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Angiostomy Cannulae for the Study of Pulmonary Circulation.*† (20102)

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London(1) used angiostomy cannulae for the purpose of directing hypodermic needles into the larger thoracic vessels. Daly(2) reported the measurement of pulmonary arterial pressure in the unanesthetized dog by means of the London Type cannulae. Johnson, Hamilton, Katz and Weinstein(3) in the same year studied the dynamics of pulmonary circulation by means of hypodermic manometers, the needles being placed in the aorta, pulmonary artery and pulmonary vein. Hamilton, Woodbury and Vogt(4) studied differential pressures in the lesser circulation of the unanesthetized dogs using angiostomy cannulae and hypodermic manometers. Katz and Steinitz(5) developed a modification of the angiostomy cannulae used by Hamilton, and used their cannulae in measuring pul-

monary arterial pressures.

The purpose of this paper is to report the development of a technic permitting direct access to the atria and large thoracic vessels of unanesthetized dogs under conditions which may be compared to normal.

Methods. Two varieties of cannulae were developed and used. The first variety, shown in Fig. 1, a., consists of silver tubes (3 mm outside diameter) fitted with perforated silver plates, one type of which is trough-shaped, to fit over the left pulmonary artery. A second type is flat and oval in shape, suitable for attachment to the left atrium. The length of each silver tube is such that its distal end, the heart serving as reference point, will lie immediately under the skin of the chest wall. The perforated silver plates are made from 2 mm silver stock. The plate attachment that is fitted over the left pulmonary artery is 8 mm long and of sufficient width so that when bent in a semicircle of the correct radius it extends over half the circumference of the

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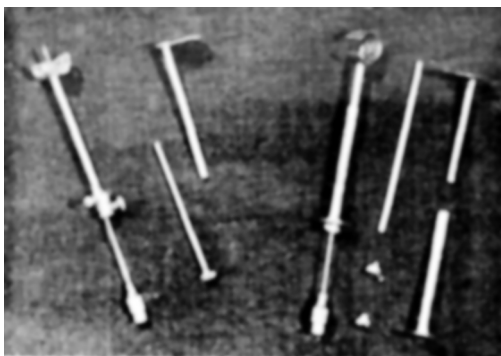


FIG. 1. a. Silver cannulae (left side). b. steel cannulae (right side) for surgical placement on left pulmonary artery and left atrium of dogs.

vessel. The oval plate for attachment to the left auricle measures 15 mm by 10 mm. The cannula tube is fixed in an opening 5 mm from one end of the oval plate. This arrangement allows placement of the cannulae on the auricle immediately beneath the entrance of the pulmonary veins into the atrium. Stainless steel stilettes must be used in the silver cannulae to prevent occluding fibrin formations and bending of the cannulae. These stilettes are made from 4 mm stainless steel rod; they are fitted on one end with No. 9 silverplated brass nuts. Hypodermic needles are fixed within the cannulae by means of "coupling" bushings equipped with 2 set-screws. These fittings are 7 mm long and of sufficient diameter so as to fit closely over the distal end of the cannula. One set-screw serves to fix the bushing to the cannula; the second set-screw serves rigidly to secure a hypodermic needle within the tube at the desired depth.

A second type of cannula shown in Fig. 1, b., is made of stainless steel tubing. Each cannula consists of 4 different parts: Two tubes, a proximal tube telescoping into a distal one; and 2 end pieces, one "closing" end piece and one "cannulating" end piece. The proximal tube measures 6.5 cm long and 3 mm in external diameter with a lumen of 1.5 mm. The proximal tubes are fitted with perforated plates 0.2 mm thick and are bent to conform in shape with the organ over which they are to be placed. One type is so shaped as to accommodate the left pulmonary artery and consists of a ring 10 mm in

diameter and 4 mm wide. The width of the slit in the open ring is adjustable in order to allow it to slip around the artery when the vessel is collapsed. This open ring is fitted with a 10 mm length of polyethylene tubing of sufficient diameter to allow slipping the latter over the band portion of the ring so as to close the open portion when the device is placed around the left pulmonary artery. The tubing protects the vessel from possible trauma from the free edges of the slit in the steel ring. The second type of perforated plate, designed to attach to the left atrial wall, is oval, flat and flexible.

The distal tube of the cannula, which telescopes over the proximal tube, is formed by a stainless steel tube 6 cm long and 4 mm in external diameter. Its distal end presents a circular perforated flange for attachment to the chest wall. This arrangement enables instantaneous adjustment of the length of the cannula to the variations in depth of the pulmonary artery or left atrium from the skin surface. The inner aspect of the flange end of the distal cannula is threaded to the depth of 4 mm so that either of two end pieces, a "closing" or a "cannulating" end piece, may be screwed into it.

The "closing" end piece is a large headed screw which threads into the flange and allows complete closure of the cannula when not in use.

The "cannulating" end piece is a bushing threaded to fit into the flange of the distal cannula. It is perforated in its center so that hypodermic needles up to 14 gauge in size may be inserted, and is fitted with a small set-screw which enables the fixing of the needle within the cannula. It is necessary to use lengths of suitably-sized polyethylene tubing as stilettes for these cannulae, to prevent fibrin occlusion.

The cannulae are placed about the left pulmonary artery and attached to the left auricle through a thoractomy incision made in the left 4th intercostal space. Nembutal anesthesia is used, and respiration is maintained by an electric mechanical respirator. The pericardial sac over the left pulmonary artery is incised, thereby exposing this vessel and the adjacent left auricle. The visceral

layer of the pericardium over the left pulmonary artery is incised and freed from the vessel for a sufficient distance to allow the placement of the cannula over or around the vessel, depending upon the type of cannula used. After placement, the visceral pericardium is sutured over the cannula end piece. The oval atrial cannula plate is sutured to the muscular wall of the left auricle. Care must be exercised to avoid entering the chamber of the organ. Aqueous penicillin (10000 units) is injected into the pericardial and pleural sacs, after which they are closed with 4-0 silk suture. It is important that the atrial cannula be directed cranially and dorsally from its attachment and that the pulmonary artery cannula be directed laterally. In event the steel telescoping cannulae are used, it is necessary at this time to place the distal portions of these cannulae over the proximal portions. Following the placement of the above-mentioned stilettes within the tubes, the distal ends of the cannulae, either steel or silver, are then fixed to the chest wall in the subcutaneous fascia. The thoractomy incision is closed in three layers; the residual air in the pleural cavities is then removed by aspiration. The skin and subcutaneous fascia are sutured over the ends of the cannulae. Procaine penicillin (150,000 units) is administered intramuscularly.

Dogs are ready for use one week following surgical preparation. Prior to experimental study, the skin over the cannulae is anesthetized with 2% procaine hydrochloride solution. Incisions through the skin and superficial subcutaneous tissues are made to expose the distal ends of the cannulae. In the event steel cannulae have been used, the closing end pieces and polyethylene tubings are removed, and the "cannulating" end pieces are screwed into place. If silver cannulae have been used, the steel stilettes are removed and the "coupling" bushings fitted and fastened on the ends of the silver tubes. The exact

distances from the distal ends of the cannulae to the left atrial cavity and to the pulmonary artery lumen may be determined by slowly inserting through the cannulae 20 gauge, 8 cm long needles fitted with saline-filled syringes to which negative pressure has been applied. The depth at which blood first appears in the syringe, indicates the desired position of the tip of the needle in the artery or atrium; this depth is marked on the needle with a small piece of zinc oxide tape. This same needle or another needle may then be used in the pulmonary artery or the left atrium for whatever purpose the investigator may desire. Pressures may be measured, samples may be taken, or temperature measuring devices may be placed within these vascular structures.

After completion of an experimental study, the needles are removed and the stilettes are replaced. In the event steel cannulae have been used, the "closing" end pieces are replaced. The wounds are liberally powdered with sulfonamide, dressed with gauze, and covered with plaster of Paris bandage. The bandage must cover the thorax of the animal and the base of the neck in order to adequately protect the wounds and limit infection. A second experimental study can be carried out 24 to 48 hours after the first. By following this procedure, it has been possible to use some animals as many as seven times within a period of 14 days.

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