Experimental Evaluation of Stent Clot Retrieval Using the Confront Clot Scrambling Method with an Equitable Automatic Withdrawal Machine

Abstract

Background: Stent clot retrievers can be used to perform mechanical thrombectomies to treat cases of acute major arterial occlusion. This approach is associated with faster recanalization and better outcomes than internal treatments. The function of the stent retrievers is based on a technique known as confront clot scrambling method (CCSM), which usually involves the insertion of two stent retrievers (one from each side) and the simultaneous withdrawal of the retrievers with an equal force. It was determined that a stent used to remove the sham clot possessed a stronger ability for clot retrieval. However, this method involves inherent manipulation bias, and the results may vary due to operator-specific factors. Thus, this approach can be difficult to teach, especially to beginners. Materials and Methods: We evaluated the accuracy of using an equitable automatic withdrawal machine for the CCSM on a model of a sham clot in the middle of a polyvinyl chloride tube. Results: This tool is expected to facilitate thorough and repeated training that is needed to learn the fine maneuvers against invisible vessels associated with actual endovascular clot retrieval, particularly for beginners.

Keywords: Clot capture, mechanical thrombectomy, push-and-fluff, stent retriever

Introduction

Generally, in vitro training for neuroendovascular intervention is challenging. Practicing coil embolization and liquid injection using simple equipment is difficult. For example, the push-and-fluff technique\(^1\) depends on a physician's skill. Conversely, the confront clot scrambling method (CCSM)\(^2\) can be repeatedly performed to practice mechanical thrombectomies at any location and time using inexpensive equipment. One advantage of the CCSM is that it allows the degree of stent dilatation to be evaluated by direct visualization. In this experimental study, we evaluated the accuracy of the CCSM using an equitable automatic withdrawal machine to optimize the training process for beginners.

Materials and Methods

Six standard stent retrievers of three different brands, as used in a previous report,\(^3\) are evaluated as listed in Table 1: The Trevo ProVue (Stryker, Kalamazoo, Michigan, USA; three sizes), Revive (Codman, Raynham, Massachusetts, USA; one size), and Solitaire 2 (Medtronic, Irvine, California, USA; two sizes).

Confront clot scrambling method

Experiments were performed in dry conditions at room temperature. A piece of urethane gel was used as a model thrombus to circumvent the konjac-associated risk of spoilage during the humid season in Japan. A polyvinyl chloride tube (5 mm in diameter and 20 cm long) was used to model the vasculature. A 15-mm long sham clot was placed in the middle part of the tube. Thereafter, two stent retrievers were simultaneously navigated and deployed from each side to reach come into contact with the sham clot [Figure 1]. Then, both stents were simultaneously withdrawn from each end with an equal force generated by an equitable automatic withdrawal machine [Figure 2]. It was determined that the stent, which successfully removed the sham clot, had superior clot-retrieval ability [Figure 3].

Automatic withdrawal machines

Multiple machines, each using a linear actuator to pull a wire with a constant force, are evaluated as listed in Table 1: Three standard stent retrievers of three different brands, from each company, are used as listed in Table 1: (Codman, Raynham, Massachusetts, USA; one size), and Solitaire 2 (Medtronic, Irvine, California, USA; two sizes).

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velocity, were fabricated and tested. The linear actuator comprised a stepping motor, a ball screw to convert the rotational motion of the motor into linear motion, and a linear guide. It was capable of linear movement for a distance of 120 mm. The deployed stents were simultaneously withdrawn at a speed of 1.0 mm/s. All trials were monitored via an overhanging charge-coupled device video camera (Dino-Lite Digital Microscope AM-2001; AnMo Electronics Corporation, New Taipei City, Taiwan).

### Standard and adjunctive techniques

Several adjunctive techniques were compared with several stents as in a previous report: a standard deployment, 5-min wait, and the push-and-fluff method.

### Results

The results of the machine-guided CCSM with different stent retrievers are shown in Table 2. For all three stent brands, it was noted that a 5-min wait after deploying the stent was more effective compared with simple deployment with immediate retrieval. Furthermore, the push-and-fluff technique resulted in a higher strength with all retrieval devices.

### Discussion

In this study, the results obtained from the machine-guided CCSM were comparable to those of the conventional method. The manual withdrawal can be affected by operator-specific factors, whereas machine-guided withdrawal led to uniform results. Therefore, the CCSM appeared to be an accurate and reliable technique. In addition, the results showed that the adjunctive push-and-fluff technique resulted in higher strength than the alternatives. Although this technique is an established adjunctive technique for closed-cell stents, the results show that it is also effective with the Solitaire stent, which employs a rolled-sheet design.

In addition, the results of the present study showed that the stent that was deployed first was generally stronger than the one that was deployed after it. On the contrary, the success of the push-and-fluff technique depended on the physician’s skill. Therefore, by deploying a stent with the push-and-fluff technique second, the effects of the physician’s maneuvering can be effectively confirmed. The degree of stent dilatation could be readily observed by direct visualization. For example, when the pushing force was too strong, the stent tended to bend distally or slip away. Because actual endovascular clot retrieval requires extremely fine maneuvering against internal vessels, repeated training is critical, particularly for beginners. The CCSM can be repeatedly performed; thus, this process can be facilitated at any location or time using low-cost equipment.

In this study, CCSM was not performed in an actual clinical setting, which is one of the limitations of the study. Further

### Table 1: List of stent retrievers evaluated in this study

<table>
<thead>
<tr>
<th>Stent retriever</th>
<th>Size: nominal diameter×length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trevo Provue (Stryker, Kalamazoo, Michigan, USA)</td>
<td>3×20, 4×20, 6×25</td>
</tr>
<tr>
<td>Revive (Codman, Raynham, Massachusetts, USA)</td>
<td>4.5×22</td>
</tr>
<tr>
<td>Solitaire 2 (Medtronic, Irvine, California, USA)</td>
<td>4×20, 6×30</td>
</tr>
</tbody>
</table>
investigations are required to confirm our findings and evaluate other vascular models and sham clots. Moreover, a quantitative evaluation is warranted to compare each technique and stent.

**Conclusion**

The present study aimed to perform one-to-one competitive analyses of stent retrievers during clot capture using CCSM and equitable automatic withdrawal machine. Our results confirm the accuracy and reliability of the CCSM. Although the push-and-fluff technique is the most effective adjunctive technique, it depends on the physician’s skill. However, these are preliminary findings in a simulated model with several limitations. The results should be validated by quantitative evaluations to further optimize the stent retrievers and evaluate adjunctive techniques.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**