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Comparison of Sprotte and Quincke needles with respect to spinal fluid leakage using artificial spinal cord

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Abstract

Purpose. This research investigated whether the Sprotte needle causes less leakage of CSF than the Quincke needle in the artificial spinal cord.

Methods. The changes in intradural pressure, extradural pressure, and leaked volume of CSF were evaluated following puncture with Sprotte and Quincke needles in the artificial spinal cord.

Results. The decrease in intradural pressure was 9.7 ± 1.8 mm H_2O with the Sprotte needle and 20.5 ± 2.7 mm H_2O with the Quincke needle ($P < 0.05$). The volume of leakage of artificial CSF was 2.0 ± 0.3 ml with the Sprotte needle and 3.3 ± 0.3 ml with the Quincke needle ($P < 0.01$). The extradural pressure increase was 166.1 ± 8.2 mm H_2O with the Sprotte needle and 186.8 ± 13.2 mm H_2O with the Quincke needle ($P < 0.05$).

Conclusion. The Sprotte needle produces less CSF leakage than the Quincke needle.

Key words: Spinal anesthesia, Spinal fluid, Spinal cord

Introduction

One of the complications of spinal anesthesia is postdural puncture headache (PDPH) [1]. PDPH is caused by several factors. Cerebrospinal leakage from the hole caused by dural puncture is believed to be the main mechanism [2]. The Sprotte needle was developed in an attempt to decrease the leakage of CSF from the dura hole by changing the shape of the spinal needle tip [3,4]. However, nobody has demonstrated a clear relationship between the volume of CSF leakage and the shape of the needle or between the pressure in the epidural space and CSF leakage. In this paper we would like to clarify the relationship between the shape of the needle tip and the volume of CSF leakage following dural puncture, as well as experimentally determine the effect of the pressure in the epidural space on the leakage of CSF.

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Materials and methods

The two types of needles examined in this experiment were the Sprotte and Quincke needles (both 24 G). A spinal column model consisting of two plastic tubes was used (Fig. 1). The diameter of the outer tube was 56 mm and that of the inner tube was 30 mm. Artificial CSF, similar to real CSF in biochemical composition (NaCl 125, $NaHCO_3$ 25, KCl 3.5, $CaCl_2$ 1.3, $MgCl_2$ 1.1, NaH_2PO_4 0.5, urea 130, and glucose 610 $mmol \cdot l^{-1}$) and in viscosity to real CSF, was poured into the inner tube corresponding to the intradural space and adjusted to produce a CSF pressure of 15 cm H_2O. Artificial CSF has the same composition as mock CSF [5].

A small window (2 × 3 cm) and a hole were made on the surface of the inner and outer tube, respectively. The small window was covered with human postmortem spinal dura mater (provided by the Department of Pathology of the Jikei University School of Medicine), using glue and with the longitudinal axis of the specimen running vertically. Nine samples of dura mater were examined with each needle. The small hole on the outer tube was plugged with rubber, through which the Sprotte and Quincke needles penetrated the inner space. The space between the inner and the outer tubes, corresponding to the epidural space, was filled with air maintained at a negative pressure of −7 cm H_2O. Pressure transducers (DP8A-50, DPA-200, NIPPON DENKI SANEI Engineering Co., Tokyo, Japan) were connected to the inner tube and the outer space to ensure that the appropriate pressure was maintained.

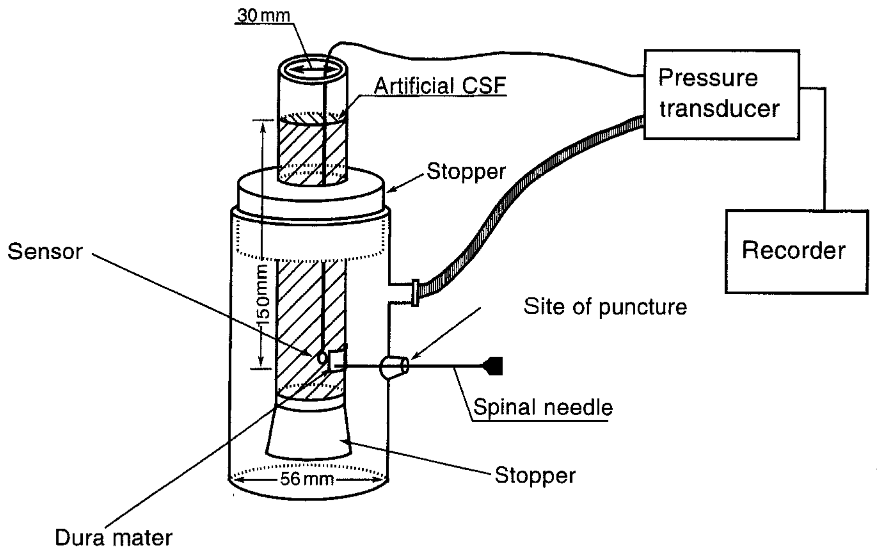


Fig. 1. Experimental model of the spinal cord

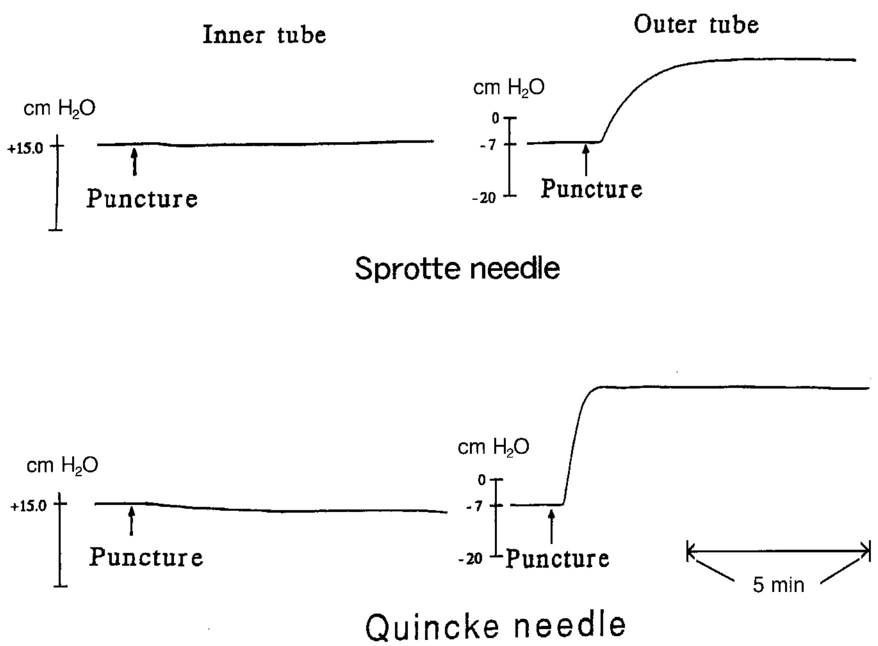


Fig. 2. Pressure change in inner and outer tubes following withdrawal of the two types of needle

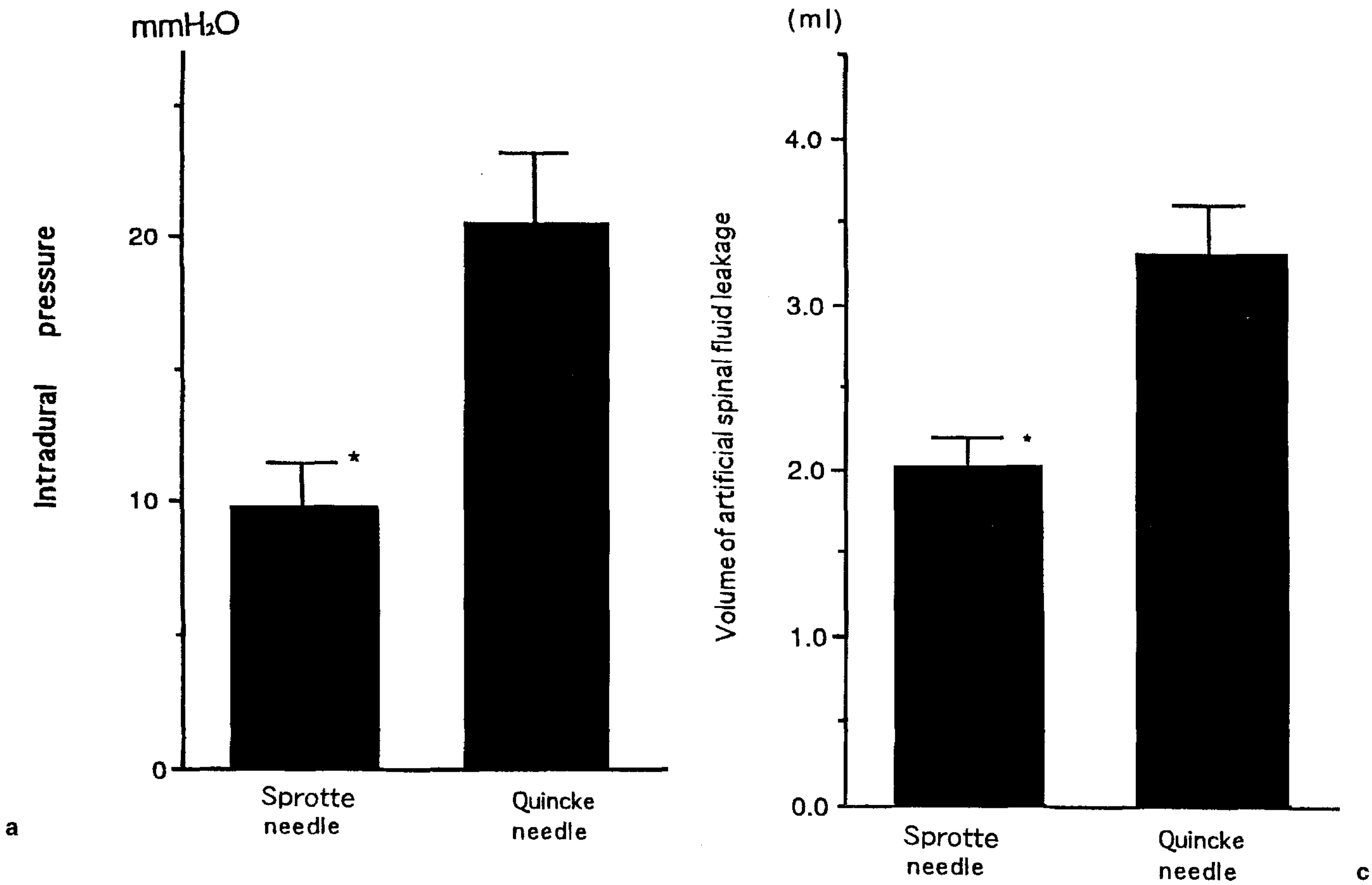
Each needle penetrated the rubber plug and the dura to enter the inner tube.

Following withdrawal of the needle, the pressure change in the inner and outer tubes was monitored (CP640G, Nippon Denki Sanel, Tokyo, Japan), and the volume of CSF leaked in 2 min was measured.

Statistical analysis was performed by Student's *t*-test, and the data are expressed as mean ± SE. Differences were considered statistically significant at $P < 0.05$.

Results

The pressure change in the inner tube following withdrawal of either the Sprotte or the Quincke needle was very slight, but the decrease in pressure was less with the Sprotte needle than with the Quincke needle, whereas the pressure in the outer tube increased rapidly following withdrawal of both types of needle. The rate of this increase was steeper when the Quincke needle was used (Fig. 2).



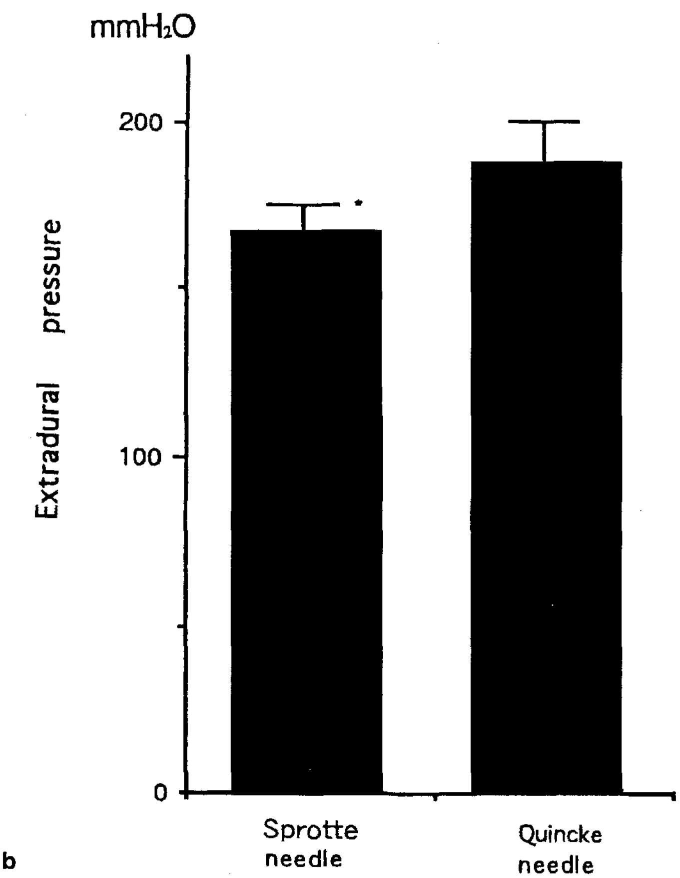


Fig. 3a–c. a. Decrease in inner tube pressure from prepuncture pressure (+150 mm H_2O). **b**. Increase in outer tube pressure from prepuncture pressure (−70 mm H_2O). **c**. Fluid leakage (volume) at 10 min following needle punctures. Values are mean ± SE (n = 9). *Difference is significant *vs* Quincke needle ($P < 0.01$)

The changes in the inner tube pressure following withdrawal of the two types of spinal needles are compared in Fig. 3. The decrease in pressure in the inner tube was greater with the Quincke needle than the Sprotte needle. The volume loss through the hole in the first 2 min after spinal needle penetration is also shown in Fig. 3. The volume of CSF leakage was greater when the Quincke needle was used than when the Sprotte needle was used. The increased pressure in the outer space was greater with the Quincke needle than with the Sprotte needle (Fig. 3).

Discussion

The Sprotte needle was developed to decrease the incidence of PDPH. The Sprotte needle has a rounded conical tip, so it is possible to insert the needle into the subarrachnoid space through the dura fibers without cutting them.

This study suggested that the shape of the spinal needle can influence the volume of CSF leakage. Our experiments demonstrated that the Sprotte needle produced less CSF leakage into the epidural space.

As shown in Fig. 2, after puncture artificial CSF leaked out through the dura puncture hole into the outer tube space within 2 min and the CSF leakage stopped as the pressure in the outer tube space increased.

The degree of CSF leakage following dural puncture depends on intradural pressure, extradural pressure, the size and shape of the dural puncture hole, and other unknown factors.

During the experimental procedure, the inner and outer tube pressures were kept constant before dural puncture and same-sized needles were used, so it is possible to compare the amount of CSF leakage following dural puncture by the two types of needles. The smaller decrease in pressure in the inner tube and the smaller volume of CSF leakage after puncture with the Sprotte needle than with the Quincke needle suggests that the Sprotte needle may be advantageous in clinical practice.

Haraldson [6] noted a decrease (from 9% to 32%) in headaches with the use of noncutting needles, such as the Whiteacre needle, which is similar to the Sprotte in shape. Ross et al. [7] reported that the Sprotte spinal needle, with a noncutting tip, resulted in a significantly lower incidence of postspinal headache than the Quincke cutting-tip needle. Buettner [8] reported that the Whiteacre needle resulted in significantly fewer postspinal headaches than the Quincke spinal needle. The results of these reports agree with ours.

There are many vessels and much fatty tissue in the human epidural space but nothing in the outer space of the artificial spinal cord, so it is impossible to reproduce exactly the intradural change following dural puncture in the human body. However, the change of pressure and volume of flow following dural puncture within 2 min may give us some information about two different-shaped needles.

We conclude that the Sprotte needle produced less CSF leakage than the Quincke needle within 2 min following dura puncture.

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