Intraventricular Pressure Measurement in a Langendorff Preparation

ADINSTRUMENTS

Introduction

In a typical Langendorff experiment, researchers may want to measure intraventricular pressure. However, because the heart is not perfused via the normal pathway, intraventricular pressure cannot be measured with an open-ended catheter. Therefore, a fluid-filled, balloon-tipped catheter is required for insertion into the ventricle. The balloon provides a closed system from which pressure measurements may be made, and intraventricular pressure (i.e. left ventricular developed pressure [LVDP]) determined. The balloon is attached to a fluid-filled catheter and connected to a pressure transducer and bridge amplifier.

The ideal intraventricular balloon should be:

- infinitely thin
- infinitely flexible (i.e. conforms to the ventricular geometry)
- non-elastic (i.e. elastic energy is not expended in compressing the structure of the balloon itself)
- highly responsive (i.e. it should have a linear frequency response to > 40 Hz)

Commercial latex balloons are limited in their ability to meet all of these criteria. Therefore, researchers often prefer to make their own balloons from Saran/Cling/Kitchen Wrap. However, if you do not have such material available then you may use the latex balloons mentioned below or construct a balloon usingthe tip from an unlubricated condom (Section 1).

ADInstruments provide latex balloons that are suitable for use with rats (#170403), guinea-pigs (#170404), miniature pigs (#170405) and small rabbits (#170406). These attach to flexible Teflon catheters:

- The #170423 Teflon catheter is suitable for use with small balloons (#170403 and #170404)
- The #170425 Teflon catheter is suitable for larg balloons (#170405 and #170406).

The catheters and balloons may also be used in conjunction with a miniature pressure transducer for high-quality intraventricular pressure measurements.

This technique note describes how to make balloon catheters from a condom tip (Section 1) or Saran/Cling/Kitchen Wrap (Section 2). While the condom tip is elastic and therefore not an ideal medium, it is still a method commonly used by investigators. For further information, and a guide to testing the function (i.e. response time characteristics) of a custom-made ventricular balloon, see:

- Sutherland FJ, Shattock MJ, Baker KE & Hearse DJ (2003). Mouse isolated perfused heart: characteristics and cautions. Clin Exp Pharmacol Physiol 30: 867-878.

Section 1: How to make a balloon catheter using a condom tip

Step 1: Obtain a long metal needle (21 gauge) with a luer connection.

Step 2: Blunt the end of the needle.

Step 3: Engrave a rim around the metal cannula (approximately 2 to 3 mm from the end of the needle).

Step 4: Cut the tip off an UNLUBRICATED condom and place it over the needle (ensuring that it is long enough to cover the engraved rim of the needle).

Step 5: Tie the condom tip at the top of the needle and then progressively spiral the thread from the first knot at the top of the cannula down to the rim of the balloon and tie a second knot.

Step 6: Carefully bend the catheter so that it may be easily inserted into the ventricle via the left atrium.

Step 7: Attach the needle to a 3-way stopcock and saline-filled syringe (Figure 1).

Step 8: Once the catheter is inserted into the ventricle, partially inflate the balloon to achieve a resting pressure of approximately 5-10 mmHg (Figure 1).

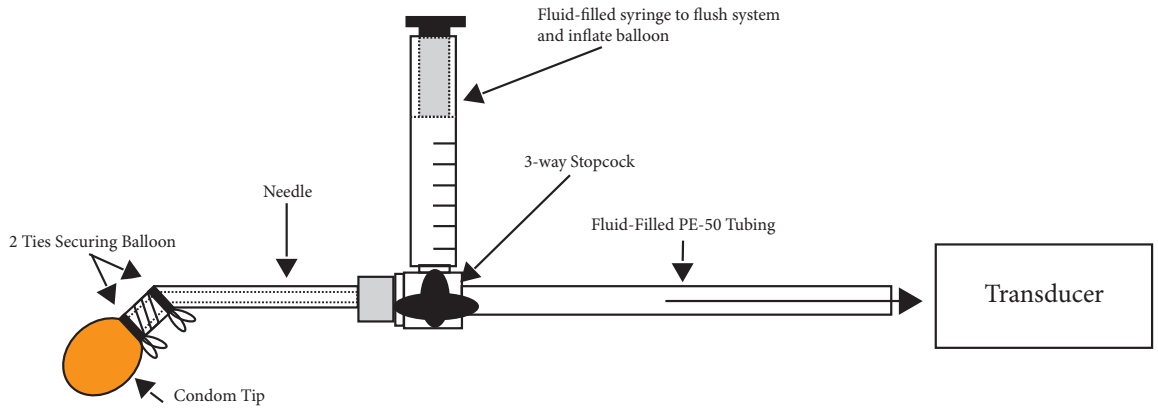


Figure 1. Schematic representation of balloon catheter.

NOTE: CONDOM TIP BALLOONS ARE ONLY SUITABLE FOR CERTAIN HEART SIZES.

Section 2: How to make a balloon catheter using Saran/Cling/ Kitchen Wrap

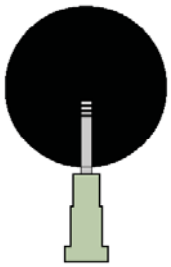
This balloon is intended for mouse hearts; however, the same technique may be used to make balloons for isolated hearts of all sizes.

Step 1: Cut a circle of ordinary domestic "cling film" (kitchen/Saran wrap) that is about 25 mm in diameter.

Step 2: Obtain a long, metal needle (21 gauge) with a luer connection.

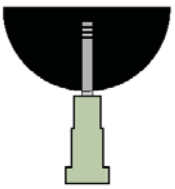
- Blunt the end of the needle.
- Cut a series of grooves (3) into the metal cannula.

Step 3: Place the needle tip slightly below the center of the cling film.

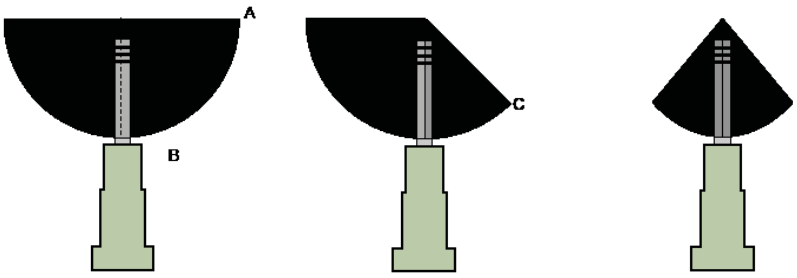


Step 4: Fold the circle in half, leaving a small space between the tip of the needle and the fold in the cling film.

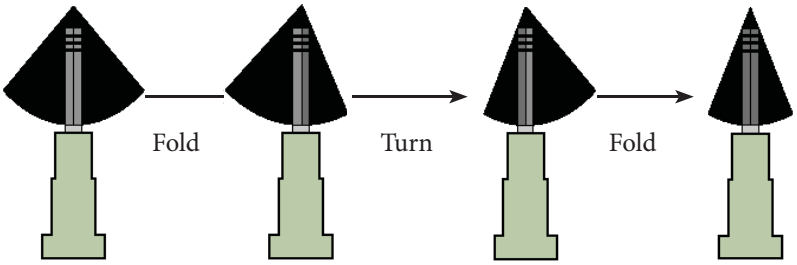
The size of the small space will determine the size of the balloon.



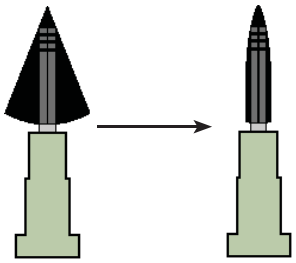
Step 5: Fold point A to B, creating point C (Repeat for other side)



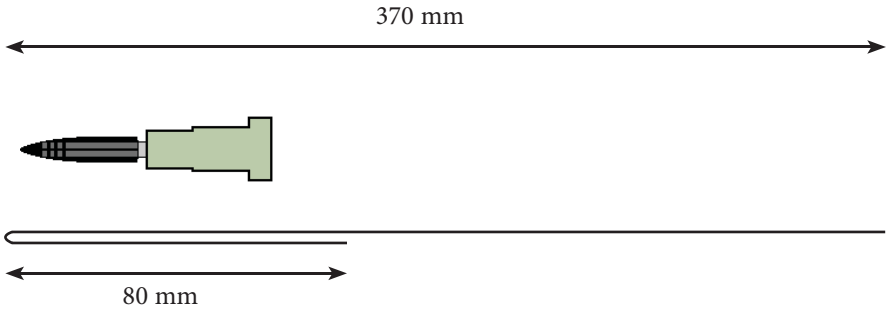
Step 6: Repeat Step 5.



Step 7: Check the position of the needle from the point of the cling film then press the cling film around the barrel of the needle, rolling it between finger and thumb to ensure a tight seal around the needle.



Step 8: Fold over a length of thread to create a loop at one end. Using your left hand (if right-handed) place the thread on the needle and cling film, allowing the loop to protrude past the tip. The shorter length should end past the plastic barrel of the needle. The longer end should be long enough to twist around the length of the cling film wrapped needle. Hold the needle tip and thread loop in your left hand. Take the end of the longer thread in your right hand and, starting at point H (just short of the cut end of the cling film), wind it tightly around the needle, moving from right to left. It is important that this is kept under tension and wound quite tightly as it stops the fluid escaping from the inflated balloon.



Continue to wind the thread around the needle until you reach the point just to the right of the tip of the needle. The end result should be a single layer of thread which is as neat as possible – remember that it has to pass through the mitral valve when the balloon is inserted and as such must not cause any irritation.

Put the end of the wound thread through the loop and hold firmly. Take hold of the short end of the thread and pull it. This will close the loop, dragging the long piece of thread so that it is trapped under the wound thread. Snip off any remaining thread. As in Section 1, slightly bend the cannula to help placing it into the ventricle.

Using boiled (degassed water) fill a syringe and inflate the balloon. Remove all air bubbles (by repeatedly filling and emptying the balloon while holding it vertically). Overstretch the balloon (130 µL should be sufficient in this case) – this makes the cling film even thinner and creates an oval shape.

Section 3: Inserting the balloon catheter into the ventricle?

The left atrium has to be cut first so that the entrance to the left ventricle is clearly visible. The balloon is inserted when it is deflated and then partially inflated (by injecting fluid through the catheter) to achieve a resting pressure of approximately 5-10 mmHg.

Note: The balloon must be sufficiently large to allow it to be fully inflated to greater than the size of the stretched ventricular lumen without itself exerting any pressure. This should be tested in the absence of a heart! It is recommended to make various size balloons and choose the most appropriate one to match the heart.

References

- Sutherland FJ, Shattock MJ, Baker KE and Hearse DJ (2003) Mouse isolated perfused heart: characteristics and cautions. *Clin Exp Pharmacol Physiol* 30: 867-878.
- Sutherland FJ, Baker KE, Shattock MJ and Hearse DJ (2003) Responses to ischaemia and reperfusion in the mouse isolated perfused heart and the phenomenon of "contractile cycling". *Clin Exp Pharmacol Physiol 30:* 879-884.
- Curtis MJ, Macleod BA, Tabrizi R and Walker MJA (1986) An improved perfusion apparatus for small animal hearts. *Journal of Pharmacological Methods* 15: 87-94.

Acknowledgements

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