Pharmacology Biochemistry & Behavior, Vol. 38, pp. 685–688. © Pergamon Press plc, 1991. Printed in the U.S.A. 0091-3057/91 $3.00 + .00

BRIEF COMMUNICATION

Lumbar Subarachnoid Catheterization in Rats

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Received 10 September 1990

WANG, B. C., D. E. HILLMAN, D. LI AND H. TURNDORF. *Lumbar subarachnoid catheterization in rats.* PHARMACOL BIOCHEM BEHAV **38**(3) 685–688, 1991.—An animal model was developed for the study of subarachnoid (spinal) anesthesia and analgesia under unanesthetized, unsedated and unrestrained conditions. Sprague-Dawley rats were anesthetized with intraperitoneal ketamine (75–100 $mg \cdot kg^{-1}$). A PE10 catheter was inserted under direct vision into the lumbar subarachnoid space, through partial laminectomy of L1 or L2 with or without removal of adjacent intervertebral ligament. One week after surgery, correct position of the catheter was verified by subarachnoid injection of 0.03–0.05 ml of 1.5% lidocaine, which produced temporary hind limb paralysis in all but one animal in 28 consecutive operations. There was neither mortality nor major complication, intraoperatively or postoperatively. Only 2 animals developed minor subcutaneous wound infections which responded to incision, drainage and debridement.

Rat Subarachnoid catheterization

EPIDURAL and subarachnoid (SAS) administration of opiates and local anesthetics have been widely used for relief of pain. However, better agents and safer ways of administration are still in demand. To meet this challenge, a practical, economic and reliable animal model is needed.

The subarachnoid rodent model developed in 1976 (4) has been widely used by many investigators for study of spinal opiates and allied drugs. However, insertion of the catheter through the atlanto-occipital membrane, blindly traversing the entire length of the vertebral column, is not without danger of injuring intervening structures. The present model was designed to overcome this problem.

METHOD

With institutional approval, male Sprague-Dawley rats weighing 500–600 grams were anesthetized with intraperitoneal ketamine 75–100 $mg \cdot kg^{-1}$.

Exposure of the Dura and Spinal Cord by Laminectomy With or Without Removal of Intervertebral Ligament

The skin over the thoracic and lumbar vertebrae was shaved and prepared with povidone iodine (betadine). Following a midline skin incision, the paravertebral muscles were detached from the spinous processes and retracted laterally. The intervertebral ligament between T13 and L1 or between L1–L2 was removed. After dissection, the inferior border of T13 or L1 was retracted cephalad, facilitating the application of a rongeur for partial laminectomy at the cephalic border of L1 or L2. This exposed the dura and the underlying spinal cord which was easily identified by a mid-line blood vessel. Lidocaine (1.5%) was applied topically to the dura to prevent movement of the animal when the dura was picked up with a fine forceps. The dura was perforated with a short bevel No. 20-ga needle, resulting in some leakage of CSF. Under magnification, a PE10 catheter (Becton Dickinson, Parsittany, NJ) was immediately inserted tangentially through the dural opening. It was directed caudally and maintained dorsal to the spinal cord (Fig. 1a). The catheter, 10 cm in length, containing a volume of 0.02 ml, was advanced slowly in SAS to a mark 1.5 cm from the tip, while 0.01–0.02 ml of normal saline (NS) was simultaneously injected to open the way. Leakage of fluid through the dural opening during injection confirmed the patency of the catheter and also indicated that the catheter was properly placed in SAS, not inside the spinal cord tissue.

Alternatively, laminectomy of L1 or L2 was started on the lamina proper, without removal of the intervertebral ligament. The rest of the procedure was as described above.

Fixation of Catheter

The spinous process rostral to the laminectomy was denuded and perforated with a No. 18-ga needle (Fig. 1b). The free end of the SAS catheter was threaded through its lumen. On retraction of the needle, the PE10 catheter was left in the perforation in the spinous process, and anchored with cyano-acrylate glue (Fig. 2d). A Tuohy-Borst connector was attached to the free end of the catheter for injection (Fig. 2e).

Incision Closure

The wound was irrigated with NS and closed in layers, leav-

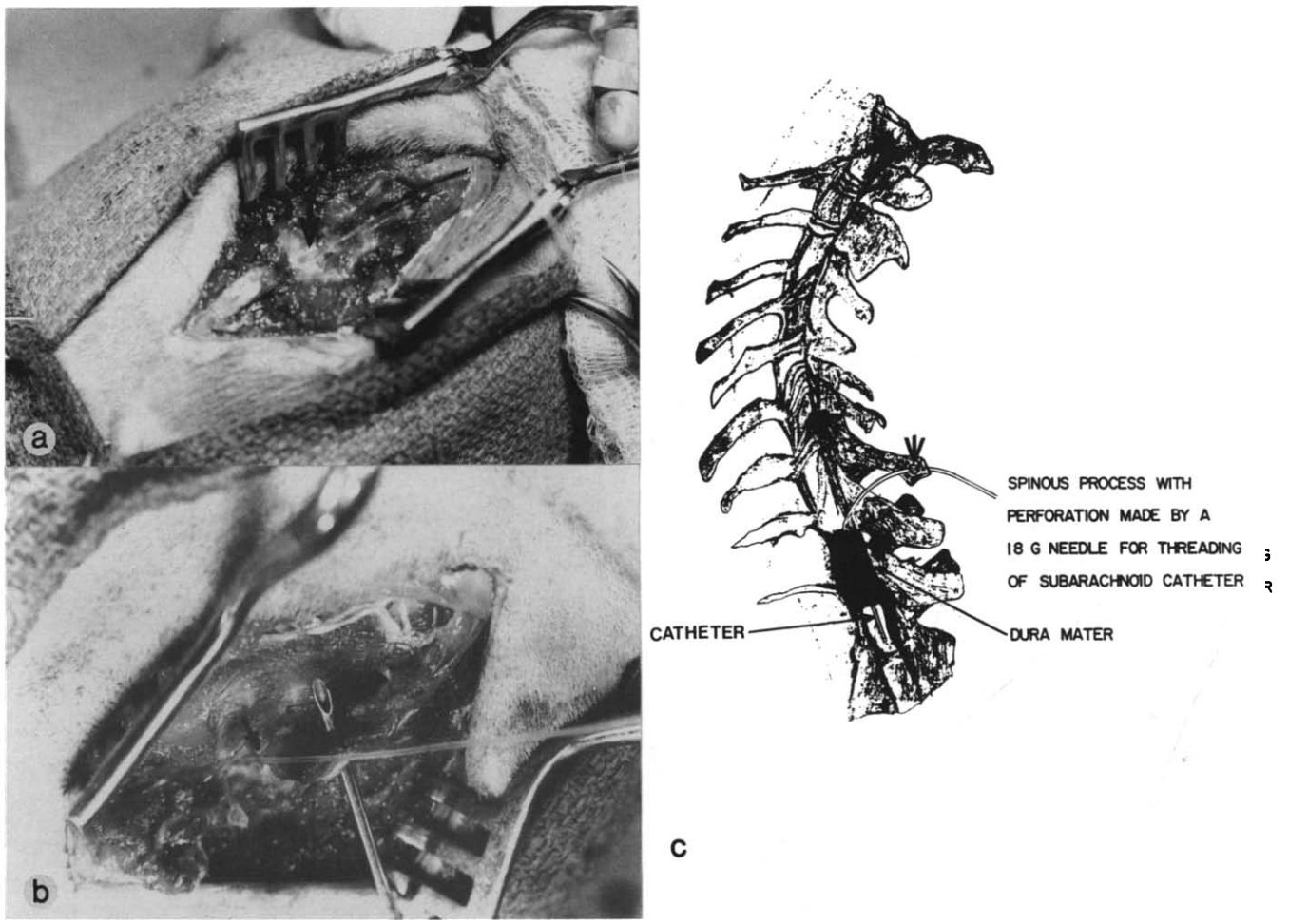

FIG. 1. (a) A PE10 catheter was inserted under the dura into the subarachnoid space. (b and c) The spinous process adjacent to laminectomy has been perforated with an 18-ga needle, for passage of the catheter. The SAS catheter was to be threaded through the lumen of the needle, and on retraction of the needle, the catheter would be left in place tunneling through the spinous process.

ing the catheter buried in the subcutaneous tissue. The hub of the Tuohy-Borst connector was sutured to the skin with fine stainless steel wire. The injection port, covered by a removable metal cap, was brought out of the skin via a separate small opening lateral to the main skin incision (Fig. 2f).

Postoperative Care

The animals were housed in the Animal Facility of the Medical School and cared for by trained technicians under the direction of a licensed veterinary surgeon. Motor functions, eating, drinking, urination and bowel movement were checked daily.

Verification of Position of SAS Catheter

One week after surgery, 0.03–0.05 ml of 1.5% lidocaine was injected through the SAS catheter. Correct position of the catheter was evidenced by prompt sensory and motor block of the hind limbs, developing in 1–5 minutes, and exhibiting motor blockade for 20–30 minutes. For control, 6 rats received 0.05 ml normal saline in SAS.

RESULTS

In 28 consecutive operations, there was neither mortality nor serious complication, intraoperatively or postoperatively. Only 2 rats developed minor subcutaneous wound infection which responded to incision, drainage and debridement. Correct subdural placement of the catheter was verified in 27 test animals. In one case, the catheter was inserted into the epidural space instead of SAS because of an accidental dural tear. Control rats (n = 6) did not show evidence of subarachnoid block following NS injection.

DISCUSSION

With the present technique, the SAS catheter was implanted directly in the lumbar SAS space without traversing the entire cervical and thoracic spinal canal (4). Partial laminectomy afforded adequate exposure for insertion of the catheter through a needle hole in the dura under direct vision. There was no need to remove the dura nor to excise the intervertebral disc, as was described in a previous technique (1). Actually, as the intervertebral disc is located ventral to the spinal cord, discectomy would be unnecessary and irrational if the SAS is approached dorsally.

A rabbit subarachnoid model has been employed in our laboratory for several years (2,3). The above described rat model may be more feasible and economical. No stereotaxic or other special instruments are needed. Anesthesia with ketamine eliminated the

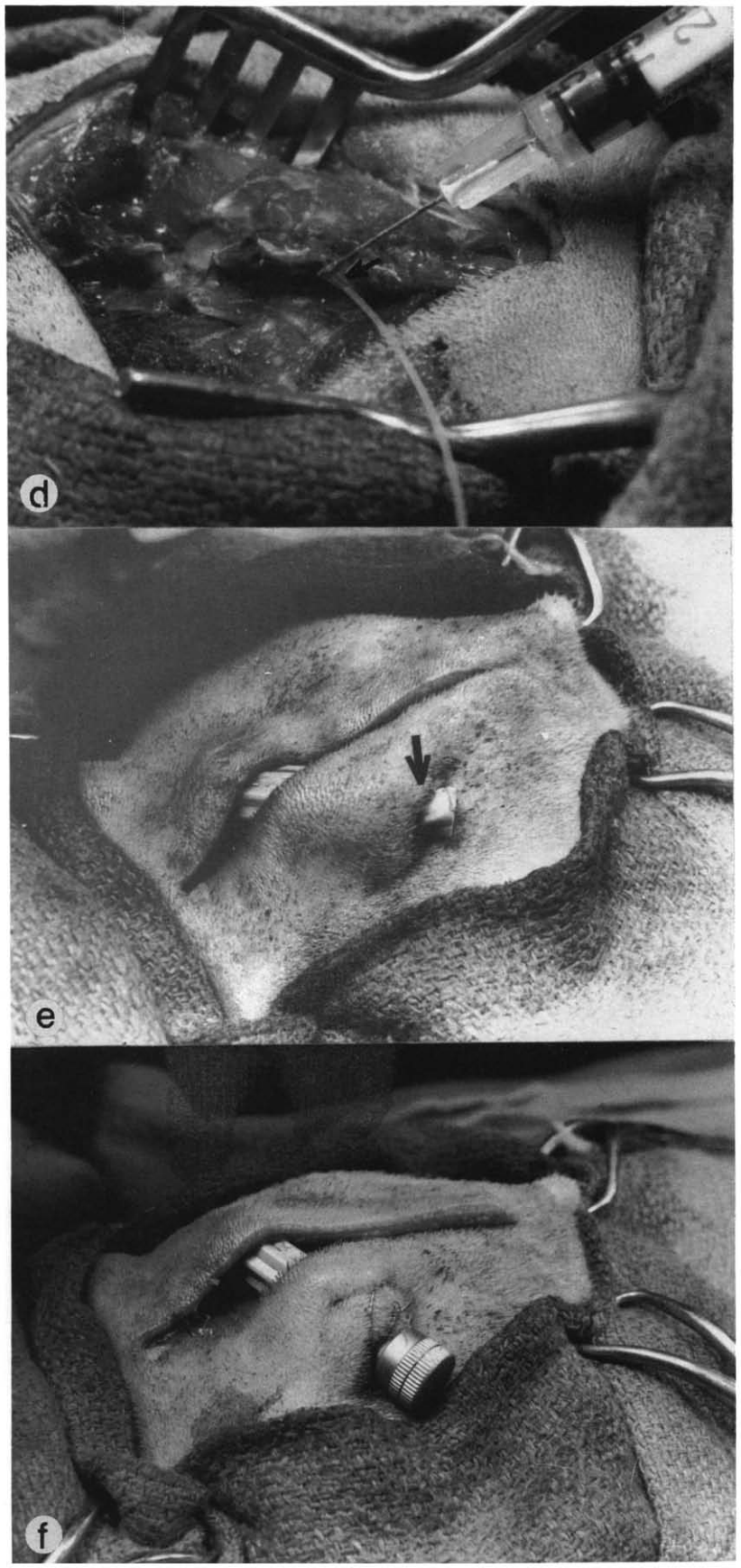

FIG. 2. (d) The catheter was anchored to bone with cyanoacrylate glue after passing through the perforation in the spinous process. (e) A Tuohy Borst Connector was attached to the catheter and buried under the skin. (f) The injection port was exteriorized outside the skin and covered with a removable metal cap.

need for endotracheal intubation, and thus simplified the procedure considerably. The duration of operation in rats was much shorter than for rabbits (1 hour vs. 3 hours). Incidence of infection is rare in rats as compared to rabbits. With proper training and practice, this procedure can be performed by individuals with ordinary dexterity.

This model has been used successfully in our laboratory for testing spinal anesthetics and related agents, in awake, active and freely moving animals, without being complicated by the use of general anesthesia or sedation.

ACKNOWLEDGEMENTS

The authors are grateful to Mr. Frank Forcino and Mr. Leon Yost for their photographic assistance and Drs. Edwin Rosman and Sanford Miller for their help in revising this manuscript.

REFERENCES

1. Dib, B. Intrathecal chronic catheterization in the rat. Pharmacol. Biochem. Behav. 20:45–48; 1984.
2. Wang, B. C.; Hillman, D. E.; Spielholz, N. I.; Turndorf, H. Chronic neurological deficits and Nesacaine CE—An effect of the anesthetic, 2-chloroprocaine, or the antioxidant, sodium bisulfite? Anesth. Analg. 63:445–447; 1984.
3. Wang, B. C.; Hiller, J. M.; Simon, E. J.; Hillman, D. E.; Rosenberg, C.; Turndorf, H. Distribution of ^{3}H morphine following lumbar subarachnoid injection in unanesthetized rabbits. Anesthesiology 70:817–824; 1989.
4. Yaksh, T. L.; Rudy, T. A. Chronic catheterization of the spinal subarachnoid space. Physiol. Behav. 17:1031–1036; 1976.

ADDENDUM

Since submission of the original manuscript, 8 more subarachnoid and 7 epidural catheterizations have been successfully performed without complication.

A rodent intramuscular anesthesia cocktail, 0.5 ml/kg, was used in this series. Each ml of this anesthetic mixture contained ketamine HCl 42 mg, xylazine HCl 8.6 mg and acepromazine 1.4 mg.