COMPARISON OF HYPERTONIC AND ISOTONIC SALINE SOLUTIONS IN DIARRHEA-INDUCED DEHYDRATION THERAPY IN GOATS

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ABSTRACT

This study was contemplated to compare the effects of hypertonic (7.5% NaCl; 2,400 mOsm/L) and isotonic (0.9% NaCl; 300 mOsm/L) saline solutions associated with oral rehydrating solution, on plasma volume, serum biochemical profile and serum electrolytes in goats with osmotic diarrhea-induced dehydration. For this purpose, eighteen Beetle goats, aged 9 to 12 months, were used. Goats were randomly divided into three groups: group A, with no treatment (diarrhea control group); group B, treatment with isotonic saline plus oral solution; and group C, treatment with hypertonic saline plus oral solution. Animals with no treatment presented aqueous diarrhea, decreased plasma volume, severe hyponatremia, hypochloremia and hypokalemia. The use of small volumes of hypertonic saline solution in a single dose restored the plasma volume and serum sodium and chloride concentrations. When compared to isotonic saline, hypertonic saline brought about a less marked hemodilution and reestablished serum potassium concentration. We concluded that a rapid infusion of small volume of hypertonic saline solution with oral rehydrating solution immediately increases plasma volume, serum sodium and chloride concentrations and restores the volume of extracellular fluid constituting a practical and economical alternative to the use of large volumes of isotonic saline solution.

***Key words*:** resuscitation, fluid therapy, hyponatremia, plasma volume, expansion.

INTRODUCTION

Diarrhea in goats is one of the serious welfare problems and an important cause of economic losses in the goat industry. The etiology of diarrhea is multifactorial and involves a wide range of infectious (bacterial, viral, protozoan) and non-infectious

(environmental, nutritional, etc.) factors (Radostits et al., 2007). Most of the dehydrations due to diarrhea are hyponatremic, hypochloremic and hypokalcemic (Berchtold, 1999; Constable, 1999), with extracellular fluid decrease and intracellular fluid increase. There is also a deficit of total body fluid and electrolyte loss results in hypovolemia concomitant decreased plasma volume, cardiac output and oxygen delivery (Hall et al., 1992; Barragry, 1994). Intravenous administration of hypertonic saline solution (NaCl, 2,400 mOsm/l) redistributes body fluids and causes rapid expansion of plasma volume partially correcting the total sodium deficit. However, hypertonic saline infusion without oral rehydrating solution causes transient hemodynamic effects which disappear within 2–8 h (Constable et al., 1996).

Hypertonic saline solution associated with oral rehydrating solution rapidly increases plasma volume with less free water administration than with isotonic plasma expanders and ultimately increases cardiac output, mean systemic arterial pressure and oxygen delivery (Velasco et al., 1980; Constable et al., 1991; Kramer, 2003). Thus, hypertonic saline solution associated with oral electrolytic solution is being effective to treat natural and osmotic-induced diarrhea and, so far, an alternative replacement to isotonic intravenous fluid therapy in diarrheas.

Many researchers have investigated the potential use of HSS in diarrheic calves (Constable et al., 1991; Walker et al., 1998b; Senturk, 2003), however, to the author's knowledge; there is not a single controlled experimental study that investigated the effects of hypertonic saline solution in osmotic induced diarrhea in goats. So, the objective of this study was to assess the effects of small volume intravenous HSS and to compare this novel therapy with large volume intravenous isotonic saline solution (ISS) in the experimentally induced diarrheic goats.

MATERIALS AND METHODS

Experimental Animals: The experimental protocol for this study was approved by the Animal Ethics Committee, University of Agriculture, Faisalabad, Pakistan. A total of 18 Beetle goats were selected. The age spectrum of all the goats ranged from 9 to 12 months. Animals underwent a 7-day adaptation period. Water and feed were provided *ad libitum*. Animals were sheltered in individual iron cages with wooden-strip floors. Beds were made of tifton, which was changed daily. After 7 days of adaptation, blood samples were collected to obtain basal values of the variables to be studied.

Induction of diarrhea: All the goats were subjected to osmotic diarrhea and dehydration with a modification in the protocol developed by Constable et al. (1996) and adapted by Walker et al. (1998a) in experimental studies. To induce the desired level of dehydration, castor oil (20 ml/kg) was added in powdered milk dissolved in water (10 mL/kg, orally, every 8 h) and aqueous sucrose solution at 20% (2 g/kg every

8 h for 24 h) were administered associated with an oral supply of hydrochlorothiazide (1 mg/kg every 8 h), spironolactone (1 mg/kg every 8 h), and furosemide (2 mg/kg, intramuscular, every 6 h) for 24 h. Diarrhea was maintained throughout the experimental period. Physical examinations were carried out every 12 h. Mean dehydration degree before treatment was 10%. Treatment was started after 24 h of inducing diarrhea and dehydration.

Experimental design: Dehydrated goats were randomly divided in three groups of six animals each: group A was untreated (diarrhea control group); group B was treated with isotonic saline solution (0.9% NaCl; 300 mOsm/l) @ 32 ml/kg BW, IV plus oral isotonic electrolyte solution; and group C was infused with hypertonic saline solution (7.5% NaCl; 2,400 mOsm/l) @ 4 ml/kg BW, IV plus oral isotonic electrolyte solution. Oral electrolyte solution was administered in milk bottles, immediately before beginning to infuse intravenous solutions in a determined volume of 55 ml/kg with 4.9 mmol Na^+/kg every 8 h, in a total of three administrations. Clinical evaluation of all 18 animals and sample collection for hematological, serum electrolytes and serum biochemical profile were carried out simultaneously at baseline (before induction of diarrhea), during diarrhea, 30 min, 1, 2, 8 and 24 hours after treatment.

Statistical Analyses: The data obtained were analyzed statistically using 2 factor Complete Randomized Design (CRD). Variables involving repeated measures were analyzed with multivariate repeat measures ANOVA. When a significant ($P < 0.05$) group or time interaction was observed, additional testing was performed using Duncan's Multiple Range Test (DMR) to determine differences among groups.

RESULTS

The induction of diarrhea resulted in intense aqueous diarrhea from 4 to 8 h after beginning the protocol in all the goats and dehydration degree of 10% was achieved. Diarrhea affected profoundly on the serum electrolytes, biochemical profile and relative plasma volume (Figures 1-8). Relative plasma volume (rPV) decreased during diarrhea in all the groups (Fig-1). After treatment, group B showed increasing trend towards normal but animals of group C showed rapid increase and significant difference ($P < 0.05$) over animals treated with isotonic saline solution. The group with no treatment (group A), however, maintained decreased values of rPV throughout the study period.

Serum sodium and chloride concentrations decreased significantly while marked decrease in potassium concentration was noted during diarrhea due to hypovolemic condition. After 30 min of hypertonic saline solution infusion, increased sodium (Fig-2) and chloride (Fig-3) ions concentration were observed in animals of group C which remained higher up to 2 h. Then these higher concentrations went back to the normal values within 24 hours and showed significant difference ($P < 0.05$) over

animals of group B which were administered with isotonic saline solution. While potassium ions concentration (Fig-4) transiently decreased after HSS infusion in group C but returned to normal within 24 h. Normal saline infusion in goats of group B showed better recovery of potassium in attaining the normal values.

Animals submitted to dehydration protocol presented increased ($P < 0.05$) values of hematocrit and hemoglobin concentration during diarrheic condition, confirming a decrease in the circulating plasma volume. In the group A with no treatment, hematocrit (Fig-5) and hemoglobin concentrations (Fig-6) remained higher than baseline values, differing ($P < 0.05$) from the other groups. One hour after treatment, hypertonic saline treated group (group C) showed significant decrease ($P < 0.05$) in hematocrit and hemoglobin concentrations than group B treated with isotonic saline solution. This result showed a fast restoration of plasma volume in the first hour of administering hypertonic saline solution.

Concentration of serum creatinine increased ($P < 0.05$) during diarrhea and dehydration compared to their basal values (Fig-7). The dehydrated group with no treatment maintained a high serum creatinine concentration ($P < 0.05$) throughout the experimental period. Serum creatinine concentrations in animals treated with hypertonic and isotonic saline solutions presented different results during the experimental period. In the group treated with isotonic saline, creatinine concentration decreased toward baseline more rapidly and showed significant different ($P > 0.05$) over group C. In group C, infusion of hypertonic saline solution caused increasing trend during first two hours, however, a significant decrease of creatinine occurred after 8 h. At 24 h, the creatinine value in the group treated with hypertonic saline was similar to those of the group treated with isotonic saline.

Serum phosphorus concentration was high in all groups during diarrhea compared to their baseline values (Fig-8). This concentration remained higher in group with no treatment throughout the observing time and never returned to the baseline. In the group B treated with isotonic saline, the restoration of phosphorus concentration occurred at 1 h after the beginning of the treatment and became normal within 24 h. In animals of group C treated with hypertonic saline solution, there was a decrease in the serum phosphorus concentration just after 30 min of the beginning of treatment. At 1 h, phosphorus concentration had returned to its normal values which showed significant difference ($P < 0.05$) over group B (Fig-8).

DISCUSSION

The protocol for induction of diarrhea was 100% successful in all the goats at the end of 24 h. This protocol promoted a decrease in plasma volume, a dehydration degree around 10%, increased serum creatinine and phosphorus concentrations, hyponatremia, hypochloremia and hypokalemia.

Hypertonic saline solution rapidly expands plasma volume, which occurs within 30 min of the infusion because of the abrupt increase in serum osmolality and serum sodium concentration, promoting fluid bypass from the intracellular compartment and from the gastrointestinal tract (Constable et al., 1991; Constable et al., 1996). Although 6% dextran 70 in association to hypertonic saline solution has been recommended by many researchers to maintain plasma volume (Constable et al., 1996; Walker et al., 1998b), however, results of our study substantiate the viability of hypertonic solution without dextran.

During diarrheic condition, hyponatremia was observed in goats of all the groups. Similar results were also observed in diarrheic calves by several researchers (Constable et al., 1991; Constable et al., 1996). According to Walker et al. (1998b), the fact that there was no hyponatremia during their study was one of the factors that differed from naturally occurring diarrheas. In contrast with the treatment with isotonic saline in group B, in the group treated with the rapid infusion of hypertonic solution, there was an immediate increase of sodium serum concentration. The key feature for successful resuscitation from diarrheic dehydration and/or hypovolemia is the total amount of sodium (Constable, 1999). In hypertonic saline treated group, the sodium ions concentration increased beyond the limit of hypernatremia that is 160 mEq/L (Tyler et al., 1994), but this increase was temporary and then these values became below this level within 3 hours. In this study, no abnormality in the behavior and attitude, ataxia, paresis, or muscular weakness was observed up to 48 h after the treatment in animals submitted to the infusion of hypertonic saline solution associated with oral rehydrating solution.

Water consumption increased in the dehydrated group treated with hypertonic saline compared to the other groups, probably due to the increase of serum osmolality caused by hypertonic solution, which constitutes the main thirst stimulation. Water consumption presented a large individual variation. As water consumption is influenced by environmental and psychogenic factors, so, there is a large individual variation, in addition to thirst stimulation (Kohn and Dibartola, 2000). Increased serum osmolality also stimulate thirst by osmoreceptors and volume receptors stimulated by angiotensin II when extracellular fluid volume is decreased (Dibartola, 2000).

CONCLUSION

It was concluded from the study that rapid infusion of small volume of hypertonic saline solution associated with oral rehydrating solution immediately increases plasma volume, serum sodium and chloride concentrations and restore extracellular fluid volume within 24 h, constituting a practical and economical alternative to the use of large volumes of isotonic saline solutions.

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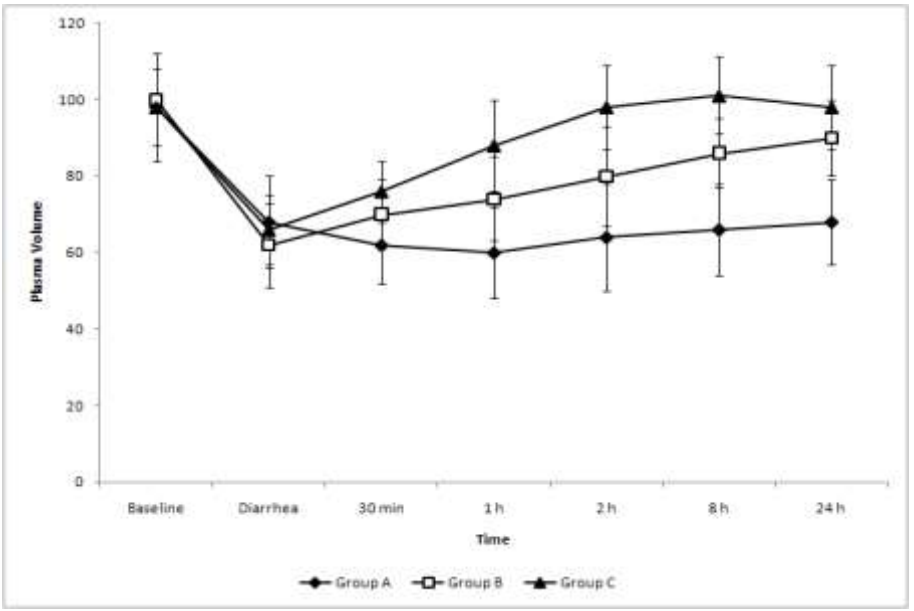

Fig 1: Plasma volume

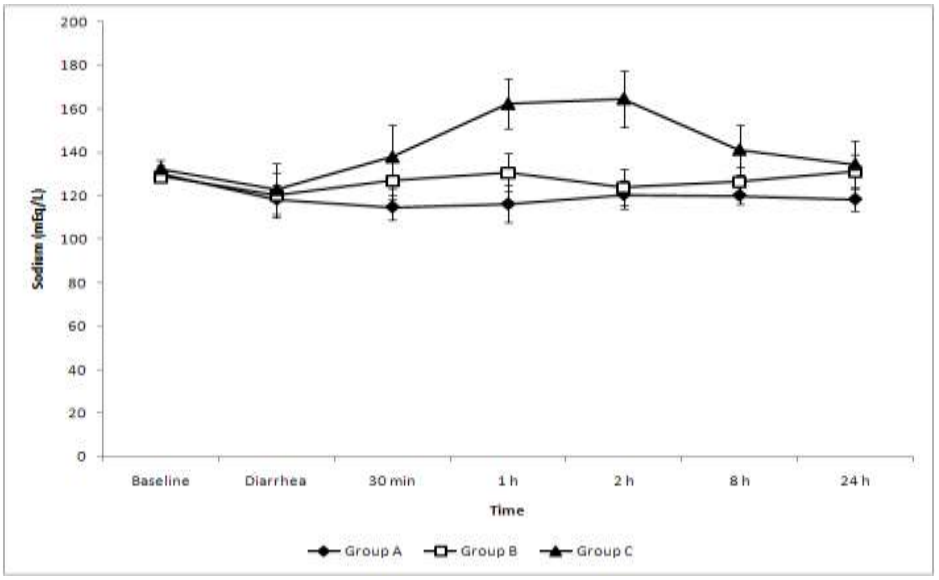

Fig. 2: Sodium Concentration.

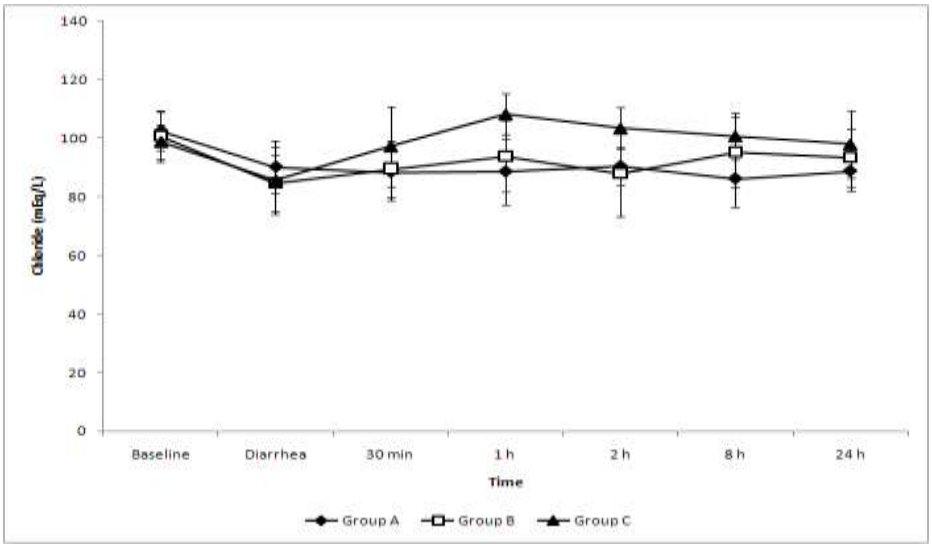

Fig. 3: Chloride Concentration

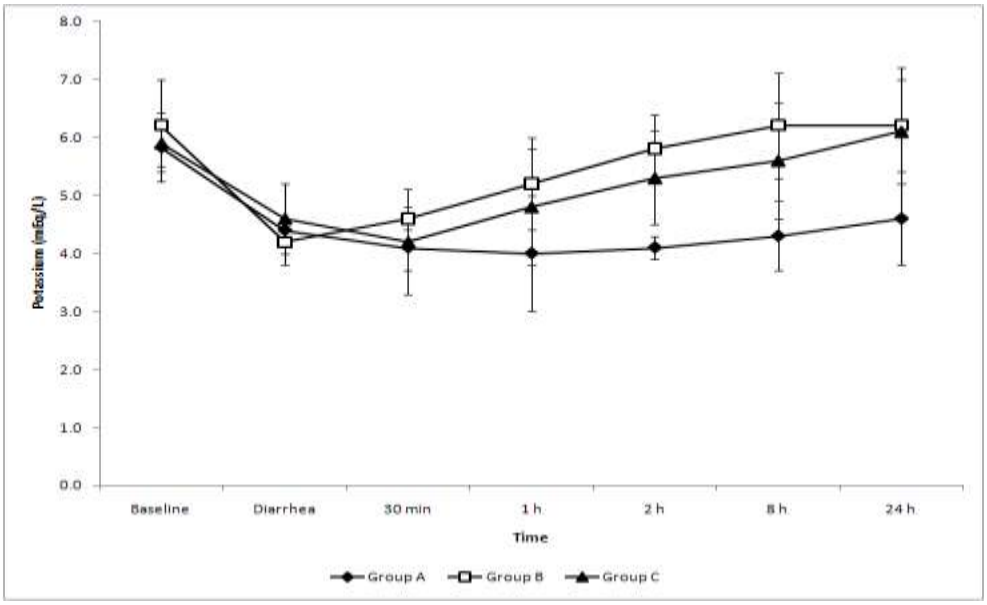

Fig. 4: Potassium Concentration

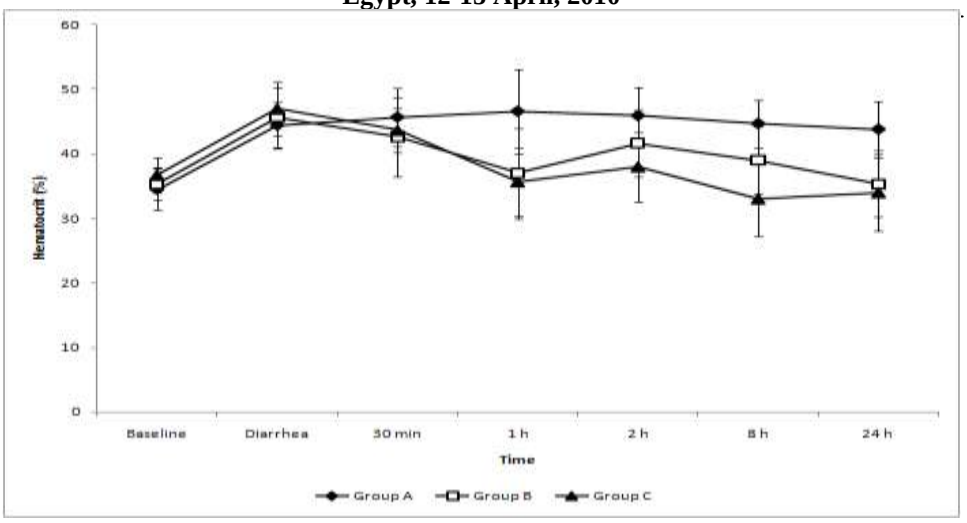

Fig. 5: Hematocrit Level

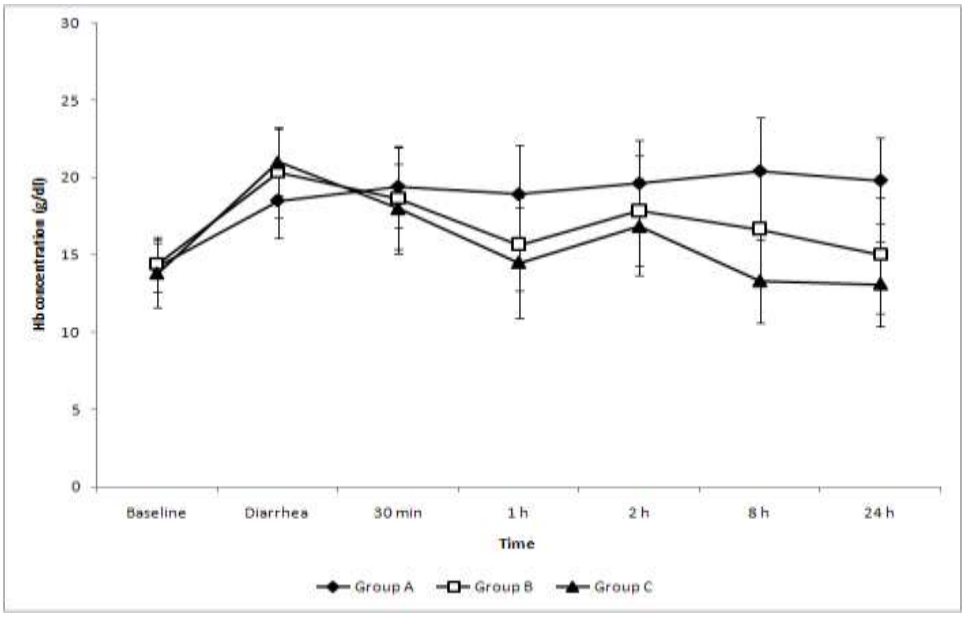

Fig. 6: Hb Concentration

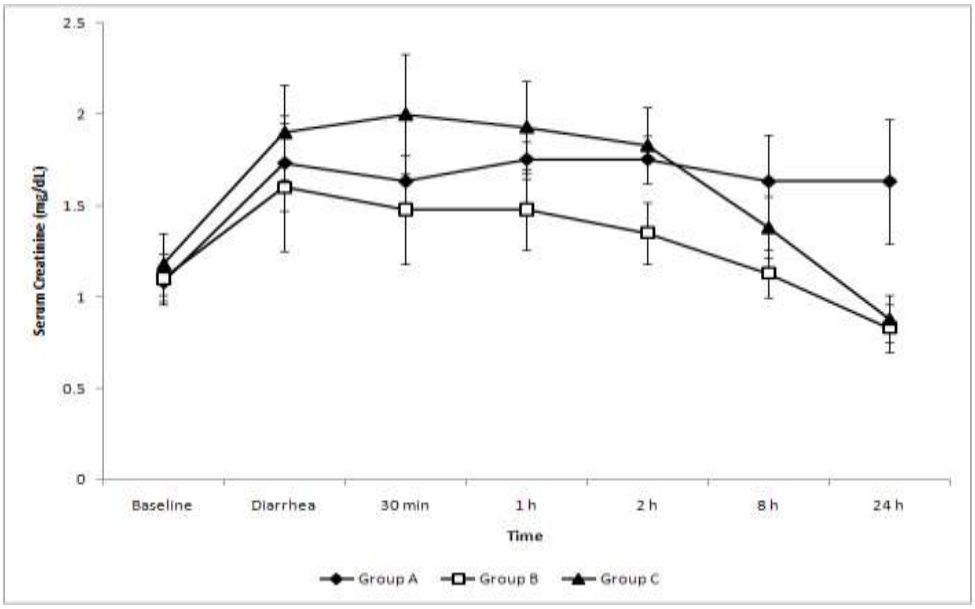

Fig. 7: Serum Creatinine Level

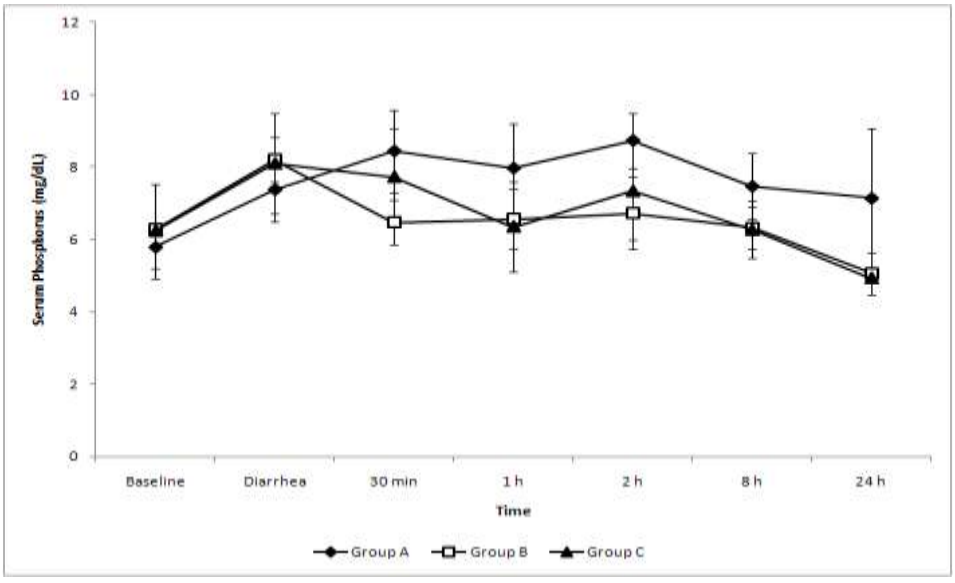

Fig. 8: Serum Phosphorus Level