Determination of Suitable Syringes Used in the Loss-of-resistance Technique for Identification of the Epidural Space by Comparison of Relative Resistance

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Abstract

To determine the most suitable syringe for the loss-of-resistance technique (LOR), we compared the relative resistance of nine syringes: TOP, TOP SK, B/BRAUN, M-S, TERUMO, Perifix, Unieter, PORT-TEX, and BD Epilor syringes. Ejecting time of the medium in a constant volume, a good index of resistance, was measured by the system to push the plunger of the syringes tested with identical force. The system was composed of three parts: the syringe to push the plunger of the syringe tested, a saline bag of a pressure infusion kit to provide driving force to the syringe, and a monitor with a pressure transducer to keep the driving force constantly. The results indicate that all of the syringes except the TERUMO syringe are appropriate for the LOR using air, and each syringe except the TERUMO and Perifix syringes is appropriate for the LOR using saline, especially B/BRAUN syringe is the most suitable when attached to a 22-gauge needle.

Key words

the loss-of-resistance technique, syringe, identification of the epidural space, resistance of syringe

Introduction

While the loss-of-resistance technique (LOR) is routinely used to identify the epidural space, an improved technique has been developed to decrease the complications associated with incorrect needle location. We value the development of new instruments. Priority should be given to investigation of originals when the diffusion rate of conventional LOR is considered. Prudent selection of a specific syringe, which is easy to use in the epidural space, is especially important for trainees. In LOR, a syringe requirement is to sensitively transmit reduction of resistance to the thumb of the operator’s dominant hand. Therefore, the factors affecting tactile feel are the most important, for instance, high friction drag dulls the tactile feel. It may attract the interest of clinicians that an appropriate syringe for LOR is determined by investigating resistance.

The purpose of this study was to determine the most suitable syringe for use in LOR. We planned experiments that compared the relative resistance of nine syringes. The ejecting time of a medium in a constant volume is a good index of resistance for the measurement of relative resistances of the syringes, provided that each syringe tested is applied with an identical load. We applied Poiseuille’s law to the present method, similar to the Ostwald viscometer determinations of relative viscosity made by time measurement. The experiments were the simplest and clearest adequate test of syringes used in LOR. As for the experiments, neither load nor pressure affects the index of resistance. To our knowledge, this is the first report that an appropriate syringe for...
LOR is determined by investigating relative resistance.

Materials and Methods

This study was conducted on four 5 ml glass syringes: TOP\textsuperscript{8} and TOP SK\textsuperscript{8} (TOP Surgical Manufacturing, Tokyo, Japan), B.BRAUN\textsuperscript{8} (B. Braun Aesculap, Tokyo, Japan), and M-S\textsuperscript{8} (MS, Tokyo, Japan), and on five resin syringes: TERUMO\textsuperscript{5} 5 ml (Terumo, Tokyo, Japan), Perifix\textsuperscript{8} 10 ml (B. Braun Melsungen AG, Melsungen, Germany), Uniever\textsuperscript{8} 7 ml (Unisys, Tokyo, Japan), PORTEX\textsuperscript{8} 10 ml (Smiths Medical ASD, Watford, UK), and BD Epilor\textsuperscript{8} 7 ml (Becton Dickinson, Franklin Lakes, NJ, USA). The resin syringes except TERUMO are used exclusively for LOR. Five syringes were assigned to each brand group. Both 18-gauge (l.: 80 mm, i.d.: 0.97 mm) and 22-gauge (l.: 80 mm, i.d.: 0.53 mm) sizes were used as Tuohy needles (B. Braun Aesculap, Tokyo, Japan).

Spontaneous fall of the plunger was observed in syringes maintained vertically. The inner diameters of the injection port and barrel, and the weight of plunger are presented in Table 1.

Under the condition using air, the ejecting time of the syringe attached to a 22-gauge needle was significantly prolonged as compared with the four non-attached syringe groups (Table 2). There was no effect in any of the syringe groups with 18-gauge needles attached. The ejecting time of the TERUMO group was significantly longer than that of the TOP group regardless of the attached needle.

Under the condition using saline, the ejecting time of the Perifix and TERUMO groups was sig-
significantly longer than that of the TOP group with 18- and 22-gauge needles attached. Although the ejecting time of the B/BRAUN group was significantly shorter than that of the TOP group with a 22-gauge needle attached, the ejecting time of the TOP SK, Uniever, PORTEX and BD Epilor groups was significantly longer than that of the TOP group. There was no differences between data of M-S and TOP groups.

### Discussion

LOR using saline as the medium is practiced in the UK\(^3\), whereas LOR with air is the custom in Spain\(^4\). To add to these clinical situations, air was employed to ascertain the relative friction drag of each syringe in the experiments. Resistance of a syringe is given by calculating the sum of the friction and viscous drags. The friction drag is generated on the contact surface between the barrel and the plunger, and the viscous drag occurs on the interface of the flow route and the medium in a syringe with a needle. Because the volume density of gaseous air is clearly lower than that of liquid saline, the viscous drag of air is nearly negligible when the plunger is slowly pushed into the syringe without a needle: syringe resistance approximates friction drag. Hence, high ejecting time values for air indicate strong relative friction drag, resulting in the syringe being unsuitable for LOR regardless of medium and needle size.

<table>
<thead>
<tr>
<th>Syringe (Material)</th>
<th>Inner diameter of injection port (mm)</th>
<th>Inner diameter of barrel (mm)</th>
<th>Weight of plunger (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP (Glass)</td>
<td>1.38±0.05</td>
<td>12.08±0.02</td>
<td>8.827±0.031</td>
</tr>
<tr>
<td>TOP SK (Glass)</td>
<td>1.58±0.07 *1</td>
<td>12.01±0.01</td>
<td>8.945±0.079 *1</td>
</tr>
<tr>
<td>B/BRAUN (Glass)</td>
<td>2.09±0.05 ***1</td>
<td>12.34±0.08</td>
<td>10.048±0.147 ***1</td>
</tr>
<tr>
<td>M-S (Glass)</td>
<td>0.94±0.02 *1</td>
<td>12.39±0.03</td>
<td>9.758±0.085 *1</td>
</tr>
<tr>
<td>TERUMO (Resin)</td>
<td>1.92±0.19 ***1</td>
<td>13.03±0.01</td>
<td>1.872±0.030 ***1</td>
</tr>
<tr>
<td>Perifix (Resin)</td>
<td>2.30±0.16 *1</td>
<td>15.77±0.03</td>
<td>4.587±0.002 *1</td>
</tr>
<tr>
<td>Uniever (Resin)</td>
<td>1.91±0.10 *1</td>
<td>15.05±0.03</td>
<td>4.138±0.006 *1</td>
</tr>
<tr>
<td>PORTEX (Resin)</td>
<td>2.04±0.06 *1</td>
<td>14.97±0.04</td>
<td>4.686±0.012 *1</td>
</tr>
<tr>
<td>BD Epilor (Resin)</td>
<td>1.77±0.03 *1</td>
<td>14.29±0.03</td>
<td>4.466±0.043 *1</td>
</tr>
</tbody>
</table>

p: probability
*1: p<0.05 vs TOP, ***1: p<0.01 vs TOP
**2: p<0.05 vs needle not attached
*2: p<0.01 vs needle not attached
Number of samples is 4-5 in each datum.
Under the conditions using air, the ejecting time results showed that relative resistances in all of the syringe groups except the TERUMO are low regardless of needle size, suggesting appropriateness for LOR using air. It was suggested that the TERUMO syringe is inadequate for LOR, because results of the TERUMO group indicated high friction drag.

Under the conditions using saline, higher relative resistance of the Perifix group became clear from the ejecting time results for both needle sizes, suggesting inadequacy for LOR using saline. The ejecting time of the B/BRAUN group was the lowest among all the groups, especially with the 22-gauge needle attached, and the data suggested that the B/BRAUN syringe is the most suitable syringe for LOR using a fine needle. In contrast, ejecting time values in the exclusive syringe groups for LOR were significantly higher than those of the TOP syringe group. The results may be due to the thicker inner diameter of the barrel in the exclusive syringe groups. Since pressure is defined as force acting on a unit area, pressure varies inversely with area under an identical load. Consequently, the pressure applied to the injection port may be low in the exclusive syringe groups as compared with the TOP group, resulting in prolongation of the ejecting time. Indeed, the Perifix group which has the barrel of maximal inner diameter showed a tendency for prolonged ejecting time.

The heavy plunger of glass syringes shifted position with gravity; accordingly, a beginner should pay attention to dropping off of the plunger and mixing saline with air bubbles during the paramedian approach in the lateral position.

In conclusion, the results indicate that all of the syringes except the TERUMO syringe are appropriate for LOR using air, and that all but the TERUMO and Perifix syringes are appropriate for LOR using saline. The B/BRAUN syringe is the most suitable, especially in the state in which a 22-gauge needle is attached.

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References

硬膜外腔確認のための抵抗消失法に用いる最適な注射筒の
相対抵抗の比較による決定

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抄 録

硬膜外麻酔において、抵抗消失法が硬膜外腔確認のために日常的に用いられている。針の不適切な位置決めによる合併症低減のため、硬膜外腔を容易に穿刺することが可能な特定の注射筒の慎重な選択が必要とされる。訓練中の人々にとって特に有用である。抵抗消失法における注射筒の必要条件は、術者の手の部位の繊細に抵抗の減少を誇張に伝達することである。したがって、注射筒の摩擦抵抗は低いほうが好ましい。本研究の目的は、抵抗消失法に最適な注射筒を決定することである。9 種類の注射筒(トップ、トップ SK、ビープラウン、エムエス、テルモ、ベリフィックス、ユニエバー、ポーテックスならびに BD エピロワール)の相対抵抗を比較した。相対抵抗は一定の力(60 あるいは 120 mmHg)を加え、注射筒に充填した 3 ml の空気あるいは生理食塩液を排出時間を計測することにより求めた。その結果、空気を用いる抵抗消失法ではテルモを除いたすべての注射筒が妥当な摩擦抵抗を示し、生理食塩液ではテルモとベリフィックスを除いた注射筒が妥当であった。また、ビープラウンはより細い注射針(22G)を装着した場合でも摩擦抵抗が最も低く、抵抗消失法に最適な注射筒であった。

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