A method for preparing and maintaining rhesus monkeys with chronic venous catheters*

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A procedure for implanting and maintaining chronic venous catheters in primates is described. Surgical procedures and hardware suitable for maintaining the S in operant behavior equipped cages are presented. All equipment can be assembled with hand tools or obtained from commercial sources at low cost.

Behavioral and drug experimentation often requires a primate preparation that permits direct repeated or continuous access to the circulatory system of a mobile S. The procedures described here evolved as the result of several years' experimentation with the development of ethanol- and drug-dependent states in primates. These procedures represent an approach that can be readily replicated and modified. Some aspects of the methods have been described by others (Pickens, Huack, & Bloom, 1966; Craig, Trost, & Talley, 1969; and Stretch & Gerber, 1970).

The preparation described here used a rhesus monkey maintained in an open-front cage equipped with operant hardware and restrained by a leather jacket/undershirt combination that protects the catheters while providing adequate mobility (Fig. 1). The materials are inexpensive and ready available.

METHOD

Preparation

All new animals are quarantined for 3 weeks while two tuberculin test are performed. A 2-ml blood serum sample is obtained for B virus determination by the Southwest Foundation for Research and Education, San Antonio, Texas. Ss catheterized previously are placed on a minimum program of 5 days of 100,000 units of penicillin or another suitable antibiotic per day. Plate sensitivity cultures are performed if the effectiveness of the specific antibiotic is in doubt. The antibiotic program is similar to a method described by Fishman.¹

In preparation for surgery, the animal is immobilized with 0.10 mg/kg ketamine HCl IM. The neck and back are shaved, washed with soap, and swabbed with tincture of Merthiolate. The animal is then placed on the operating table and anesthetized with halothane. A polyethylene bottle, with the end removed, is held in place with Velcro straps; this makes an excellent face mask. All surgery is performed under aseptic conditions.²

Size 00 1/16-in. od, 1/32-in. id tubing cut to 2-m lengths is used as the catheter. Tygon polyvinyl tubing is used exclusively as the catheter material. Since no appreciable difference has been found, laboratory formulation R-3603 is used rather than surgical formulation S-50-HL. The end to be inserted into the

vein is beveled to a 30-deg angle and a 2 x 3 cm piece of unbonded Dacron felt (of the type used for upholstery stuffing) is glued around the catheter 25 cm from the bevel. This practice was recommended by McCarthy (1973) as a means of encouraging vigorous tissue growth at the catheter exit. A suitable glue is made by dissolving enough ¼-in. lengths of Tygon tubing in cyclohexanone to form a thin paste with the aid of a high-speed blender. After glueing, the tubing is dried with a heat lamp for 24 h, then placed in a 1:750 Zephiran chloride solution. Twenty-four hours before use, the catheter is removed from the solution, rinsed repeatedly with sterile distilled water, and stored in sterile distilled water.

Surgery

An incision in the neck region over the sternocleidomastoid muscle exposes the area desired. The incision extends from 2 cm below the mandible to a point well above the clavicle. A 3-cm-long opening should be sufficient for catheter implantation.

The skin is stretched slightly with cystic duct forceps or a similar instrument. Although any vein in the neck region large enough to accommodate the catheter is suitable, the subclavian, transverse cervical, internal, and external jugulars are most frequently used for implantation. With as little disturbance of the surrounding tissue as possible, the vein is blunt-dissected free. A ligature of 00 silk is placed around the vein above the site where the catheter will enter.

A slight traction is applied to the upper ligature while a 45-deg angle entrance into the vein is made with the point of a 20-ga hypodermic needle. One tip of a splinter forceps then replaces the needle, guiding the catheter 1 cm into the vein. The splinter forceps is then removed and the catheter is inserted to a total distance of approximately 10 cm. This should situate the catheter tip just inside the atrium. Several autopsies have revealed that 10 cm is usually the correct length for insertion for rhesus monkeys of 5-7 kg body weight. The catheter is then ligated to the vein with 3-4 ties of 00 silk. A 10-ml syringe and 20-ga needle are used after each ligation to draw back blood ensuring that blood flow is not occluded.

The 18-in. steel needle is directed through the incision, under the muscles then subcutaneously to a point midway between the two scapulae and pushed through the skin. The catheter is threaded through the needle eye and pulled through. A small loop in the catheter is left in the neck area. The catheter is withdrawn until the Dacron felt just protrudes through the skin. Tissue will eventually infiltrate the felt, closing the wound and minimizing the possibility of infection. The catheter is covered by joining the connective tissue with 5-0 silk. The incision is closed with 5-0 silk using a subcuticular stitch to minimize drainage and prevent the monkey from picking at the wound. A weeping wound will cause the leather jacket to harden and cut the skin.

Before the monkey is returned to its cage, blood flow is

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Fig. 1. Rhesus monkey self-administering drug while restrained in an open-front cage by a leather jacket and flexible hose device with an undershirt for additional protection against chafing.

checked again to ensure that the catheter is unobstructed. The closed wound is coated with Furacin and 100,000 units per day of penicillin or appropriate antibiotic are given via catheter for 7 days postoperatively.

CATHETER PROTECTION SYSTEM

After the catheter is implanted, the S is housed in the open-front cage. Each animal wears a leather jacket attached to the back wall of the cage by a grease gun hose (Alemite No. 317850-1F or similar) with a rubber-covered double layer of braided steel wire. This device keeps the S in the cage and prevents it from reaching and manipulating the catheter which exits from its back. A cotton pullover undershirt without snaps (Kresge Mix n Match, 9-12 months) is worn under the jacket to prevent abrasions that occur as the jacket leather hardens with age or becomes damp and rubs on the skin. The jacket is fashioned of garment leather,

rough side out, obtained from a leather wholesaler and altered individually from a basic design (Fig. 2). The dimensions of the jacket are suitable for an animal that weighs 5-10 kg. Holes are made with a leather punch. The shoulders of the jacket are attached by matching Holes 1-1, 2-2, 3-3, and 4-4 and inserting copper rivets (Rapid Rivets No. 3) from the inside through the opening. The rivets are hammered flat to secure the shoulders in place. Sleeves are then fashioned from rectangles of leather about 10 cm by 25-30 cm, depending upon the size of the monkey, and attached to the vest armholes with 6-32 x 1/2-in. round-head screws and nuts. Number six brass washers are used to prevent the nuts from pulling through the leather. The middle of the long side of the sleeve is placed at the top of the shoulder with the ends of the leather rectangle overlapping underneath the arm. The outer edge of the sleeve tapers to midway to the elbow, not binding the arm but allowing as little room as possible for the monkey to reach inside and manipulate the catheter. (The sleeves shown in Fig. 1 are of very light colored leather, hence are somewhat hard to discern.) The opening down the front of the jacket is fastened with bolts, nuts, and washers in a similar manner.

The jacket is attached to a 4 x 4 x 2-1/8-in. electrical junction box (1900 box) by 6-32 x 1/2-in. round-head bolts with washers inserted from the inside through the holes in the jacket back and holes on the junction box. Before attaching the leather, a 3-in. radius cut-out tangent to the center knock-out hole is cut from the top and bottom of the box to provide a better fit to the animal's back. The two ears and all knock-out holes are removed from the sides and back of the box to reduce weight. The box is located so that the center will be above the catheter exit between the scapulae. As shown in Fig. 1, all except the center hole are covered with electrical tape. This prevents access to the catheter by the animal, but allows visual inspection of the catheter exit after quick removal of the tape. Bolted over the center hole is an electrical fixture stud which has a

Fig. 2. Pattern for leather jacket. Attachment holes are marked.

1/8 NPT female thread and accepts the grease gun hose fitting. A flexible hose permits a full range of movement by the animal while protecting the catheter tubing. A hole in the cage wall anchors the hose by a 1¼ x 1/8 NPT reducing bushing with conduit nuts. The hose is attached to this assembly by a 1/8 NPT brass pipe union, which permits the animal to be removed from the cage with harness and catheter intact.³

The S's catheter tubing is connected to a drug-dispensing roller pump by a length of Tygon catheter tubing. The pump is mounted in an adjacent room. Connectors are made from a 19-ga hypodermic needle by removing the hub and beveled end. The needle is notched with a file and snapped, much as glass tubing is broken. The ends may be filed slightly until smooth. Masking tape flags placed over the junctions prevent the catheter from slipping off the joint or leaking and keep the joint clean. When the joint is opened for testing it is first washed with 73% ethanol solution. To maintain a functional catheter, 0.05 ml of saline is automatically infused every 20 min by pump. Ten milliliters of heparinized saline (10 units Heparin/ml) is flushed rapidly through the catheter (once each day) after each manual blood withdrawal to ensure that the catheter is functional. The flushing allegedly reduces fibrin deposition at the tip of the catheter.

Animals on test are given a 5-day course of antibiotic by catheter every 6 weeks as a prophylactic measure. It is possible that this form of prophylaxis will lead to the development of antibiotic resistant strains of bacteria. We change the antibiotic regularly with the hope of forestalling such an eventuality. General cleanliness is maintained by scrubbing each cage daily with a solution of warm water and Lysol cleaner, and rinsing with cold water.

SUMMARY

The methods described are the result of development and

incorporation of suggestions over a period of 5 years. The system as it stands includes a specified surgical procedure, restraint system for catheter protection, and a set of maintenance procedures which include daily verification of catheter function and a regular antibiotic treatment schedule. At the present time, a total of 16 Ss are being maintained with the system described. The catheters have been functional from the time of implanting, which has been 11, 117, 134, 137, 148, 158, 171, 176, 184, 184, 186, 197, 213, 263, 283, and 342 days.

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NOTES

1. Fishman, M. University of Chicago, Department of Psychiatry, private communication, 1973.
2. The operating table is washed immediately before surgery with Roccal 1:2500 germicide and covered with a sterile disposable drape. All instruments are soaked in a 1:750 Zephiran chloride solution for ½ h prior to use and rinsed in sterile distilled water before use. Sterile gowns, caps, and masks are worn by all attendants. Surgical gloves, scalpel, scissors, probe, splinter and thumb forceps, mosquito forceps, and an 18-in.-long, 1/8-in.-diam stainless steel needle for threading the catheter tubing are also required for surgery. Suture materials consist of 5-0 silk with needle for closing the incision and several strands of 00 silk to ligate the vein. A cuticular needle is used.
3. Electrical and plumbing items described are readily available from large hardware stores or hardware suppliers. Tygon tubing may be obtained from Cole-Parmer Instrument Company, Chicago, Illinois 60626 as No. 6408-61 Size 00 at \$4/100 ft. The S-50-HL tubing must be especially formulated by U.S. Stoneware, Akron, Ohio. Additional construction details may be obtained from the authors.

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