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Partial Gastrectomy Concurrent with Enterectomy in a Rat model: An Evaluation of Sub-Clinical Electrolytes and Haematological Complications

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Key words:
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ABSTRACT

Gastro-oesphageal reflux, oesophagitis, stricture formation, haemorrhage, infection, anastomotic failure, herniation, hematoma, short bowel syndrome and nutritional deficiencies are the post-surgical complications reported to be associated with partial gastrectomy (PG) and enterectomy (E). In this study, we evaluated the effects of PG performed concurrently with E on haematology and electrolytes of Wistar rat model. 20 Wistar rats (191.08 ± 19.58g), 5 in each group, were randomized into groups: A (Control), B (partial gastrectomy alone, PG), C (enterectomy alone, E), and D (gastrectomy performed concurrently with enterectomy, PG & E). All rats were sacrificed on 14th day post-surgery. Serum and blood samples were collected and evaluated for electrolytes and haematological changes, respectively. We observed significant reduction in sodium ion (Na^+) ($p < 0.05$) as well as potassium ion (K^+) ($p < 0.01$) 14 days after PG & E when compared with E. There was a significant elevation in Red Blood Cells (RBC), Haemoglobin (Hb) and Packed Cell Volume (PCV) without significant differences in Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) post PG & E when compared with PG and those that underwent E. A significant increase in platelets post PG & E was observed when compared with control and those that underwent E ($p < 0.01$). In conclusion, post-surgical hyponatraemia, hypokalaemia, polycythaemia and reactive thrombocythaemia were sub-clinical complications consistent with partial gastrectomy performed concurrently with enterectomy.

1. INTRODUCTION

A combination of surgery, chemotherapy, radiotherapy and targeted therapy has been successfully used to treat gastric cancer (Wagner et al. 2017), but with surgery alone being the only cure (Orditura et al., 2014). It has been reported that surgical resection and lymphadenectomy are the mandatory surgical principles in the management of gastric cancer (Seevaratnam et al. 2012). Also, gastric tumor resection is based on its histologic subtype, location and extension (Someya et al. 2013). Gastric cancer is however, limited to stomach tissue only, but the most common neoplasms of mesenchyme of the entire gastrointestinal tract is called gastrointestinal stromal tumors (GISTs). These are tumors originating from the smooth muscle pacemaker interstitial cell of Cajal (DeVita, Lawrence, and Rosenberg 2011).

GISTs have been reported to be unresponsive to most chemotherapies, with less than 5% responses (DeVita et al. 2011). Due to rarity of lymph node metastasis in GISTs, surgical excision of GISTs without routine lymph node removal is considered primary treatment of choice (von Mehren et al. 2016).

Partial gastrectomy has been indicated for the surgical management of stomach GISTs (Keung and Raut 2017) (El-Hanafy et al. 2011) (Iwahashi et al. 2006) while enterectomy of intestinal benign tumors has also produced a favourable result (Schwandt 2008).

However, several life-threatening post-surgical complications have been reported to be associated with the partial gastrectomy and the enterectomy. They include partial gastro-oesphageal reflux, oesophagitis, stricture formation, hypoglycemia, haemorrhage, post-operative infection, anastomotic failure, herniation, hematoma, short bowel syndrome, nutritional deficiencies (Windsor 1964).

A useful indicator for prediction of prognosis for patients in post-operative intensive care unit is hypochloraemia (Kimura et al. 2014). It is usually caused by hyponatraemia. Hypernatraemia causes fluid retention and surgical excision is a cause of post-operative fluid retention (Poon et al. 1996). Potassium is the primary intracellular electrolyte that is responsible for the production of high osmotic pressure to maintain cell volume, normal cell resting membrane potential and for generation, as well as propagation of action potentials in excitable cells (Brunkhorst 2014).

As mentioned by Porth, 2011, leukocytosis is known to be a sign of an inflammatory response that is mostly caused by infection such as bacterial infection resulting in neutrophilia (Smith, Herbert, and Hinkle 1986). Lymphocytopenia is also usually caused by infection, too (Ng et al. 2006).

Red blood cells encapsulate haemoglobin, that is responsible for oxygen delivery by whole blood to tissues for metabolism (Muir and Wellman 2003). Anaemia and polycythaemia are complications of underlying pathology during surgery (Gombotz 1998). It takes a few days before reticulocytosis becomes relevant to shift initial pre-regenerative normocytic and normochromic anaemia (due to hemolysis or blood loss) to the microcytic hypochromic pattern (PALTRINIERI 2017). High platelet count is consistent with reactive thrombocythaemia, which is usually caused by inflammation, post-surgery and haemolytic anaemia (Bleeker and Hogan 2011).

However, changes in haematology and electrolytes associated with partial gastrectomy performed concurrently with enterectomy have not been reported. Therefore, we hypothesized that partial gastrectomy performed concurrently with enterectomy could result in haematological and electrolyte complications in Wistar rats.

2. MATERIALS AND METHODS

2.1. Experimental animals

Twenty (20) Wistar rats with mean body weight of 191.08 ± 19.58g were obtained from the University of Ilorin, Faculty of Veterinary Medicine Laboratory Animal Unit. They were housed in well-ventilated cage compartments with adequate space for exercise. They were fed on commercial rat feed (Guinea feeds®) and were given distilled water ad libitum. Pre-experimental clinical examination confirmed that were healthy, fit for the experiment and were therefore approved by the Ethical Review Committee of the Faculty of Veterinary Medicine, University of Ilorin (approval number FVER/005/2019).

All animals were allowed 14 days of acclimatization with natural light exposure of approximately 12-hour light and 12-hour darkness daily. This protocol is consistent with the guidelines of the National Institutes of Health (NIH) guidelines for laboratory animal care and use (Clark et al. 1997; Sponholtz III, Trujillo, and Gribble 2000).

2.2. Experimental protocol

The rats were chosen at random into four (4) experimental groups (A, B, C and D) with each group consisted of five (5) rats. Table (1) below shows summary of grouping of experimental rats.

Group A: This is the control group. All rats in this group did not undergo any surgery. Group B: All rats in this group underwent partial gastrectomy alone. Group C: All rats in this group underwent enterectomy of duodenum alone. **Group D:** All rats in this group underwent partial gastrectomy concurrent with enterectomy of duodenum concurrently. All rats were sacrificed by means of cervical dislocation.

2.3. Surgical Procedures

Anesthesia: All rats undergoing surgery were sedated with intramuscular administration of 10mg/kg xylazine (V.M.D® XYL-M2) while induction of anesthesia was achieved by intramuscular administration of 90mg/kg ketamine (JAWA KETAMINE®).

Laparotomy: Ventral abdomen was aseptically prepared by clipping of the hair and cleaning with antiseptic solution. Then, a ventral midline laparotomy incision was made on the linea alba. The stomach and the duodenum were then identified and exteriorized.

Partial Gastrectomy: An elliptical partial gastrectomy excision was made on the greater curvature of the glandular part of the stomach. Thereafter, the partial gastrectomy was closed twice using Lembert suture pattern with 5-0 Polyglactin 910 (Vicryl® Ethicon® Johnson & Johnson International).

Enterectomy: An elliptical enterectomy excision of antimesenteric portion of the duodenum was made caudal to the opening of pancreatic duct. Thereafter, it was closed using simple interrupted suture pattern with

5-0 Polyglactin 910 (Vicryl® Ethicon® Johnson & Johnson International).

Closure: The linea alba was closed with 4-0 chromic catgut (Trugut®) using simple interrupted suture pattern while the skin was closed using simple interrupted pattern with 4-0 Nylon (Ogotex®).

Table (1): Grouping of experimental animals, surgical procedures performed and post-surgical sample collection.

Group	Rats	Surgery	Sample Collection
A	5	none	14 days PF
B	5	PG	14 days PO
C	5	E	14 days PO
D	5	PG and E	14 days PO

PG = Partial Gastrectomy; E = Enterectomy; PO = Post-Operative; PF = Post-Feeding

2.4. Blood Collection for Electrolytes and Haematological Analyses

Retro-orbital venous plexus blood sample collection technique was performed (van Herck et al. 2001). This same technique of blood collection was performed in all the 20 rats in the same manner. The whole blood samples collected were divided into two – one, for haematology while the other was allowed to clot for 30 minutes. The clotted ones were then centrifuged at 3000x g for 10 minutes under refrigeration at 4^{o}C. The supernatant collected after centrifugation was immediately transferred into a clean polypropylene sample tube using a Pasteur Pipette (Milosavljević et al. 2011). These serum samples were stored at -20^{o}C, ready for electrolyte analysis.

2.5. Statistical Analysis

All data collected were expressed as Mean ± Standard Deviation (SD), after statistical evaluation. Statistical significances $p < 0.05$ and $p < 0.01$ were used for all data. Student's *t*-Test was used to compare two sets of data for significance while One Way Analysis of Variance (ANOVA) with Turkey's Post-hoc test using GraphPad Prism 8.0 was also used to compare all data sets for significance ($p < 0.05$) (Hedges and Rhoads 2010), and all graphs were plotted using GraphPad Prism 8.0.

3. RESULTS

3.1. Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Electrolytes (Sodium ion, Potassium ion, Chloride ion and Bicarbonate ion)

Levels of Sodium ions (Na^+), Potassium ion (K^+), Chloride ion (Cl^-) and Bicarbonate ion (HCO_3^-) in serum samples are shown in fig.(1), fig. (2), fig. (3) and Fig 4, respectively.

The level of Na^+ in the serum samples of rats that underwent enterectomy alone significantly ($p < 0.05$) increased when compared with that of Control group, while there was a significant reduction in the level Na^+ in the serum of the rats in which partial gastrectomy concurrent with enterectomy was carried out when compared with those that underwent enterectomy alone, as shown in fig. (1).

In fig. (2), there was a significant reduction in the level of K^+ in the serum of rats that underwent partial gastrectomy concurrent with enterectomy when compared with the Control group, as well as the group in which partial gastrectomy alone was performed. The level of Cl^- in the serum samples of rats that had their stomachs alone partially gastrectomized significantly reduced when compared with those of Control group. However, significant increase in Cl^- level in the serum was recorded in group that underwent enterectomy alone when compared with the group that had their stomachs alone partially gastrectomized, as shown Fig 3. No significant difference was observed when Cl^- levels in the serum of rats that went through partial gastrectomy concurrent with enterectomy when compared with the Control group and other two groups that underwent partial gastrectomy alone and enterectomy alone, respectively, although, there was a reduction when compared with control, an increase when compared with partial gastrectomy alone, and a reduction when compared with enterectomy alone.

In fig. (4), neither significant reduction nor significant increase in HCO_3^- levels was observed in all the groups that underwent partial gastrectomy alone, enterectomy alone and partial gastrectomy concurrent with enterectomy, although, there was an increase in the levels of HCO_3^- in groups B, C and D where partial gastrectomy alone, enterectomy alone and partial gastrectomy concurrent with enterectomy were performed,respectively.

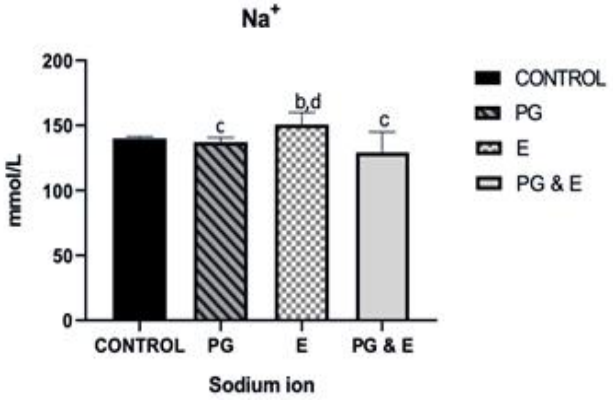

Fig. (1): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Sodium ion**.** Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone.[c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone. [d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. Na^+ = Sodium ion; K^+ = Potassium ion; Cl^- = Chloride ion; HCO_3^- = Bicarbonate ion

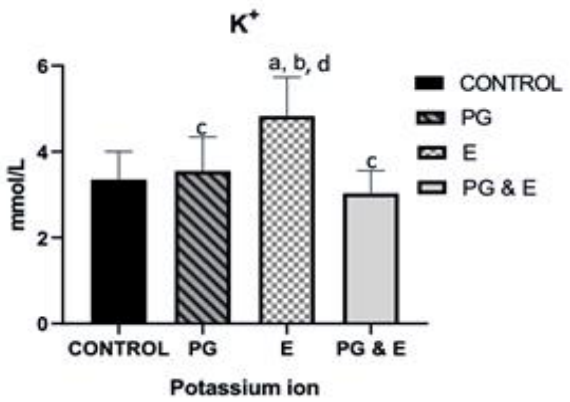

Fig. (2): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Potassium ion. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone .[c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy .PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. Na+ = Sodium ion; K+ = Potassium ion; Cl- = Chloride ion; HCO3- = Bicarbonate ion

3.2 Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Haematology

Fig. (5) shows that following partial gastrectomy alone, there was an increase in circulating WBC when compared with control group. There was also an increased WBC in circulation when partial gastrectomy concurrent with enterectomy was carried out in comparison with the control. Also, in Fig 5, a significant increase in WBC was observed in comparison with the control group when enterectomy alone was performed. In Fig.(6), circulating neutrophils increased when enterectomy alone as well as when partial gastrectomy concurrent with enterectomy was performed in comparison with the control group. Meanwhile, a significant rise in neutrophils was observed when partial gastrectomy alone was performed in comparison with the control group.

Partial gastrectomy with enterectomy resulted in decreased lymphocytes in circulation when compared with control group, so also enterectomy alone, as shown in Fig 7. A significant decrease in lymphocytes was however recorded in group that underwent partial gastrectomy alone when compared with the control group (Fig. 7). The effects of partial gastrectomy alone and partial gastrectomy concurrent with enterectomy, in Fig 8, produced an increase in circulating monocytes while enterectomy alone resulted in decreased monocytes in circulation when compared with control group. Fig 9 shows that there was no change in circulating eosinophils in groups that underwent partial gastrectomy alone and enterectomy alone when compared with control, while it was observed that circulating eosinophils dropped when partial gastrectomy concurrent with enterectomy was performed, when compared with the control. There was a significant decrease in circulating RBC in partial gastrectomy alone and enterectomy alone groups when compared with control.

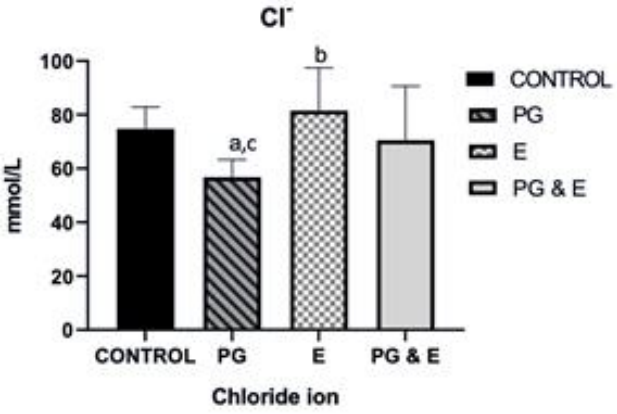

Fig. (3): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Chloride ion. Values are expressed as Mean ± Standard Deviation .[a] indicates significant differences ($p < 0.05$) compared with Control. [b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy.

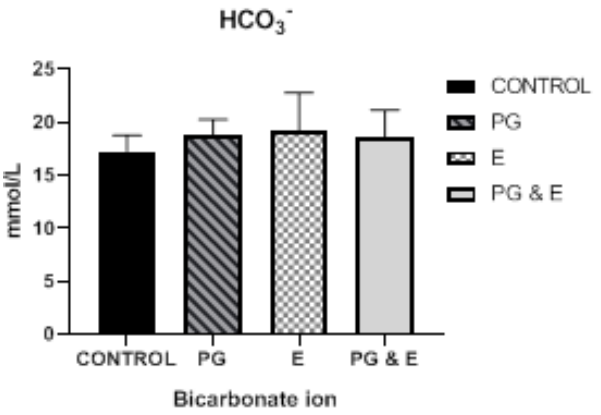

Fig. (4): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Bicarbonate ion. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone .[c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone. [d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy and Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. Na^+ = Sodium ion; K^+ = Potassium ion; Cl^- = Chloride ion; HCO_3^- = Bicarbonate ion.

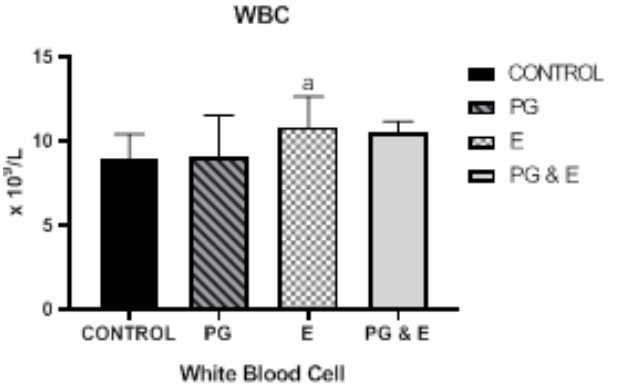

Fig. (5): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on White Blood Cells. Values are expressed as Mean ± Standard Deviation. [a]indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone.[c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

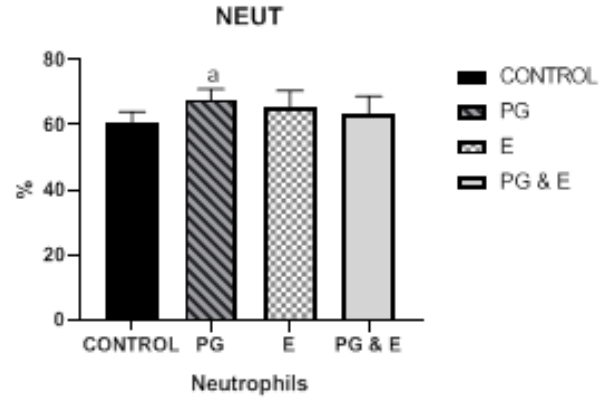

Fig. (6): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Neutrophils. Values are expressed as Mean ± Standard Deviation. [a] indicates significant differences ($p < 0.05$) compared with Control [b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone. [d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

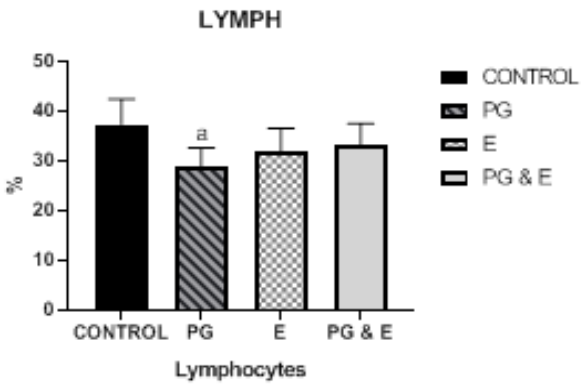

Fig. (7): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Lymphocytes.Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone.[c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

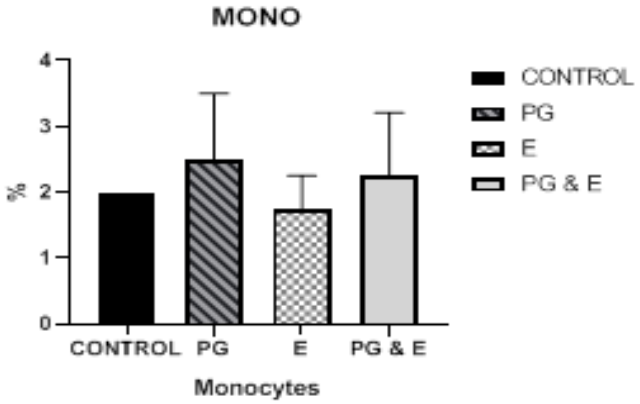

Fig (8): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Monocytes. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control. [b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

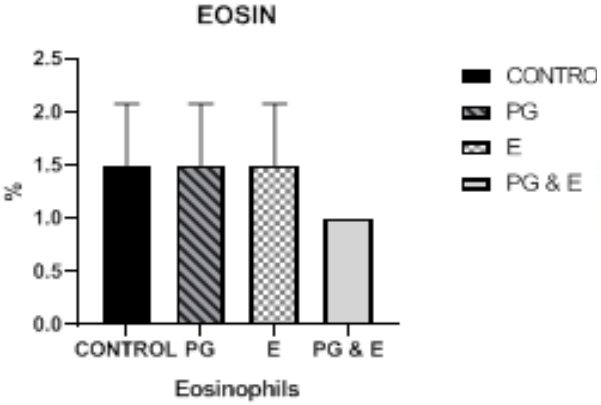

Fig. (9): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Eosinophils.Values are expressed as Mean ± Standard Deviation. [a] indicates significant differences ($p < 0.05$) compared with Control. [b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone. [d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy .PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

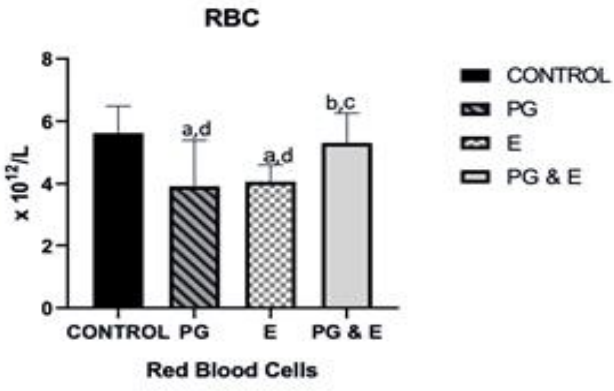

Fig. (10): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Red Blood Cells. Values are expressed as Mean ± Standard Deviation. [a] indicates significant differences ($p < 0.05$) compared with Control [b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

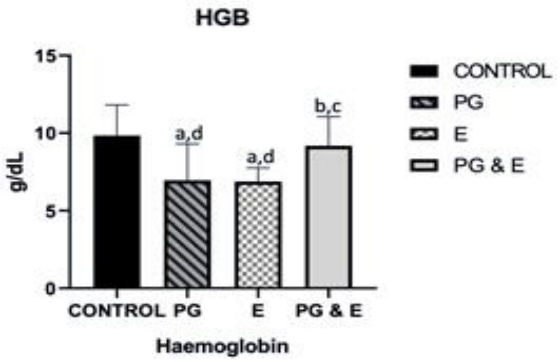

Fig. (11): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Haemoglobin. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

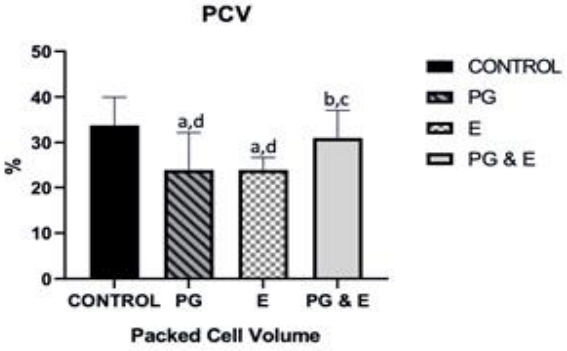

Fig. (13): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Mean Corpuscular Volume. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone. [d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

In fig 10, whereas, circulating RBC increased significantly when partial gastrectomy concurrent with enterectomy was performed in comparison with partial gastrectomy alone and enterectomy alone as shown in fig. (10). Fig. (11) and fig. (12) follow the same trend as Fig. (10), where they show significant reduction in Haemogblobin and PCV in groups that underwent partial gastrectomy alone and enterectomy alone when compared with the control group, while a significant increase in both Haemoglobin and PCV was recorded in the group that had their stomach undergo partial gastrectomy concurrent with enterectomy of duodenum when compared with partial gastrectomy alone and enterectomy alone.

No significant differences in MCV, MCH and MCHC were observed when either partial gastrectomy alone, enterectomy alone or partial gastrectomy concurrent with enterectomy were performed in comparison with either control or within groups, as shown in fig. (13), fig. (14) and fig. (15).

In fig. (16), a slight increase in platelets was observed in groups that underwent partial gastrectomy alone and enterectomy alone when compared with control, whereas, partial gastrectomy concurrent with enterectomy resulted in significant increase in platelet when compared with either the control group or the group that underwent enterectomy alone.

4. DISCUSSION

In this present study, we investigated the effects of partial gastrectomy concurrent with enterectomy on the electrolytes and haematological parameters 14 days after surgery. There was a significant post-operative hypernatraemia following enterectomy alone while a significant hyponatraemia occurred post partial gastrectomy concurrent with enterectomy. Hypernatraemia causes fluid retention. Our findings of post-gastrectomy concurrent with enterectomy hyponatraemia might have led to post-operative fluid loss, whereas post-operative hypernatraemia might have resulted in fluid retention following enterectomy alone, which is in tandem with previous reports of W.S. et al., 1996, that surgical excision is a cause of post-operative fluid retention. Our present study also showed that there was post-operative hyperkalaemia after partial gastrectomy alone, and a significant post-operative hyperkalaemia following enterectomy alone. However, a significant hypokalaemia was recorded

when partial gastrectomy concurrent with enterectomy was performed. This might have resulted in low osmotic pressure and inability of cell to maintain its volume as previously reported by Brunkhorst, (2014).

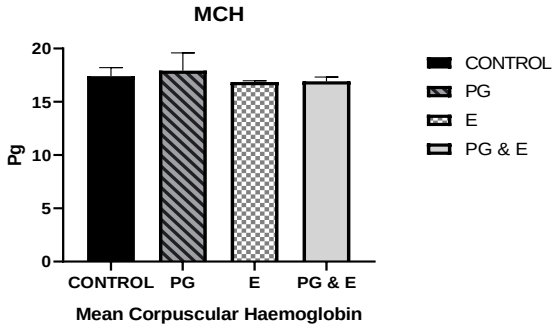

Fig (14): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Mean Corpuscular Haemoglobin. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alon.e[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

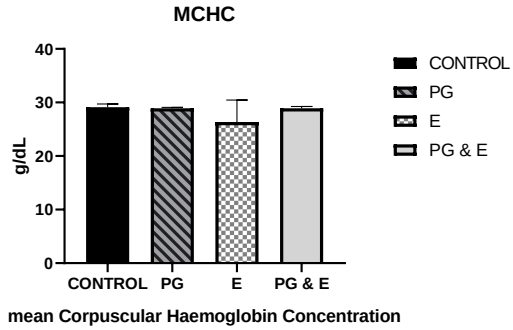

Fig (15): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Mean Corpuscular Haemoglobin Concentration. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alon.e[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

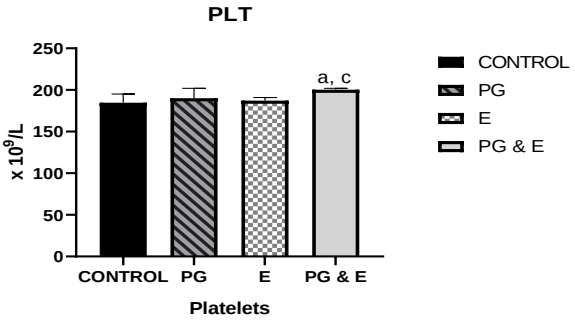

Fig (16): Effects of Partial Gastrectomy alone, Enterectomy alone and Partial Gastrectomy concurrent with Enterectomy on Platelets. Values are expressed as Mean ± Standard Deviation.[a] indicates significant differences ($p < 0.05$) compared with Control.[b] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy alone. [c] indicates significant differences ($p < 0.05$) compared with Enterectomy alone.[d] indicates significant differences ($p < 0.05$) compared with Partial Gastrectomy concurrent with Enterectomy. PG = Partial Gastrectomy alone; E = Enterectomy alone; PG & E = Partial Gastrectomy concurrent with Enterectomy. WBC = White Blood Cells; NEUT = Neutrophils; LYMPH = Lymphocytes; MONO = Monocytes; EOSIN = Eosinophils; RBC = Red Blood Cells; HGB = Haemoglobin; PCV = Packed Cell Volume; MCV = Mean Corpuscular Volume; MCH = Mean Corpuscular Haemoglobin; MCHC = Mean Corpuscular Haemoglobin Concentration; PLT = Platelets

In this study, a significant hypochloraemia as well as a significant hyponatraemia were consistent with partial gastrectomy alone, indicative of metabolic alkalosis, which might be as a result of on-going fluid losses.

Leukocytosis was observed in partial gastrectomy alone and in partial gastrectomy

concurrent with enterectomy, but a significant leukocytosis in enterectomy alone suggested a post-operative inflammatory response as mentioned by Porth, 2011. Also, we recorded a significant post-operative neutrophilia following partial gastrectomy alone. This report is in accordance with that of Tabatabaie, Maleki, Talebpour, 2017. Post-operative inflammatory response to inflection characterized by neutrophilia following partial gastrectomy alone correlates with our finding that there was a significant lymphocytopenia 14 days after partial gastrectomy alone, which is in consonance with earlier published article on lymphocytopenia (Ng et al. 2006).

In our present study, there was anaemia indicated by significant low PCV consistent with severe erythropaenia and haemoglobinaemia 14 days post-partial gastrectomy alone and 14 days post-enterectomy alone. This might have resulted in severe tissue hypoxia due to slow recovery of haemoglobin synthesis, which was earlier reported to take between day 7 and day 28 post-surgery (Wallis et al. 2005).

However, MCV, MCH and MCHC remained unchanged, 14 days post-partial gastrectomy alone, post-enterectomy alone and post-partial gastrectomy with enterectomy, indicative of normocytic normochromic pre-regenerative anaemia, which is in consonance with the earlier documented and published reports of Paltrinieri, 2014. Conversely, partial gastrectomy performed concurrently with enterectomy resulted in significant polycythaemia as reported earlier by Gombotz, 1998.

We also observed a significant reactive thrombocythaemia 14 days post-partial gastrectomy concurrent with enterectomy. This might be due to post-surgical inflammation as earlier reported by Bleeker & Hogan, 2011.

5. CONCLUSION

Post-operative hyponatraemia, hypokalaemia, polycythaemia and reactive thrombocythaemia were sub-clinical complications observed to be consistent with partial gastrectomy performed concurrently with enterectomy in Wistar rats.

CONFLICT OF INTEREST

The authors declare that no conflict of interest, whatsoever, arose during this research work.

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