

## Direct Effects Of Glucose Administration On Heart Rate, Myocardial Contraction And Duration Of Cardiac Cycle In Frog's Heart

Basheer Waziri<sup>1</sup> And Shahzad Ahmad<sup>2</sup>

<sup>1</sup>(Cardiopulmonary unit, Department of Human Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University kano, Nigeria)

<sup>2</sup>(Endocrine physiology unit, Department of Human Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University kano, Nigeria)

Corresponding Author: Basheer Waziri

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**Abstract: Background:** Recent and emerging evidences show that glucose ingestion causes prolong  $Q - T$  interval and can trigger arrhythmia. **Objective:** To examine the effects of administration of glucose solutions on the heart rate, strength of myocardial contraction and duration of cardiac cycle in frog's heart. **Methods:** Five pithed frogs with mean weight of 119g obtained from the research lab, department of human Physiology, Bayero University Kano Nigeria, were dissected and their hearts were exposed, 2 to 3 drops of frog ringer's solution were added regularly to keep the heart moist. A kymograph was used to record the frog's myocardial activity. This was also recorded after subsequent addition of 2ml of 5%, 10% and 50% dextrose solutions to the heart. Heart rate (b/min), strength of myocardial contraction (mm) and the duration of cardiac cycle (seconds) were calculated. Data were analyzed using SPSS version 20.0 and the calculated parameters for each glucose solution were compared with that of frog's ringer's solution using paired t test.  $P < 0.05$  is significant. **Results:** The result showed a significant decrease in the heart rate (b/min) from that obtained with ringer's solution (54.40) after addition of 5%, 10% and 50% dextrose solutions with mean heart rates of 50.40, 47.60, and 41.00 respectively. The height of myocardial contraction (mm) was found to be significantly decreased after addition of 50% dextrose solution only, with the mean heights for frog's ringer's, 5%, 10% and 50% dextrose solutions been 8.65, 8.90, 8.40 and 5.35 respectively. The duration of cardiac cycle in seconds was significantly increased after addition of 10% and 50% dextrose solutions, with the mean duration for the ringer's, 5%, 10% and 50% dextrose solutions been 1.11, 1.18, 1.26 and 1.47 respectively. **Conclusion:** Both 5%, 10% and 50% dextrose solutions caused a significant decrease in frog's heart rate. Fifty percent dextrose solution caused a significant decrease in the strength of frog's myocardial contraction and addition of both 10% and 50% dextrose solutions has significantly increased the duration of cardiac cycle in frogs.

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### I. Introduction

Dextrose solutions have been used worldwide in the management of patients in our hospitals suffering from one form of disease or another. One of the most common conditions where dextrose is administered via parenteral route, is in the management of severe hypoglycemia usually characterized by impaired level of consciousness and seizures occasionally,<sup>[1]</sup> thus preventing the patient from taking oral glucose.<sup>[2]</sup> The common practice involves intravenous administration of 50% dextrose for adults presenting with hypoglycemia and 10% to 25% for children with the same condition.<sup>[2]</sup> Recent evidences have also shown that, even in the adults, IV infusion of 100 ml of 10% dextrose solution is an alternative to 50 ml of 50% dextrose in the treatment of hypoglycemia and it reduces the risk of extravasation injury and other toxic effect of hypertonic dextrose.<sup>[3]</sup> Dextrose solutions were also reported to be used during resuscitation of patients with cardiac arrest in order to prevent or reverse hypoglycemia.<sup>[4]</sup>

Researches have shown that glucose ingestion or administration affects cardiac function.<sup>[5]</sup> More recently, it has been found that glucose ingestion causes cardiac repolarization disturbances and prolong QTc interval leading to increased risk of cardiac arrhythmia.<sup>[5,6]</sup> It was also reported that, administration of dextrose in patient with cardiac arrest in the hospital is associated with increase mortality and neurologic impairment.<sup>[4]</sup> The alteration in cardiac function following glucose administration is partly due to autonomic and endocrine responses to elevated plasma glucose.<sup>[7]</sup> Data on the direct and immediate effects of glucose administration on the heart itself are scanty and need to be further investigated.

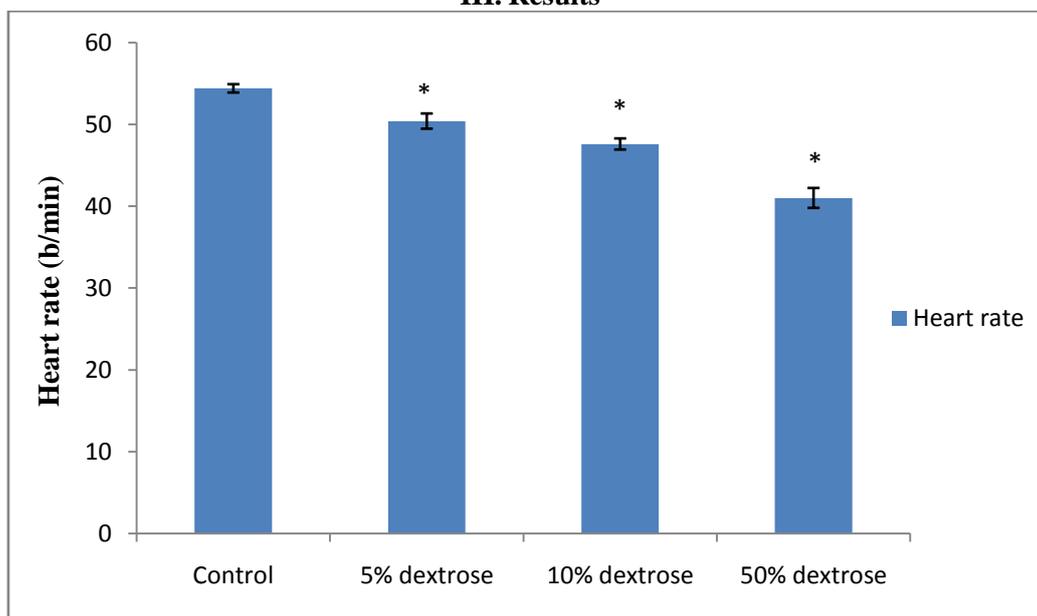
This study assessed the direct and immediate effects of dextrose administration on the heart rate, duration of cardiac cycle and myocardial contractility in frog's heart.

## II. Material And Methods

The study was conducted in the research laboratory, Department of Human Physiology, Faculty of Basic Medical Sciences, College of Health Sciences, Bayero University Kano, Nigeria. Five pithed frogs with mean weight of 119g were obtained from the lab and placed on dissecting boards. For each frog, a small incision was made into the abdominal cavity using the sharp end of scissors and the abdominal wall was dissected carefully with dissecting kits. The sternum was lifted up and its sides were cut together with the pectoral girdle to expose the heart in its pericardial sac. The sac was then excised and removed carefully thus exposing the heart completely. A heart clip attached to a thread was then inserted to the apex of the ventricles and the frog was positioned on a frog board attached to a kymograph in such a way that the heart lied vertically and below the attachment of the clip. The thread was then connected to the recording pen on the kymograph. Two to three drops of frog's ringer's solution (containing 3.6g NaCl, 0.1g KCl, 0.1g CaCl<sub>2</sub>, 0.9g glucose and 0.2g MgCl<sub>2</sub> in 500ml of the solution) were added to the heart regularly at interval of 30 seconds after the exposure. Finally, the kymograph was then switched on to record the frog's myocardial activity in one minute. The myocardial activity was first recorded 30 seconds after addition of 2ml of ringer's solution and then subsequently 30 seconds after addition of same amount of 5%, 10% and 50% dextrose solutions each. The heart rate (b/min) was calculated from the graph by counting the number of contractions in one minute. The duration of cardiac cycle (seconds) was estimated by dividing 60 seconds with the heart rate (Duration of cardiac cycle = 60 / heart rate) and the strength of myocardial contraction was estimated by measuring the average height of the contractions (mm) using a meter rule.

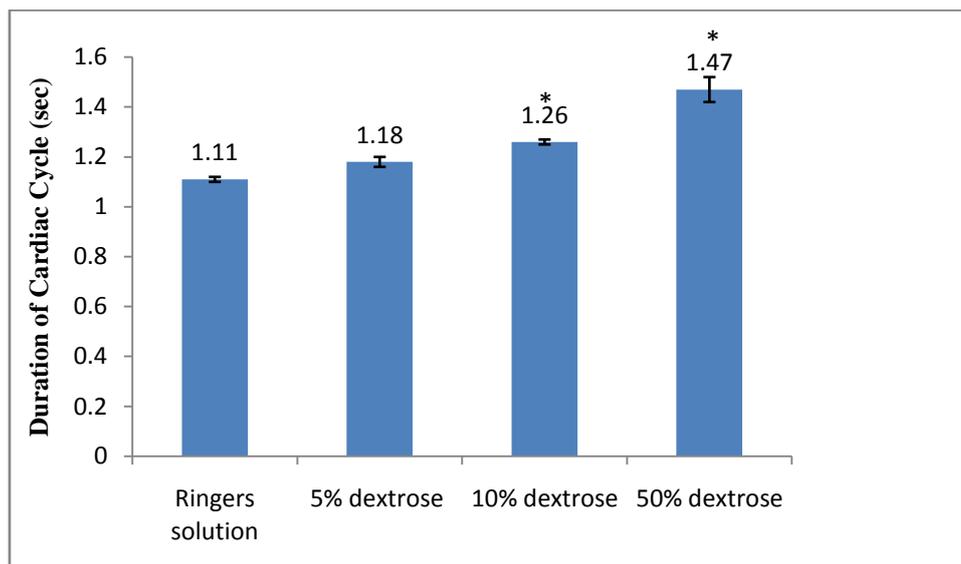
Data were summarized and presented as Means  $\pm$  S.E.M, and analyzed using SPSS version 20.0. Mean heart rate, duration of cardiac cycle and strength of myocardial contraction for each dextrose solution were compared with that obtained from addition of frog ringer's solution (control) using paired t test. Values of P < 0.05 were considered significant.

## III. Results



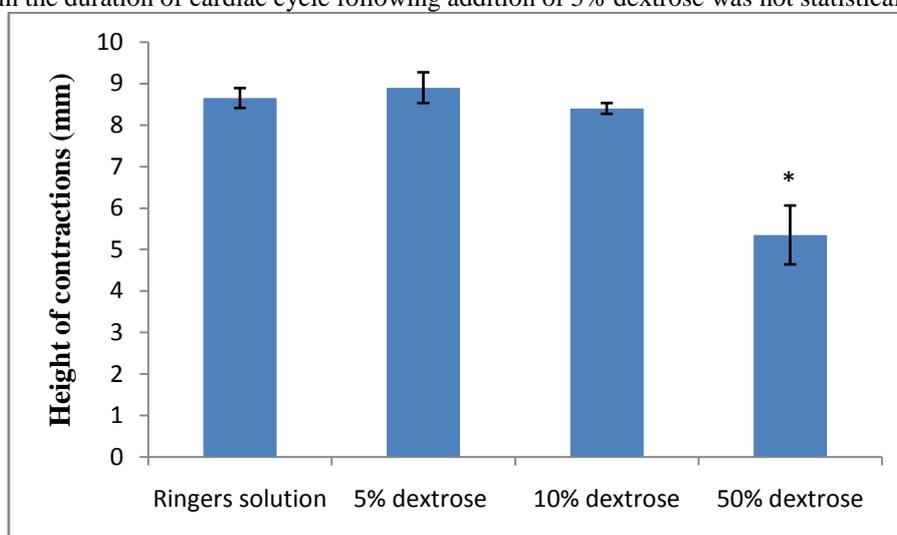
**Figure 1:** showing the frog's heart rate (b/min) obtained after addition of 2ml of frog ringer's, 5%, 10% and 50% dextrose solutions. \* = significant (P < 0.05)

The result shows a significant decrease (P < 0.05) in the heart rate from that obtained with ringer's solution (54.40  $\pm$  0.51) after addition of 5%, 10% and 50% dextrose solutions with mean heart rates of 50.40  $\pm$  0.93, 47.6  $\pm$  0.68 and 41.00  $\pm$  1.22 respectively. The decrease is proportional to the concentration of glucose in the solution.



**Figure 2:** showing the duration of cardiac cycle (seconds) obtained addition of frog ringer’s solution, 5%, 10% and 50% dextrose solutions. \* = significant ( $P < 0.05$ ).

The result shows a significant increase in the duration of cardiac cycle following addition of 10% and 50% dextrose solutions compared with that obtained from addition of ringer’s solution (control) with the mean durations for ringers, 5%, 10% and 50% dextrose been  $1.11 \pm 0.01$ ,  $1.18 \pm 0.02$ ,  $1.26 \pm 0.01$  and  $1.47 \pm 0.05$ . The increase in the duration of cardiac cycle following addition of 5% dextrose was not statistically significant.



**Figure 3:** showing the strength of myocardial contraction (mm) following addition of frog ringer’s, 5%, 10%, and 50% dextrose solutions. \* = significant ( $P < 0.05$ ).

The result shows a significant decrease in the strength of myocardial contraction after addition of 50% dextrose solution only in comparison with the control with the mean strength of myocardial contraction for ringers, 5%, 10% and 50% dextrose solutions been  $8.65 \pm 0.24$ ,  $8.90 \pm 0.37$ ,  $8.40 \pm 0.13$  and  $5.35 \pm 0.71$  respectively. There was slight increase in the strength of myocardial contraction following addition of 5% dextrose solution. However, it was not statistically significant.

#### IV. Discussions

The heart rate reduced significantly following addition of 5%, 10% and 50% dextrose solutions and the reduction was proportional to the concentration of glucose in the solutions. This might be due to direct effect of glucose on the intrinsic heart rate. It was reported that hyperglycemia and glucose intolerance as in metabolic syndrome reduce the rate of spontaneous firing of the S.A nodal cells.<sup>[8]</sup> Our finding is in agreement with that of Schaane *et al.*, (2004),<sup>[9]</sup> who also found a decrease in heart rate in Streptozotocin induced diabetes rats just 5 to 7 days after the induction. They suggested that the decrease in the heart rate was possibly due to effect of hyperglycemia on the intrinsic sino-atrial node function. Contrary to this, other researchers<sup>[7,10]</sup> have reported increase in heart rate due to elevated plasma glucose level, but this might be due to autonomic and endocrine

responses to hyperglycemia such as increase sympathetic activity, which in turn causes increase in heart rate unlike in this present study where the immediate and direct effect of dextrose administration on the heart itself were assessed.

The duration of the cardiac cycle was significantly prolonged following administration of 10% and 50% dextrose solutions. No significant change was found after addition of 5% dextrose. This has indicated that high glucose concentration might interfere with impulse generation, its spread and conduction in the heart. It has been reported that, acute hyperglycemia in healthy subjects causes increase in P-R interval<sup>[11]</sup> indicating slow A-V conductivity and prolong QTc<sup>[11]</sup> indicating impaired depolarization or repolarization, all of which can result to increase in the duration of cardiac cycle. Recently, researchers found that glucose ingestion and hyperglycemia cause cardiac repolarization disturbances, characterized by prolong QTc interval<sup>[5,6]</sup>. It has been suggested that elevated level of glucose might suppress the function of I<sub>kr</sub> ion channels responsible for potassium extrusion, therefore resulting to delay in cardiac repolarization<sup>[12]</sup> which in turn increases the duration of cardiac cycle. Elevation in intracellular glucose was also found to modify the effects of dofetilide (a potent pro-arrhythmic agent) acting directly on I<sub>kr</sub> channels resulting to decrease potassium efflux and prolong QTc.<sup>[5]</sup>

The strength of the myocardial contraction was found to be significantly reduced following addition of 50% dextrose solution to the heart. No significant changes were observed with 5% and 10% dextrose solutions. This has indicated that hypertonic dextrose has negative effect on the strength of myocardial contraction. This is possibly due to its toxic effect on tissues as it is known that hypertonic solution can cause vascular injury and tissue necrosis.<sup>[13]</sup> It was also reported that hyperglycemia has a negative effect on myocardial blood flow and perfusion<sup>[14]</sup> which can also result to decrease in the strength of myocardial contraction. Our findings are in support of a previous study<sup>[9]</sup> where they demonstrated that hyperglycemia results to myocardial dysfunction and decrease force of myocardial contraction.

### Conclusion

Direct administration of 5%, 10% and 50% dextrose solutions to the frog's heart caused a significant decrease in the heart rate, 10% and 50% dextrose significantly prolonged the duration of the cardiac cycle, and the strength of myocardial contraction was significantly reduced following administration of 50% dextrose solution.

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