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Research Article

Lactated Ringer's Versus Hypertonic Saline in Early Resuscitation of Polytrauma Patients

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Abstract

Background: Because polytrauma patients usually have a wide variety of injuries, the initial focus is the resuscitative care. Dilemma is still existing in fluid administration of polytrauma victims. Most of studies comparing fluids in critically ill patients in general.

Objective: The aim of this study was to compare between using lactated ringer's and HS solutions in management of polytrauma patients during 24 hrs from admission to emergency department (ED).

Methods: This Study was conducted on 60 polytrauma patients. All patients were randomly assigned to 2 groups. LR group (n=30) were resuscitated using lactated ringer's solution. HS Group (n=30) were resuscitated using 3% hypertonic saline solution. Then, all patients were assessed for improvement, complications and electrolytes imbalance.

Results: Improvement was nearly similar in HS group and LR group (24 *Vs* 21, p=0.276). AKI was higher in HS group (13 *Vs* 3, p= 0.004). ARDS was higher in LR group (26 *Vs* 19, p= 0.036). Conclusion: we concluded that, no ideal resuscitation fluid exists.

Keywords: Emergency; Trauma; Resuscitation; Fluid; Ringer; Hypertonic

Introduction

Emergency physicians usually deal with stabilization, diagnosis, and treatment of polytrauma victims. The management of polytrauma patients' needs decisive leadership ability and technical skills [1].

Because polytrauma patients usually have a wide variety of injuries, the initial focus is the resuscitative care, with emphasis on how to perform interventions in an optimal sequence [2].

Hemorrhagic shock is responsible for 30-40% of mortality due to polytrauma. Administration of intravenous fluids here is important as it replenishes intravascular volume [3].

Dilemma is still existing in fluid administration of polytrauma victims. Establishment of vascular access is time crucial, especially in polytrauma patients who are liable to have a vascular collapse [4-6]. Fluid resuscitation remains a matter of controversy regarding using whether colloids or crystalloids, and more specifically, which fluid, should be used. The choice of fluid, the target of hemodynamic goals and the optimal prevention of coagulopathy are the most questions [7].

Lactated Ringer's (LR) is the primary resuscitation fluid employed in American prehospital and trauma centers, also in the Canadian Forces [8]. Different strengths of Hypertonic Saline (HS) solutions have been studied in resuscitation from hemorrhagic shock [9].

The ideal resuscitation fluid should produce a predictable and sustained increase in intravascular volume and has a composition as close as possible to that of extracellular fluid. Ideal fluid should be metabolized and completely excreted without accumulation in tissues, does not produce adverse effects, and is cost-effective [10].

Most of studies comparing fluids in critically ill patients in general [11]. The aim of this study was to compare between using LR and HS solutions in management of polytrauma patients during 24 hrs from admission to Emergency Department (ED).

Methods

This Study was conducted on 60 polytrauma patients who were presented to the emergency department. Approval of the medical ethics committee and an informed consent were taken. All patients were evaluated by Revised Trauma Score [12].

All patients were polytrauma adult patients of both sexes with signs of hemorrhagic shock; pulse >100 beats/min, systolic blood pressure <90 mmHg, poor capillary refill >2 seconds, low urine output <0.5 ml/kg/hr and RTS <4.

Patients who were presented with chronic medical conditions, using beta-blockers or calcium channel blockers, intoxicated, burns were excluded. Patients suspected to have other signs of shock rather than hemorrhagic shock or hypovolemic shock due to causes other than bleeding were also excluded.

After full clinical, laboratory and radiological investigations, all patients were randomly assigned to 2 equal groups (Research Randomizer sheet generated from randomizer.org). LR group (n=30) were resuscitated using lactated ringer's solution. HS Group (n=30) were resuscitated using 3% hypertonic saline solution. After the end of resuscitation, all patients were assessed for improvement, complications and electrolytes imbalance.

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Statistical methods

Data were fed to the computer and analyzed using IBM SPSS software package version 24.0. Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level. Chi-square test was used for categorical variables, to compare between different groups. Fisher's Exact or Monte Carlo correction for chi-square was used when more than 20% of the cells have expected count less than 5. Student t-test was used for normally quantitative variables. Mann Whitney test was used for abnormally quantitative variables.

Results

In this study, sixty trauma patients were enrolled. Table 1 shows baseline characteristics of all patients. There were no any statistically significant differences between the 2 groups in their age (p=0.373) or sex (p=0.5). There was no a statistically significant difference between the 2 groups in their mechanism of trauma (p=0.191). There were no any statistically significant differences between the 2 groups in their RTS (p=0.836).

Table 2 shows laboratory investigations of all studied patients at admission. There were no any statistically significant differences between the 2 groups in their hemoglobin level (p=0.1) or platelets count (p=0.236). Regarding renal function tests, there were no any statistically significant differences between the 2 groups in their urea level (p=0.17) or serum creatinine (p=0.201). At admission, there were no any statistically significant differences between the 2 groups in their sodium level (p=0.487), potassium (p=0.316), chloride level (p=0.873) or HCO3- level (p=0.696).

After resuscitation and follow-up, the mean volume of resuscitation fluid used in LR group was significantly higher than the mean volume used in HS group (2000 *Vs* 250 ml, p<0.0001). The mean sodium level was 137.73 (± 3.27) mEq/L in LR group, while HS group showed a higher mean 145.40 (± 4.19). There was a statistically significant difference between them (p<0.0001). The mean chloride level was 91.10 (± 9.27) mEq/L in LR group and higher value of 107.5 (± 23.36) in HS group with a significant difference between them (p<0.0001). The mean potassium level was 4.0 (± 0.38) mEq/L in LR group and lower value of 3.6 (± 0.5) in HS group with a significant difference between them (p<0.01). The mean HCO3- level was significantly lower in HS group than LR group (p=0.001). It was 18.33 ± (5.73) mEq/L in LR group and 13.50 (± 4.36) in HS group.

Regarding the measured outcomes, number of patients who improved was nearly similar in HS group and LR group (24 *Vs* 21) without a statistically significant difference (p=0.276). Number of patients who developed renal failure was higher in HS group than LR group (13 *Vs* 3) and there was a statistically significant difference between the 2 groups in development of renal failure (p= 0.004). Both groups showed a nearly similar number of patients in developing liver failure (3 *Vs* 2, p= 0.5). Number of patients developed acute respiratory distress syndrome (ARDS) was higher in LR group than HS group (26 *Vs* 19) and there was to a statistically significant difference between the 2 groups in development of ARDS (p= 0.036).

Table 1: Comparison between the two studied groups according to baseline characteristics.

	LR (n = 30)		HS (n = 30)		p
	No.	%	No.	%	
Sex					
Male	22	73.33	21	70	^{FE}p= 0.5
Female	8	26.66	9	30	
Age (years)					
Range	18 – 58		21 – 58		0.373
Mean ± SD.	37.87 ± 13.76		40.73 ± 10.77		
Median	36		40		
Mode of trauma					0.191
RTA	24		80		
FFH	6		20		
RTS					0.836
0	19		63.33		
1	5		16.66		
2	4		13.33		
3	2		6.66		

RTA: Road Traffic Accident, FFH: Falling from Height. RTS: Revised Trauma Score.
χ^2, p: χ^2 and p values for **Chi square test** for comparing between the two groups
FE: **Fisher Exact** for Chi square test for comparing between the two groups
t, p: t and p values for **Student t-test** for comparing between the two groups
p value is significant when ≤0.05.

Discussion

In this study, 25% of all enrolled patients didn't show any clinically improvement. Percentage of patients improved was nearly the same in both groups (80% in HS group and 70% in LR group, p=0.276). Previous studies showed that volume expansion by HS is due to its high sodium concentration, which increases plasma osmolarity, resulting intravascular volume expansion. Plasma volume expansion is followed by BP elevation, tissue perfusion, and oxygen transport, which have been clearly demonstrated [13-15]. Results showed that HS facilitates a near instantaneous mobilization of fluids from intracellular to extracellular compartments through an osmotic gradient [16]. Redistribution of fluid, caused by a higher intravascular osmotic pressure, leads to plasma expansion with a resultant increase in MAP [17,18].

However, the effects of 3% HS cannot be attributed to volume expansion. Frithiof et al [19], reported that the beneficial cardiovascular effects of HS are caused by the stimulation of cardiac sympathetic nerve activity and are dependent on cardiac beta-receptors. Also, HS may increase the renal excretion of myocardial depressant factor, which contributes to myocardial contractility and increases COP [20]. The administration of HS offers several advantages in the prehospital settings. The main advantage is that a smaller volume of HS can be used for fluid administration [21-23].

In addition, HS are bacteriostatic, stable under warm conditions [24].

In this study, resuscitation with HS was associated with increased

Table 2: Comparison between the two studied groups according to Laboratory investigations**.**

	LR (n = 30)	HS (n = 30)	p
Hb (g/dl)			
Mean ± SD.	11.65 ± 1.78	12.68 ± 1.11	0.1
PLTs (×10³/µl)			
Mean ± SD.	301.53 ± 73.74	320.53 ± 46.01	0.236
Urea (mg/dl)			
Mean ± SD.	41.67 ± 14.24	57.13 ± 30.92	0.17
Creatinine (mg/dl)			
Mean ± SD.	1.111 ± 0.28	1.033 ± 0.172	0.201
Na⁺ (mEq/L)			
Mean ± SD.	136.1 ± 4.366	136.97 ± 5.189	0.487
K+ (mEq/L)			
Mean ± SD.	4.0 ± 0.39	4.1 ± 0.77	0.316
CL⁻ (mEq/L)			
Mean ± SD.	95.63 ± 9.257	96.00 ± 8.481	0.873
HCO3⁻ (mEq/L)			
Mean ± SD.	12.37 ± 3.296	12.01 ± 3.732	0.696

Hb: Hemoglobin level, PLT: Platelets count t, p: t and p values for **Student t-test** for comparing between the two groups. p value is significant when ≤0.05.

incidence of Acute Kidney Injury (AKI) than resuscitation with LR (43.33% *Vs* 10%, p=0.004). These findings were parallel to previous studies, which stated that treating trauma victims with large volumes of chloride-rich crystalloids leads to hyperchloremic metabolic acidosis which may hike the incidence of AKI owing to decreased renal blood flow and renal cortical hypoperfusion [25].

Krajewski et al [26], showed an association between fluids with high chloride content and AKI. Balanced salt solutions ('chloride-restricted' crystalloids containing acetate, lactate or gluconate) showed no harmful effects in any particular type of patientS [25,27]. Although, these solutions may be associated with hypotonicity, hyperlactatemia, and metabolic alkalosis [28].

In contrast to these findings, Han et al [29], in 2015 compared the effects and complications associated with 3% HS, 7.5% HS, and LR in resuscitation in 294 severe polytrauma patients in a double-blind randomized clinical trial. Higher risks of AKI (p < 0.001) was associated with LR group. Their results indicated that 3% and 7.5% HS can rapidly restore MAP and led to the requirement of an approximately 50% lower total fluid volume compared with the LR group (p < 0.001). 7.5% HS was associated with higher incidence rates of arrhythmia and hypernatremia. LR was associated with higher risks of coagulopathy (p < 0.001) and pulmonary edema (p < 0.001). This study concluded that 3% HS had similar efficacy but with a lower incidence of complications.

Patanwala et al. in 2010 [30], showed that HS can restore hemodynamics without complications. Also Banks et al [17], in 2008 showed the same results.

In this study, LR group showed larger mean of resuscitation fluid volume (2000 mL) than in HS group (200 mL) with a statistically

Table 3: Comparison between the two studied groups according to outcomes.

	LR (n = 30)		HS (n = 30)		p
	No.	%	No.	%	
Volume of fluid (mL)					<0.0001*
Mean ± SD.	2000 ± 500		220 ± 10		
Na⁺ (mEq/L)					<0.0001*
Mean ± SD.	137.73 ± 3.27		145.40 ± 4.19		
K+ (mEq/L) Mean ± SD.	4.0 ± 0.38		3.6 ± 0.5		<0.01*
CL⁻ (mEq/L) Mean ± SD.	91.10 ± 9.27		107.5 ± 23.36		<0.0001*
HCO3⁻ (mEq/L) Mean ± SD.	18.33 ± 5.73		13.50 ± 4.36		0.001*
Improvement	21	70	24	80	0.276
Renal failure	3	10	13	43.33	0.004*
Liver Failure	2	6.66	3	10	0.5
ARDS	26	86.66	19	63.33	0.036*

ARDS: Acute Respiratory Distress Syndrome
t, p: t and p values for **Student t-test** for comparing between the two groups
χ^2, p: χ^2 and p values for **Chi square test** for comparing between the two groups
*p value is significant when ≤0.05

significant difference (p<0.0001). LR group showed higher incidence of ARDS. Number of patients who developed ARDS was higher in HS group than LR group (26 *Vs* 19) and there was a statistically significant difference between the 2 groups in development of ARDS (p= 0.036). This may be explained by that isotonic crystalloid fluids may not restore hemodynamic stability rapidly unless administered in large volumes. However, administration of large volumes of isotonic fluids has been associated with multiple system dysfunctions, including cardiac, lung, gastrointestinal tract, coagulation disturbances, and acid-base imbalances [31].

Results in this study clarified the high sodium load and hyperchloremic metabolic acidosis associated with HS resuscitation. HS group showed a significantly higher mean of sodium levels (145.40 mEq/L), while it was 137.73 in LR group (p<0.0001). Hypernatremia is inevitable with repeated administration of HS [17]. HS group showed a significantly higher mean of chloride levels (107.5 mEq/K), while it was 91.10 in LR group (p <0.0001). The mean HCO3- level was significantly lower in HS group than LR group (p =0.001). It was 18.33 mEq/L in LR group and 13.50 in HS group. The mean potassium level was 4.0 (± 0.38) mEq/L in LR group and lower value of 3.6 (± 0.5) in HS group with a significant difference between them (p<0.01). This result may be explained by that hypokalemia is a common electrolyte disorder encountered after repeated doses of HS [17] Table 3.

MODS is the major cause of death among patients with hemorrhagic shock Inflammation and excess neutrophilic activation can cause Multiple Organ Dysfunction Syndrome (MODS). Traditional strategies may exacerbate inflammation. Regarding other complications, resuscitation with HS showed a higher incidence of ARDS than LR. 86.66% of patients in HS group developed ARDS. Only 63.33% in LR group showed that. These result was statistically (p=0.036).

Resuscitation with HS or LR were not associated with liver failure in all studied patients as only 8% of all enrolled patients showed liver failure. There was no difference between the 2 studied groups regarding development of liver failure (p=0.5). In contrast to this results, Homma et al. in 2005 [32] showed that small volume resuscitation with HS is more effective in ameliorating trauma-hemorrhagic shock-induced lung injury.

In contrast to this study results, HS showed a reduction of MODS in animal models. Junger et al [33], in 2012 studied the anti-inflammatory efficacy of HS in a controlled clinical trial. Hypovolemic shocked patients were resuscitated in with HS. MODS, and leukocytosis were lower in the HS group than in the NS group.

Limitations

There are some limitations in this study, small sample size, short time of study, liability to selection bias and study design liability to confounders.

Conclusion

From the previous results of this study, we concluded that, no ideal resuscitation fluid exists. Hypertonic saline (HS) was associated with higher incidence of acute kidney injury and hyperchloremic metabolic acidosis. Lactated ringer (LR) was associated with higher incidence of acute respiratory distress syndrome. Further randomized controlled studies on larger scale dealing with polytrauma patients to assess the effectiveness of different resuscitation fluids are recommended. More outcomes should be identified to define the optimal type of fluid and its needed amount in resuscitation process.

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