International Journal of Basic, Applied and Innovative Research
IJBAIR, 2016, 5(3): 57 - 61
ISSN: 2315 - 5388 www.arpjournals.com; www.antrescentpub.com E-ISSN: 2384 - 681X

RESEARCH PAPER

RATES OF GASTRIC EMPTYING AND SMALL INTESTINAL MOTILITY IN PREGNANT RATS FED ESSENTIALLY CARBOHYDRATE DIET

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Received: 19th August, 2016 Accepted: 10th September, 2016 Published: 30th September, 2016

Endorsed By: *Innovative Science Research Foundation* ***(ISREF)*** *and International Society of Science Researchers* ***(ISSCIR). Indexed By:*** *African Journal Online (AJOL); Texila American University; Genamics; Scholarsteer; EIJASR; CAS-American Chemical Society; and IRMS Informatics India (J-Gate)*

ABSTRACT

This study investigated the effect of essentially carbohydrate diet (cooked mashed yam) on gastric emptying and small intestinal motility rates in pregnancy. It involved 24 female Wistar rats weighing between 180 to 200gand randomly assigned to four groups. Groups I and II served as the control (non-pregnant rats)fed normal rat chow and essentially carbohydrate diet respectively, while Groups III and IV served as test animals(pregnant rats) fed essentially carbohydrate diet in early and late gestation periods respectively. Gastric emptying and small intestinal motility rates were determined in early and late gestation periods using standard laboratory procedures and the values obtained were compared with those of the control groups. Results showed that gastric emptying was significantly higher ($p<0.05$) in group 2 compared to other groups, while small intestinal motility rate was significantly reduced ($p<0.05$) in group II compared to groups I and III but not significant ($p>0.05$) with group IV. The findings of this study, suggests that gastric emptying can be inhibited as small intestinal motility is enhanced following the ingestion of essentially carbohydrate; indicating that the nature of food substance and possibly, pregnancy hormones, may account for these modulations.

Key words: Carbohydrate diet, Pregnancy, Gastric emptying, Small intestinal motility

INTRODUCTION

Gastrointestinal disorders (Boeckxstaens *et al.,* 2000) as well as decreased motility leading to delay in gastric emptying time (Davidson *et al.,* 1970) constitute one of the most frequent symptoms during pregnancy. These effects were said to be probably caused by sex steroids (Hutson*et al.,* 1999). For instance, post-menopausal women being treated with sex hormone replacement therapy showed rates of gastric emptying of solids similar to those of men (Hutson*et al.,* 1999).

On the other hand, nutrient needs have been reported to increase during pregnancy to meet the high demands of both the growing fetus and the mother (Chen *et al.,* 1997; Prieto *et al.,* 1994). In this regard, pregnant women were advised to increase their food intake during pregnancy (Institute of Medicine, 2009).Nevertheless, gastrointestinal disorders still constitute one of the most frequent symptoms during pregnancy (Boeckxstaens *et al.*, 2000). Decreased motility of the stomach leading to delay in gastric emptying time has been observed in pregnant women (Davidson et al., 1970). According to Claudia (2006), high protein food empties slower than carbohydrate and a little bit faster than fatty foods; suggesting the influence of food type on the activities of the gastrointestinal tract.

On energy food intake during pregnancy, the revised Dietary Reference Intake (DRI) recommends that there should be no additional calories in the first trimester, but 340 and 452 an additional kilocalories in the second and third trimesters respectively (Institute of Medicine, 2002). Unfortunately, most staple diets in developing countries are laden with carbohydrates; triggering concerns about the likely implications on gastrointestinal motility changes in pregnancy. This study therefore, investigates the effect of essentially carbohydrate diet ingestion on gastric emptying and small intestinal motility during pregnancy.

MATERIALS AND METHODS

Animals for the study: A total of twenty-four (24) adult female Wistar rats of comparable weights were used for this study. They were procured as at when needed by ordering in advance from the Animal House unit of the College of Medicine, Ambrose Alli University, Ekpoma, Nigeria and kept in the animal holding within physiological laboratory II of the College of Medicine, Ambrose Alli University, Ekpoma. They were housed in cages designed to allow for adequate ventilation and equipped with a convenient feeding and drinking troughs. The animals were allowed 2 weeks to acclimatize and had unlimited access to normal rat chow and clean water throughout the duration of study.

Experimental design: The animals were randomly selected into four (4) groups of 6 female rats each. Groups I and II served as the control groups and consisted of non-pregnant female rats fed with normal rat chow (100g) and essentially carbohydrate diet (70g cooked mashed yam + 30g normal rat chow) respectively throughout the period of 21 days. Groups III and IV served as the test groups and consisted of pregnant rats fed essentially carbohydrate diet (70g mashed cooked yam + 30g normal rat chow)in their early (5 days post confirmation of pregnancy) and late (16 days post confirmation of pregnancy) stages of pregnancy.

Mating: A male and a female rat of close weight were paired for mating. During this period, vaginal smears were made for each female and examined under the microscope for the presence of spermatozoa and the presence or absence of copulation plug was determined. The absence of the plug and the presence of spermatozoa in smear provided evidence of copulation. Day I of pregnancy was the day the plug disappears and spermatozoa is detected. Thereafter, the female rats were returned to their respective cages where they remained until sacrificed for the experiments.

Gastric emptying: On the 6^{th} and the 16^{th} day of pregnancy, the rats were starved overnight, allowing water only. Following this, a measured amount of feed was administered to each rat for a period of 30 minutes. The quantity consumed was determined by subtracting the amount of feed left from that provided, after which it was sacrificed. The abdominal cavity was cut open and the stomach and intestine dissected out. The content of the stomach was oven-dried to a constant weight at 27^{o}C. The quantity of feed that transited from the stomach into the small intestine within the 30 minutes was gotten by subtracting the quantity of food left in the stomach from that eaten. With the formular below, the amount of feed leaving the stomach for the small intestine was divided by 30, giving the rate of gastric emptying per minute;

$$\text{Rate of Gastric Emptying} = \frac{\text{Amount leaving the stomach for small intestine}}{\text{Time}}$$

Intestinal motility rate study: The rat chow was fortified with 1% activated charcoal and rat was allowed to feed for 30 minutes before being sacrificed, and the gut dissected out. The total length of the small intestine in each case was measured as well as the distance travelled by the test meal along the small intestine. The transit of food material for each rat was expressed as a percentage of the entire length of the small intestine using the formula:

$$\text{Intestinal Transit (\% travelled)} = \frac{\text{Small intestine distance travelled by test meal x 100}}{\text{Total length of the small intestine} \quad 1}$$

$$\text{Small Intestinal motility rate} = \frac{\text{Small intestine distance travelled by test meal}}{\text{Duration (30 mins)}}$$

Statistical Analysis: The data generated from each experiment were analyzed using the Statistical Package for Social Science (SPSS version 20). The statistics include; the Means, Standard Error of Mean (SEM) and Analysis of Variance (ANOVA). P-values of less than 0.05 were considered significant.

RESULTS

Figure 1 represents the rate of gastric emptying in pregnant rats fed essentially carbohydrate diet compared to non pregnant controls. The rate of gastric emptying was significantly delayed ($p<0.05$) in early (0.017 ± 0.011) and late (0.027 ± 0.025) pregnancy and in non pregnant control fed normal diet (0.010±0.001) compared to non pregnant control fed essentially carbohydrate diet (0.067±0.037).

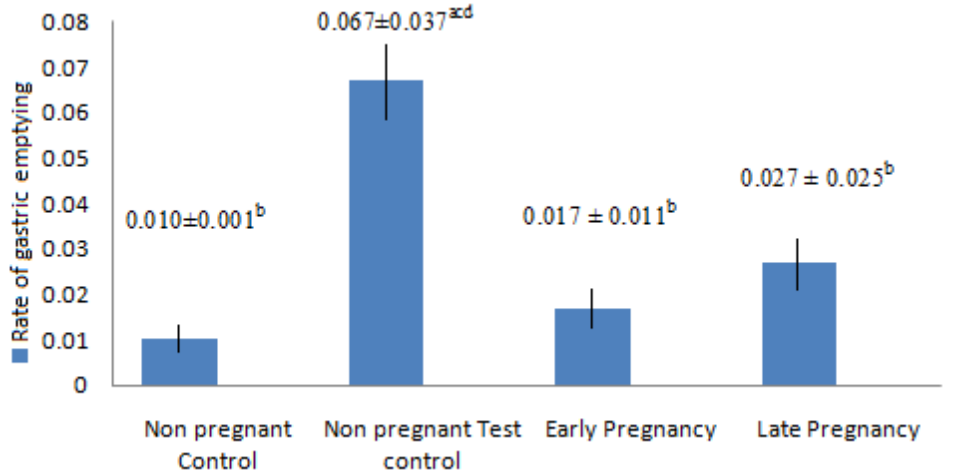

Figure 1: Rate of gastric emptying in pregnant rats fed essentially carbohydrate diet compared to non pregnant controls.(*n=6; Where a= p≤0.05 compared with non pregnant control; b= p≤0.05 compared with non pregnant test control; c= p≤0.05 compared with early pregnancy; d= p≤0.05 compared with late pregnancy*).

Figure 2 represents the small intestinal motility rate in pregnant rats fed essentially carbohydrate diet compared to non pregnant controls. Small intestinal motility rate was faster in early pregnancy (2.55±0.35) of rats fed essentially carbohydrate diet compared to late pregnancy stage (2.33±0.35). However, the difference was not statistically significant ($p>0.05$). Although small intestinal motility was higher in control fed normal diet (2.57±0.15) compared to those in the early and late pregnancy, the difference were not significant ($p>0.05$). The ingestion of essentially carbohydrate diet in non-pregnant group was observed to slow small intestinal motility (2.16±0.25) compared to other groups, but significantly so ($p<0.05$) when compared to normal control and early pregnancy group fed essentially carbohydrate diet.

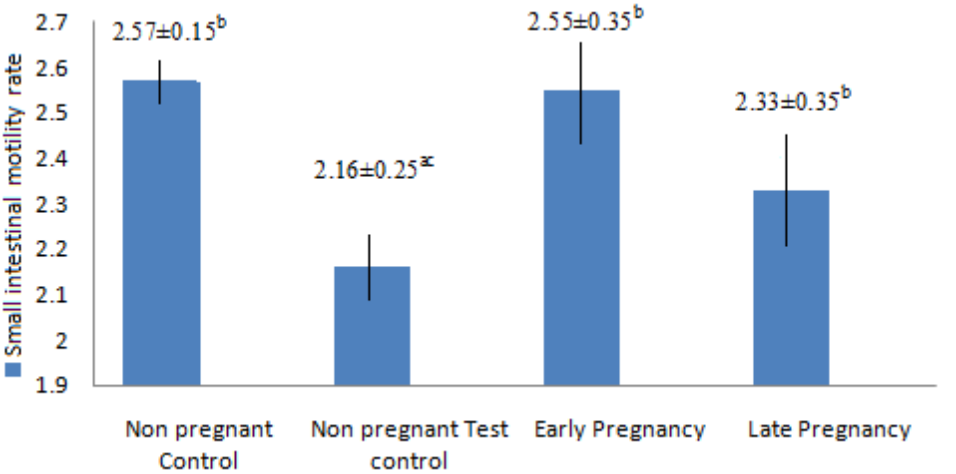

Figure 2: Small intestinal motility in pregnant rats fed essentially carbohydrate diet compared to non pregnant controls.(*n=6; Where a= p≤0.05 compared with non pregnant control; b= p≤0.05 compared with non pregnant test control; c= p≤0.05 compared with early pregnancy; d= p≤0.05 compared with late pregnancy*).

DISCUSSION

This study showed that the ingestion of the essentially carbohydrate diet; in this case cooked mashed yam, can delay gastric emptying in pregnancy. This delay was more noticeable in early pregnancy. However, compared to mixed diet (normal rat chow), gastric emptying in pregnancy was enhanced with the ingestion of the essentially carbohydrate diet (Figure 1). It has been documented that food does not necessarily exit the stomach in the same order that they arrived since different nutrients take varying time to exit (Bowen, 2006). Specifically, compared to the control diet, our results suggest that ingestion of the essentially carbohydrate diet tend to empty gastric content faster but slows small intestinal motility. The study by Claudie (2006) has also reported carbohydrate rich food to empty much faster and this is in line with our findings with respect to gastric emptying. Although the rate of gastric emptying was higher in pregnant groups fed essentially carbohydrate diet, it was similar and non-statistically significant with non-pregnant group fed mixed diet. However, the rate was significantly higher in the non-pregnant group fed essentially carbohydrate diet compared to pregnant groups on same diet. Also, gastric emptying was non-significantly higher in late pregnancy in essentially fed carbohydrate group compared to early pregnancy. The difference in gastric activity between early and late pregnancy state in essentially fed carbohydrate diet may be related to the size of the fetus which may have exerted pressure on intestinal organs. This assertion is based on the finding that rate of gastric emptying depends on pressure generated by antrum against pylorus resistance (Kong and Singh, 2008). This is further supported by the fact that pregnant women experience a 30% increase in blood volume and increased intra-abdominal pressure from uterine growth (Singer and Brandt, 1991).

On the other hand, the ingestion of the essentially carbohydrate diet stimulates small intestinal motility in pregnancy compared to non-pregnant state. Compared to the control, small intestinal motility was reduced and this was more evident in late pregnancy (Figure 2). However, intestinal motility was non-significantly higher in non-pregnant control fed mixed diet compared to pregnant rats fed essentially carbohydrate diet. This result showed that while pregnancy may increase intestinal motility in essentially carbohydrate diet condition, it may reduce intestinal activities in the case of mixed diets. Although not significantly different, intestinal motility was higher in early pregnancy compared to late pregnancy following the ingestion of essentially carbohydrate diet. This observation may be due to the increase abdominal pressure by the growing foetus in late pregnancy. In another line of thought, the reduced intestinal motility observed in late pregnancy may be related to the increase external pressure that may have resulted from increased fetal growth; which in our thinking may have compressed intestinal lumen.

The difference in gastric emptying and small intestinal motility in the different stages of pregnancy suggests energy need differences with progressive gestation periods. In support of this assertion, a comprehensive report released by Butte *et al.*(2004), stated that additional energy needs not only differ by trimester but also should be "tailored" based on the mother's preconception Body Mass Index. Conclusively, our study indicates that the ingestion of essentially carbohydrate diet during pregnancy may alter gastric emptying and small intestinal motility. Although the mechanism was not investigated, it may however, not be without the influence of pregnancy hormones.

ACKNOWLEDGEMENT

The assistance given by Akpamu U from the onset of this research work to its end is greatly acknowledged.

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AUTHOR'S CONTRIBUTIONS

Otamere H.O. conceptualized and designed this study. Ojieh A.E. and Ujaddughe M.O. were involved in laboratory experimentations and development of the first draft. Ernest-Nwoke I.O. was involved in animal care, laboratory documentations and reporting.