this area [24]. We did not see any GI-related side effects in this case, suggesting that the perfusion to the gut was adequately maintained. This was true in the absence of using any pharmacological agent to promote gastric emptying, which has proven beneficial in preclinical models [25, 26].

As more evidence emerges regarding the potentially deleterious effects of crystalloid administration, more interest may arise in the use of ORS. A randomized controlled trial pitting enteral fluids versus IV fluids in patients up to 15% TBSA demonstrated non-inferiority in terms of urine output for enteral fluids, and no hemodynamic concerns. Still, the authors documented a difficult time in recruiting patients for the oral fluid group due to patient "skepticism". Despite a relatively limited amount of evidence when compared to current IV fluid management of burns, enteral fluid resuscitation has a well-established historical record going back as early as the 1940s, and as far back as World War I for hemorrhagic shock. Developments in enteral fluid treatment have paralleled those of traditional IV resuscitation. Our strategy is somewhat different, in that we do not envision enteral and IV fluids as mutually exclusive. Instead, we propose to initiate IV fluids as most burn centers do, with the adoption of ORS through the enteral route. We believe this combination type of approach has the potential to support intravascular volume and urine output.

### Conclusions

This case report highlights the safe and effective use of enteral fluids as a complement to IV

fluids in the resuscitation of a patient in burn shock. This case shows that a patient's gastrointestinal tract was able to tolerate a large volume of oral fluids without any adverse clinical sequelae. This report and discussion suggest a feasible and readily available adjunct to IV fluids in definitive clinical care; however, there are still some challenges in the provider community for accepting this therapeutic intervention. Larger clinical studies will be needed to demonstrate efficacy and safety. Additional research is needed to determine the optimal ORS type for absorption, total volumes tolerated and rates that are efficacious and safe, as well as algorithms for patient selection to stratify those who would clinically benefit from the use of enteral strategies for resuscitation.

### Acknowledgements

Extensive efforts were taken to obtain consent for publication from this patient, and next of kin. As these efforts were unsuccessful, detail has been removed from this case report to ensure anonymity. This manuscript was cleared by the Research Regulatory Compliance Division of the US Army Institute of Surgical Research.

### Disclosure of conflict of interest

The opinions or assertions contained herein are the private views of the authors, and are not to be construed as official or as reflecting the views of the Department of the Army, Uniformed Services University of the Health Sciences, or the Department of Defense.

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