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A Simple Intravenous Catheter for Use with a Cranial Pedestal in the Rat[1]

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STRIPLING, J. S. *A simple intravenous catheter for use with a cranial pedestal in the rat.* PHARMAC. BIOCHEM. BEHAV. 15(5) 823–825, 1981.—A catheter design and implantation technique are described which permit the repeated infusion of drugs into the external jugular vein of the rat. The catheter is designed specifically for use when electrode implantation or other surgery requires the construction of a cranial pedestal from dental acrylic. The speed and simplicity of the catheter's construction and implantation are advantageous, and it performs reliably for several months after implantation.

Rat Intravenous catheter

THE use of chronically implanted intravenous catheters for the administration of drugs to freely moving laboratory rats is an important technique in behavioral pharmacology, and a number of successful catheter designs have been reported [1–10]. Many of these designs are for applications in which only a catheter is to be implanted, in which case a major concern is externalizing and anchoring the catheter in such a way that the animal's movements will not damage it or pull it loose from the vein. To solve this problem, several catheter designs [3, 8, 10] involve the coupling of soft, flexible silicone rubber (Silastic) tubing for insertion into the vein with stiffer, more durable polyethylene tubing to withstand the flexing and stress present at the point of exit from the animal and at the points where it is anchored by sutures. This type of design, while satisfactory, is somewhat time-consuming to construct and cumbersome to implant. A simpler design omitting the polyethylene tubing can be used if the Silastic tubing is coupled to a connector anchored to a cranial pedestal. Several designs of this sort have been reported, each differing from the others in the details of the construction and the implantation technique [4, 6, 7, 9].

The present report describes a catheter for intravenous drug infusion in the rat which is designed specifically for use when electrode implantation or other surgical procedures require the construction of a cranial pedestal from dental acrylic. The catheter is very easily and rapidly constructed because of the simplicity of its design and because there is no need for a previously constructed pedestal. Its design and the implantation techniques described here reduce implantation time to a minimum. In addition the catheter is reliable and has been shown to remain functional for several months following implantation.

DESIGN AND CONSTRUCTION

The design of the catheter is illustrated in Fig. 1. The catheter itself has three parts: (A) a 105 mm length of Silastic tubing (Dow Corning 602-105, 0.305 mm (0.012 in.) i.d. $\times$0.635 mm (0.025 in.) o.d.); (B) an 18 mm length of 23 gauge (0.635 mm o.d.) stainless steel hypodermic needle tubing; and (C) a 9 mm length of flexible polyolefin heat shrinkable tubing (1.191 mm (3/64 in.) Alpha FIT-221 or Voltrex FPS). The length of the Silastic tubing is suitable for rats weighing 350–450 g; it should be adjusted for animals of different size. The 23 gauge tubing should be deburred and slightly rounded at the ends to avoid damage to the Silastic.

The catheter is assembled as follows. One end of the Silastic tubing is placed in chloroform for 1 min to expand it. The 23 gauge tubing is then inserted into it a distance of 7 mm. When the chloroform has evaporated, the heat shrinkable tubing is placed around the joint so that its end is even with that of the Silastic tubing and shrunk over a flame, taking care not to burn the Silastic. The purpose of the heat shrinkable tubing is to reinforce the joint and to protect the Silastic tubing at its point of exit from the cranial pedestal. The first 1–2 mm of the open end of the Silastic tubing is then occluded with silicone adhesive; Silastic Medial Adhesive Silicone Type A (Dow Corning 891) is recommended, but the hardware store variety (Dow Corning 698) can be used successfully. The adhesive can easily be inserted into the catheter using a syringe with a 27 gauge blunt needle. When the adhesive is dry, 6 holes are made in the catheter near the plug by pressing a 25 gauge hypodermic needle through both walls of the Silastic tubing. This forms a one-way valve which allows drug out under pressure but prevents blood from entering [3]. The catheter is coupled to the infusion system with polyvinyl chloride tubing (Tygon S-54-HL, 0.508 mm (0.020 in.) i.d. $\times$1.524 mm (0.060 in.) o.d.), which makes a tight friction fit onto the open end of the 23 gauge tubing. When the catheter is not in use it is capped with a short segment of the Tygon tubing which has been sealed with pliers heated in a flame. The volume of the assembled catheter is 8.4 μl.

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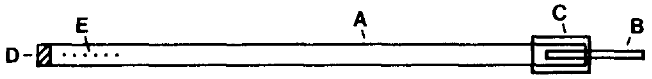

FIG. 1. Illustration of the catheter design (not drawn to scale). (A) Silastic tubing. (B) 23 gauge stainless steel tubing. (C) Heat shrinkable tubing. (D) Plug of silicone adhesive. (E) Holes forming the one-way valve.

The most time-consuming aspect of the catheter construction is cutting and deburring the 23 gauge tubing. This step can be eliminated by ordering 23 gauge tubing cut to length from the Everett Products Division of Popper & Sons, Inc., 300 Denton Ave., New Hyde Park, NY 11040. Once the 23 gauge tubing is prepared, the assembly time is only a few minutes per catheter.

IMPLANTATION

Detailed surgical procedures for catheter implantation have been published elsewhere [3, 8, 10]. Only the essential steps for the use of this design will be described here. An incision is first made in the scalp where the cranial pedestal will be built. The right external jugular vein is then exposed, cleared of surrounding tissue, punctured with a 25 gauge hypodermic needle 5–10 mm rostral to the clavicle, and the catheter inserted. The length of insertion depends upon the animal's size; in this laboratory the catheter is inserted 34 mm for rats weighing 350–450 g. The catheter is attached to the vein with a cyanoacrylate adhesive such as Eastman 910 [8,10]. The vein should be held apart from surrounding tissue with a small spatula or blunt probe while the adhesive dries. No sutures are used to anchor the catheter. The end of the catheter is run subcutaneously to the posterior edge of the scalp incision using a trocar, and the incision over the jugular vein is closed with 9 mm Autoclips (Clay-Adams) after application of an antibacterial powder (nitrofurazone). The 23 gauge tubing is bent 90 degrees at the point where it exits from the heat shrinkable tubing. This bend is made with flat-and-round-nose pliers (Vigor PL-47 optical pliers) to prevent crimping of the tubing, which could result in its becoming occluded. The electrode implantation or other surgery is then carried out and a cranial pedestal is built of Nuweld dental repair resin (L. D. Caulk). The 23 gauge tubing is built into the posterior end of the pedestal (the tubing fits nicely through the posterior mounting hole in the Amphenol 223–1505 electrode connector used in this laboratory). The catheter is positioned so that the open end of the 23 gauge tubing points upward while the silastic tubing lies flat on the skull. The heat shrinkable tubing protrudes from the pedestal 1–2 mm in a posterior direction, protecting the Silastic tubing from being torn at the point of exit (see Fig. 2).

DISCUSSION

The catheter design described here has several advantages. It is very easily and quickly constructed. In addition, implantation is also rapid; with practice the procedure adds only 10–20 min to the duration of stereotaxic surgery. Sutures are not needed to anchor the catheter because it is anchored at the cranial pedestal and because the path it follows from pedestal to vein leaves it relatively well-protected from displacement or damage by scratching or other animal movements.

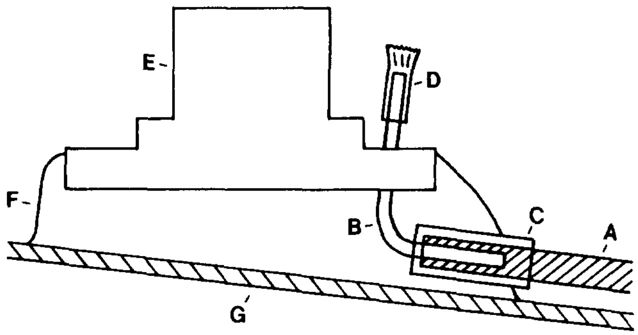

FIG. 2. Position of the catheter with respect to skull and cranial pedestal. (A) Silastic tubing. (B) 23 gauge stainless steel tubing. (C) Heat shrinkable tubing. (D) Catheter cap made of Tygon tubing. (E) Electrode connector. (F) Nuweld dentral acrylic. (G) Skull. Catheter parts are enlarged relative to pedestal for the purpose of illustration.

The catheter is also quite reliable due to its simple construction and well-protected positon. The present design has thus far been used in 65 rats in this laboratory (Stripling and Hendricks, in press). The catheters were first used 2–3 weeks following implantation, at which time 61 of 65 (94%) were functioning properly. At the time of histology 5 to 9 weeks later, only one additional failure had occurred. This longevity is impressive given that none of the catheters were used or flushed for the last 4 weeks prior to histology, and 29 of them were unused for the last 8 weeks.

Several comments concerning the longevity of the catheters can be made based on experience from these animals and numerous others in which preliminary designs were tested. The majority of catheter failures have been due to tearing of the Silastic tubing at the pedestal. In most cases when a catheter has failed at this point, histology has revealed careless workmanship likely to cause irritation and scratching, such as a catheter which juts upward or laterally from the pedestal. Thus it is important that the catheter be carefully positioned so that it is well protected at the point of exit from the pedestal.

At the time of implantation the catheter is loaded with sodium pentobarbital (Nembutal), which makes the maintenance of anesthesia an easy matter. This solution is left in the catheter after surgery on the assumption that the viscous propylene glycol base will help prevent entry of blood into the catheter. On the day before the catheter is first used experimentally it is flushed by hand with saline to test the catheter and remove the Nembutal. Other than that, neither flushing nor heparin is used to keep the catheter patent. Under these circumstances the one-way valve appears to work quite well in preventing clogging of the catheter, as indicated by its low failure rate over long periods without use or flushing. The use of propylene glycol seems unnecessary, since the catheters remain patent for months after the Nembutal has been flushed out.

Although no sutures are used to anchor the catheter, it is rare for it to come out of the vein. While it takes some practice to learn to use the Eastman 910 adhesive to best advantage, it saves time during implantation and is quite effective. In fact, it is often difficult to remove a catheter from the vein at histology several months after implantation. If the catheter does come out of the vein, it is likely to do so within the first few days after surgery, so the animal should be handled carefully at that time.

A final comment should be made regarding infusions using the one-way valve design. In this laboratory an infusion pump is used to produce infusions at a constant and reliable rate. It is common practice in this situation to use a large (e.g., 5 ml) disposable syringe to permit the infusion of several animals without reloading the syringe. However, moderate pressure is required to initiate flow through the one-way valve, and the large neoprene tip on the plunger of these syringes may compress considerably before flow starts, creating an undesirable time lag and possible error in the amount of drug delivered. This problem is negligible if a 1 ml disposable syringe is used.

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