A Home-Made Low-Cost Hydraulic Swivel and Catheter Assembly for Blood Pressure Recording and Drug Infusion in Freely Moving Mice

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Abstract: We constructed a chassis that tightly fixes catheters for cannulation to the muscle. It can buffer pulling forces to avoid a mechanical tearing of the skin of mice as a result of movement.

Key words: mice, freely moving, arterial blood pressure.

Blood pressure (BP) is an important parameter for monitoring the cardiovascular functions. For a better physiological approach, recording the BP under a conscious condition is becoming the basic operation. For example, the BP variability provided abundant information on the neural regulation of cardiovascular functions [2], and most studies that focus on this subject were performed with freely moving animals. Since most genetically engineered animals currently being generated are mice, the requirements for the miniaturization of experimental tools to fit their small size have gradually become more important. Tethering catheters for artery and vein cannulation is a basic operation for BP recording and drug infusion in freely moving animals. Some published studies performed this work on mice using techniques modified from the rat [1, 3, 4], but there are still some limitations. With rats, catheters are usually tunneled subcutaneously, exteriorized between the scapulae, and fixed there by suturing to the nearby muscles and skin. This is a tricky task because of the thin and pliable skin of a mouse; the sutured site is easily rent, or the fixed catheters may fall off under the dragging forces of tethered catheters during movement. In the present study, we describe a method for fabricating a catheter assembly, which is easy to implant with sufficient robustness for long-term recording. Furthermore, it can resist many pulling forces produced by the movement of a mouse and will thus avoid subjecting the skin to mechanical tearing.

Moreover, a hydraulic swivel is necessary for continuous BP recording and drug infusion in freely moving mice. It prevents the tethered catheters from becoming entangled and impeding the animal’s movement. Although there are commercially available swivels, we have developed a low-cost, home-made device resulting from economic considerations and flexibility of the experimental design.

Methods

Preparation of the catheter assembly. The device consists of two portions, a silicon tube-based chassis for fixation and a set of PE tube catheters for cannulation (Fig. 1).
The design of the chassis for fixation was modified from the work of Tsai et al. [5]. An 8-mm silicone tube (AM systems, catalog no. 807000) was cut as the girder of the chassis. A 15-mm PE50 (Becton Dickinson, USA) tube runs transversely across the middle of the girder tube aided by the sleeve of a 27G needle. Two pieces of 3-mm silicone tube (which serve as lateral braces) were then bilaterally sleeved onto the outer portions of the pierced PE50 tube and closely leaned against the girder tube. The bilaterally exposed PE50 tubes (outside the braces) were then melted by brief firing to form a small gobbet at the end of the silicone tube. Therefore this pierced PE50 tube served as a horizontal rivet to fix the bilateral silicone braces that are placed tightly against the girder tube.

One 3-cm and two 10-cm PE10 tubes were together inserted into a 5-mm silicone tube (which serves as a pillar tube). The two 10-cm PE10 tubes (which serve as part of the catheter) were inserted into the girder tube against the inner horizontal rivet and dragged out from one open end of the girder tube with assistance of the sleeve on a 27G needle. The upper end of the 3-cm PE10 tube (which serves as a vertical rivet) was melted by brief firing to form a small gobbet at the end of the silicone tube and protruded out the bottom also against the inner horizontal rivet, which was aided by passing through a guiding 20G needle.

The portion above the chassis of the two 10-cm PE10 catheter tubes were respectively heat-sealed to a 5-cm piece of PE50 tube (which serves as the output of the tethered catheters). The free end of the vertical rivet and the PE10 end of the PE10-PE50 sealed tubes were then pulled down to make the gobbet and the sealed sites tightly against the upper edge of the pillar tube and the lower edge of the pillar tube tightly against the girder tube. The free end of the vertical rivet was also fired to form a small gobbet below the girder tube. A larger (8-mm) silicone tube (AM systems, catalog no. 807600) was cut as the girder of the chassis. A portion with a rubber gasket forming an intact internal seal of the swivel. Two circular notches spaced 1 mm apart were made with an electronic cutter in a 30-mm long 20G stainless steel needle (which serves as the shaft of the swivel) at sites about 12 mm from the sharp tip.

Two 27G stainless steel needle pieces were cut (at a length of about the inner diameter of the syringe) and heated until they burned; then they were pierced parallel and transversely lodged in the syringe at a site 5-mm from the edge of the barrel bottom at a 2-mm interval. The cut rubber gasket was lodged flat on the parallel 27G needle in the barrel. Two 20G stainless steel needle pieces with 2-mm spacing were pierced parallel and transversely lodged in the barrel against the flattened rubber gasket at the other side from where the 27G needle was lodged. The chinks between the pierced needles and barrel wall were stuffed with melted polypropylene (material from a melted polypropylene syringe). These lodged needles served as the beams for the cement that was subsequently added.

The shaft needle penetrated to the bottom of the rubber gasket at its center and was pushed forward until the two circular notches were in the space between the plane of the rubber gasket and the edge of the barrel bottom. The portions of the shaft needle that were merged in the barrel were thinly and evenly smeared with petroleum jelly, which lowers frictional torque when the shaft is rotated. The bilateral spaces that were up to 2 mm from the rubber gasket between the shaft and barrel were filled with dental acrylic cement. After the cement hardened, the shaft was bent to an angle of about 135° at a site 2 mm from the edge of the lower cement. These two layers of hardened cement were independently lodged in the barrel: the shaft was...
fixed to the lower cement by being jammed at the circular notches, and the upper cement curbs the damping caused by the elastic property of the rubber gasket.

Implantation and data acquisition. The experimental procedures on the mice were approved by the Institutional Animal Care and Use Committee, National Ilan University. The mice (129 Sev, 25–35 g) were anesthetized with pentobarbital (50 mg/kg, i.p.). An 8-mm long incision was made at the nape of the neck and another at the groin. These incisions permitted the cannulated catheters to be tunneled subcutaneously from the neck to the groin. The four protruding silicone portions of the crisscrossed chassis were all sutured to penetrate the silicone and tightly anchor it to the musculature near the neck; the skin incision was closed with fine sutures.

The cannulated catheters were cut to fit the length for implantation and bent into an L-shape at the site about 1.5 cm from the tip with the aid of a heated metal rod. This operation can produce the proper angle for cannulation. The femoral artery and vein were respectively cannulated for systemic BP recording and drug administration. The catheter was secured to the leg muscle for fixation, and the skin incision was then also closed with fine sutures. The catheter for BP recording was connected to the swivel via extended PE tubes. The BP signals were obtained using a pressure transducer and digitized at 2,000 samples/s (PowerLab 4/25, ADInstruments) for storage and further analyzed on a computer.

Results and discussion
A representative example of a BP recording after being tethered for 16 h to a mouse in a freely moving state is shown in Fig. 3. The pulse pressure was in the range of 20–30 mmHg, which matched the quality shown in a previous study [1]. The low frictional torque of the hydraulic swivel allows the shaft to rotate smoothly with the movement of the mouse, and it prevented injury for 16 h as a result of mechanical tearing by the tethered catheters.

As shown in a previous study by Tsai et al. [5], the advantages of the chassis are that it can absorb many of the pulling forces produced by the tethered catheters during movement, and the flexible and smooth characteristics of the silicone pillar tube avoid subjecting the skin to mechanical tearing. We modified the manufacturing processes of the chassis in this study, especially for the bilateral braces and pillar tube fixation. PE rivets were used instead of the parent syringe barrel. It is easy to locate bubbles in the fluid path and remove them to avoid a possible damping of the BP recording.

In conclusion, the presented homemade low-cost hydraulic swivel and catheter assembly are well suited for BP recording and drug infusion in freely moving mice and rats. They allow the animals unimpeded movement and avoid injury, and they have sufficient robustness for long-term recording.

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