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Accuracy of Prehospital Intravenous Fluid Volume Measurement by Emergency Medical Services

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Abstract

Prehospital treatment protocols call for intravenous (IV) fluid for patients with shock, yet the measurement accuracy of administered fluid volume is unknown. The purpose of the current study was to assess the accuracy of documented and self-reported fluid volumes administered to medical patients by paramedics during prehospital care. We conducted a pilot, observational study nested within a parent cohort study of prehospital biomarkers in a single EMS agency transporting patients to a tertiary care hospital in Pittsburgh, Pennsylvania over 8 months. Among eligible nontrauma, noncardiac arrest patients, we studied the self-reported IV fluid volume on ED arrival by paramedics, documented fluid volume in the EMS record, and compared those to the mass-derived fluid volume. We quantified the absolute error between methods, and determined EMS transport times or initial prehospital systolic blood pressure had any effect on error. We enrolled 50 patients who received prehospital IV fluid and had mass-derived fluid volume measured at ED arrival. Of these, 21 (42%) patients had IV fluid volume subsequently documented in EMS records. The median mass-derived fluid volume was 393 mL [IQR: 264–618 mL]. Mass-derived volume was similar for subjects who did (386 mL, IQR: 271–642 mL) or did not (399 mL, IQR: 253–602) have documented fluid administration ($p > 0.05$). The median self-reported fluid volume was 250 mL [IQR: 150–500 mL] and did not differ by documentation ($p > 0.05$). The median absolute error comparing self-reported to mass-derived fluid volume was 109 mL [IQR: 41–205 mL], and less than 250 mL in more than 80% of subjects. The median absolute error comparing documented fluid to mass-derived fluid volume was 142 mL [IQR: 64–265 mL], and was less than 250 mL in 71% of subjects. No difference in absolute error for either self-reported or document fluid volumes were modified by transport time or prehospital systolic blood pressure. Prehospital IV fluid administration is variably documented by EMS, and when recorded is typically within 250 mL of mass-derived fluid volume.

Keywords

emergency medical services; prehospital resuscitation; intravenous fluids; fluids

Introduction

Shock is a common and deadly syndrome, encountered often by emergency medical services (EMS) personnel.¹ For the critically ill patient with shock, prehospital fluid administration is included in many EMS treatment guidelines or protocols.^{2–6} The National EMS Research Agenda also highlights the treatment of prehospital shock as a research priority.⁷

While many trials investigate the role of prehospital fluid in various shock states,^{8–13} these studies rely on the documented prehospital fluid volume from the EMS record. However, prehospital data are often missing, erroneous, or recorded differently due to patient or system factors.¹⁴ A better understanding of how often IV fluid administration is documented and its accuracy against a gold standard measurements could guide future prehospital shock research, treatment guidelines, and quality improvement efforts.

We sought to prospectively determine the accuracy of documented and self-reported fluid administration in nontrauma, noncardiac arrest, EMS patients compared to mass-derived IV fluid volume at emergency department (ED) arrival. We further examined whether documented or self-reported fluid volumes differed by EMS transport time or initial prehospital systolic blood pressure.

Methods

Study Design

We enrolled a nested convenience sample of subjects from a larger, NIH-funded prospective, observational study of prehospital biomarkers in sepsis (K23GM104022). We included adult, nontrauma, noncardiac arrest EMS treated patients transported to a tertiary care hospital in Pittsburgh, Pennsylvania. Data were collected within the parent study under an approval by the University of Pittsburgh Institutional Review Board. Subjects were screened and enrolled under a waiver of informed consent for minimal risk research during EMS care, and research associates obtained consent for continued participation from subjects after hospital arrival. This study was a planned comparison of fluid volume measured using two different methods.

Study Setting and Population

We included subjects transported by City of Pittsburgh Bureau of EMS and receiving prehospital IV fluid from August 1, 2013 to February 28, 2014. Pittsburgh EMS has 175 paramedics that staff 14 ALS ambulances and 2 rescue trucks servicing 305,000 residents. They respond to approximately 56,000 emergency calls each year and perform approximately 40,000 patient transports to a hospital. This all-advanced life support service provides medical care based on the Pennsylvania statewide protocols. Paramedics identify the need to establish peripheral vascular access for specific patient conditions, as determined

by their clinical judgment after assessing the condition of the patient. Paramedics administer 0.9% normal saline solution for specific patient conditions, including cardiac arrest, hypotension, infection, signs of dehydration, or shock. Statewide protocols for fluid administration recommend 500 mL bolus for systolic blood pressure <90mmHg in the presence of tachycardia, tachypnea, or hypotension. The EMS agency under study uses these protocols; however, the adherence to this particular aspect was not part of study documentation. No colloids are given as these are outside of the scope of practice for paramedics in Pennsylvania. No flow-restriction devices were utilized during the study period.

Eligible subjects were 1) age ≥ 18 yrs; 2) given IV fluid by paramedics; 3) transported to the study hospital; 4) without cardiac arrest, trauma, or burns; 5) not a prisoner or pregnant; 6) any primary psychiatric diagnosis; and 7) capable of supplying IV fluid bags and tubing for weighing on ED arrival (e.g., mass-derived IV fluid volume).

Study Protocol

Trained study staff screened for eligibility; once enrolled, we weighed the prehospital IV fluid bag(s) and connected tubing using a portable balance (Fischer scientific SLF 3001, 3000 gram capacity, accurate to 0.01 gram) and determined a “mass-derived fluid volume” (further discussed in the following section). The study staff also recorded paramedics’ self-reported volume in mL. We entered both self-reported and mass-derived fluid volume into an online case report form and abstracted the fluid volume recorded from the electronic EMS record (“documented prehospital fluid volume”). We abstracted demographics, prehospital location, chief complaint category, past medical history of congestive heart failure, initial vital signs including heart rate (beats per min), respiratory rate (breaths per min), systolic blood pressure (mmHg), oxygen saturation (SaO₂), capillary blood sugar, and Glasgow Coma Scale. Study staff recorded procedures performed by paramedics including intubation, bag mask ventilation, Advanced Cardiac Life Support (ACLS) maneuvers including CPR, defibrillation, and cardiac resuscitation drug administration, supplemental oxygen, bronchodilator administration from the EMS record. We defined total EMS time with subject as the interval between reported date/time at patient scene to date/time arriving at receiving hospital.¹⁵ A study investigator (PJC) abstracted all data.

Determining Reference Mass of Saline

Per protocol, Pittsburgh EMS used 1-liter normal saline bags for care (0.9% Sodium Chloride Injection USP 1000 mL Baxter Healthcare Corporation, Deerfield, IL; and 0.9% Sodium Chloride Injection USP 1000 mL Hospira inc., Lake Forest, IL). For the saline bag reference mass, we obtained representative fluid bags, connected to IV tubing, and determined the mean mass over 20 attempts (1114 $\pm$ 0.2 grams). We calculated the mass derived fluid volume as the reference fluid mass minus the mass of the IV fluid bag, converted to volume (mL) (1000 mL 0.9nNaCl $\sim$ 1000 g).

Outcomes and Statistical Analysis

The primary outcome was the absolute value of the error between either the self-reported or documented fluid volume vs. the mass-derived fluid volume.¹⁶ We summarized absolute

errors using mean, standard deviation (SD), median, and interquartile range (IQR). We calculated the proportion of documented and self-reported volumes within 100 mL and 250 mL of the measured volume.¹⁷ We compared demographic and incident characteristics of subjects with and without documented fluid volumes using Fishers exact and Wilcox rank-sum tests. In a sensitivity analysis, we compared the proportion of subjects with documented IV fluid administration between those with lower than median prehospital systolic blood pressure (vs. greater) and longer than median transport times (vs. shorter). We illustrated differences in fluid volume measurements using scatter and Bland Altman plots. We considered two sided tests of inference significant if $p \leq 0.05$. We used STATA 11.0 (College Station, TX) for all analyses.

Results

Among nontrauma, nonarrest prehospital subjects enrolled in the parent study, we studied a convenience sample of 50 subjects administered prehospital IV fluid. We observed that 21 (42%) patients had IV fluid documented in electronic EMS records. We observed that 37 paramedics provided direct care to study patients, with a mean of 1.2 patients per paramedic (range: min 1 to max 4 patients per paramedic). As shown in Table 1, subjects commonly presented with nonspecific complaints (e.g., sick person), did not report history of congestive heart failure, and uncommonly received other prehospital procedures (e.g., intubation). Comparing EMS subjects who did and did not have documented IV fluid administration, we found no differences in demographics, illness severity, or transport characteristics (Table 2). Paramedics administered a median mass-derived fluid volume of 393 mL [IQR: 264–618mL]. Mass-derived fluid volume was similar comparing subjects who did (386 mL, IQR: 271–642) or did not (399 mL, IQR: 253–602) have documentation in the EMS record ($p > 0.05$). The median self-reported fluid volume by paramedics was 250 mL [IQR: 150–500 mL] and did not differ comparing groups who did and did not document ($p > 0.05$).

The absolute error comparing self-reported to mass-derived fluid volume was median 109 mL [IQR: 41–205 mL], and was less than 250 mL in more than 80% of subjects (Table 3). Among the 21 subjects with EMS-documented IV fluid administration, the absolute error comparing documented fluid volume to mass-derived fluid volume was 142 mL [IQR: 64–265 mL] and was less than 250 mL in 71% of subjects. As shown in scatter and Bland Altman plots (Figure 1), the absolute errors did not change with the magnitude of the volume administered and were modest in size. In sensitivity analyses, the absolute errors for self-reported volumes for longer transport times were unchanged (median 99 mL, IQR: 36–164), and subjectively greater for documented volumes (median 264 mL, IQR: 64–309). We found no change in absolute errors for self-reported or document fluid volumes among transports with lower than the mean prehospital systolic blood pressure.

Discussion

We found that paramedic documentation of IV fluid administration was variable, consistent with prior reports of frequent missing data in prehospital health records. Evans et al. utilized real-time video recording of EMS transports to quantify documentation of prehospital data

by the trauma team.¹⁸ They observed that of 89 prehospital treatments administered by EMS, 7 treatments (8%) were not included in the EMS or hospital record. These included prehospital fluid administration, analgesic administration, airway management, and spinal immobilization. What is more, many physiologic and demographic data points (9%–25%) were not documented or provided during hand-over to the hospital team. Similarly, Laudermitch et al. report that prehospital data may be missing in up to 28.2% of encounters and could be modified by illness severity.¹⁴ Other cohort studies show missingness of physiologic data like Glasgow coma scale score may occur in the majority of patients.¹⁹ In a separate study, we observed discrepancies in the recorded and actual timing of critical interventions during cardiac arrest.²⁰ Taken together, our data reinforces that important prehospital interventions may be missing in prehospital care records, and that researchers should consider prospective or automated documentation.

We observed that the absolute errors in self-reported or documented IV fluid volumes were small. Many potential mechanisms may underlie these small differences. First, EMS transports occur over a limited time interval. This short transport interval may prevent larger fluid volumes and practically limit the range of potential errors. The Bland Altman plots do not suggest the volume of IV fluid was related to the magnitude of error(s). Second, paramedics performed few other prehospital interventions in this cohort, and no subjects required endotracheal intubation. These transports were likely lower acuity, providing ample time for recollection and observation of fluid administration. The magnitude of documentation errors are previously shown to be quite small even in high acuity cardiac arrest events.²⁰ Third, the collection of self-reported fluid volume by study staff and documentation by paramedics in the EMS record occurred after the patient hand-off in the ED, creating an opportunity to reinforce the volume administered. We reasoned this approach in our protocol to avoid interruption in the clinical care of the patient. Multiple factors may influence the accuracy of fluid documentation. EMS may note the amount of fluid administered when approaching the hospital. Yet, this volume may not reflect the true volume when patients are assessed in the ED, given ongoing fluid flow during exit from the vehicle, rooming, and ED triage. Because IV fluids are not routinely administered by infusion pump during prehospital care, paramedics who leave IV bags open to gravity could unintentionally administer more fluid than they estimate.

These findings have implications for clinical practice and EMS research. From a clinical perspective, prehospital IV fluid administration is a recommended treatment for medical patients with shock.²¹ In fact, recent observational studies suggest that IV access and fluid administration may improve patient outcomes in severe sepsis and shock.^{13,22} These patients account for a large and growing proportion of EMS transports.^{23,24} The volume of fluid administered may have important implications for subsequent hospital sequelae like renal dysfunction or pulmonary edema, as shown in recent trials of prehospital therapeutic hypothermia.²⁵ Although the modest inaccuracies that we report would not be the direct cause of downstream organ failures, they may be of greater importance in specific patient subgroups. These may include trauma patients with penetrating injury where fluids may be limited,² or in those with septic shock in whom aggressive fluid resuscitation may at first be helpful.¹³ One solution is the use of real-time electronic health record documentation by

EMS.²⁶ Such an approach could link prehospital interventions with the hospital record and limit inaccuracies during patient hand-off and delayed documentation.

From a research perspective, the variable record of fluid administration and under or over estimation in fluid volume could impact observational prehospital research.^{12,23,27} Second, future studies may need to consider whether prehospital fluid administration is missing in their data, and if bias is introduced from missingness not at random.¹⁴ Techniques such as multiple imputation are preferable to handle the bias from missing data, rather than studying complete cases.²⁸ Other research groups employ a prospective mandate of prehospital fluid administration and volume to encourage paramedics to accurately obtain these measurements in registry data.¹³ Finally, investigators must take into account the degree of accuracy required for continuous variables in prehospital research design. Dichotomous variables such as epinephrine administration, advanced airway maneuvers, or cervical spine stabilization may be abstracted more easily from prehospital records. In contrast, continuous variables such as fluid volume are more prone to errors, and may need prospective or automated collection if a high degree of accuracy is required.

We recognize a number of limitations to our analysis. First, all subjects were transported by a single EMS agency. Practice variability in peripheral vascular access, IV fluid use, and documentation is likely present across individual paramedics and agencies, and our results may not be generalizable to other EMS systems. Second, we studied lower acuity medical patients without trauma, cardiac arrest, or other EMS interventions. More severely ill patients may have different documentation accuracy.¹⁴ The additional impact of illness severity on the documentation and accuracy of IV fluid volume could be explored with a larger sample size. Paramedics documenting in our trial may have differing estimating and reporting behaviors than would be seen outside this effort. We expect this may bias our documentation rates even higher than reported, and we blinded the EMS providers to mass-derived IV fluid volumes, limiting the threat. Finally, EMS personnel data were not available, and it is unknown how demographic characteristics such as age, gender, or years of experience could influence the reporting or accuracy of fluid documentation.

In summary, the administration of prehospital IV fluid is variably documented in EMS records. When recorded or self-reported by paramedics, the errors in IV fluid volume were modest.

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References

1. Seymour CW, Cooke CR, Heckbert SR, et al. Prehospital systolic blood pressure thresholds: a community-based outcomes study. *Acad Emerg Med*. 2013; 20:597–604. [PubMed: 23758307]
2. Cotton BA, Jerome R, Collier BR, et al. Eastern Association for the Surgery of Trauma Practice Parameter Workgroup for Prehospital Fluid R. Guidelines for prehospital fluid resuscitation in the injured patient. *J. Trauma*. 2009; 67:389–402. [PubMed: 19667896]

3. Badjatia N, Carney N, Crocco TJ, et al. Brain Trauma F and Management BTFCfG. Guidelines for prehospital management of traumatic brain injury, 2nd edition. Prehosp Emerg Care. 2008; 12(Suppl 1):S1–52. [PubMed: 18203044]
4. Teach SJ, Antosia RE, Lund DP, Fleisher GR. Prehospital fluid therapy in pediatric trauma patients. Ped Emerg Care. 1995; 11:5–8.
5. Kochanek PM, Carney N, Adelson PD, et al. American Academy of Pediatrics-Section on Neurological S; American Association of Neurological Surgeons/Congress of Neurological S; Child Neurology S; European Society of P; Neonatal Intensive C; Neurocritical Care S; Pediatric Neurocritical Care Research G; Society of Critical Care M; Paediatric Intensive Care Society UK; Society for Neuroscience in A; Critical C; World Federation of Pediatric I and Critical Care S. Guidelines for the acute medical management of severe traumatic brain injury in infants, children, and adolescents—second edition. Ped Crit Care Med. 2012; 13(Suppl 1):S1–82.
6. Brain Trauma F, American Association of Neurological S; Congress of Neurological S; Joint Section on N; Critical Care AC. Bratton SL, Chestnut RM, Ghajar J, et al. Guidelines for the management of severe traumatic brain injury. I. Blood pressure and oxygenation. J Neurotrauma. 2007; 24(Suppl 1):S7–13. [PubMed: 17511549]
7. Sayre MR, White LJ, Brown LH, McHenry SD, National EMSRSPWT. The National EMS Research strategic plan. Prehosp Emerg Care. 2005; 9:255–66. [PubMed: 16147473]
8. Haut ER, Kalish BT, Cotton BA, et al. Prehospital intravenous fluid administration is associated with higher mortality in trauma patients: a National Trauma Data Bank analysis. Ann Surg. 2011; 253:371–7. [PubMed: 21178760]
9. Hampton DA, Fabricant LJ, Differding J, et al. Prehospital intravenous fluid is associated with increased survival in trauma patients. J Trauma Acute Care Surg. 2013; 75:S9–15. [PubMed: 23778518]
10. Talving P, Palstedt J, Riddez L. Prehospital management and fluid resuscitation in hypotensive trauma patients admitted to Karolinska University Hospital in Stockholm. Prehosp Disaster Med. 2005; 20:228–34. [PubMed: 16128470]
11. Band RA, Gaieski DF, Hylton JH, Shofer FS, Goyal M, Meisel ZF. Arriving by emergency medical services improves time to treatment endpoints for patients with severe sepsis or septic shock. Acad Emerg Med. 2011; 18:934–40. [PubMed: 21883637]
12. Seymour CW, Cooke CR, Mikkelsen ME, et al. Out-of-hospital fluid in severe sepsis: effect on early resuscitation in the emergency department. Prehosp Emerg Care. 2010; 14:145–52. [PubMed: 20199228]
13. Seymour CW, Cooke CR, Heckbert SR, et al. Prehospital intravenous access and fluid resuscitation in severe sepsis: an observational cohort study. Crit Care (London, England). 2014; 18:533.
14. Laudermitch DJ, Schiff MA, Nathens AB, Rosengart MR. Lack of emergency medical services documentation is associated with poor patient outcomes: a validation of audit filters for prehospital trauma care. J Am Coll Surg. 2010; 210:220–7. [PubMed: 20113943]
15. Carr BG, Caplan JM, Pryor JP, Branas CC. A meta-analysis of prehospital care times for trauma. Prehosp Emerg Care. 2006; 10:198–206. [PubMed: 16531377]
16. Hyndman RJ, Koehler AB. Another look at measures of forecast accuracy. Int J Forecasting. 2006; 22:679–88.
17. Kottner J, Audige L, Brorson S, et al. Guidelines for reporting reliability and agreement studies (GRRAS) were proposed. J Clin Epidemiol. 2011; 64:96–106. [PubMed: 21130355]
18. Evans SM, Murray A, Patrick I, et al. Assessing clinical handover between paramedics and the trauma team. Injury. 2010; 41:460–4. [PubMed: 19735917]
19. Seymour CW, Kahn JM, Cooke CR, Watkins TR, Heckbert SR, Rea TD. Prediction of critical illness during out-of-hospital emergency care. JAMA. 2010; 304:747–54. [PubMed: 20716737]
20. Frisch A, Reynolds JC, Condle J, Gruen D, Callaway CW. Documentation discrepancies of time-dependent critical events in out of hospital cardiac arrest. Resuscitation. 2014; 85:1111–4. [PubMed: 24830870]
21. Pennsylvania Statewide Advanced Life Support Protocols. Pennsylvania Department of Health Bureau of Emergency Medical Services; Harrisburg, PA: 2014.

22. Seymour CW, Cooke CR, Hebert PL, Rea TD. Intravenous access during out-of-hospital emergency care of noninjured patients: a population-based outcome study. *Ann Emerg Med.* 2012; 59:296–303. [PubMed: 21872970]
23. Wang HE, Shapiro NI, Yealy DM. Characteristics of out-of-hospital shock care. *Crit Care Med.* 2011; 39:2431–9. [PubMed: 21705898]
24. Seymour CW, Rea TD, Kahn JM, Walkey AJ, Yealy DM, Angus DC. Severe sepsis in pre-hospital emergency care: analysis of incidence, care, and outcome. *Am J Resp Crit Care Med.* 2012; 186:1264–71. [PubMed: 23087028]
25. Kim F, Nichol G, Maynard C, et al. Effect of prehospital induction of mild hypothermia on survival and neurological status among adults with cardiac arrest: a randomized clinical trial. *JAMA.* 2014; 311:45–52. [PubMed: 24240712]
26. Finnell JT, Overhage JM. Emergency medical services: the frontier in health information exchange. *AMIA Ann Symp Proc.* 2010; 2010:222–6.
27. Seymour CW, Band RA, Cooke CR, et al. Out-of-hospital characteristics and care of patients with severe sepsis: a cohort study. *J Crit Care.* 2010; 25:553–62. [PubMed: 20381301]
28. Newgard CD, Haukoos JS. Advanced statistics: missing data in clinical research—part 2: multiple imputation. *Acad Emerg Med.* 2007; 14:669–78. [PubMed: 17595237]

Figure 1. Scatter plots of self-reported vs. mass-derived volumes (panel A), documented vs. mass-derived fluid volumes (panel B). Bland Altman plots for self-reported and measured fluid volumes (panel C) and documented vs. mass-derived fluid volumes (panel D) shows minimal systematic bias.

Table 1**Cohort characteristics**

Characteristic	Statistic
Demographics	
Age (yr), median [IQR]	47 [28–64]
Male gender, no. (%)	21 (42%)
Prehospital Location, no. (%)	
Home	28 (56%)
Health Care Facility	3 (6%)
Other	19 (38%)
Chief Complaint Category, no. (%)	
Sick person	20 (40%)
Unconscious/fainting	11 (22%)
Ingestion/poisoning	7 (14%)
Breathing problems	2 (4%)
Other *	10 (20%)
History of CHF, no. (%)	1 (2%)
Initial vital signs, mean $\pm$ SD	
Heart rate	97 $\pm$ 28
Respiratory rate	17 $\pm$ 4
Systolic blood pressure	127 $\pm$ 32
Oxygen saturation	98 $\pm$ 3
Glucose	122 $\pm$ 45
Initial Glasgow Coma Scale, mean $\pm$ SD	
Eye	3.9 $\pm$ 0.4
Verbal	4.8 $\pm$ 0.6
Motor	4.8 $\pm$ 0.6
Prehospital interventions, no. (%)	
Intubation	0 (0%)
Bag mask ventilation	1 (2%)
ACLS	0 (0%)
IV	50 (100%)
Supplemental Oxygen	11 (22%)
Bronchodilators	1 (2%)
Prehospital fluid volume reported in ED, no. (%)	50 (100%)
Prehospital fluid volume documented in EMS record, no. (%)	21 (42%)

Abbreviations: CHF = Congestive Heart Failure; ACLS = Advanced Cardiac Life Support; IV = Intravenous access.

* Other categories include abdominal pain, chest pain, back pain, heart problems, heat/cold exposure, hemorrhage/laceration, diabetic problems, and medical assist/backup.

Table 2

Cohort characteristics among subjects receiving IV fluid, stratified by documentation in the EMS record

Characteristic	Subjects With Documented Fluid (N = 21)	Subjects Without Documented Fluid (N = 29)
Demographics		
Age (yr), median [IQR]	44 [30–72]	47 [25–57]
Male	11 (52%)	10 (34%)
Prehospital Location		
Home	12 (57%)	16 (55%)
Health Care Facility	2 (10%)	1 (3%)
Other	7 (33%)	12 (42%)
Chief Complaint Category		
Sick person	8 (38%)	12 (42%)
Unconscious/fainting	6 (28%)	5 (17%)
Ingestion/poisoning	1 (5%)	6 (21%)
Breathing problems	0 (0%)	2 (7%)
Other	6 (29%)	4 (13%)
Initial vital signs, mean $\pm$ SD		
Heart rate	101 $\pm$ 36	94 $\pm$ 21
Respiratory rate	17 $\pm$ 2	17 $\pm$ 4
Systolic blood pressure	121 $\pm$ 30	132 $\pm$ 34
Oxygen saturation	98 $\pm$ 2	97 $\pm$ 3
Glucose	133 $\pm$ 51	113 $\pm$ 38
Initial Glasgow Coma Scale, mean $\pm$ SD		
Eye	4 $\pm$ 0	3.8 $\pm$ 0.6
Verbal	4.9 $\pm$ 3	4.8 $\pm$ 0.8
Motor	6 $\pm$ 0	5.8 $\pm$ 0.9
Prehospital interventions		
Intubation	0 (0%)	0 (0%)
Bag mask ventilation	0 (0%)	1 (3%)
ACLS	0 (0%)	0 (0%)
IV	21 (100%)	29 (100%)
Supplemental Oxygen	5 (24%)	6 (21%)
Bronchodilators	0 (0%)	1 (3%)
Total EMS time with patient, median [IQR]	31 [25–34]	33 [26–36]
Self-reported fluid volume in the ED, mean $\pm$ SD	357 $\pm$ 210	274 $\pm$ 164
Self-reported fluid volume in the ED, median [IQR]	250 [200–500]	250 [100–400]
Mass-derived fluid volume, mean $\pm$ SD	449 (238)	450 (270)
Mass-derived fluid volume, median [IQR]	386 [271–642]	399 [253–602]

Categorical variables analyzed using Fisher's exact test. Continuous variables analyzed using Wilcoxon rank-sum test.

Table 3

Comparison of measurement methods

	Mass-derived	Self-reported	Documented
Overall (<i>N</i> = 50)	<i>N</i> = 50	<i>N</i> = 50	<i>N</i> = 21
Mean (SD) volume, mL	449 (254)	309 ± 187	421 ± 261
Median [IQR] volume, mL	393 [264 – 618]	250 (150–500)	400 [200–500]
Mean (SD) error (mL) vs. to “mass-derived”	—	173 (190)	193 (187)
Median [IQR] error (mL) vs. to “mass-derived”	—	109 [41–205]	142 [64–265]
Subjects within 100mL of “mass-derived”, no. (%)	—	23 (46%)	9 (43%)
Subjects within 250mL of “mass-derived”, no. (%)	—	41 (82%)	15 (71%)
Transports greater than median total EMS time (<i>N</i> = 23) [^]	<i>N</i> = 23	<i>N</i> = 23	<i>N</i> = 9
Mean (SD) volume, mL	487 (229)	343 ± 166	544 ± 316
Median [IQR] volume, mL	423 [336–691]	300 (200–500)	500 (300–800)
Mean (SD) error (mL) vs. to “mass-derived”	—	148 (192)	264 (236)
Median [IQR] error (mL) vs. to “mass-derived”	—	99 [36–164]	264 [64–309]
Subjects within 100mL of “mass-derived”, no. (%)	—	12 (52%)	3 (33%)
Subjects within 250mL of “mass-derived”, no. (%)	—	20 (87%)	4 (44%)
Transports less than median prehospital systolic blood pressure (<i>N</i> = 25)	<i>N</i> = 25	<i>N</i> = 25	<i>N</i> = 12
Mean (SD) volume, mL	460 (263)	331 (198)	421 (248)
Median [IQR] volume, mL	399 [336–602]	300 [200–500]	400 [225–500]
Mean (SD) error (mL) vs. to “mass-derived”	—	175 (199)	154 (133)
Median [IQR] error (mL) vs. to “mass-derived”	—	115 [37–199]	105 [50–242]
Subjects within 100mL of “mass-derived”, no. (%)	—	11 (44%)	6 (50%)
Subjects within 250mL of “mass-derived”, no. (%)	—	20 (80%)	9 (75%)

[^] Two patients with missing prehospital time intervals.