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Comparison of the Effects of Fluid Therapy With Normal Saline, Ringer, and Ringer's Lactate During Anesthesia on the Hemodynamic Status and Events During Orthopedic Lower Limb Orthopedics Surgeries

Mirmohammadtaghi Mortazavi[1], Mohammadreza Moharrami[2], Behrooz Nazari[2], Hassan Mohammadipour Anvari[3*]

Abstract

Objectives: Given that no study has so far carefully examined the effects and benefits of crystalloids on the hemodynamic status and events during the surgery for lower limb orthopedic surgeries, the current study aimed to compare fluid therapy with normal saline (NS), Ringer (R), and Ringer's lactate (RL) during anesthesia on the hemodynamic status and events during lower limb elective orthopedic surgeries.

Materials and Methods: This cross-sectional descriptive study was conducted in 2019 with the participation of 270 patients (three groups each including 90 subjects) who were scheduled for an elective lower limb orthopedic surgery in Imam Reza hospital of Tabriz. Patients received one of these serums of NS, R, and RL. Electrolytes were measured before and after the surgery. Finally, data were analyzed using ANOVA and chi-square tests.

Results: Based on the results, there was no significant difference between the three groups in terms of hemoglobin, hematocrit, sodium, calcium, potassium, chlorine, albumin, creatinine, urea, bicarbonate, pH, and arterial oxygen levels (P>0.05), and RL serum had the least effect on all factors.

Conclusions: In general, the administration of NS, R, and RL in lower limb orthopedic surgeries did not result in significant differences although RL had the least adverse effects and was associated with better results.

Keywords: Orthopedic, Lower limb, Ringer's Lactate, Normal saline, Ringer

Introduction

Fluid therapy and blood transfusion are the most common methods of compensating for the loosed blood. Fluid therapy is commonly accepted by anesthesiologists because of its lower adverse effects in terms of sensitivity, shock, fever, and respiratory distress (1,2). Two types of liquids are administered for this type of therapy, namely, colloidal and crystalloid solutions. The first type is extensively administered during the surgeries. According to the evidence (3,4), the clinical outcomes of crystalloid solutions are much better compared to colloidal solutions. The most commonly used crystalloid solutions in operation rooms are normal saline (NS, 0.9%), Ringer (R), and Ringer's lactate (RL).

Crystalloid serums are known as ionic solutions, with NS and RL having the lowest and the highest ion contents, respectively. These serums balance water and electrolytes and are a good alternative to bleeding during surgery. NS contains chlorine (Cl) and sodium (Na) and is administered to patients with concussion although due to its adverse effects such as renal impairment, increased mortality, and impaired immune function (5), other balanced solutions (e.g., R) are developed and widely used in the hospitals. Although the R solution is mostly administered in surgeries that are associated with bleeding, it may cause hyperkalemia and metabolic acidosis. Considering the previously mentioned adverse effects, the RL serum was developed, which contains less Na and Cl preventing acidosis, thus it is the best option in trauma patients (6, 7).

Since the choice of the serum type regarding infusion for orthopedic surgery (the surgery is a procedure) is an inaccurate criterion for anesthesiologists and the type of the received serum can affect the hemodynamic status of patients, the present study sought to compare fluid therapy with NS, R, and RL during anesthesia on hemodynamic status and events during lower limb elective orthopedic surgeries.

Materials and Methods

Study Design

The current cross-sectional descriptive study was

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[1]Department of Anesthesiology, Medicine Faculty, Tabriz University of Medical Sciences Tabriz, Iran. [2]Department of Orthopedics, Medicine Faculty, Tabriz University of Medical Sciences Tabriz, Iran. [3]Department of Anesthesiology and Operating Room, School of Allied Medical Sciences, Tabriz University of Medical Sciences, Tabriz, Iran.
*Corresponding Author: Mohammadipour Anvari, Email: Dr.anvaritbzmed@yahoo.com

Key Messages

- Crystalloids are the most commonly used fluid in orthopedic surgery.
- Anesthesiologists use different crystalloids in orthopedic surgery.
- Crystalloids in orthopedic surgery are based on the experience of anesthesiologists.
- Crystalloids do not cause significant changes in electrolyte status.
- RL serum had the least effects on the hemodynamic status and electrolytes compared to R and NS.
- It is better to administer a balanced serum in orthopedic surgeries.

performed on 270 patients who were scheduled for an elective lower limb surgery in Imam Reza training hospital (affiliated to Tabriz University of Medical Sciences) in 2019. Participants were selected using a simple random sampling technique. To estimate the minimum sample size, the data of a similar study was used (8) and related values were applied as β = 90%, α = 0.05, and CI = 0.95. Accordingly, a minimum of 45 subjects was obtained for each of the three groups, and then it was doubled for all groups in order to increase the statistical power of the study. Therefore, a total of 270 patients were entered into the study and each group had 90 patients. It was attempted to make the choice of the serum type irrelevant to the type of the surgery and laboratory tests, and the like. The inclusion criteria were the age range of 20-60 years, a candidate for an elective lower limb surgery, American Society of Anesthesiologists classes I and II, and surgery duration of less than 90 minutes. On the other hand, the exclusion criteria included trauma patients, patients hospitalized at the intensive care unit (ICU), and patients with electrolyte disturbances, cardiovascular diseases, kidney problems, and endocrine system problems.

Implementation

All patients were hospitalized a day before the surgery at Imam Reza Hospital and underwent several tests such as routine laboratory tests (i.e., complete blood count, urine culture, and urinalysis), as well as tests for determining albumin, Na, potassium (K), and Cl levels. If laboratory tests were routine, patients were eligible for participation. On the next day, spinal anesthesia was performed by using Marcain after receiving half a liter of the serum and monitoring the hemodynamic status (i.e., heart rate, systolic and diastolic blood pressure, and arterial oxygen saturation). After anesthesia and before the surgery, a blood sample was taken from the radial artery to examine the bicarbonate, pH, and oxygen level.

For each patient, the amount of serum injection was calculated using the formula for the amount of injection (i.e., one milliliter of the serum for each kilogram of weight plus three times the amount of bleeding during the surgery). Finally, an arterial blood sample (similar to the first surgery) was further taken after the operation and before transferring the patient to the recovery room. Laboratory routine tests (i.e., complete blood count, urine culture, and urinalysis) were performed and albumin, Na, K, and Cl were measured for the second time (before performing any procedure, a blood sample was taken for examination).

Study Groups

Patients who entered the operating room for orthopedic surgery received NS, R, or LR according to the anesthesiologist's decision. There was no bias on the part of the patient and the relevant surgeon, and the patients would be excluded from the study and another person would be replaced if they needed to receive another type of serum.

Data Collection Tools

Three types of information were collected, including demographic information such as age, gender, height, weight, and body mass index (BMI), the results of laboratory tests, and the need for blood transfusion and the incidence of postoperative complications. The data were recorded using the pen and paper method and then were sent to the statistical consultant.

Data Analysis

Initially, the data were recorded using the pen and paper method, and then data were sent to the statistical consultant after the confirmation of the main researcher. Linear diagrams were used to compare changes in the hemodynamic status at different minutes. Eventually, ANOVA and Chi-square (To compare the effects in different study groups) tests were used for data analysis. All analyses were performed using SPSS, version 20.

Results

The mean age and the mean of the BMI of participants were 12.03 ± 24.29 years and 22.15 ± 03.42, respectively. Most participants were men (143 or 52.96%). Based on the obtained data (Table 1), the investigation of demographic information indicated no significant difference between the groups ($P > 0.05$).

The examination of pre-surgery laboratory tests revealed that hemoglobin, hematocrit, Na, calcium, K, Cl, albumin, creatinine, urea, bicarbonate, pH, and arterial oxygen levels were normal without a significant difference between the three groups ($P > 0.05$). The evaluation of post-surgery data represented no significant difference ($P > 0.05$). Those receiving RL had fewer changes compared to the other two groups in terms of all variables. A comparison of changes in electrolyte status before and after the surgery is provided in Table 2.

Based on the investigation of the hemodynamic status of patients, those who received RL were more stable than

Table 1. Comparison of Demographic Information

Variable		Groups (N=270)			*P* Value
		NS Group (n=90)	R Group (n=90)	RL Group (n=90)	
Age (y)		28.49 ± 03.12	29.89 ± 03.03	28.89 ± 03.11	0.293*
Gender (No., %)	Male	48-53.33	50-55.55	46-51.11	0.129**
	Female	42-46.66	40-44.44	44-48.88	
Weight (kg)		79.45 ± 09.15	81.12 ± 10.03	80.15 ± 09.95	0.312*
Height (cm)		169.15 ± 15.42	172.50 ± 15.43	175.29 ± 16.18	0.298*
BMI (kg/m²)		22.41 ± 3.15	20.15 ± 3.10	21.82 ± 3.23	0.502*

Note. NS: Normal saline 0.9%; R: Ringer; RL: Ringer lactate; BMI: Body mass index.
*ANOVA; **Chi-square.

Table 2. Comparison of Changes in Electrolyte Status Before and After the Surgery

Variable		Groups (N=270)			*P* Value*	*P* Value**
		NS Group (n=90)	R Group (n=90)	RL Group (n=90)		
Na	Pre-S	133.15 ± 4.52	132.56 ± 5.55	133.49 ± 4.60	0.367	0.129
	Post-S	139.26 ± 5.10	136.36 ± 2.50	134.12 ± 5.12		
Ca	Pre-S	08.12 ± 0.49	08.10 ± 0.55	08.11 ± 0.61	0.619	0.319
	Post-S	08.33 ± 0.66	08.16 ± 0.78	08.15 ± 0.55		
Cl	Pre-S	104.02 ± 02.55	104.10 ± 02.11	104.05 ± 02.15	0.396	0.109
	Post-S	110.15 ± 02.10	107.71 ± 02.25	105.55 ± 02.19		
K	Pre-S	03.22 ± 0.15	03.21 ± 0.19	03.20 ± 0.23	0.417	0.293
	Post-S	03.99 ± 0.19	03.71 ± 0.40	03.30 ± 0.29		
Albumin	Pre-S	03.45 ± 0.10	03.46 ± 0.15	03.45 ± 0.19	0.711	0.319
	Post-S	03.55 ± 0.12	03.51 ± 0.14	03.46 ± 0.12		
HCO_{3-}	Pre-S	21.41 ± 3.18	21.49 ± 3.20	21.35 ± 3.12	0.529	0.319
	Post-S	25.55 ± 3.45	23.15 ± 3.49	21.52 ± 3.79		
PH	Pre-S	07.30 ± 0.11	07.31 ± 0.12	07.30 ± 0.15	0.211	0.19
	Post-S	07.39 ± 0.10	07.36 ± 0.15	07.32 ± 0.10		
O_2 Sat	Pre-S	97.55 ± 2.10	97.45 ± 2.03	97.61 ± 2.21	0.103	0.099
	Post-S	97.35 ± 2.15	97.39 ± 2.10	97.60 ± 2.50		
HCT	Pre-S	39.15 ± 4.52	40.10 ± 4.15	39.55 ± 4.18	0.278	0.1
	Post-S	33.52 ± 4.15	35.42 ± 4.15	34.42 ± 4.19		
Hb	Pre-S	13.56 ± 2.49	13.69 ± 2.73	12.99 ± 2.79	0.251	0.069
	Post-S	11.89 ± 1.95	12.51 ± 2.21	12.10 ± 2.20		
Urea	Pre-S	31.15 ± 3.81	31.76 ± 3.12	31.55 ± 3.12	0.413	0.216
	Post-S	36.10 ± 3.10	35.25 ± 3.55	32.10 ± 3.25		
Cr	Pre-S	01.01 ± 0.02	01.01 ± 0.05	01.01 ± 0.03	0.512	0.310
	Post-S	01.03 ± 0.05	01.02 ± 0.06	01.01 ± 0.05		

Note. NS: Normal saline 0.9%; R: Ringer; RL: Ringer lactate; Na: Sodium; Ca: Calcium; Cl: Chlorine; K: Potassium; HCO3−: Bicarbonate; HB: Hemoglobin; HCT: Hematocrit; Cr: Creatinine; Pre-s: Pre-surgery; Post-s: Post-surgery.
* Intergroup; ** Between groups.

those receiving R serum, and they were more stable than those who received the NS serum. The mean heart rate was 45 ± 10.15.88, 25 ± 12.22.90, and 93.50 ± 10.45 for those who were given RL, R, and NS serum, respectively, indicating no significant difference (*P*=0.206). Moreover, the mean systolic blood pressure was 125.16 ± 25.40, 129.15 ± 26.50, and 131.40 ± 25.15 for those who received RL, R, and NS serum, respectively, representing no significant difference between the groups (*P* = 0.159). For those who received RL, R, and NS serum, the mean diastolic blood pressure was 81.45 ± 8.33, 85.36 ± 9.10, and 88.45±10.25, respectively, demonstrating no significant difference (*P* = 0.203). The mean oxygen saturation for those who received RL, R, and NS serum was 98.15 ± 0.1.45,

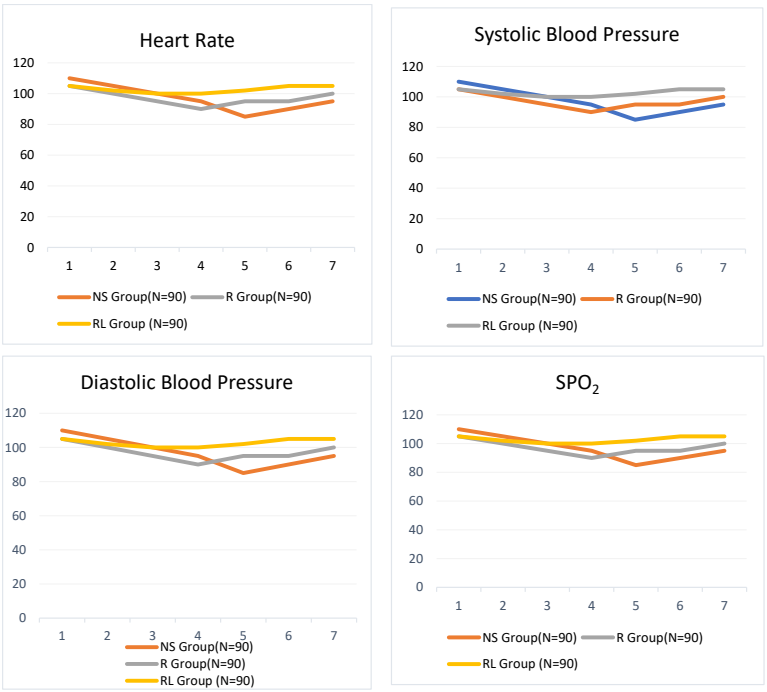

Figure 1. Hemodynamic Status of Patients Before and After the Surgery. *Note.* NS: Normal saline; RL: Ringer's lactate.

97.45 ± 0.1.15, and 95.15 ± 01.40, respectively, showing no significant difference ($P = 0.209$). The hemodynamic status of patients before and after the surgery is illustrated in Figure 1.

Based on the results, 9 (10%) of patients receiving RL needed a blood transfusion. For those who received R and NS, 12 (13.33%) and 15 (16.66%) needed a blood transfusion during the surgery, respectively. According to the results of the ANOVA test, there was a significant difference between the three groups ($P = 0.329$). In terms of the other adverse effects of the surgery and ICU hospitalization, there was no significant difference between the three groups (Table 3).

Discussion

The current study attempted to compare the effects of fluid therapy with NS, R, and RL during anesthesia on the hemodynamic status and events during lower limb orthopedics surgeries. According to the results, laboratory tests and electrolytes were not significantly different between the three groups. However, those who received RL serum were more stable compared to others. In a similar study (8) investigating the impacts of RL and R serums on blood acidity, the researchers found that RL serum had the least effect on blood acidity and blood cells, which is consistent with the results of the current study. It seems that the lack of any change is due to the ingredients and the ionic composition of the solutions or compensatory process, including the conversion of lactate to bicarbonate or bicarbonate to carbon dioxide and the like.

The findings also revealed that patients who received RL serum were more stable than those receiving R, and those who received R were more stable compared to those who received NS serum. In a similar study conducted in Iran (9) evaluating the impacts of crystalloid serums in cesarean section, it was demonstrated that using balanced serums increased the stability of hemodynamic status, and patients who received RL were more stable.

In the current study, no significant difference was observed between the three groups in terms of the amount

Table 3. Comparison of Complications During and After the Surgery

Variable	Groups (N=270)			*P* Value*
	NS Group (n=90)	R Group (n=90)	RL Group (n=90)	
Nausea (No., %)	15-16.66	13-14.44	10-11.11	0.239
Vomiting (No., %)	14-15.55	13-14.44	8-08.88	0.316
Shivering (No., %)	11-12.22	10-11.11	10-11.11	0.553
Abnormal duration of anesthesia (No., %)	8-08.88	7-07.77	8-08.88	0.503

Note. NS: Normal saline 0.9%; R: Ringer; RL: Ringer lactate.
*Chi-square.

of bleeding, the amount of blood transfusion, time spent in the recovery room, and complications such as nausea, vomiting, and fever after the surgery. However, patients who received RL serum experienced more adverse effects in comparison with other groups. In this regard, the results of a similar study are in line with the results of the current study (10) indicating the least changes among those who received RL serum. It seems that the modified ingredients of RL serum are the main reason for the minimum changes and adverse effects. On the other hand, because the lower extremity surgery is used to reduce the amount of bleeding from the tourniquet, the amount of bleeding in this study has been affected by the tourniquet. The findings of our study cannot be used in relation to the effect of LR on maintaining the blood volume and reducing the need for blood transfusions.

Despite numerous studies on the effects of fluid therapy on blood acidity, electrolytes, bleeding during surgery, and postoperative complications, different effects of various crystalloids on these conditions remain unclear. The study looked at changes in laboratory parameters, electrolytes and bleeding levels, postoperative complications (nausea and vomiting, and delays in eliminating the effects of spinal anesthesia) on NS, R, and RL. In elective surgeries, it seems that replacing the volume of fluids with different crystalloids has significant effects, which was not observed in the present study (11).

Since RL serum was more desirable in our study than R and NS serums, and its side effects were less, it would be better for anesthesiologists to perform orthopedic surgery if the patient has no underlying problems. Recent studies (12,13) have suggested that orthopedic surgery can be used to restore the lost blood volume in a timely manner using RL serum, which is consistent with our study results.

Limitations of the Study

This study has some limitations such as ignoring the type of surgery and the prognosis of surgeries that require blood transfusions, as well as ignoring the use of tourniquets for reducing bleeding in the lower limbs that can affect electrolytes and a low sample size. On the other hand, the duration of surgery and the skill of the surgeon, which could affect the length of the surgery and could affect the balance of electrolytes, were not taken into account.

Conclusions

Crystalloids are widely used in orthopedic surgeries, in which according to the results of the current study, no significant difference was observed between those who received NS, R, and RL although the RL had the least adverse effects.

Suggestions for Future Studies

It is suggested that other researchers conduct clinical trials to investigate the effects of crystalloids on the outcomes of a particular type of surgery. On the other hand, future studies should examine the volume of large samples and the effects of using different serums in orthopedic surgeries. According to the results, it is better to administer RL serum in orthopedic surgery.

Authors' Contribution

MiM: Study design; MoM: intervention, follow-up; BN: intervention, follow-up; HMA: article preparation, article submission.

Conflict of Interests

None declared.

Ethical Issues

The current study was confirmed by the Ethics Committee of Tabriz Medical University of Medical Sciences (Ethical Code: TBZMED.REC.1394.678). In addition, written consent was taken from all participants, and they were informed that participation is voluntary and free.

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