Article published online: 2022-09-09

Original Article

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

Reo Kawaguchi, Tomotaka Ohshima[1], Yoshitaka Nagano[2], Shigeru Miyachi[1], Naoki Matsuo, Masakazu Takayasu

Department of Neurosurgery, Aichi Medical University, [1]Neuroendovascular Therapy Center, Aichi Medical University, [2]Department of Electronic Control and Robot Engineering, Aichi University of Technology, Aichi, Japan

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,[2] 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

How to cite this article: Kawaguchi R, Ohshima T, Nagano Y, Miyachi S, Matsuo N, Takayasu M. Experimental evaluation of stent clot retrieval using the confront clot scrambling method with an equitable automatic withdrawal machine. Asian J Neurosurg 2019;14:1165-7.

Address for correspondence:
Dr. Tomotaka Ohshima, Neuroendovascular Therapy Center, Aichi Medical University, 1-1 Yazakokarimata, Nagakute, Aichi 480-1195, Japan.
E-mail: tmtkoh@gmail.com

Access this article online

Website: www.asianjns.org

DOI: 10.4103/ajns.AJNS_285_18

Quick Response Code:

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).

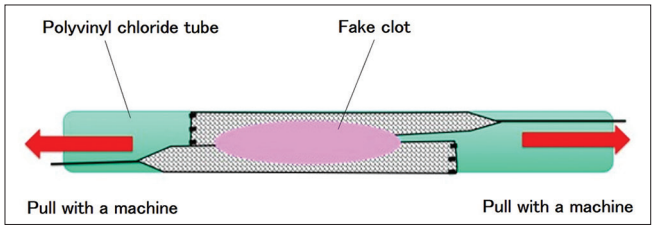

Figure 1: Schematic illustration of the confront clot scrambling method showing an artificial positioned in the middle of the tube. Then, two stent retrievers were inserted (one from each side) to contact the clot. Next, each stent was simultaneously withdrawn with the same speed, from each end, using automatic withdrawal machines

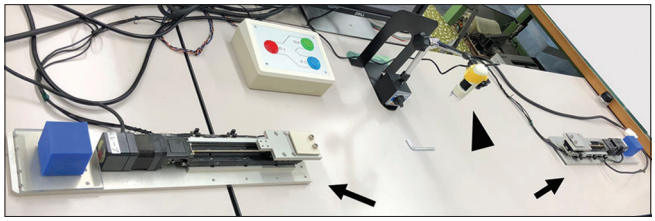

Figure 2: Photographs of the equitable automatic withdrawal machines. Black arrows indicate actuator machines. The stent delivery wires were simultaneously withdrawn to the opposite side at speed of 1.0 mm/s. Black arrowhead shows the over-hang charge-coupled device video camera

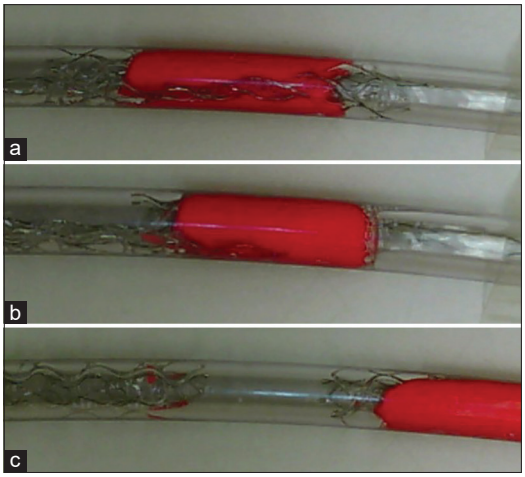

Figure 3: Photographs of the confront clot scrambling method using the machines with two stent devices. (a) The state just after stent deployment. Both stents were simultaneously deployed. The right stent was deployed using the push and fluff technique. (b and c) When both stents were withdrawn, with the same force from each end using the machines, the clot was retrieved by the right stent

Standard and adjunctive techniques

Several adjunctive techniques were compared with several stents as in a previous report: [2] 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

Stent retriever	Size: nominal diameter×length (mm)
Trevo Provue (Stryker, Kalamazoo, Michigan, USA)	3×20, 4×20, 6×25
Revive (Codman, Raynham, Massachusetts, USA)	4.5×22
Solitaire 2 (Medtronic, Irvine, California, USA)	4×20, 6×30

Table 2: Results of confront clot scrambling method with stent retrievers

□	Stent 1	Adjunctive		Adjunctive	Stent 2	□
×	Trevo 4×20	None	Versus	5 min	Trevo 4×20	○
×	Trevo 4×20	None	Versus	P & F	Trevo 4×20	○
×	Trevo 4×20	5 min	Versus	P & F	Trevo 4×20	○
×	Trevo 3×20	None	Versus	P & F	Trevo 3×20	○
×	Trevo 6×25	None	Versus	P & F	Trevo 6×25	○
×	Revive 4.5×22	None	Versus	5 min	Revive 4.5×22	○
×	Revive 4.5×22	None	Versus	P & F	Revive 4.5×22	○
×	Revive 4.5×22	5 min	Versus	P & F	Revive 4.5×22	○
×	Solitaire 4×20	None	Versus	5 min	Solitaire 4×20	○
×	Solitaire 4×20	None	Versus	P & F	Solitaire 4×20	○
×	Solitaire 4×20	5 min	Versus	P & F	Solitaire 4×20	○
×	Solitaire 6×30	None	Versus	P & F	Solitaire 6×30	○

P & F: push and fluff

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.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Haussen DC, Rebello LC, Nogueira RG. Optimizating clot retrieval in acute stroke: The push and fluff technique for closed-cell stentrievers. Stroke 2015;46:2838-42.
2. Ohshima T, Goto S, Yamamoto T, Ishikawa K. Experimental evaluation and training of stent clot retrieval: The confront clot scrambling method. Nagoya J Med Sci 2017;79:401-6.