The Effects of Low Atmospheric Pressure on Blood Chemistry and Cell Structure

Sarah Bell, Scott Bain, M.S., Sherry McCormack, M.S.
Hopkinsville Community College – Balloon Satellite Team, Hopkinsville, Kentucky

INTRODUCTION

The purpose of this research experiment was to study the effects that a large change in atmospheric pressure would have on the blood chemistry and cell structure of a canine. The question of interest was whether the blood cells would burst due to the low pressure and how this would affect the blood's chemistry, if at all. The pressure, at an altitude of 90,000ft, would be 1.76kPa or approximately 1.8% of that on Earth's surface (Knight 403-404). The effects of hemolysis due to freezing have been well studied, but the effects on blood chemistry and cell structure due to low atmospheric pressure have not been as well studied. If blood is exposed to temperatures below 2-4oC, or exposed to temperatures above 66-70oC, the cells will burst. Controlling the temperature of the samples sent to near-space, was therefore imperative to the success of the experiment.

MATERIALS

In this experiment an insulated box (Figure 1) was used to assist in maintaining the temperature, blocking radiation, and in preventing the blood tubes from breaking due to the rough landing of the parachute and payload line.

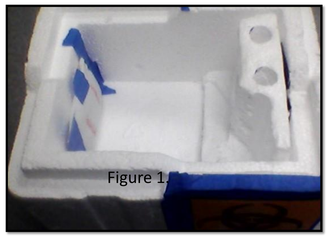


Figure 1.

PROCEDURES

Two tubes of blood containing the anticoagulant powder "EDTA" were used to study the blood's cell structure and two tubes of whole blood that were allowed to clot were used to study the blood's chemistry. One tube of blood containing the anticoagulant and one of whole blood without an anticoagulant were placed in the end of the box opposite the handwarmer (Figure 1). The other two tubes (the controls) were kept in a room that was at a constant 23°C.

RESULTS

The data for the time vs. temperature graph (Figure 2) was collected by an exposed sensor attached to the payload line. The lowest temperature reached was -67C.

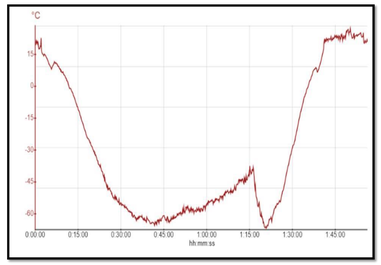


Figure 2.

The blood's cell structure in the control sample (Figure 3) showed no hemolysis. The cell structure of the near-space sample (Figure 4) showed severe hemolysis.

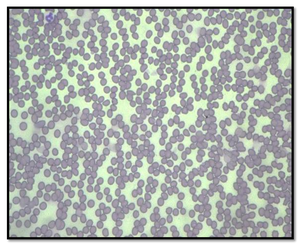


Figure 3.

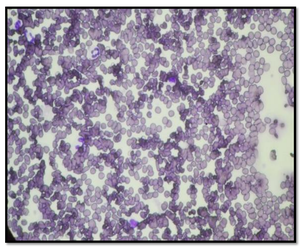
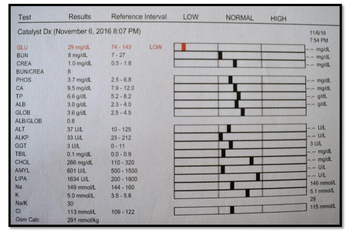


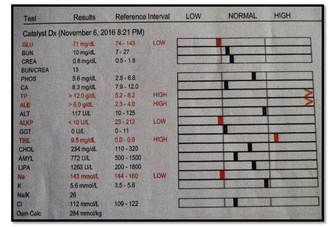
Figure 4.

The chemistry of the control sample (Figure 5) was normal for the length of time and the temperature it was kept at before testing. The chemistry levels of the near-space sample (Figure 6) were all attributable to the low temperature the blood sample was exposed to.



Test	Results	Reference Interval	LOW	NORMAL	HIGH
Catalyst Dx (November 6, 2016 8:07 PM)					11/6/16 7:54 PM
GLU	29 mg/dL	74 - 143	LOW		
BUN	8 mg/dL	7 - 27			
CREA	1.0 mg/dL	0.5 - 1.8			
BUN/CREA	8				
PHOS	3.7 mg/dL	2.5 - 6.8			
CA	9.5 mg/dL	7.9 - 12.0			
TP	6.6 g/dL	5.2 - 8.2			
ALB	3.0 g/dL	2.3 - 4.0			
GLOB	3.6 g/dL	2.5 - 4.5			
ALB/GLOB	0.8				
ALT	37 U/L	10 - 125			
ALKP	33 U/L	23 - 212			
GGT	3 U/L	0 - 11			
TBIL	0.1 mg/dL	0.0 - 0.9			
CHOL	266 mg/dL	110 - 320			
AMYL	601 U/L	500 - 1500			
LIPA	1634 U/L	200 - 1800			
Na	149 mmol/L	144 - 160			
K	5.0 mmol/L	3.5 - 5.8			
Na/K	30				
Cl	113 mmol/L	109 - 122			
Osm Calc	281 mmol/kg				

Figure 5.



Test	Results	Reference Interval	LOW	NORMAL	HIGH
Catalyst Dx (November 6, 2016 8:21 PM)					
GLU	71 mg/dL	74 - 143	LOW		
BUN	10 mg/dL	7 - 27			
CREA	0.8 mg/dL	0.5 - 1.8			
BUN/CREA	13				
PHOS	5.6 mg/dL	2.5 - 6.8			
CA	8.3 mg/dL	7.9 - 12.0			
TP	> 12.0 g/dL	5.2 - 8.2			HIGH
ALB	> 8.0 g/dL	2.3 - 4.0			HIGH
ALT	117 U/L	10 - 125			
ALKP	< 10 U/L	23 - 212	LOW		
GGT	0 U/L	0 - 11			
TBIL	9.5 mg/dL	0.0 - 0.9			HIGH
CHOL	234 mg/dL	110 - 320			
AMYL	772 U/L	500 - 1500			
LIPA	1263 U/L	200 - 1800			
Na	143 mmol/L	144 - 160			LOW
K	5.6 mmol/L	3.5 - 5.8			
Na/K	26				
Cl	112 mmol/L	109 - 122			
Osm Calc	284 mmol/kg				

Figure 6.

DISCUSSION

When the payload was retrieved and the insulated box containing the blood was opened, the blood was found to have frozen. This was potentially due to a change in the type of balloon used that allowed the payload to reach an altitude of 94,850ft and a lower temperature of -67°C instead of the forecasted -57°C. The blood chemistries of the near-space sample were consistent with that of a sample that had been frozen, with all differences in the two samples attributable to that cause. The blood's glucose levels were low in both samples although significantly lower in the control sample, providing further indication that the near-space sample froze (Figures 5 and 6). These low glucose levels were due to the length of time before the samples were tested, with that of the control being normal for that length of time. Red blood cells use up glucose over time and if the sample is not immediately tested or kept at a temperature low enough to stop the use of the glucose, the glucose will appear abnormally low in the chemistry results.

REFERENCES

Knight, Randall, Brian Jones, and Stuart Field. College Physics: A Strategic Approach. Third ed. Boston: Pearson, 2015. Print.