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Mini Review Article

## Safety of 1.5% Glycine Irrigation Fluids on Electrolytes and Hemoglobin in Shoulder Arthroscopy: A Prospective Cohort Study

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### Abstract

**Introduction:** The recent developments in minimally invasive surgeries made enormous effects on using small incisions to access different regions of the human body. In orthopedic surgeries and the use of arthroscopy to visualize specific joints and treat different pathologies have been great achievements yet the safety of such instruments and the use of fluid during these surgeries didn't negotiate before. This study aims to check the safety of using hypoosmolar fluids during shoulder arthroscopic surgeries concerning amount and duration of surgery.

**Methods:** This is a prospective cohort study that was conducted to evaluate the effect of 1.5% glycine infusion amount in liters during shoulder arthroscopic procedure on serum sodium, potassium, and hemoglobin levels and any other observations of symptoms and signs that might be related to electrolytes imbalance. A sample of 106 patients was evaluated to measure the assigned electrolytes and hemoglobin levels before the procedure and 4 hours and 18 hours after the procedure.

**Results:** According to this study, a sample of 106 patients using a data collection form that organized by the research team the average of serum sodium of all included patients observed a drop after 4 hours and 18 hours of surgery of 3.5 m Eq/L, and 2.7 m Eq/L, respectively. However, after we compare the amounts of glycine fluids and its correlation with changes in the levels of sodium, potassium and hemoglobin there was mild negative serum sodium correlation after 4 hours of surgery (Pearson correlation -0.3, p-value of 0.005) and mild positive correlation with serum potassium levels after 18 hours (Pearson correlation 0.21, p-value 0.031). There was no significant effect of duration of procedures and the changes in serum sodium, potassium and hemoglobin levels between the two assigned groups of patients using T-test for independent samples means. **Conclusion:** this study has demonstrated that patients undergoing operative shoulder arthroscopy using a nonconductive 1.5% glycine fluid is relatively safe to be used about amount and duration of surgery.

**Keywords:** Shoulder arthroscopy; glycine effect; electrolytes imbalance; complications; fluid overload; hyponatremia

## INTRODUCTION

Shoulder arthroscopy is a surgery that uses a small camera called an arthroscope to examine or repair the tissues inside or around your shoulder joint. Because the arthroscope and surgical instruments are thin, your surgeon can use very small incisions (cuts), rather than the larger incisions needed for standard, open surgery. These results in less pain for patients and shortens the time it takes to recover and return to favorite activities. Shoulder arthroscopy has been performed since the 1970s. It has made diagnosis, treatment, and recovery from surgery easier and faster than was once thought possible [1]. Improvements to shoulder arthroscopy occur every year as new instruments and techniques are developed. In the procedure fluid is pumped under pressure in order to inspect, diagnose, and treat problems inside the shoulder joint, where according to availability it can be normal saline or glycine. The pumped fluid can migrate into surrounding soft tissue and systemic circulation leading to complications such as airway edema with airway compromise, chest edema, neck edema [2-5]. Moreover, systemic absorption of large amounts of fluid can produce laboratory abnormalities of electrolyte and complete blood count panels and lead to dysfunction of remote organs, including the central nervous system, and possibly even death [6]. A 1.5% solution of glycine is commonly used in urologic, gynecologic endoscopy and in arthroscopic surgeries [7-9]. Intravascular absorption of this solution may cause cardiovascular, neurological, visual disorders and water intoxication that can occasionally be fatal because of cerebral edema [8, 10, 11]. By having an elevated pressure and using a significant amount of irrigation fluid, there is potential for absorption of this fluid into the systemic circulation. This could lead to changes in the circulatory physiology of the patient, and to detrimental effects, especially in the elderly [12]. Therefore, this study was conducted to assess the effect of amount glycine absorption and duration of surgery on serum sodium, potassium and hemoglobin levels after operative shoulder arthroscopic surgery. Up to our knowledge this is the first study that assess the effect of glycine joint infusion and duration of surgery on the serum electrolyte levels.

## MATERIALS AND METHODS

This is a prospective cohort study that was conducted at the Orthopedic department in the Specialty hospital in Amman, Jordan to evaluate the effect of 1.5% glycine infusion during shoulder arthroscopic procedure on serum sodium, potassium and hemoglobin levels and any other observations of symptoms and signs that might be related to electrolyte imbalances such as nausea, vomiting, disorientation, confusion, hypotension, and transient visual abnormalities. Serum levels of sodium, potassium and hemoglobin were compared pre and postsurgery and correlated to the duration of the procedure and the amount of fluid used. We divided our patients in to two groups based on procedure duration; a less than 2 hours' duration procedure group, and 2 or more than 2 hours' Procedure group with similar demographic characteristics. Data were collected between March/2020 and March/2021. Surgical patients aged 18 years and above whom planned to undergo shoulder arthroscopy procedures were eligible to be included.

## EXCLUSION CRITERIA WERE AS FOLLOWS

Patients younger than 18 years of age, patients with chronic kidney disease, pregnant women, patients with less than one-hour procedure, a diagnostic procedure, and Fluids other than 1.5% glycine or mixing with other type of fluid during the surgery.

## ETHICAL CONSIDERATIONS

This study was approved by the Institutional Review Board (IRB) of the Specialty hospital in Amman, Jordan. Study participants voluntarily agreed to participate and they signed an informed consent before collection of blood samples by field researchers. The anonymity and confidentiality of the participants were ensured by assigning

identification numbers to participants, restricted to the research team.

## DATA COLLECTION AND MEASURES

Data was collected from a convenience sample of 106 patients using a data collection form that organized by the research team. It included two sections: the first section dealt with patients' baseline characteristics such as age, gender, height and weight, chronic diseases and previous surgical procedures. The second part included the electrolytes, hemoglobin measurements and the surgical information as follows; serum creatinine level once prior to surgery. Serum sodium, potassium and hemoglobin levels that obtained prior to surgery, 4 hours and 18 hours after surgery. The diagnosis of shoulder pathology, position of the patient, type of surgery, site of surgery, duration of surgery and amount of 1.5% glycine that pumped inside the joint. A venipuncture was done for each patient to draw the blood samples in specific timing before the surgery immediately, 4 hours and 18 hours after the surgery. The blood samples immediately processed to prevent false results and more accurate measurements. The blood samples were analyzed in a multichannel analyzer with an error of  $\pm 2$  mmol serum sodium,  $\pm 0.2$  mmol serum potassium and  $\pm 0.5$  g hemoglobin level. The shoulder arthroscopic procedures were carried out using Arthrex Dualwave Arthroscopy Pump and the irrigant fluid was 1.5% glycine with intra-articular pressure between 50 mmHg-70 mmHg. One consultant surgeon with an orthopedic resident assistant performed all the operations. All procedures were performed under general anaesthesia with or without a regional scalene block, and the anaesthesiologist administered 1 liter of normal saline 0.9% solution routinely to all the patients during the procedure. The time taken for the procedure and the amount of fluid used were recorded. Each incision was sutured with simple interrupted surgical polypropylene sutures then dressed with sterile gauze and Mefix self-adhesive tape; the extremity was placed in a sling.

## STATISTICAL ANALYSIS

The data was entered into and analyzed using the Statistical Package for Social Sciences (SPSS), version 25.  $P < 0.05$  was assigned as the alpha value. Descriptive analysis, including mean and standard deviation, were performed. All categorical variables are reported as frequencies and percentages (%). Data was assessed for normality using Kolmogorov-Smirnov test, histograms and Q-Q plots. Assumptions for using parametric statistics were satisfactory using Levene test for equal variances.

## RESULTS

All patients tolerated shoulder arthroscopy extremely well with minimal changes in the serum sodium, potassium and hemoglobin levels along no abnormal signs or symptoms were observed. A total of 106 patients were eligible for this study with a mean age of 43 years (SD 13.8, range 18-84). Among the study of all participants 70 patients were male (66%), and 70 right shoulders (66%) were operated on. The majority of patients were overweight (42.5%), and (67.9%) positioned in a beach chair. The mean time for surgery of the cohort was 108.8 minutes (SD 39, range 60-260) with a mean fluid used of 18.3 liters (SD 9.36, range 5-62) (Table 1).

Regarding to the types of procedures that were performed, the majority were rotator cuff repairs (45.3%) whereas only one Remplissage procedure was performed with a percentage of (0.9%). According to this study, the average of serum sodium of all included patients observed a drop after 4 and 18 hours of surgery of 3.5 mEq/L, and 2.7 mEq/L, respectively. There was a mean serum potassium elevation of 0.07 mEq/L after 4 hours of surgery, however a drop of serum potassium after 18 hours of 0.1 mEq/L. There was a mean hemoglobin elevation of 0.73 g/dl after 4 hours from surgery, and returning to almost preoperative hemoglobin mean value after 18 hours from surgery for all included patients. A full descriptive changes of serum sodium, potassium and hemoglobin levels are summarized in Table 1. After we compare the

amounts of glycine fluids and its correlation with changes in the levels of sodium, potassium and hemoglobin there was mild negative serum sodium correlation after 4 hours of surgery (Pearson correlation-0.3, p-value of 0.005) and mild positive correlation with serum potassium levels after 18 hours (Pearson correlation 0.21, p-value 0.031).

However, no correlations were found between the amount of fluid used and the drop in hemoglobin or hematocrit at both 4 hours and 18 hours of surgery, or serum sodium after 18 hours, or serum potassium after 4 hours as shown in (Table 2).

We have assigned our patients into 2 groups according to the duration of surgery; the first group with less than 2 hours' surgery duration, a total of 60 patients. The second group who had surgery equal or more than 2 hours, a total of 46 patients. The majority of type of shoulder arthroscopy procedure in both groups were a rotator cuff repair with a

percentage in the first group is (35%) and (58.7%) in the second group (Tables 3 and 4).

A mean of 83.2 minutes ( $\pm 16.95$ ) duration of surgery and 13.6 liters of glycine fluid ( $\pm 5.18$ ) was observed for the first group while a mean of 142.3 minutes ( $\pm 34.17$ ) and 24.5 liters of glycine fluid ( $\pm 0.05$ ) for the second group. There was no significant effect of duration of procedures and the changes in serum sodium, potassium and hemoglobin levels between the two assigned groups of patients (Table 5).

**Table 3.** A descriptive measures that compare between the 2 groups are shown in Table III.

Variables, N (%)	Duration of surgery	
	<2 hours, (n=60)	≥ 2 hours, (n=46)
Gender		
Male	38 (63.3%)	32 (69.6%)
Female	22 (36.7%)	14 (30.4%)
Body Mass Index, kg/m <sup>2</sup> , n (%)		
Underweight	2 (3.3%)	0 (0%)
Normal	18 (30%)	8 (17.4%)
Overweight	25 (41.7%)	20 (43.5%)
Obese	15 (25%)	18 (39.1%)
Type of procedure, n (%)		
Acromioplasty	8 (13.3%)	1 (2.2%)
Bankart repair	5 (8.3%)	8 (17.4%)
Biceps tenodesis	10 (16.7%)	2 (4.3%)
Capsular release	6 (10%)	3 (6.5%)
Rotator cuff repair	21 (35%)	27 (58.7%)
Remplissage	0 (0%)	1 (2.2%)
Labrum repair (other than Bankart lesion)	10 (16.7%)	4 (8.7%)
Shoulder site		
Left shoulder	19 (31.7%)	17 (37%)
Right shoulder	41 (68.3%)	29 (63%)
Position		
Beach chair	40 (66.7%)	32 (69.6%)
Lateral	20 (33.3%)	14 (30.4%)

**Table 4.** All the measured data of serum sodium, and potassium and hemoglobin levels pre and post operations between the 2 groups

Variables, Mean $\pm$ Standard Deviation	Duration of surgery	
	<2 hours, (n=60)	≥ 2 hours, (n=46)
Age	40.2 $\pm$ 13.45	46.6 $\pm$ 13.59
Creatinine	0.8 $\pm$ 0.14	0.9 $\pm$ 0.19
Weight	77.7 $\pm$ 14.12	84.7 $\pm$ 15.34
Height	1.7 $\pm$ 0.09	1.7 $\pm$ 0.09
Na preoperational	139.2 $\pm$ 2.36	139.6 $\pm$ 1.99
Na 4h later	136.2 $\pm$ 2.36	135.3 $\pm$ 3.10
Na 18h later	136.8 $\pm$ 2.27	136.6 $\pm$ 2.32
K preoperational	4.3 $\pm$ 0.32	4.4 $\pm$ 0.39
K 4h later	4.4 $\pm$ 0.38	4.5 $\pm$ 0.58
K 18h later	4.2 $\pm$ 0.38	4.2 $\pm$ 0.42
Hb preoperational	14.8 $\pm$ 1.79	14.8 $\pm$ 1.55
Hb 4h later	14.3 $\pm$ 1.78	17.1 $\pm$ 18.55
Hb 18h later	13.5 $\pm$ 1.95	16.4 $\pm$ 19.54
Duration surgery (Min)	83.2 $\pm$ 16.95	142.3 $\pm$ 34.17
Portals number	3.6 $\pm$ 0.74	4.04 $\pm$ 0.94
Glycine (liter)	13.6 $\pm$ 5.18	24.5 $\pm$ 0.05

**Table 1.** The characteristics of the study participants are presented

Variable, Mean $\pm$ Standard Deviation	Total (n=204)
Age	43 $\pm$ 13.8
Gender, n (%)	
Male, Female	70 (66%), 36 (34%)
Body Mass Index, kg/m <sup>2</sup> , n (%)	
Underweight	2 (1.9%)
Normal	26 (24.5%)
Overweight	45 (42.5%)
Obese	33 (31.1%)
Creatinine	0.8 $\pm$ 0.17
Na preoperational	139.4 $\pm$ 2.2
Na 4h later	135.8 $\pm$ 2.7
Na 18h later	136.7 $\pm$ 2.28
K preoperational	4.35 $\pm$ 0.35
K 4h later	4.42 $\pm$ 0.48
K 18h later	4.25 $\pm$ 0.4
Hb preoperational	14.80 $\pm$ 1.68
Hb 4h later	15.54 $\pm$ 12.30
Hb 18h later	14.76 $\pm$ 12.87
Glycine (liter)	18.32 $\pm$ 9.37
Duration surgery (Min)	108.82 $\pm$ 39.09
Type of procedure, n (%)	
Acromioplasty repair	9 (8.5%)
Bankart Repair	13 (12.3%)
Biceps tenodesis	12 (11.3%)
Capsular release	9 (8.5%)
Rotator cuff repair	48 (45.3%)
Remplissage	1 (0.9%)
Labrum repair (other than Bankart lesions)	14 (13.2%)
Shoulder site	
Left shoulder	36 (34%)
Right shoulder	70 (66%)
Position	
Beach chair	72 (67.9%)
Lateral	34 (32.1%)

**Table 2.** Discussion about variable and glycine

Variable	Glycine (liter)	
	Correlation Coefficient	P-value
Na 4 h later	-0.272	0.005
Na 18 h later	-0.087	0.38
K 4 h later	0.169	0.08
K 18 h later	0.211	0.03
Hb 4 h later	0.068	0.5
Hb 18 h later	0.089	0.37

Table 5. Using T-test for independent samples means, results are shown

Variables	Duration of surgery						p- value	Confidence interval	
	<2 hours, (n=60)			≥ 2 hours, (n=46)				Upper	Lower
	Mean	SD	Std. Error	Mean	SD	Std. Error			
Na 4h later	136.25	2.36	0.31	135.35	3.11	0.46	0.092	1.95	-0.15
Na 18h later	136.78	2.27	0.29	136.62	2.32	0.35	0.722	1.06	-0.74
K 4h later	4.38	0.38	0.05	4.49	0.58	0.08	0.276	0.09	-0.3
K 18h later	4.22	0.38	0.05	4.29	0.42	0.06	0.358	0.08	-0.23
Hb 4h later	14.31	1.78	0.23	17.15	18.55	2.73	0.241	1.93	-7.61
Hb 18h later	13.56	1.95	0.25	16.36	19.54	2.91	0.271	2.22	-7.84

## DISCUSSION

According to our knowledge there were no previous studies on the effect of duration of shoulder arthroscopy and the risk of hyponatremia. However, according to other procedures that use a glycine fluid, it mentioned in literature that a hysteroscopic procedures showed the possibility of intravasation of infused fluid is significantly enhanced when the procedure is operative and lasts more than 60 minutes [13]. In addition to the description of Hahn RG et al, as they studied the effect of procedure duration of TURP and the absorption of fluid was associated with all operating times but the incidence increased from approximately 20% in shorter resections to 60% in the longer procedures [14]. In operative shoulder arthroscopy procedures, we found that the ability to finish the procedure in less than one hour is unusual so we opted to make the cut off in our cohort to be a 2 hours between the 2 groups. Comparison between the two groups, which were statistically matched and yet were not chosen by a randomized controlled method, seems to suggest that duration of shoulder arthroscopy procedure doesn't effect on serum sodium, potassium and haemoglobin changes. However, there

was a significant mild negative correlation between amount of glycine infused and serum sodium levels which can be explained partially by the water excess absorbed of 1.5% glycine infused fluid. In addition to the mild positive correlation between the amount of glycine and serum potassium level after 18 hours, we could conclude that it might be related to absorbed irrigant but no proper physiologic response was identified. Although this study was unable to validate or identify a significant association between the amount of glycine fluids and the hemoglobin, it showed a return of hemoglobin to preoperative levels after 18 hours from the operation and after full returning of physiologic homeostasis in the blood. Therefore, we could conclude that the dilution effect of glycine fluid on hemoglobin concentration was insignificant and the amount of bleeding during shoulder arthroscopy procedures is low and inconsequential. In conclusion, this study has demonstrated that patients undergoing operative shoulder arthroscopy using a nonconductive 1.5% glycine fluid is relatively safe. As there were no significant disturbances of electrolytes or hemoglobin levels or presence of signs and symptoms correlated with electrolytes and hemoglobin changes.

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