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Case Reports: Rapid Fluid Delivery for Hypotension via a Novel Device (LifeFlow®) Leads to Improved Patient Outcome

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Abstract

Introduction: Critically ill patients presenting to the emergency department with shock often require a rapid intravenous fluid bolus to correct hypotension, restore tissue perfusion, and prevent cardiovascular collapse. In patients who require intravenous fluid bolus administration, a variety of barriers can limit effective resuscitation, including difficult vascular access, technically complex or slow infusion devices, and inadequate nursing resources. LifeFlow® (410 Medical, Inc., Durham, NC) is a handheld, manually-operated device that allows the user to precisely and rapidly deliver appropriate measured boluses of crystalloid fluid during resuscitation. No reports of the clinical use of LifeFlow currently exist in the literature.

Aim: To report the first clinical cases of the use of LifeFlow for the rapid delivery of fluid resuscitation in adult patients with hypotension.

Methods: A convenience sample of the first patients to use LifeFlow for fluid resuscitation was queried and patient's charts were reviewed for relevant case information.

Results: We present five cases of critically ill patients with shock and hypotension that benefited from fluid resuscitation via LifeFlow. In each case, shock was quickly reversed as a result of rapid delivery of one or more fluid boluses, preventing the need for central venous access and other interventions.

Conclusion: Rapid administration of controlled resuscitative fluid led to significant clinical improvements in each of the cases. The LifeFlow device facilitated rapid fluid delivery, allowing clinicians to make prompt clinical assessments and potentially avoid the need for additional interventions.

Introduction

Patients presenting to the Emergency Department (ED) with shock and hypotension are some of the most challenging cases encountered by emergency providers. Without immediate restoration of adequate tissue perfusion, shock may rapidly lead to organ dysfunction, cardiovascular collapse, and death. A fluid bolus is often the first intervention used to stabilize patients, and the response to the fluid may provide diagnostic hints to the underlying etiology of shock. While volume resuscitation is most applicable in hypovolemic and vasodilatory shock, an initial fluid bolus may provide diagnostic and therapeutic benefit even in patients with cardiogenic shock [1]. Similarly, while patients with hemorrhagic shock are ideally resuscitated with blood products, these may not be immediately available in many emergency settings and intravenous fluids are the only realistic option for early reversal of severe hypotension. Push dose pressors are another alternative for quickly correcting hypotension, but are associated with a significant risk of adverse events and dosing errors [2].

Although the merits of fluid resuscitation have been well documented [1,3,4], little effort has been devoted to the evaluation of fluid administration techniques. Existing methods such as gravity infusion, infusion pumps, pressure bags, and powered rapid infusers, may not be ideal methods for administration due to low flow rates or increased complexity. We present five cases of the first documentations of the use of a handheld rapid infusion device (LifeFlow®), which can provide precise, measured bolus fluid resuscitation. No previous reports of the clinical use of this device in adult patients currently exist in the literature. The reporting of these cases will provide clinical documentation of its use and the initial experience by clinicians. In each of the cases, rapid correction of hypotension and reversal of shock states were noted.

Methods and Case Presentations

This case series was a convenience sample of adult patients treated with rapid fluid infusion via LifeFlow. The purpose of this series is to provide the first clinical accounts of the use of this device. A sample of five patients was chosen to provide examples of diverse clinical cases with different etiologies of shock. Cases were chosen based on a retrospective query of patients who received fluid resuscitation via LifeFlow and were prioritized based on completeness of data and documentation. Data were extracted retrospectively by the authors in each of the cases and included patient demographics, past medical history, documentation of interventions, hemodynamic variables, and clinical course. The collection of data for this case series was approved by the WakeMed Institutional Review Board.

Case 1

A twenty-two year-old female was recently discharged after recovering from hemorrhage associated with a spontaneous abortion. At her 2-week follow up visit, an attempt to remove retained placental tissue resulted in profuse hemorrhage. She lost approximately 900 ml of blood in the office, and arrived in the ED with altered mental status, a Heart Rate (HR) of 140 Beats Per Minute (BPM), and Systolic Blood Pressure (SBP) of 70 mmHg. Preparations were made for emergent

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intubation while a 20-gauge Intravenous (IV) catheter was placed. Using the LifeFlow device, one liter of normal saline was delivered over approximately 4 minutes with immediate improvement in SBP to 120 mmHg and return of normal mentation. The patient sat up slightly in her bed and began speaking. Emergent intubation was deferred, and she was taken to the operating room for dilatation and curettage within 30 minutes of arrival to the ED. She had an uneventful recovery and was discharged in good health.

Case 2

A forty year-old male presented to the ED with acute onset diarrhea and vomiting. He had become progressively weaker and developed abdominal cramping of increasing severity. He was described as lethargic, with a Blood Pressure (BP) of 83/40 mmHg and HR of 127 BPM. Given his hypotension and worsening mental status, he was given 2 liters of normal saline using the LifeFlow device, each over 5 minutes. His BP increased to 132/61 mmHg, and his mental status returned to normal. The abdominal cramping, vomiting, and diarrhea rapidly resolved. After a period of observation, the patient was able to tolerate oral fluids and requested to be discharged. He was sent home after a total time in the ED of 2.5 hours.

Case 3

A ninety year-old male presented *via* Emergency Medical Services (EMS) to the ED for evaluation of nose bleed. The patient had a history of hypertension, hypercholesterolemia, and pacemaker placement. En route to the ED, EMS collected three large emesis bags filled with liquid blood and clots. The patient was pale, weak, lightheaded and still actively bleeding. He denied shortness of breath or chest pain.

In the ED, he became more pale, diaphoretic, and confused. The family noted that the patient had a do-not-resuscitate order in place. During an IV catheter placement attempt, he lost consciousness and developed sinus tachycardia with HR increased to the 200s. His pulse was barely palpable and SBP dropped to 65 mmHg. An 18-gauge IV catheter was placed in an antecubital vein and an infusion of 1L NS fluid was given with LifeFlow over approximately 5 minutes. The patient responded immediately, with repeat BP of 143/72 mmHg and HR of 72 bpm. He became alert and stated that he felt better. Posterior foam packing was placed in both the left and right nares to control the bleeding. He was transfused one unit of O-negative packed red blood cells, hospitalized overnight, and discharged the following day in good condition.

Case 4

A twenty-one year-old female called 911 announcing her intention to overdose. On EMS arrival, the patient was found unresponsive with pinpoint pupils, and was noted to have empty bottles of quetiapine, lamotrigine, fluoxetine, and aripiprazole near her. On ED arrival, the patient did not respond to painful stimuli and had a Glasgow Coma Score of 3.

Initial vital signs included BP 86/45 mmHg, HR 106 BPM, and O_2 saturation of 100% on non-rebreather face mask oxygen. Her SBP then dropped to 70 mmHg, and preparations were made for central line placement and endotracheal intubation while an 18-gauge IV catheter was placed into the patient's left hand. Given the risk of hemodynamic collapse with rapid sequence induction, one liter of saline was rapidly infused utilizing a LifeFlow device over approximately 6 minutes. The patient's blood pressure improved to 107/65 mmHg, and she was successfully intubated without any deterioration of her vital signs. Central line placement was cancelled. Within 6 hours of presentation she was following commands. She was subsequently extubated and discharged the next day from the Intensive Care Unit (ICU) with normal mental status.

Case 5

A sixty-eight year-old male with history of coronary artery disease, Automatic Implantable Cardioverter-Defibrillator (AICD) placement, congestive heart failure (ejection fraction 15%), hypertension, chronic obstructive pulmonary disease, and chronic kidney disease called EMS with a one day history of fever, cough, and shortness of breath. He was found to be tachypneic and tachycardic with a HR of 150 BPM, a temperature of 103° F, and an initial BP of 90/60 mmHg. During transport, he was given 800ml of normal saline with improvement in BP to 120/90 mmHg. On arrival to the ED, he remained tachycardic and febrile, with an oxygen saturation of 89% on room air, which improved to 100% on 5L of oxygen through a non-rebreather mask. Initial BP was 83/47 mmHg but dropped to 74/53 mmHg within 10 minutes. Given his worsening hypotension, a one-liter bolus of normal saline was administered using the LifeFlow device through a 20-gauge catheter in the right antecubital vein over approximately 5 minutes. His blood pressure rose to 120/80 mmHg, and an additional liter of normal saline was administered. The initial lactate was 2.3 mmol/L, and creatinine was 2.7 mg/dL (baseline =1.2 mg/dL). The source of his presumed sepsis was thought to be either the urinary tract or his sacral decubitus ulcer, and he was treated empirically with vancomycin and cefepime.

Over the next 6 hours his oxygen requirement decreased to 3 liters, and he did not require further fluid boluses or vasopressors for hypotension. Lactate decreased from 2.3 to 1.6 mmol/L within three hours. Echocardiogram performed 7 hours after presentation showed severely depressed left ventricular function with ejection fraction of 10%, with normal right ventricular size and mildly decreased right ventricular function. His blood culture became positive for gram negative rods within 12 hours, with urinary tract as the presumed source. Cumulative fluid balance for the entire hospital stay was 3 liters. Within 3 days he was discharged on oral antibiotics in his baseline condition.

Discussion

The cases presented highlight the use of a novel device for the early administration of fluid boluses to stabilize patients with shock and hypotension. In each case, one liter of fluid was delivered within approximately 5 minutes, leading to improved hemodynamics and in several cases potentially preventing the need for additional interventions. The underlying etiologies of shock in these patients included vasodilatory shock from polypharmacy overdose, hypovolemic shock secondary to severe gastroenteritis, hemorrhagic shock from epistaxis and post-partum bleeding, and septic shock.

Although the role of fluid bolus therapy for septic patients remains debated, concerns about the adverse effects of fluid arise largely from the use of large volumes of fluid given in the initial hours and days of care, particularly without careful and frequent

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reassessment of the patient's intravascular volume status and volume-responsiveness [5]. In the initial phases of shock, even brief periods of arterial hypotension lead to tissue ischemia and are associated with increased mortality [6,7]. The use of early fluid therapy for targeted reversal of hypotension in shock patients is associated with improved outcome [3,8,9]. Furthermore, early targeted fluid therapy may actually decrease the need for subsequent fluids and reduce the risk of harm from excess fluids [4,10]. This is even true in patients with a history of congestive heart failure or chronic renal failure, the very patients for whom providers may be reluctant to provide a fluid bolus [10,11].

It is noteworthy that the patient with septic shock was effectively resuscitated with early fluid boluses, and then required no subsequent hemodynamic support. By providing a rapid and measured fluid bolus with immediate bedside reassessment, clinicians were able to quickly reverse hypotension and shock and determine that he was fluid responsive. The patient experienced rapid reversal of end-organ ischemia and injury, as measured by lactate and creatinine clearance, and showed no signs of volume overload by echocardiogram, chest x-ray, or increases in oxygen requirement. This patient's course is consistent with the data presented in previous studies [3,10-12].

While delivery of intravenous fluid would seem to be a simple task, the precise means of delivering a fluid bolus is rarely described in the literature. In clinical practice, providers face many barriers to delivering an effective fluid bolus [13]. Usual methods such as gravity infusion, pressure bags, infusion pumps, and mechanical rapid infusers may be limited by speed, complexity, or accuracy, and may be associated with safety risks [14,15]. LifeFlow is a Food and Drug Administration (FDA) approved, novel, hand-operated device that provides an alternative to current administration methods. It allows fluid bolus delivery at significantly faster speed than traditional infusion pumps, pressure bags, or gravity infusion, and may be less complex than powered rapid infusers [16]. In simulation studies, LifeFlow was associated with improved fluid delivery rate, decreased risk of aseptic technique violations, and decreased user fatigue [17-19].

Limitations of this report include the convenience sample design, the small number of patients reported, and the possibility that experiences reported are not representative of all patients who received fluid resuscitation via LifeFlow. Furthermore, since the choice of infusion technique was at the discretion of each clinician, there may have been underlying patient characteristics that may have influenced the choice of fluid delivery technique. Therefore the results of this case series should be considered illustrative examples of the use of this novel technique and not as evidence that it is superior to other fluid administration methods. Retrospective and prospective trials are currently underway to further evaluate the effects of this fluid resuscitation technique.

Conclusion

Early, rapid, and measured delivery of fluid boluses may be lifesaving therapy for patients presenting with shock and hypotension, yet this is often a challenging task in the ED. The LifeFlow device allows providers to rapidly deliver a controlled fluid bolus, immediately assess clinical response, and determine if additional fluid is required. This technique may help improve patient care in a wide variety of emergency conditions.

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