Normal Saline Solution and Lactated Ringer's Solution Have a Similar Effect on Quality of Recovery: A Randomized Controlled Trial

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Study objective: The purpose of this study is to test the hypothesis that balanced crystalloids improve quality of recovery more than normal saline solution (0.9% sodium chloride) in stable emergency department (ED) patients. Secondary outcomes measured differences in health care use.

Methods: A single-site, participant- and evaluator-blinded, 2-arm parallel allocation (1:1), comparative effectiveness, randomized controlled trial allocated adults receiving intravenous fluids in the ED before discharge to receive 2 L of lactated Ringer's solution or normal saline solution. The primary outcome was symptom scores measured by the validated Quality of Recovery–40 instrument (scores 40 to 200) 24 hours after enrollment. Secondary outcomes included subsequent health care use and medication compliance.

Results: Participants (N=157) were enrolled and follow-up was analyzed for 94 (follow-up rate of 60%) with intention-to-treat methodology. There was no difference in postenrollment Quality of Recovery–40 scores between normal saline solution and lactated Ringer's solution groups (mean difference 2.4; 95% confidence interval [CI] −6.8 to 11.6). Although preenrollment scores were higher in the lactated Ringer's solution group (mean difference 10.5; 95% CI 1.9 to 19.0), adjusting for presurvey imbalances did not change the primary outcome (adjusted difference −3.9; 95% CI −12.9 to 5.2). There were no differences in return to ED (mean difference 7.5%; 95% CI −8.7% to 23.8%), prescriptions filled (mean difference 22.2%; 95% CI −3.3% to 47.6%), or seeking care from another provider (mean difference −2.0%; 95% CI −19.9% to 15.9%) at 7 days.

Conclusion: Normal saline solution and lactated Ringer's solution were associated with similar 24-hour recovery scores and 7-day health care use in stable ED patients. These results supplement those of recent trials by informing fluid choice for stable ED patients. [Ann Emerg Med. 2019;73:160-169.]

Please see page 161 for the Editor's Capsule Summary of this article.

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0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2018.07.007

SEE EDITORIAL, P. 170.

INTRODUCTION

Background

Nearly 25% of emergency department (ED) patients receive intravenous fluids, making their administration the most common ED procedures, with many patients receiving them before ED discharge.[1,2] Crystalloid intravenous fluids are administered to increase effective blood volume and maintain organ perfusion in patients with signs or symptoms of volume depletion and dehydration.[3] Since its discovery in the 19th century, normal saline solution, 0.9% sodium chloride, has been the most frequently administered crystalloid.[4,5]

High chloride loads associated with normal saline solution administration cause hyperchloremic acidosis, which has been hypothesized to contribute to poor clinical outcomes and impaired recovery.[6-9] Normal saline solution contributes to acute kidney injury, persistent kidney dysfunction, and mortality among critically ill patients.[7] It is also associated with decreased renal tissue perfusion because the high chloride concentration increases afferent arteriole resistance.[10] Even in healthy adults, normal saline solution impairs renal function and causes hyperchloremia, which can lead to myalgias, abdominal discomfort, and persistent kidney dysfunction.[10-12] In contrast, balanced crystalloid solutions, such as lactated Ringer's solution, have a lower chloride concentration and avoid many of the concerns associated with normal saline solution.[6,7,9,13-16]

Recently, 2 large, pragmatic, randomized controlled trials compared normal saline solution and balanced

Editor's Capsule Summary

What is already known on this topic

Studies in noncritically ill, hospitalized patients given either normal saline solution or lactated Ringer's solution have found no difference in hospital-free days at 28 days, although small differences were noted in renal adverse events.

What question this study addressed

In similar emergency department (ED) patients randomized to normal saline solution or lactated Ringer's solution, are there differences in patient-reported symptoms and other measures of recovery 24 hours after ED discharge?

What this study adds to our knowledge

Follow-up in 94 patients treated with either fluid found no differences in Quality of Recovery–40 score or (for 78 patients) measures of further health care use.

How this is relevant to clinical practice

Despite a high rate of loss to follow-up, these findings support the conclusion that normal saline solution and lactated Ringer's solution lead to similar clinical recovery in discharged ED patients.

solutions.[6,9] In hospitalized, noncritically ill patients, there was no difference in the primary outcome of hospital-free days; however, in the balanced solution group there was lower incidence of the major adverse kidney events: a composite outcome of death, new renal-replacement therapy, and persistent renal dysfunction at 30 days (number needed to treat=91).[6]

In both trials, heterogeneity in the effect of balanced crystalloid solutions was observed by severity of illness, principal hospital diagnosis, and comorbidities.[6,9] Therefore, it is difficult to generalize these recent trial results to a different patient population consisting of mildly ill patients discharged from the ED. Furthermore, the difference in major adverse kidney events outcomes suggests there could be differences in subjective recovery based on intravenous fluids. Given that many patients receive intravenous fluids before ED discharge, it is important to determine whether balanced solutions will have a recovery benefit in this mildly ill population.

Importance

For many patients receiving intravenous fluids in the ED before discharge, the principal indication for fluid administration is to decrease symptoms and improve patients' perception of well-being. Although several studies have recently reported objective effects of fluid selection on clinical outcomes, the lack of patient-reported outcomes significantly impairs clinicians' ability to fully appreciate the range of effects that fluid selection might have. Furthermore, these patient-reported outcomes may influence ongoing health care resource use, even in the absence of differences in mortality or renal failure. Identifying an optimal fluid choice could lead to significant benefits for patients and health care systems.

Goals of This Investigation

The objective of this study was to measure the effect of fluid selection on patient-reported symptoms 24 hours after ED discharge in noncritically ill patients. The primary outcome was patient-reported symptoms after ED discharge, using the Quality of Recovery–40, a validated instrument that quantifies patients' self-assessment of functional recovery, symptoms, and physical comfort. Secondary outcomes included 7-day health care use, defined as return visits to the ED, filled ED prescriptions, and seeking care from another health care provider. We hypothesized that administration of a balanced crystalloid solution would lead to greater symptom improvement and decreased health care use compared with administration of normal saline solution.

MATERIALS AND METHODS

Study Design and Setting

This study was a single-center, participant- and evaluator-blinded, 2-arm parallel allocation (1:1), comparative effectiveness, randomized controlled trial comparing the quality of recovery of a single 2-L intravenous bolus of lactated Ringer's solution or normal saline solution. Study enrollment was conducted in a Midwestern academic ED with an annual census of 60,000 patients. The study was approved by the local institutional review board. All participants provided written informed consent for study participation, and this trial is reported in accordance with the Consolidated Standards of Reporting Trials guidelines.[17]

Selection of Participants

Participants were enrolled from May 2017 to October 2017 from a convenience sample of adult (18 to 100 years) ED patients presenting with one of the following complaints: nausea, vomiting or emesis, diarrhea, abdominal pain, dizziness, weakness, heat stroke or heat exhaustion, dehydration, fatigue, or volume depletion.

Participants were included if they were being administered intravenous fluids by their ED treatment team, could tolerate 2 L of intravenous fluids (according to the treating clinician), and were expected to be discharged from the ED without hospital admission. Between 8 AM and 11 PM, trained research assistants identified potential study participants according to chief complaint and discussed eligibility criteria with the ED treatment team. Patients were excluded if they were pregnant, were prisoners, did not speak English, were undergoing current chemotherapy, had signs of jaundice, had already received greater than 250 mL of intravenous fluids, or were unable to provide informed consent. No financial incentive was given for study participation.

Interventions

Participants were randomized to receive 2 L of either lactated Ringer's solution (treatment) or normal saline solution (control), using 1:1 allocation in randomized, permuted blocks by computerized random-generated sequence (block sizes 2 to 6). Allocation was concealed in opaque, sealed, numbered envelopes. Participants received fluids in a peripheral intravenous line in the upper extremity, placed for clinical care, and fluids were delivered directly from a standard preparation (Baxter Healthcare Corporation, Deerfield, IL). Intravenous fluid bags were prepared outside the room and covered with an opaque bag to maintain participant blinding before being brought into the clinical care room by the treating nurse and administered. Participants continued to receive standard clinical care while in the ED, and the remainder of care was not dictated by the study protocol.

Methods of Measurement

The primary outcome was the Quality of Recovery–40 score, measured at 24 hours after the ED visit. The Quality of Recovery–40 is a validated survey tool previously used in anesthesia and surgical populations that measures patient-reported recovery across 5 independent domains: comfort, emotion, physical independence, patient support, and pain (Table E1, available online at http://www.annemergmed.com). The Quality of Recovery–40 was selected for use in this study because it measures quality of life during short-term recovery. Survey scores range from 40 to 200, with 40 indicating a poor quality of recovery and 200 indicating an excellent one.[18,19]

Trained research assistants administered the Quality of Recovery–40 to participants immediately after study enrollment and consent, but before randomization and fluid administration (to confirm the adequacy of randomization). The same research assistant enrolled the participant, administered the survey, randomized the participant, and oversaw fluid administration. Twenty-four to 48 hours after ED discharge, a different research assistant blinded to treatment allocation administered the same Quality of Recovery–40 by telephone (primary outcome). Participants who did not respond to 3 telephone calls were considered lost to follow-up, but were still eligible for 7-day follow-up of secondary outcomes. Survey data were recorded first on paper and then transcribed into an electronic database (REDCap, version 8.1.1; Vanderbilt University, Nashville, TN, USA). A randomly selected sample (10%) of paper records was validated by an independent reviewer (to ensure accuracy of transcription between paper and electronic data) and achieved perfect concordance.

Seven days after patient discharge from the ED, the same blinded research assistant (who had collected primary outcome) contacted participants by text message to evaluate their health care use. Participants were asked 3 questions: "Have you returned to the ED for the same problem?," "Have you filled any prescriptions from the ED?," and "Have you seen another medical provider for the same complaint?" Responses were provided by text message or telephone as dichotomous responses, and participants who did not respond to 3 queries were considered lost to follow-up.

Covariates were abstracted from the participant's electronic medical record by a trained research assistant. Comorbidities, including psychiatric disease, chronic kidney disease, and chronic gastrointestinal disease, were defined as the presence of a previous diagnosis in the medical record. For example, "chronic gastrointestinal disorders" was defined as a medical history of chronic disorders of the gastrointestinal tract, including Crohn's disease, celiac disease, chronic pancreatitis or pancreatic insufficiency, lactose intolerance, diverticulosis, chronic diarrhea, gastroparesis, tubular adenoma, irritable bowel syndrome, and diverticulitis.

A power calculation was performed to select the necessary sample size before enrollment, and this calculation assumed that a minimum difference of 10 points on the Quality of Recovery–40 survey score was clinically meaningful. This 10-point difference is equivalent to a 15% clinical recovery, which has been widely used in previous research, established from a distribution-based method of inferring a clinically relevant difference.[18-21] Expected loss to follow-up was estimated from a previous ED pilot study with similar telephone follow-up methods.[20] The estimated necessary sample size (α=.05, β=.20, 40% expected loss to follow-up, and difference of 10 points) was 156 total participants.

Primary Data Analysis

Baseline characteristics were analyzed with a *t* test for continuous variables and Pearson χ^2 test for categorical variables and reported with basic descriptive statistics and 95% confidence intervals (CIs). The primary outcome, the 24-hour Quality of Recovery–40 score, was analyzed with a Wilcoxon-Mann-Whitney test in an intention-to-treat analysis because Quality of Recovery–40 scores were not expected to follow a normal distribution.[18] An a priori–defined sensitivity analysis was planned with per-protocol analysis to measure the sensitivity of results to treatment crossover. Individual analyses of the 5 survey domains (pain, patient support, emotions, comfort, and physical independence) were conducted to identify specific areas of recovery. The 7-day survey responses were analyzed with a χ^2 test to evaluate health care use after discharge.

An a priori plan was followed to develop a multivariable linear regression model if there were imbalances in the baseline demographic variables or pretreatment Quality of Recovery–40 scores. Variables to be included in the regression model included any of the collected covariates with imbalances between the 2 treatment groups. Linear regression was planned because the error terms followed a normal distribution.

A blinded, monthly safety analysis was performed by treatment received during the enrollment period by an independent safety monitor. No interim efficacy analysis was included (Quality of Recovery–40 scores were not reported at interim analyses). The trial continued to the estimated sample size. There were no adverse drug events during the study.

After data collection, several pretreatment Quality of Recovery–40 surveys were found to have missing values on individual questions. These values were imputed with multiple imputation to preserve variance in the variable with missing data. The missing-at-random assumption was supported by visualization of missing data patterns and assessment of correlation of other variables with a missing presurvey score (threshold of $r>0.4$). One hundred imputed data sets were generated according to the distribution of the nonmissing presurvey scores. Then, regression parameters for each of the 100 data sets were pooled in a final model. Results are reported with complete case analysis and multiple imputation. No values were missing in the primary outcome Quality of Recovery–40 score at 24 hours, and no imputation was performed for participants lost to follow-up.

A post hoc sensitivity analysis was conducted to test the robustness of the primary outcome to participants lost to follow-up by estimating the necessary difference in the participants lost to follow-up to change the conclusion of the study. All statistical analyses were performed with SAS (version 9.4; SAS Institute, Inc., Cary, NC).

RESULTS

Characteristics of Study Subjects

Of 777 patients screened, 217 were eligible for study participation, and the accrual rate was 71.7% (n=157) (Figure). One participant was withdrawn from the study after randomization because of an unrecognized current pregnancy. The primary outcome was available for analysis for 60.3% of participants, and follow-up was higher in the normal saline solution group (68.8%) compared with the lactated Ringer's solution group (51.9%) (difference 17.0%; 95% CI 1.8% to 32.1%). Participants were primarily women (62%) and white (84%), with a median age of 33.5 years (interquartile range 23.0 to 44.0 years). The study arms were similar in most demographics, including ED and out-of-hospital medications, ED chief complaint, and laboratory values. However, the normal saline solution group was more likely to have diabetes, chronic gastrointestinal disease, and psychiatric disease (Table 1). Approximately 5% of participants (n=8) had a missing value for a question in the presurvey, resulting in a missing presurvey score, and these scores were imputed.

The analysis population on the primary outcome (n=94) was mostly similar to the population lost to follow-up (Table E2, available online at http://www.annemergmed.com). However, they were less likely to receive antiemetic medication in the ED (45.2 versus 26.6%; difference 18.6%; 95% CI 3.3% to 33.8%) and less likely to receive nonsteroidal anti-inflammatory medications after survey administration in the ED (24.5% versus 9.7%; difference 14.8%; 95% CI 3.4% to 26.2%) compared with participants lost to follow-up (n=62). Preanalysis scores between participants who responded to the follow-up survey and those who did not were not statistically different (difference –1.23; 95% CI –10.3 to 7.8). Study participants admitted to the hospital (18.0%) were included in the analysis.

Main Results

Participants in both treatment groups (normal saline solution and lactated Ringer's solution) showed an improvement in their Quality of Recovery–40 score 24 hours after receiving intravenous fluids in the ED (normal saline solution 22.7, 95% CI 14.6 to 30.4; and lactated Ringer's solution 14.7, 95% CI 7.2 to 20.0). There was no difference in the primary outcome between the lactated Ringer's solution and normal saline solution groups

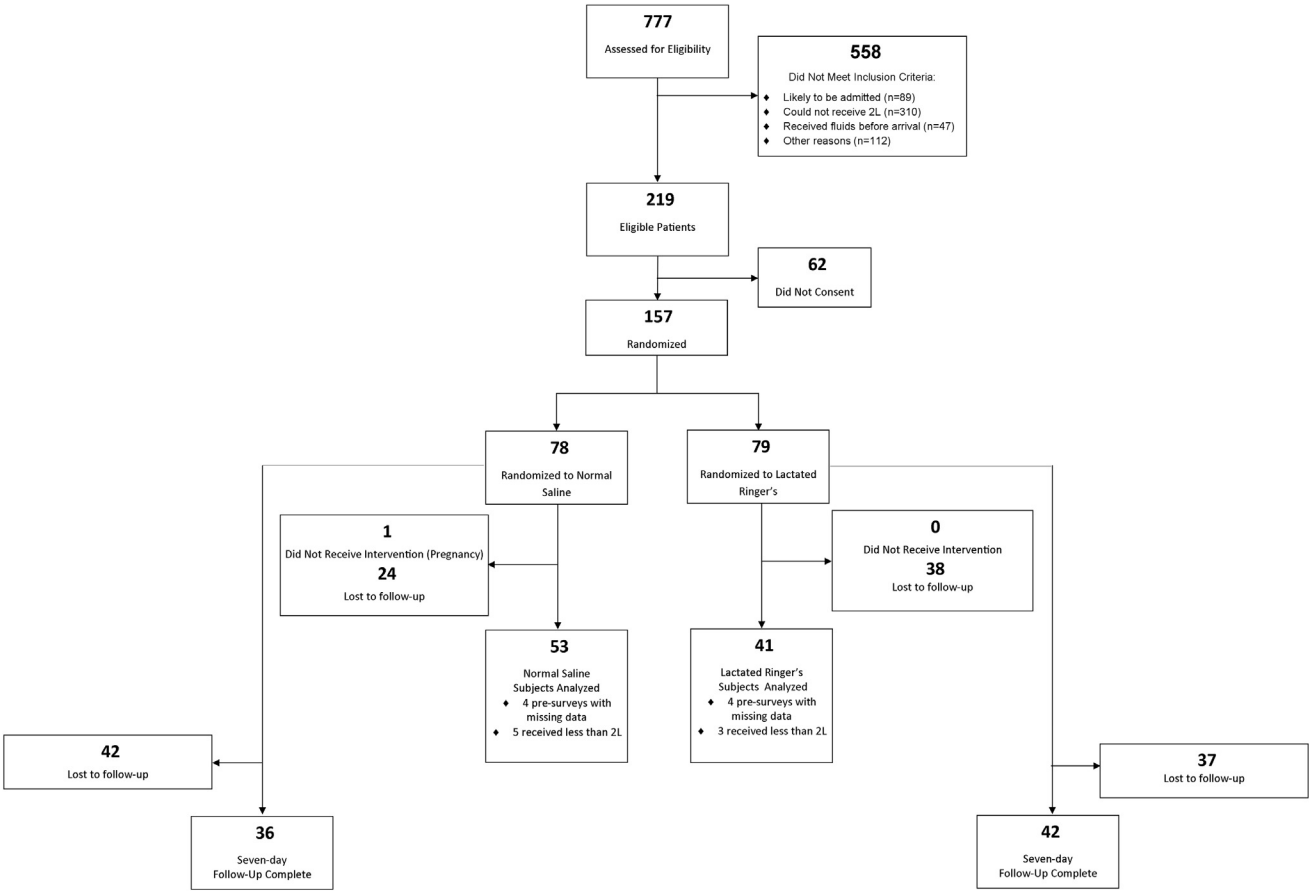

Figure. Flowchart of study participants.

(166.8 lactated Ringer's solution versus 164.4 normal saline solution; mean difference 2.4; 95% CI –6.8 to 11.6) (Table 2). There was a difference between preenrollment Quality of Recovery–40 scores (152.1 lactated Ringer's solution versus 141.7 normal saline solution; mean difference 10.5; 95% CI 1.9 to 19.0). As determined by a post hoc exploratory analysis, 62.3% of the normal saline solution group (n=33) experienced a significant improvement (defined as a change in 10 points) in Quality of Recovery–40 score compared with 51.2% (n=21) of the lactated Ringer's solution group (difference 11.0%; 95% CI –9.1% to 31.2%).

A multivariable linear regression analysis was conducted adjusting for the preenrollment score differences and unbalanced covariates (Table 3), and this continued to show no relationship between group allocation and postsurvey scores (adjusted difference –3.85; 95% CI –12.94 to 5.24).

There was no difference between the groups in emotional state, comfort, patient support, physical independence, or pain 24 hours after receipt of intravenous fluids in the ED (Table 2). Overall, comfort scores had the largest increase from pre- to postsurvey scores, whereas scores for pain and emotional state increased modestly. None of the differences were statistically significant.

Table 4 shows the results of the 7-day health care use survey. Response rates for the secondary outcomes were 47.4% (n=36) in the normal saline solution group and 53.3% (n=42) in the lactated Ringer's solution group (difference –5.9%; 95% CI –21.6% to 9.8%). The most common way patients used more health care was filling a prescription (64.7%). There were no differences in health care use between the treatment groups. Overall, 15.4% of participants returned to the ED for the same complaint within 7 days of the study visit.

There were no treatment crossovers during the study. A per-protocol analysis was completed with subjects who received the full 2 L of intervention (90.6%, n=48 of the normal saline solution group; 92.7%, n=38 of the lactated Ringer's solution group). The primary outcome, posttreatment Quality of Recovery–40 scores, remained similar between the 2 treatment groups (167.3 lactated Ringer's solution versus 164.4 normal saline solution; mean difference 2.9; 95% CI –5.0 to 23.2).

Table 1. Characteristics of study participants.

Characteristics	Normal Saline Solution (N=53)		Lactated Ringer's Solution (N=41)	
Age, median (IQR), y	39 (25, 45)		29 (22, 41)	
Intravenous fluid volume administered, mean (SD), mL	1,921 (252)		1,954 (237)	
Calculated GFR, median (IQR), mL/min/BSA	84 (72, 91)		90 (81, 91)	
	No.	**%**	**No.**	**%**
Women	34	64.2	24	58.4
Race				
Black	7	13.2	2	4.9
Asian	0		3	7.3
White	45	84.9	34	82.9
Other	1	1.9	2	4.9
ED chief complaint				
Abdominal pain	28	52.8	15	36.6
Diarrhea	1	1.9	2	4.9
Dizziness	3	5.7	4	9.8
Fever	2	3.8	2	4.9
Flank pain	6	11.3	4	9.8
General illness	1	1.9	0	
Headache	3	5.7	5	12.2
Vomiting or emesis	7	13.2	7	17.1
Other	2	3.8	2	4.9
Out-of-hospital medications	5	9.4	6	14.6
ED medications before presurvey				
Opiates	10	18.9	12	29.3
NSAIDs	6	11.3	4	9.8
Antiemetics	14	26.4	11	26.8
Benzodiazepines	0		1	2.4
None	35	66.0	25	61.0
ED medications after presurvey				
Opiates	19	35.9	16	39.0
NSAIDs	12	22.6	11	26.8
Antiemetics	26	49.1	17	41.4
Benzodiazepines	0		1	2.4
None	17	32.1	13	31.7
ED disposition				
Discharged from ED	44	83.0	37	90.2
Admitted to inpatient floor	5	9.4	2	4.9
Admitted for observation	4	7.6	1	2.4
Other	0		1	2.4
Comorbidities				
Chronic kidney disease	0		1	2.4
Congestive heart failure	0		0	
Diabetes	7	13.2	0	
Chronic gastrointestinal disease	11	20.8	3	7.3
Migraine history	7	13.2	6	46.2
Psychiatric disorder	24	45.3	8	19.5
Urine specific gravity				
Not measured	21	55.3	19	46.3
<1.000	2	3.8	1	2.4
1.000–1.030	26	49.1	19	46.3
>1.030	4	7.8	2	4.9
BUN/Cr ratio				
<10	17	32.1	17	41.5
10–20	31	58.5	21	51.2
>20	5	9.4	3	7.3
ED discharge diagnoses				
Abdominal pain/disease	13	31.7	15	28.3
Fever	3	5.7	1	2.4
Flank pain/disease	10	18.9	4	9.8
Headache or migraine	4	7.6	5	12.2
Nausea, vomiting, or diarrhea	7	13.2	6	14.6
Syncope	0		3	7.3
Urinary tract infection	1	1.9	1	2.4
Viral syndrome	2	3.8	1	2.4
Other	11	20.8	7	17.1
Any GI (abdominal pain or nausea, vomiting, or diarrhea)	19	46.3	22	53.7

IQR, Interquartile range; *GFR*, glomerular filtration rate; *BSA*, body surface area; *NSAIDs*, nonsteroidal amti-inflammatory drug; *BUN/Cr*, blood urea nitrogen/creatinine; *GI*, gastrointestinal.

Sensitivity Analyses

Because of differential loss to follow-up between the 2 treatment groups, a sensitivity analysis estimated the magnitude of a hypothetical difference between the 2 groups' postsurvey scores needed to change the interpretation of the primary outcome. The control group (normal saline solution) was assumed to have the mean value, whereas the treatment group's value was varied to identify the minimum increase or decrease in Quality of Recovery–40 score that would change the conclusion of the study results. If all participants had responded to the 24-hour survey, a 6-point reduction or an 8-point increase in the post–Quality of Recovery–40 scores of participants lost to follow-up would have been needed to change the study conclusion of no difference between the 2 treatment groups.

LIMITATIONS

Our study has several important limitations. First, this was a single-center study.

Second, only 11% of participants had an abnormal blood urea nitrogen–to-creatinine ratio (Table 1), suggesting that many of them may not have been

Table 2. Primary outcome by treatment allocation: Quality of Recovery–40 scores.

	Presurvey			Postsurvey		
Survey Domain (Possible Range of Scores)	**Normal Saline Solution (n=70)**	**Lactated Ringer's Solution (n=67)**	**Mean Difference (95% CI)**	**Normal Saline Solution (n=53)**	**Lactated Ringer's Solution (n=41)**	**Mean Difference (95% CI)**
QoR–40*	141.7	152.1	10.5 (1.9 to 19.0)	164.4	166.8	2.4 (–6.8 to 11.6)
Emotional state (9–45)	30.7	32.2	1.6 (–0.9 to 4.0)	36.2	37.4	1.3 (–1.4 to 3.9)
Comfort (12–60)	37.6	40.4	2.8 (–0.3 to 5.9)	48.6	49.0	0.4 (–3.1 to 3.8)
Patient support (7–35)	31.0	32.1	1.1 (–0.5 to 2.7)	31.8	32.7	0.8 (–1.1 to 2.8)
Physical independence (5–25)	20.1	21.4	1.3 (–0.3 to 2.8)	22.8	22.4	–0.4 (–1.7 to 0.9)
Pain (7–35)	23.7	25.1	1.4 (–0.4 to 3.2)	28.6	28.8	0.1 (–2.0 to 2.2)

QoR–40, Quality of Recovery–40.
*The QoR–40 ranges from 40 to 200, with higher scores indicating a higher quality of recovery.

objectively volume depleted. This finding could reflect broad inclusion criteria, but because this clinical judgment reflected current ED practice, we think that our findings apply broadly to the population receiving intravenous fluids before discharge. Considering recent findings of differences in hospitalized patients,[6] the inclusion of admitted patients in our study population may have biased the reported results toward finding a significant difference. However, our results still showed no difference between the treatment groups. An exploratory analysis was conducted for hospitalized patients, which showed that the Quality of Recovery–40 scores improved by 17.8 points (SD 24.0 points) in the hospitalized participants compared with 18.8 points (SD 24.8 points) in the discharged participants. It is also possible that some patients received intravenous fluids for alternate reasons (eg, hydration before receiving intravenous contrast agents). Third, our study design included a heterogeneous ED patient population. Participants might have been expected to have different recovery patterns based on the various indications for care, which could have diluted our observed effect. Similar to other studies on this topic,[6] though, this participant heterogeneity reflects current ED practice, and no imbalances on indication for fluids were observed in the randomization. Additionally, the primary outcome measure, Quality of Recovery–40, has been validated in anesthesia and surgery populations, but has not been used in emergency medicine populations. Although some questions directly relate to general anesthesia, the majority of response items capture relevant dimensions of recovery for the study population.

Fourth, the study dose of 2 L may be a larger dose than generally administered for noncritical patients, but dosing

Table 3. Results of multivariable regression to predict postsurvey scores.

Model	**Mean Difference**	**95% CI**	**Adjusted Mean Difference**	**95% CI**
Complete case analysis*				
Treatment group	–2.81	(–11.31 to 5.69)	–4.91	(–14.44 to 4.63)
Pretreatment QoR–40 score	—†	—	0.44	(0.27 to 0.61)
Diabetes	—	—	–5.44	(–26.57 to 15.69)
Psychiatric disease	—	—	–4.87	(–14.28 to 4.53)
Chronic gastrointestinal disease	—	—	–2.14	(–15.48 to 11.21)
Imputed presurvey score analysis‡				
Treatment group	–1.70	(–10.09 to 6.68)	–3.85	(–12.94 to 5.24)
Pretreatment QoR–40 score	—	—	0.40	(0.23 to 0.57)
Diabetes	—	—	–4.98	(–22.96 to 13.00)
Psychiatric disease	—	—	–4.72	(–13.65 to 4.22)
Chronic gastrointestinal disease	—	—	–2.58	(–15.64 to 10.47)

*Complete case analysis includes participants who had no missing responses for the pretreatment QoR–40 survey.
†Dashes indicate not available.
‡Imputed presurvey score analysis used multiple imputation to estimate the pretreatment QoR–40 score for subjects with missing pretreatment survey data (n=8) before development of the adjusted model.

Table 4. Secondary outcomes by treatment group.

Outcome	Normal Saline Solution (N=36)		Lactated Ringer's Solution (N=42)		Mean Difference 95% CI
	No.	%	No.	%	
Returned to the ED	7	19.4	5	11.9	7.5 (−8.7 to 23.8)
Sought care from another provider	7	19.4	9	21.4	−2.0 (−19.9 to 15.9)
Filled prescription*	19	76.0	14	53.9	22.2 (−3.3 to 47.6)

*Patients without ED prescriptions (n=27: 11 normal saline solution, 16 lactated Ringer's solution) were not included in the analysis of prescriptions filled.

was selected to ensure that patients received a sufficient chloride load to observe effects if they existed. Two liters has been shown to induce physiologic changes,[7] and a study of noncritical, admitted ED patients showed differences in renal function with only 1 L.[15] Because participants in our study received a higher dose of chloride, our conclusion of no observed effect of fluid choice on subjective outcomes is strengthened.

Fifth, loss to follow-up is a significant limitation of this study, with nearly a 40% loss to follow-up and more participants in the normal saline solution group completing follow-up surveys compared with the lactated Ringer's solution group. Although we powered the study for a high loss to follow-up, it remains a major limitation. The differential loss to follow-up between treatment groups creates an unequal group distribution that was not predicted in the sample size calculation. Because presurvey score was a strong predictor of postsurvey score, it is likely that differences in the population lost to follow-up compared with the analysis population were minimal. A sensitivity analysis showed that the study results were robust to changes in the responses of the participants lost to follow-up because a 6-point reduction or an 8-point increase in the post–Quality of Recovery–40 scores was required to change the study conclusion. Because presurvey scores and ED diagnoses did not differ according to follow-up status, the population of those lost to follow-up is unlikely to be substantially different from the analysis population.

DISCUSSION

Although previous studies have evaluated the effects of fluid choice in critical patients and patients admitted to the general ward, our study evaluated fluid choice in ED patients who were anticipated to be discharged home. It also evaluated the patient's subjective perception of recovery. Patient-reported recovery is an important outcome for patients for whom fluid administration is being considered, and differences in patient-reported symptom scores would support selection of fluids better targeting improved symptoms.

In noncritically ill patients, crystalloid choice may not affect recovery time or health care use. The Saline Against Lactated Ringers or Plasmalyte in the Emergency Department (SALT-ED) study reported no difference in hospital-free days between admitted patients receiving balanced solutions compared with normal saline solution. Our study supports these findings because fluid choice had no effect on subjective recovery of participants, even when fluid was administered at higher doses.

The studies by Semler et al[9] and Self et al[6] suggest that fluid choice has a larger effect on outcomes in critically ill patients compared with noncritically ill ones. In critically ill patients, balanced solutions resulted in a benefit in major adverse kidney events outcomes.[9] Similar decreases in major adverse kidney events outcomes were observed in noncritically ill patients, but the lower incidence in these outcomes was driven by differences in persistent renal dysfunction (defined as final serum creatinine concentration $\geq$200% of the baseline value).[6] The increased creatinine level could be reflective of sentinel microvascular changes and interstitial edema in encapsulated renal tissue because of normal saline solution's chloride load.[21] The participants we enrolled may not have been ill enough for the acidosis associated with normal saline solution administration to lead to symptoms, and the ability to buffer that chloride load may have preserved their rapid recovery.

Our study population included patients who received intravenous fluids according to clinician judgment and as part of standard clinical care. However, only 10% of our participants had an elevated blood urea nitrogen–to-creatinine ratio out of those with a ratio measured. This suggests intravenous fluid administration may not be necessary in this population, and that liberal use of intravenous fluids may not prevent repeated health care visits. Our data are not sufficient to recommend against intravenous fluid use, but few data support liberal crystalloid fluid administration in patients with normal laboratory study results who are discharged to home, despite its ubiquitous practice. Intravenous fluid administration in our study population may not have been

necessary or therapeutic. During recent intravenous fluid shortages, some hospitals have reserved intravenous fluid treatment for critically ill patients while using oral rehydration protocols for ED patients who would have previously received intravenous fluids.[22,23] Future studies could evaluate the effect of different rehydration protocols, such as a comparison of oral rehydration and intravenous fluid treatments, on quality of recovery in these ED patients. Moreover, our secondary outcomes, although underpowered, demonstrated a notable ED revisit rate during the first 7 days after discharge. This suggests a potential need to identify predictors of increased health care use among noncritically ill patients discharged from the ED.

In summary, lactated Ringer's solution and normal saline solution were associated with similar patient-reported recovery in patients anticipated to be discharged home from the ED. Use of lactated Ringer's solution does not lead to improved quality of recovery compared with use of normal saline solution. Our findings supplement the conclusions of recent large trials that either lactated Ringer's solution or normal saline solution may be a reasonable choice for fluid resuscitation in patients who are not critically ill.

The authors acknowledge the statistical support and expertise of Patrick Ten Eyck, PhD, for his help with multiple imputation, the University of Iowa Department of Emergency Medicine, and the University of Iowa Emergency Department–Research Enrollers Program.

Supervising editor: Allan B. Wolfson, MD

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Author contributions: All authors completed the initial literature search and critically reviewed the article. AF and NM completed participant consent and data collection and drafted the article. MBS, BAF, and NMM developed the study design. MBS conducted data analysis. NM takes responsibility for the paper as a whole.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist. Research reported in this publication was supported by the University of Iowa Department of Emergency Medicine and the National Center for Advancing Translational Sciences of the National Institutes of Health (NIH) under award U54TR001356 and NIH training grant 5 T35 HL 7485-38.

Publication dates: Received for publication April 18, 2018. Revisions received June 12, 2018, and June 20, 2018. Accepted for publication July 9, 2018. Available online August 23, 2018.

Presented at the Society for Academic Emergency Medicine (SAEM) Great Plains regional meeting, September 2017, Columbia, MO; and the SAEM annual meeting, May 2018, Indianapolis, IN.

Trial registration number: NCT03133767

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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IMAGES IN EMERGENCY MEDICINE

(continued from p. 117)

DIAGNOSIS:

Foreign body in the appendix. Foreign bodies in the gastrointestinal tract are common findings in emergency departments worldwide. In many instances, a small foreign body may successfully pass through the entire gastrointestinal tract and exit in the feces.[1] Occasionally, gastrointestinal perforation occurs because of sharp edges or points that the foreign body may have.[2]

The patient underwent a peritoneoscopic appendectomy to remove the appendix, which was swelling and congestive with the C+ file obstructing the lumen of the middle part of the appendix. The patient had no postoperative complications.

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