

Scisense PV Surgical Protocol

Rat Left Ventricle Acute Pressure-Volume Measurement (Open Chest Approach)

APPLICATION BASICS

Site: Left Ventricle - Open Chest

Species: Rat

Body Weight: 200 - 500 grams

Duration: Acute

CATHETER

Size: 1.9F

Type: Pressure Volume or VSL Pressure Volume

Catalog #: FTH-1912B-8018 or FTH-1918B-E218

SYSTEM ADV550 / ADVantage

Application

The hemodynamic properties measured by the pressure-volume system can be used to determine cardiac function. Performing an IVC occlusion as part of the pressure-volume measurement process allows for the determination of load-independent indices.

Anatomical Landmarks

Open chest approach - thorax/upper abdomen area over the xyphoid, proximity of the sternal manubrium. Cut through the diaphragm to expose the apex of the heart. To reduce bleeding avoid incisions around sternum.

Pre-Surgical Preparations and General Anesthesia

See Research Equipment Sources (RL-90-tn) for recommended equipment suppliers. Prepare an area for scrubbing in a separate location from where the surgical operation will take place. For cardiac surgery, it is best to find low-traffic area. Ideally, clean surfaces using disinfectants with low reaction to organic materials (e.g. Phenolics -- Lysol, TBQ).

Basic surgical supplies for rat cardiac surgery should include a sterile surgical instrument pack and sterile supplies (i.e. drapes, 4 x 4" gauze squares, Q-tips, disposable high-temp fine tip cautery, 5 ml syringes, saline rinse, tray, gloves, mask, head bonnet and sterile suture packs). In addition, a glass bead sterilizer, heating water blanket or approved electrical heating/feedback control unit should be used. Heat lamps are not ideal for body temperature maintenance and can often be a source of electrical noise/interference. Delicate rodent surgical instruments should be inspected for damage before sterilizing.

Set up surgical microscope (interpupillary distance, check light bulbs, adjust to check magnifications), organize surgical table and fine-tune surgical stool to a comfortable setting where the triangular position can be reached (both feet touching the ground with both arms comfortably resting on the surgical table). Turn on glass bead sterilizer.

Prepare 0.9% saline or a similar isotonic fluid and pre-warm the solution if it will be given pre-operatively. When a decision is made to use pre-warmed sterile isotonic fluids subcutaneously it is also suggested to use a preventive analgesia.

Before inducing anesthesia be sure to record weight, age, sex, strain, colony history and health status of each rat, and determine whether animals have had enough acclimatization time (usually 3 days post arrival). Check rat's respiratory rate (65-110 breaths/min), heart rate (305-500 beats/min) and temperature (38.1-38.5°C).



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Rat Left Ventricle Acute PV Measurement (Open Chest) Cont.

Pre-Surgical Preparations and General Anesthesia Cont.

Shave the animal while on the warming pad using a #40 blade attached to Oster small animal clippers (Harvard Apparatus). Remove any remaining hair from the surgical area using a depilatory cream (e.g. Nair). Apply surgical scrub alternating between disinfectant (i.e. iodophores, chlorhexidines) and alcohol. Please remember: iodophores will inactivate a wide range of microbes, however literature describes their reduced activity in the presence of organic matter.

Use gauze squares for scrubbing. Scrubbing should always begin along the incision line and extend outwards, ensuring contaminants are not pulled towards the surgical site. Always scrub larger surface area than surgical field. Do not wet large area of skin or fur with alcohol to avoid hypothermia. Consider using drapes to maintain a sterile field and preserve body temperature.

Pre-anaesthetize rats for cardiac surgery with 3-4% Isoflurane (Forane) mixed with driving gas (Oxygen) 0.5 L/min inhaled in Plexiglas induction chamber with lid. It is important not to disturb rat during induction. Apply an ophthalmic ointment to both eyes following induction of anesthesia to prevent corneal drying.

Use pre-cut Styrofoam as a reclined platform with rubber band attached to the edges at the top to allow rat's neck to be situated at the top with rubber band attached to his upper incisors. Use atraumatic forceps to carefully pull out the tongue. Transorally intubate using a 16-gauge polyethylene catheter with help of fiberscope by directly illuminating ventral area of the neck. Insert catheter into the larynx past the 2 valves (vocal cords). Ventilate with tidal volume of 2.5 mL, with 85 ventilation cycles per minute. Keep the intubation catheter in alcohol between intubations for disinfection, use 50 mL syringe to clear off any residual alcohol, to avoid aspiration.

When connected to ventilator, inspect breathing pattern, color of membranes and capillary refill time. If feasible, use pulse oximetry. We have found that Isoflurane produces an excellent long-term controllable anesthesia for cardiac surgery as well as for other procedures in the chest cavity. Adequate anesthesia is accompanied by loss of muscle tone and by loss of reflexes (e.g. corneal, pinnae and pedal).

Regulate post-induction anesthesia to 2% with animal placed on a warming pad (38°C) in a supine position, with the upper and lower extremities attached to the table with surgical tape. Maintain rat on 2% Isoflurane by using rodent ventilator operated in pressure-controlled mode with a maximal airway pressure of 30 cm H₂O, and a positive-end expiratory pressure of 1–3 cm H₂O. Prior to surgery calculate the ventilator set up. Formula is based on animal mass (M_b):

- Respiration rate (RR, min⁻¹) = 53.5 * M_b^{-0.26}
- Tidal volume (V_t, ml) = 6.2 * M_b^{1.01}

Rat Weight (g)	RR (min ⁻¹)	V _t
250	77	1.53
300	73	1.84

It is recommended that a "circle re-breathing circuit" with the vaporizer positioned outside of this system is used for anaesthetic delivery. Control successful ventilation by running blood gas analysis to confirm normal gas exchange.

Prior to surgery, soak the tip of the PV Catheter in 0.9% saline for ~ 20 minutes. Connect the ADV550/ ADVantage system to the data acquisition software, ensuring all channels are calibrated. See Manual and Quick Start Guide for more details. After soaking, adjust the pressure balance to zero for atmospheric pressure.

Other methods of anesthesia may be used. Be sure to consider cardiovascular impact of anesthetic choice. Please adhere to your institutions guidelines for anesthesia and pain management. See Rodent Anesthesia Guidelines (RL-67-tn) for more considerations.

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Rat Left Ventricle Acute PV Measurement (Open Chest) Cont.

Surgical Approach

Prior to surgery, soak the tip of the PV Catheter in 0.9% saline for ~ 20 minutes. After soaking, adjust the pressure balance to zero for atmospheric pressure. See "Balancing Pressure Sensors Before Use" on page 29 for guidelines.

Anesthetize rats with 3- 4% Isoflurane and maintain anesthesia with 2% Isoflurane by ventilator. Secure animal in dorsal position on the heating pad. Make V shape skin incision in the lower thorax/upper abdomen area over the xyphoid (Fig. 1). Separate the skin from the chest wall by blunt lateral dissections. Open the abdominal wall in the proximity of the sternal manubrium (Fig. 2). Cut through the diaphragm to expose the heart apex (Fig. 3). Try to avoid any incisions around sternum to limit bleeding. Try not to artificially retract rib cage. Gently maneuver the apex, using Q-tips into the diaphragm opening.

Use the 25G needle for the LV apical stab. After a successful stab, blood is found in the needle tip (Fig. 4). As the needle is withdrawn from the LV myocardium, with your other hand, insert the 1.9F Catheter through the stab wound (Fig. 5) until the distal electrode of the catheter is fully surrounded by LV muscle (Fig. 6). This is a critical step where all electrodes have to be fully submerged in the ventricle's cavity. Position the Catheter using the live volume feedback function of the ADV550. Additional data provided by phase and magnitude will help in this process as well and is covered in several of our technical notes.

Allow the Catheter to stabilize in the LV for 5-10 min before marking the data file to start protocol. Catheter positional adjustment needs to be made based on acquired signals, primarily coming from the live volume channel, but also coming from phase angle (θ) and admittance magnitude (Y) channels. All signals should have a sinusoidal wave profile. In the case of an off-center position, acquired sinusoid signals might be distorted as e.g. (low amplitude, frequency etc.). Reposition the Catheter until an optimal position is found – essentially this is where magnitude waves are at their largest and phase waves are stable and devoid of noise or spikes. This position will coincide with physiological data coming from the volume channel. Record load-dependent values during steady state for at least 10 min for each animal before attempting IVC occlusion.

See Catheter Positioning Guide for more information.



Fig. 1: Initial incision in the upper abdomen of rat in dorsal position.



Fig. 2: Open the abdominal wall.

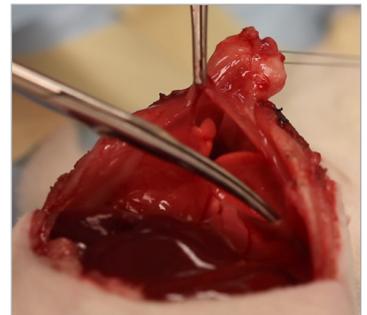


Fig. 3: Cut through the diaphragm to expose the heart apex.

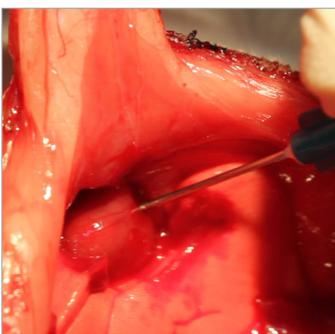


Fig. 4: Stab apex with a 25G needle.

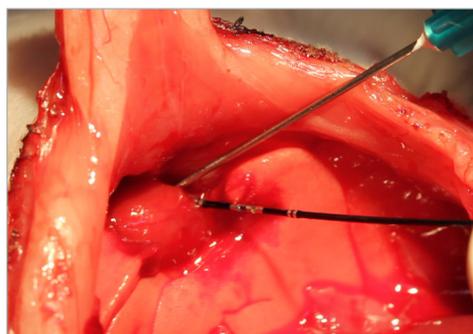


Fig. 5: Insert Catheter into the stab wound.

Rat Left Ventricle Acute PV Measurement (Open Chest) Cont.

Surgical Approach Cont.

IVC occlusion is used to derive various load-independent indices of systolic function. During preparation of the open chest, an IVC occlusion suture (5-0 silk) is placed under the vena cava as it is carefully separated from its adventicia and thoracic aorta (Fig. 7). 5-0 silk is placed above the liver at close proximity of the heart. This position will ensure an immediate volume drop to better control and compare the data sets. IVC occlusions can be performed by pulling on a suture placed around the vessel (Fig. 8). Shut off the ventilation for a few seconds to acquire data without lung motion artifacts.

At the end of the experiment, carefully remove the PV Catheter by gently pulling it back through the stab wound. Immediately, insert Catheter tip into 5 ml saline pre-filled syringe. Clean Catheter as soon as possible according to proper care guidelines to considerably prolong the Catheter's life see Cleaning Guidelines for Scisense Catheters.

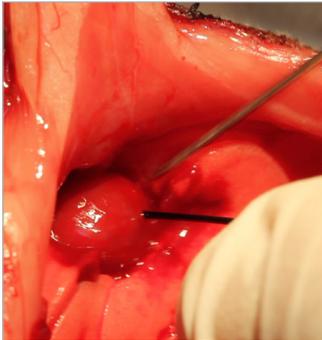


Fig. 6: Submerge all electrodes.



Fig. 7: Place sutures for IVC occlusion.

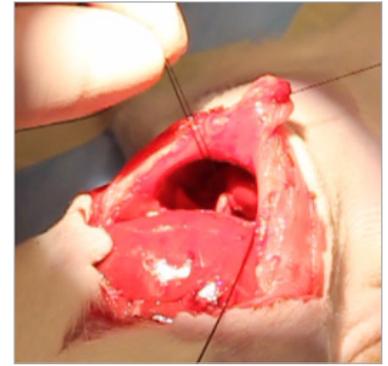


Fig. 8: Pull sutures to perform IVC occlusion.

ACKNOWLEDGMENTS

Toronto General Research Institute,
McEwen Centre for Regenerative
Medicine, University of Toronto, 200
Elizabeth Street, MaRS 3-908, Toronto,
ON, M5G 2C4, Canada.

REFERENCE

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