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A Simple Double Channel Swivel for Infusions of Fluids into Unrestrained Animals

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BLAIR, R., B. FISHMAN, Z. AMIT AND J. R. WEEKS. *A simple double channel swivel for infusions of fluids into unrestrained animals.* PHARMAC. BIOCHEM. BEHAV. 12(3) 463–466, 1980.—The construction of a double channel swivel for infusing two fluids separately into an unrestrained animal is described. The swivel is constructed of readily available, inexpensive materials and does not require any machining of parts. These swivels have been found to last for 720 hr without leakage.

Double channel Flow-thru Swivel Unrestrained animals Infusions Two-channel

THE ADMINISTRATION of fluids into unrestrained animals requires the use of a fluid-tight, flow-thru swivel. To date, there are several reports describing the construction of one channel, fluid swivels designed for animal research [3, 6, 7]. In some experiments it is necessary to infuse two different fluids into the same animal. If a one channel swivel is used, the animal must be restrained while infusing the second fluid. In situations when it is more desirable not to restrain the animal, a double channel swivel is needed. Double channel swivels have been described [2,5]. Although these swivels are useful, they require machining of the casing [5] or a motor to rotate the swivel [2].

We describe here an inexpensive, double channel, low torque swivel which is easily assembled with readily available materials and common hand tools. The swivel is illustrated in Fig. 1. The external casing is made from a 3 ml plastic syringe (o). Inside of this syringe there is a rotating assembly (h–m) made from a 1 ml plastic syringe divided into two chambers by rubber plunger tips from 1 ml syringes (i, l). Fluids enter the top and bottom chambers thru 22 or 27 ga hypodermic tubing, respectively (a, b). The two rubber tips are the seals. Fluid from the bottom chamber flows out thru a 22 ga hypodermic needle (q) attached to the chamber assembly. Fluid from the top chamber flows out thru 26 ga hypodermic tubing welded into the side of the chamber, which then passes alongside the shaft of the 22 ga needle from the bottom chamber. Another 1 ml plastic syringe (s) and a length of 14 ga hypodermic tubing (u) forms the bearing and a sleeve for the outlets.

MATERIALS

Becton, Dickinson and Co., Rutherford, NJ 07070 (thru local distributors): Plastipak disposable syringes, 1 ml (8045) and 3 ml (5586), Discardit Yale disposable needle, 22 ga, 38 mm (5156). Small Parts, Inc., 6901 N.E. 3rd St., Miami, FL 33138: hypodermic needle tubing 12, 14, 26, 27 ga standard and 22 ga thin-wall (HTX-12, 14, 26, 27 and 22TW, respectively), stainless steel wire 0.36 and 0.46 mm (SWX-14 and 18). National Camera Supply, 2000 W. Union Ave., Englewood, CO 80110: music steel wire 0.18 mm (W-3920). Flexible polyolefin shrink tubing, white, 1.2 mm size, either Alpha Wire Corporation (FIT-221) or SPC Technology (Voltrex type FPS) thru electronic suppliers as Newark Electronics, 500 N. Pulaski Road, Chicago, IL 60624. Dow Corning Corporation, Midland, MI 48640 (thru laboratory suppliers): silicone stopcock grease. Local hardware stores: epoxy glue.

The following tools will be needed: a small hobbyists drill, as Dremel Moto-tool, equipped with a silicon carbide cutting wheel (as dental separating discs, flat, S. S. White Co., 221 S. 12th St., Philadelphia, PA 19105 (No. 17), arranged for a stream of water playing on the wheel (see Fig. 1 [4] or Fig. 4 [8]); a small soldering iron with a pencil tiplet (as Ungar 776 with 45 W element 4035-S and tiplet 332; a vernier caliper rule and a small penknife or scalpel.

ASSEMBLY

Figure 1 illustrates the swivel as four components: the external casing (o), inlet assembly (a–f), chamber assembly (h–l) and the outlet assembly (r–u), which includes the bearing. Hypodermic needle tubing is cut as previously described [3,8]. Cut ends of the tubing are smoothed and rounded by twirling against the grinding wheel, and then sharp points removed by holding perpendicular to the wheel and touching it briefly. The lumen is then cleaned of debris by reaming with the point of a hypodermic needle, passing a wire through the lumen, and flushing with water. Plastic syringes

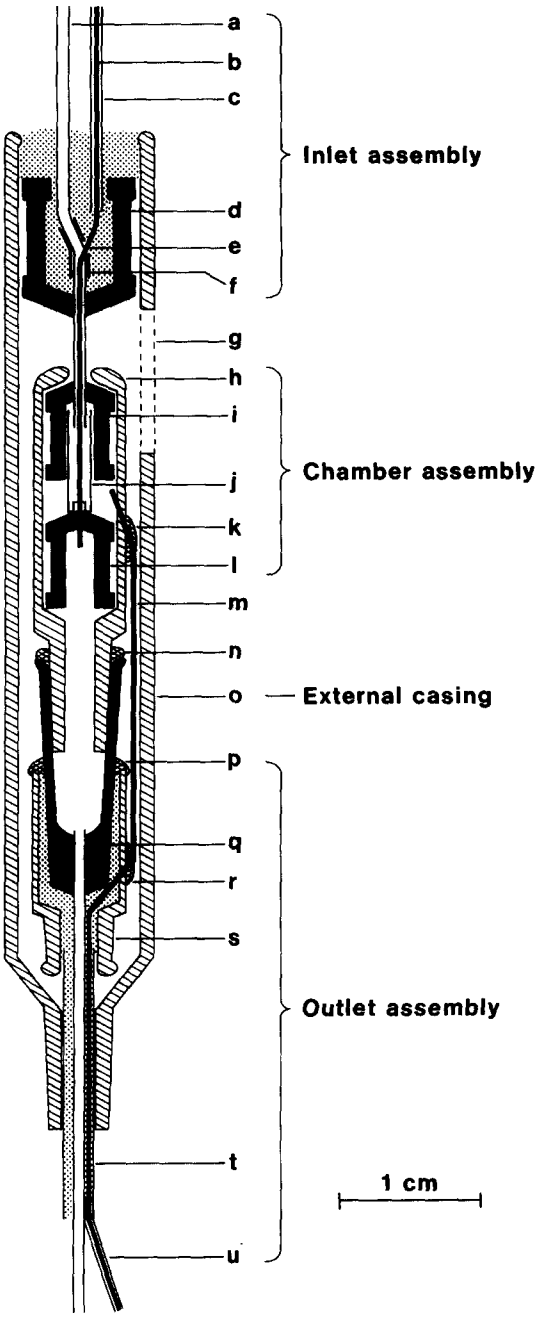

FIG. 1. Longitudinal section of the swivel. (a) Inlet tubing (22 ga thin-wall) to top chamber. (b) Inlet tubing (27 ga) to bottom chamber. (c) Sleeve (22 ga thin-wall). (d) Rubber tip from 3 ml syringe plunger. (e) Slot in 22 ga inlet tubing for 27 ga tubing. (f) Shrink tubing. (g) Inspection window in external casing. (h) Molten crimp on syringe barrel. (i) Top chamber rubber tip from 1 ml syringe plunger. (j) Spacer tubing (14 ga with slot on bottom). (k) Spot weld around 26 ga tubing. (l) Bottom chamber rubber tip from 1 ml syringe plunger. (m) Outlet tubing from top chamber (26 ga). (n) Spot weld of needle hub to Luer tip. (o) External casing from 3 ml plastic syringe. (p) Needle hub and syringe barrel welded together. (q) Outlet from bottom chamber (22 ga disposable need). (r) Spot weld around 26 ga tubing. (s) Bearing from fire-polished Luer tip. (t) Bearing sleeve (14 ga). (u) Sleeve (22 ga thin-wall). Material code: syringe barrels, diagonal hatch; plastic welds, cross hatch; plunger tips and needle hub, solid; epoxy glue, stipple.

are easily cut with grinding wheel operated dry. Cut rapidly to minimize melting of the plastic. Clean edges by picking and trimming with the knife.

Cut the following pieces of hypodermic tubing: 27 ga, 55 ± 1 mm (b, inlet to the bottom chamber); 26 ga 75 ± 1 mm (m, outlet from top chamber); 22 ga thin wall, 35 ± 0.5 mm (a, inlet to top chamber), 20 ± 0.5 mm (c, sleeve over 27 ga inlet tubing), 15 ± 0.5 mm (u, sleeve over 26 ga outlet tubing); 14 ga 7.5 ± 0.2 mm (j, top chamber spacer), 20 ± 0.5 mm (t, bearing sleeve), 75 ± 2 mm (a tool); and 12 ga, 75 ± 2 mm (a tool). Cut a slot 0.7 ± 0.2 deep and about 0.5 mm wide (the thickness of the cutting wheel) across one end of the 14 ga spacer. Cut off the point of the 22 ga, 38 mm needle.

Prepare the plastic syringes as follows. Three ml external casing: enlarge the lumen in the Luer tip with a 2.3 mm (No. 43) drill. Cut off 58 mm from the 0.0 graduation and fire polish at the base of a small gas flame to shrink the end slightly (o). Cut a rectangular opening about 6 mm wide between the 2.0 and 2.6 ml graduations (g). One ml chamber assembly: heat a 0.46 mm wire red hot, hold at about a 30° angle to the syringe barrel, and melt a hole starting at the 0.12 ml graduation angled toward the open end of the barrel (k). Do not force the hot wire. Repeat as often as necessary, allowing the wire to cool each time before withdrawing from the hole. Cut off the barrel at the 0.32 ml graduation. One ml outlet assembly: cut off about half of the Luer tip, twirl against the wheel to insure accurate facing, and fire polish to provide a smooth bearing surface (s). Melt a hole starting at the 0.05 ml graduation angled toward the lumen of the Luer tip [4]. Cut off the barrel at the 0.15 ml graduation. Wipe all parts with a tissue moistened with chloroform to remove the ink.

Inlet Assembly

Take the 35 mm 22 ga thin-wall tubing, remove the temper from an 8 to 10 mm segment starting 10 mm from one end by heating red hot in the base of a small gas flame. Cut a slot in this untempered portion, 12 mm from the end, the width of the cutting wheel and not more than half way through the tubing (e). Center a 5 mm piece of shrink tubing over the slot and shrink in place. Bend the tubing 45 to 60°, insert the 27 ga tubing into the lumen and force through the shrink tubing until 9 mm remains protruding from the lumen. Bend the 27 ga tubing about 45° at the slot, and then bend both 22 and 27 ga tubing to form a "Y" with the arms parallel and about as far apart as the hole in the 3 ml syringe plunger tip. Slide the 20 mm 22 ga thin-wall sleeve over the 27 ga tubing (h). Apply a small amount of epoxy glue to both ends of the sleeve, slide back and forth a few times, taking care not to get any glue into the open lumen of the 27 ga tubing. Align the end of the sleeve even with the other inlet tubing. Then coat the shrink tubing and slot area with epoxy glue (avoid an excess) and allow to harden. Cut excess 27 ga tubing flush to the sleeve.

Take the rubber tip from the plunger of the 3 ml syringe and insert the 12 ga tubing tool in the hole. Place the point of a small sewing needle or common pin (not a hypodermic needle) precisely on the point of the rubber tip. Hold the needle in line with the tubing, rotate the tip slowly and force the needle through the rubber. Remove the 12 ga tubing, place the needle point in the lumen of the 27 ga tubing, and push until the shrink tubing is flush against the rubber (f). (This technique assures that the tubing passes thru the rubber precisely centered and in line, otherwise the swivel will not rotate freely.) If the two inlet tubes are placed further

apart than the hole in the rubber tip, cut out two V-shaped wedges of rubber. Mark the 22 ga tubing 4 mm from the end using a felt pen.

Outlet Assembly

Insert the 20 mm 14 ga tubing into the Luer tip until flush with the inside of the barrel (t). Pass the 26 ga tubing through the hole in the barrel and through the 14 ga tubing until 25 mm protrudes. Force the 22 ga needle into the barrel until tightly in place. The flat side of the needle hub should be under the 26 ga tubing. Make certain that the needle hub is precisely aligned with the bearing by rolling the 14 ga tubing along the edge of the table. Clamp the soldering iron in a suitable support. Weld the barrel and needle hub together by holding the joint against the tip of the iron until the plastic flows together. Then rotate very slowly to complete the weld (p). Take the chamber syringe barrel, align the hole in its side with the 26 ga tubing, and insert tightly into the needle. Spot weld at the two flanges on the needle hub (n). To spot weld the plastic, put a molten drop of plastic on the tip of the iron by wiping with a scrap of syringe barrel. Then apply to the surface, holding the piece almost touching the iron until the plastic flows together. Insert the 26 ga tubing into the hole in the top chamber until the tip is just visible inside the barrel. Force any extra tubing through the outlet assembly (m). Again check the position of the tip of the tubing in the chamber. Spot weld where the tubing enters the chamber and outlet assemblies (k, r).

Pass a 15 cm 0.18 mm wire through the 22 ga needle. Insert the 14 ga tubing tool into one of the 1 ml rubber plunger tips. Force a pin precisely through the center and replace with a 75 mm length of 26 ga tubing. Pass the wire into the tubing and pull out the tubing. This wire will serve as a guide for insertion of the inlet tubing. Push the plunger tip into the chamber. Put some silicone stopcock grease into a 1 ml plastic syringe, attach a 22 ga needle (with the tip cut off). Fill the space between the rings on the plunger tip and syringe barrel with grease. If this space is not filled, pressure in the chambers can deform the rubber tips. Wipe the chamber with a cotton swab to remove excess grease. Slide the 14 ga spacer, slotted end first, over the guide wire. Put the second plunger tip over the wire as above. Push the spacer into the plunger tip and push both as far as possible into the chamber. If the plunger tip touches the 26 ga outlet tubing, use a longer (maximum 8 mm) spacer. Put stopcock grease between the rings on the plunger tip. Rotate the open end of the chamber near the base of a small glass flame until softened, then roll between the thumb and forefinger to crimp the end around the plunger tip (h).

Assembly in the External Casing

Put the chamber and outlet assemblies in the external casing (o). Adjust the bearing sleeve if necessary so the assembly remains centered in the casing when rotated. Put the guide wire into the lumen of the 27 ga inlet tubing and carefully push tubing and plunger tip into the casing. Push the 22 ga inlet tubing into the upper rubber plunger tip to the 4 mm mark. Again check that the chamber assembly is centered. Remove the guide wire.

Spot weld a 22 ga needle (with point cut off) to a 1 ml plastic syringe. Put some epoxy glue in the syringe, expel the air, and insert the needle into the 14 ga bearing sleeve and fill the entire space with glue. Slide the 15 mm 22 ga thin-wall sleeve over the 26 ga tubing, apply a little epoxy glue at both ends, slide back and forth a few times, then force into the bearing sleeve until the end is even with the 22 ga outlet (u). Wipe off any excess glue. Allow the glue to harden while the open end is held upright. Cut excess 26 ga tubing flush to the sleeve.

Fill the open end of the casing, including the lumen of the plunger tip, with epoxy glue. Allow to harden.

A torque arm for the bearing sleeve can be made from the plastic tip protector supplied with the 22 ga needle as described for the single channel swivel [3]. Alternatively, an adapter for the set screw collar used with the BRS/LVE No. 191-10 rat saddle may be made, also as previously described, except that the lumen is 2.2 mm (No. 44 drill).

Optional Construction for Minimal Dead Space

Because of the volume of the chambers and needle hub, solutions cannot be changed without flushing the swivel. The dead space in the lower chamber can be virtually eliminated by filling with silicone stopcock grease and using a 27 ga inlet tubing which extends through the 22 ga needle to its tip. Cut instead 125 ± 2 mm of 27 ga tubing. In making the inlet assembly, allow 80 mm to protrude from the 22 ga thin wall tubing. Select a 22 ga needle which readily passes the 27 ga tubing. If necessary, ream the inner end of the needle tubing. Before putting the first 1 ml plunger tip into the chamber, fill both the needle hub, Luer tip and lumen of the plunger tip with silicone stopcock grease. Put a piece of 22 ga needle tubing in the chamber barrel while inserting the plunger tip to allow entrapped air to escape. Then remove the needle tubing and complete assembly in the same manner. Finally, cut excess 27 ga tubing flush with the end of the 22 ga outlet.

INSTRUCTIONS FOR USE

Air bubbles in the chambers may be eliminated by connecting two syringes each about half filled to both the inlet and outlets, and then force fluid back and forth rapidly.

We have used these swivels for self-injection studies in which rats with two venous cannulas can select between two drugs (drug or vehicle). In addition, in rats with both aortic and venous cannulas, blood pressure has been recorded continuously while giving intravenous injections or infusions of vasoactive substances. For this latter application, blood pressure should be recorded through the upper chamber so the plunger tips will be forced firmly against the ends of the chamber.

The swivels should be checked periodically for leaks. A leak from the upper chamber is readily visible through the opening in the casing. To detect a leak from one chamber to the other, use a colored fluid in one channel, force through using moderate pressure, and examine the fluid in the other channel for color. For more accurate testing, flush one chamber with a quinine solution and test fluid in the other for quinine using a spectroflurometer [1]. We have found no leaks between chambers after 4 weeks of continuous use.

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