CONTROL OF RESPIRATION AND CIRCULATION IN THE DOG

INTRODUCTION

This experiment is designed to demonstrate some aspects of the reflex control of the cardiovascular and respiratory systems. Try to predict the response to each experimental procedure before it is performed. What is stimulating the cardiovascular and/or respiratory system? What is the sensor? What are the afferent and efferent pathways of the response? How do local factors modify centrally mediated effects? Which effects are primary; which are secondary?

OBJECTIVES

The student understands and recognizes the stimuli and cardiopulmonary effects of the major cardiovascular and pulmonary reflexes.

1. Demonstrates the cardiopulmonary effects of increasing the anatomic dead space to stimulate the arterial and central chemoreceptors, and intravenous cyanide or lactic acid to stimulate the arterial chemoreceptors.
2. Demonstrates the effects of the arterial baroreceptor reflex by bilaterally occluding the common carotid arteries.
3. Uses positive airway pressure to demonstrate the Hering-Breuer inflation reflex and the effects of compression of pulmonary blood vessels and the great veins on blood pressure.
4. Uses a nociceptive stimulus to elicit the cardiopulmonary response to somatic pain receptor stimulation.
5. Administers norepinephrine before and after bilateral vagotomy to demonstrate the effects of cardiovascular adrenoreceptor stimulation with and without the buffering effects of the arterial baroreceptor reflex.
6. Bilaterally transects the vagus nerves to demonstrate the tonic effects of the Hering-Breuer inflation reflex.
7. Uses weak and strong peripheral vagal stimulation to demonstrate the effects of the parasympathetic innervation of the heart and to produce different kinds of A-V block by varying the stimulator parameters.
8. Uses varying parameters to stimulate the central end of the vagus to mimic the afferent information carried by the vagus that can produce cardiopulmonary reflexes.
9. Occludes the inferior vena cava to demonstrate the effects of decreased venous return.
10. Stimulates a nerve innervating the spleen to demonstrate its red blood cell reservoir function in the dog.
PREPARATION (See also General Directions for Dog Experiments)

A dog, anesthetized with sodium pentobarbital, is provided for each lab group. Its weight is noted on a tag.
   Intubate the trachea.
   Isolate and cannulate the femoral vein to use for intravenous administrations.
   Locate the carotid sheaths. Carefully isolate both carotid arteries and both vagus nerves. Tie a loose ligature around each. **DO NOT CANNULATE THE CAROTIDS.**
   Expose a femoral artery and cannulate it. Push the catheter far into the vessel so that the open end of the catheter is located in the thoracic aorta. Prepare to record the arterial blood pressure via the femoral arterial catheter.
   Isolate the sciatic nerve. **ASK INSTRUCTOR FOR ASSISTANCE.**

Protect exposed structures from drying by applying gauze soaked in saline. Attach electrocardiograph leads in the lead II configuration and attach the spirometer to the end of the trachea tube.
The MacLab will be set up as follows:

   Channel 1: ECG
   Channel 2: Arterial Blood Pressure - Femoral
   Channel 3: Heart Rate
   Channel 4: Tidal Volume from the spirometer
   Channel 5: Respiration Rate
   Channel 6: MABP

Remember to get a control recording before each intervention and to mark any pertinent information on the comment line. Also use the notebook function for more in depth records of the experiment.
Injections should be made rapidly and the injectate quickly flushed into the vein with saline. The injection time should be marked on the comment line of the computer.

After any procedure wait at least 3-5 minutes before starting the next one. In some instances a longer period will be required for full recovery.
PROCEDURE

CONTROL

Make a 5-10 second control recording at a higher speed (change the screen ratio in the bottom right corner of the screen to 1:1) before beginning the experiment. Note the general features of these traces. How do heart rate, blood pressure, respiratory rate, and the ECG compare with those expected for normal animals? Does breathing influence heart rate or blood pressure?

EXPERIMENTS

I. Increased Dead Space

After recording a short control run, attach a 100 cm long rubber tube to the tracheal cannula. Be sure to adjust the endotracheal tube so that the animal must breathe through the 100 cm tube. Continue respiration through the tube for about 3 minutes to produce a significant response. What is the primary response?

II. Response to Peripheral Nociceptive Stimuli

Stimulate the sciatic nerve by tugging on the ligature around the nerve. Observe the response. Continue recording until respiration and blood pressure are restored to control values.

III. Administration of Potassium Cyanide

Inject 1.0 ml / kg KCN intravenously. How quickly does the response occur? (If there is no definite response, double the dose).

IV. Carotid Artery Occlusion

Suddenly occlude both common carotid arteries (without pulling on them), maintain the occlusion for two minutes and then suddenly release the occlusion. How has pressure within the carotid sinus been affected?

VI. Administration of NaHCO$_3$ (Metabolic Alkalosis)

Quickly inject 1.0 ml / kg of 4% NaHCO$_3$.

VII. Administration of Lactic Acid (Metabolic Acidosis)

Quickly inject 1.0 ml / kg of 19% lactic acid.
VIII. Administration of Norepinephrine

Inject 1.0 ml / kg of Norepinephrine.

IX. Effect of Bilateral Vagotomy

Find the loose ligatures around the left and right vagi. Now tie two tight ligatures around each vagus and cut in-between the ligatures. Leave the ligatures on the cut ends in order to facilitate electrical stimulation of the central and peripheral ends later in this experiment. Note that a tight ligature around a nerve creates a pressure block, so effects may occur before the vagi are actually cut.

X. Administration of Norepinephrine after Bilateral Vagotomy

Inject the same dose of norepinephrine as in Part VIII.

XI. Peripheral Vagal Stimulation

Stimulate the peripheral end of the right vagus for 10 seconds. The stimulator should be set up as follows:

Volts: Approx. 5 volts  Frequency: Approx. 60 Hz.
Duration: 2-4 msec  Delay: 0

Now try altering the voltage and frequency controls to show the response to milder and more intense stimuli (Stay below 15V.)

Repeat the above stimulation using the left vagus. Is there any difference between the response to stimulation of the right and left vagi? Are the ECG results similar?

XII. Central Vagal Stimulation

Stimulate the central end of the vagus with several different combinations of frequency and intensity. Are the results consistent? Explain.
Procedures XIII and XIV should be performed if there is sufficient time.

XIII.  Occlusion of Vena Cava

Make a midline incision in the abdomen. Gently push the abdominal contents to one side and locate the vena cava. Briefly occlude the vena cava with your fingertips.

XIV.  Stimulation of the Sympathetic Innervation of the Spleen

Gently expose the spleen. Locate and electrically stimulate one of the nerves innervating the spleen.

REFERENCES
Circulatory Physiology, Smith and Kampine – 3rd Ed. Williams & Wilkins

Pulmonary Physiology, 5th Ed. - Levitzky - McGraw-Hill

LAB REPORT: DUE BY 1:00 DAY FOLLOWING LAB
BOX OUTSIDE PHYSIOLOGY OFFICE 7205 7TH FLOOR

1 PER GROUP : TURN IN PRINT OUT OF:

RESPONSE TO NaHCO3
RESPONSE TO LACTIC ACID
RESPONSE TO NOREPINEPHRINE THE SECOND TIME

TURN IN DATA SHEET
FILL IN WITH ARROWS RELATIVE TO CONTROL
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