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Review Article

# Questionnaire Survey of Neurointerventional Simulation Training in the Japanese Society for Neuroendovascular Therapy

*Yuki Ebisudani, Kenji Sugiu, Satoshi Murai, Jun Haruma, Masafumi Hiramatsu, Tomohito Hishikawa, and Isao Date*

**Objective:** Simulation training has focused on education and practical training. However, the adoption rate of neurointerventional simulation training in Japan is unknown. Therefore, we sent a questionnaire survey form to consulting specialists from the Japanese Society for Neuroendovascular Therapy (JSNET) to clarify the actual simulation training situation and compare the differences between university hospitals and general hospitals in Japan.

**Methods:** The questionnaire survey was conducted in 243 neurosurgical training facilities that had JSNET consulting specialists between May 31, 2021 and July 31, 2021. The questionnaire survey forms were distributed by Google Forms.

**Results:** A total of 162 facilities responded to the survey (response rate: 66.7%; 35.2% from university hospitals and 64.8% from general hospitals). The adoption rate for simulation training was 53.7%, and it was significantly higher in the university hospitals than in the general hospitals (64.9% vs. 47.6%, $p = 0.035$). On the simulation effectiveness survey, more than 80% of respondents answered that the simulation training was a useful tool for upskill training. The open-ended question on interventional simulation training showed that there are limiting factors such as financial constraints. Additionally, respondents expressed a desire for a standard neurointerventional simulation training and education program.

**Conclusion:** The adoption rate for simulation training was 53.7% in the training facilities of JSNET, and it was higher in the university hospitals than in the general hospitals. Most of the respondents answered that simulation training is an effective tool to improve neurointerventional skills. They also requested the establishment of simulation training programs and simulation tools.

**Keywords▶** neurointervention, simulation training, questionnaire survey

## Introduction

Recently, neurointerventional treatment has been spreading widely because it is less invasive and there have been improvements in neurointerventional devices. Compared to the last decade, neurosurgical residents have more opportunities to attend neurointerventional treatment.[1,2)]

Simulation training is expected to be a useful tool for medical education and clinical applications because there is no risk of harm to patients. In recent years, realistic models for near-clinical situations have been developed for neurointervention training, such as ANGIO Mentor,[3)] VIST,[4–6)] and 3D printed models.[7,8)] These simulation trainings offer improvements in accuracy, reduction in procedural time, and neurointerventional knowledge. However, useful simulators have not yet been introduced to all training facilities in Japan. Simulation training may be imbalanced between university hospitals and general hospitals.

For this background, we conducted a questionnaire survey on the training facilities of the Japanese Society for Neuroendovascular Therapy (JSNET) to reveal the current situation of neurointerventional simulation training and the differences between university hospitals and general hospitals in Japan.

*Department of Neurological Surgery, Okayama University Faculty of Medicine, Dentistry and Pharmaceutical Sciences, Okayama, Okayama, Japan*

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Corresponding author: Kenji Sugiu. Department of Neurological Surgery, Okayama University Faculty of Medicine, Dentistry and Pharmaceutical Sciences, 2-5-1 Shikata-cho, Kita-ku, Okayama, Okayama 700-8558, Japan
Email: ksugiu@md.okayama-u.ac.jp

**Table 1** Survey questions and answers

| Questions | Answers |
|---|---|
| Part 1. Information on respondents | |
| Age group | 30–39, 40–49, 50–59, 60–69, 70–79 |
| Gender | Male or female |
| Type of facility | University hospitals or general hospitals |
| Name of facility | Free comment |
| Part 2. Actual situation of simulation training | |
| Does your facility adopt any simulation training for self-improvement or education? | Yes or no (If "No," move to Part 5.) |
| Part 3. Simulation training for self-improvement | |
| Does your facility adopt any simulation training for self-improvement? | Yes or no (If "No," move to Part 4.) |
| What are the contents of simulation training?† | Mechanical thrombectomy, coil embolization, carotid artery stenting, catheterization |
| What are the tools of simulation training?† | Virtual simulation, 3D model, patient-specific model |
| What is the frequency of simulation training? | Once a week, once a month, once half of a year, once a year, others |
| Part 4. Simulation training for education | |
| Does your facility adopt any simulation training for education? | Yes or no (If "No," move to Part 5.) |
| Who is the target of the education?† | Medical students, junior residents (PGY1-2), residents (PGY ≥3), medical staff |
| What are the contents of simulation training?† | Mechanical thrombectomy, coil embolization, carotid artery stenting, catheterization |
| What are the tools of simulation training?† | Virtual simulation, 3D model, patient-specific model |
| What is the frequency of simulation training? | Once a week, once a month, once half of a year, once a year, others |
| Part 5. Simulation effectiveness survey | |
| How useful is the simulation training? | 1: no usefulness, 2: low usefulness, 3: medium usefulness, 4: high usefulness, 5: extreme usefulness |
| Part 6. Open-ended question | |
| Do you have any comments on simulation training? | Free comment (skip allowed) |

†Duplicates were allowed. PGY: postgraduate year

## Material and Methods

The questionnaire survey was conducted in 243 neurosurgical training facilities that had JSNET consulting specialists between May 31, 2021, and July 31, 2021. The questionnaire survey was conducted using Google Forms. Respondents were representative of their facilities.

The survey content was divided into six parts. Part 1 related to information on respondent age, gender, and facility type. Facility type was either university hospital or general hospital. Part 2 was the actual situation survey relating to simulation training. Simulation training was divided into self-improvement or education. Self-improvement related to one's own skills training, regardless of the number of attendees (single or more than two individuals). In contrast, education relates to the skill training of another person. Those who answered No in Part 2 moved on to Part 5. Parts 3 and 4 related to the details of simulation training for self-improvement or education (contents, tools, and frequency). The training contents included mechanical thrombectomy, coil embolization, carotid artery stenting, and catheterization (duplicates were allowed). The training tools included virtual simulation, 3D model, and patient-specific model (duplicates were allowed). The frequency was once a week, once a month, once half of a year, once a year, and others. In Part 4, we set an additional question about the target of the education that included medical students, junior residents (postgraduate year: PGY1–2), residents (PGY ≥3), and medical staff (duplicates were allowed). Part 5 was the simulation effectiveness survey. Respondents rated simulation training using a 5-point scale (1: no usefulness, 2: low usefulness, 3: medium usefulness, 4: high usefulness, and 5: extreme usefulness). In part 6, an open-ended question was provided to collect personal opinions on neurosurgical simulation training. All questions and answers are shown in **Table 1**.

**Data analysis**

Statistical analysis was performed using JMP version 14.0 (SAS Institute, Cary, NC, USA). We investigated the differences in the purpose, contents, frequency, tools, and simulation training educational target between the university hospitals and the general hospitals. Chi-square tests were used for categorical variables. A *p*-value <0.05 was deemed statistically significant.

## Results

A total of 162 facilities responded to the survey (response rate: 66.7%, 35.2% from university hospitals and 64.8% from general hospitals). The results of part 1 are shown in **Table 2**.

**Table 2** Baseline characteristics

| | All |
|---|---|
| N | 162 |
| Responder's characteristics, (%) | |
| Male | 157 (96.9) |
| Age | |
| 30–39 | 11 (6.8) |
| 40–49 | 80 (49.4) |
| 50–59 | 59 (36.4) |
| 60–69 | 12 (7.4) |
| Type of facility, (%) | |
| University hospital | 57 (35.2) |
| General hospital | 105 (64.9) |

The results of parts 2–4 are shown in **Table 3**. The adoption rate for simulation training was 53.7% for all respondents. The adoption rate for simulation training was significantly higher in the university hospitals than that in the general hospitals (64.9% vs. 47.6%, $p = 0.035$). In the content breakdown, the self-improvement simulation training adoption rate was significantly higher in the general hospitals than that in the university hospitals (27.6% vs. 21.1%, $p = 0.018$). The educational simulation training adoption rate was significantly higher in the university hospitals than that in the general hospitals (64.9% vs. 41.0%, $p = 0.017$) (**Table 3**).

For self-improvement, there were no differences between the university hospitals and the general hospitals: mechanical thrombectomy (66.7% vs. 58.7%, $p = 0.629$), coil embolization (91.7% vs. 79.3%, $p = 0.312$), carotid artery stenting (41.7% vs. 24.1%, $p = 0.270$), and catheterization (41.7% vs. 44.8%, $p = 0.853$). For education, there were no differences between the university hospitals and the general hospitals: mechanical thrombectomy (75.7% vs. 86.0%, $p = 0.236$), carotid artery stenting (54.1% vs. 44.2%, $p = 0.378$), and catheterization (81.1% vs. 69.8%, $p = 0.241$). Only coil embolization was significantly different between the university hospitals and the general hospitals (89.2% vs. 69.8%, $p = 0.030$) (**Table 3**).

For educational simulation training, the general hospitals had a higher frequency than the university hospitals (34.9% vs. 10.8%, $p = 0.009$) for once a month. For self-improvement, there was no difference between the groups (**Table 3**).

Respondents weighed in on simulation training tools from four contents (duplicates were allowed), including virtual simulation, 3D models, patient-specific models, and others. Virtual simulation includes virtual reality, augmented reality, and VIST™ (Mentice, Gothenburg, Sweden). The 3D models include endovascular evaluator (EVE) (FAIN-Biomedical, Okayama, Japan) and artificial vessel models. The patient-specific models include models created based on patient data.

For self-improvement, there were no differences between the two groups. However, for education, “Others” had a significant difference between the university hospitals and the general hospitals (0.0% vs. 14.0%, $p = 0.005$) (**Table 3**). All respondents who chose “Others” indicated benchtop training in their open-ended response.

Respondents answered based on the four contents (duplicates were allowed) for the education target: medical students, junior residents, residents, and medical staff. Junior residents were defined as having 1–2 PGYs of experience and residents were defined as having more than three PGYs of experience. There were significantly higher rates for medical students between the university hospitals and the general hospitals (43.2% vs. 16.3%, $p = 0.007$) (**Table 3**).

Part 5 was the simulation effectiveness survey on simulation training. The answer options were 1: no usefulness (0.0%), 2: low usefulness (1.2%), 3: medium usefulness (14.2%), 4: high usefulness (36.4%), and 5: extreme usefulness (48.2%). As for the usefulness rate, 84.6% of respondents answered that “simulation training is useful (4+5)” (**Fig. 1A**). The usefulness rate was higher in the university hospitals than in the general hospitals (89.5% vs. 81.9%, $p = 0.258$) (**Fig. 1B**).

Part 6 was an open-ended question. The open-ended question was answered by 32 respondents (13 from the university hospitals and 19 from the general hospitals). We divided these into the following three types based on the answers: 1) differences in feasibility between simulation training and the actual clinical procedure (n = 5), 2) the

**Table 3** Simulation training contents and frequency comparison by the facility

| | University hospital | | General hospital | | Total | |
|---|---|---|---|---|---|---|
| All (n) | 57 | | 105 | | 162 | |
| Number of adoption (n) | 37 | | 50 | | 87 | |
| Adoption rate (%) | 64.9 | | 47.6 | | 53.7 | |
| | | | | | *p* value | |
| | Self-improvement | Education | Self-improvement | Education | Self-improvement | Education |
| Number of adoption | 12 | 37 | 29 | 43 | | |
| Adoption rate (%) | 21.1 | 64.9 | 27.6 | 41.0 | 0.018* | 0.017* |
| Contents (%)† | | | | | | |
| Mechanical thrombectomy | 66.7 | 75.7 | 58.7 | 86.0 | 0.629 | 0.236 |
| Coil embolization | 91.7 | 89.2 | 79.3 | 69.8 | 0.312 | 0.030* |
| Carotid artery stenting | 41.7 | 54.1 | 24.1 | 44.2 | 0.270 | 0.378 |
| Catheterization | 41.7 | 81.1 | 44.8 | 69.8 | 0.853 | 0.241 |
| Frequency (%) | | | | | | |
| Once a week | 0.0 | 0.0 | 6.9 | 4.7 | 0.232 | 0.112 |
| Once a month | 41.7 | 10.8 | 34.5 | 34.9 | 0.666 | 0.009** |
| Once half of a year | 58.3 | 62.2 | 51.7 | 48.8 | 0.699 | 0.231 |
| Once a year | 0.0 | 19.0 | 6.9 | 7.0 | 0.232 | 0.212 |
| Others | 0.0 | 8.1 | 0.0 | 2.3 | (–) | 0.230 |
| Tools (%)† | | | | | | |
| Virtual simulation | 33.3 | 37.8 | 13.8 | 18.6 | 0.165 | 0.054 |
| 3D model | 66.7 | 89.2 | 82.8 | 81.4 | 0.270 | 0.325 |
| Patient-specific model | 33.3 | 16.2 | 20.7 | 7.0 | 0.400 | 0.191 |
| Others†† | 0.0 | 0.0 | 10.3 | 14.0 | 0.140 | 0.005** |
| Trainee (%)† | | | | | | |
| Medical students | (–) | 43.2 | (–) | 16.3 | (–) | 0.007** |
| Junior residents (PGY1-2) | (–) | 0.0 | (–) | 4.7 | (–) | 0.112 |
| Residents (PGY ≥3) | (–) | 94.6 | (–) | 95.3 | (–) | 0.878 |
| Medical staff | (–) | 2.8 | (–) | 4.7 | (–) | 0.643 |

$^*p$ <0.05, $^{**}p$ <0.01, †duplicates were allowed, ††All respondents who chose "Others" indicated benchtop training in their open-ended response. PGY: post-graduate year

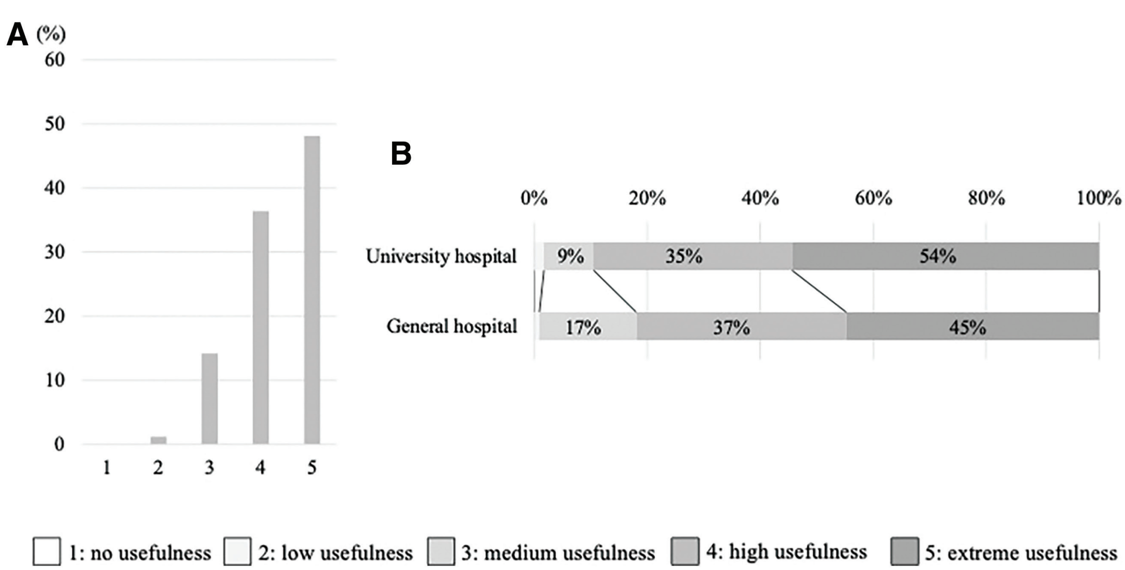


**Fig. 1** On the simulation effectiveness survey, respondents rated the usefulness of simulation training on a 5-point scale (1: no usefulness, 2: low usefulness, 3: medium usefulness, 4: high usefulness, and 5: extreme usefulness). An increasing trend is evident for simulation training expectation (**A**). The bar chart shows the trends in simulation effectiveness between the university hospital group and the general hospital group (**B**).

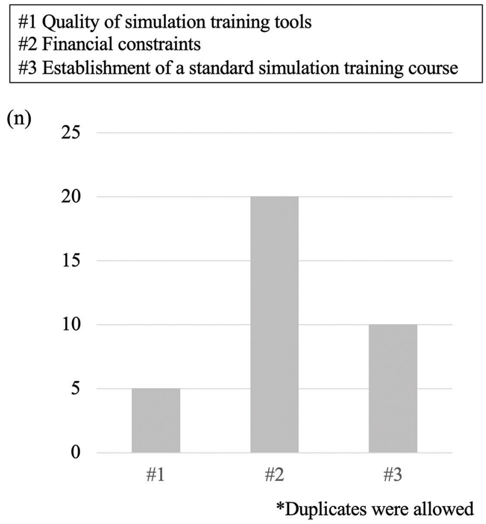


**Fig. 2** Thirty-two respondents answered the open-ended question. The most common answer was that financial limitations prevented the purchase of simulation tools. The second most common answer was an expression of the desire to establish a high-quality simulation training program.

high financial cost of purchasing and maintaining simulation training equipment (n = 20), and 3) the expressed desire for the establishment of a standard simulation training course of neurointerventional education (n = 10). Financial constraints was the most common answer among respondents (**Fig. 2**).

## Discussion

Simulation training is used to practice clinical skills in a safe environment and is effective in reducing complications. Recently, there has been an increase in simulation training tools, such as virtual reality,[4] 360° 3D virtual reality video with head-mount display,[9] and patient-specific models made by 3D printers.[7,8]

Virtual reality and 3D vascular models are reported to be useful tools for neurointerventional simulation training. Simulation training with virtual reality leads to reduced radiation exposure time and procedure time, and these effects are larger for beginners than for experts.[4] A patient-specific 3D model made using the patient's digital imaging and communication in medicine data can reproduce the disease status with high accuracy.[8,10] Thus, patient-specific 3D models are used for preoperative simulation, such as microcatheter shaping, microcatheter navigation, and coil test.[11,12] However, there has not yet been a systematic review of simulation training with the patient-specific 3D model in the neurointerventional field. Our survey revealed that the adoption rate of neurointerventional simulation training is 53.7% (response rate: 66.7%) in training facilities that have JSNET consulting specialists. There was only one report: Ospel et al. conducted a web-based international multidisciplinary survey about the unruptured aneurysm embolization for neurointerventionalists. They showed that the adoption rate of neurointerventional simulation training for unruptured intracranial aneurysm is 67.4%.[13] The simulation implementation rate in our survey was lower than that in Ospel et al.'s report. This was partly due to the possibility that simulations were performed at facilities without JSNET consulting specialists, which were not included in the survey, and partly because of the low response rate of less than 70%. Furthermore, there have been no reports examining the differences in simulation training between university hospitals and general hospitals. Interestingly, we revealed a difference in the simulation training adoption rate between the university hospitals and the general hospitals (64.9% vs. 47.6%, $p = 0.035$). This likely reflects the educational responsibility and number of trainees such as residents and medical students in university hospitals. In addition, most of the university hospitals owned an upskill lab. According to a previous report on medical simulation training in university hospitals in Japan in 2016, 97% of them have their own general upskill labs.[14] Another questionnaire survey on surgical training in Africa showed that the most-cited barriers to the integration of surgical simulation into residents' education were the lack of suitable tools and models (85%), funding (73%), and maintenance of facilities (49%).[15] This finding is in line with the results of our open-ended question. There are no reports regarding neurointerventional training in general hospitals. However, in terms of the contents of the simulation training in the general hospitals, respondents used "Other" tools and had a low ratio of virtual reality. This suggested that they faced financial barriers to acquiring or maintaining the simulation training tools.

In terms of the purpose of simulation training, the adoption rate is higher in education than in self-improvement in both groups (64.9% vs. 21.1% in university hospitals, and 41.0% vs. 27.6% in general hospitals). The most frequent education target is residents (university hospitals: 94.6%, general hospitals: 95.3%), and the frequency is once a month (university hospitals: 62.2%, general hospitals: 48.8%). A questionnaire survey on neurosurgical simulation training for neurosurgery residency program directors in the United States showed that 94% of respondents expected a daily training time of less than 1 hour from their residents.[16] From these results, it is expected that residents have insufficient opportunities to engage in simulation training. A questionnaire survey on simulation-based medical education in Japan showed that the barriers to training are instructors not having sufficient time and challenges related to simulation schedule management.[17] These findings are consistent with our results.

A previous report on neurointerventional simulation training showed that the training effects for neurointervention-experienced operators are not as marked when compared to inexperienced operators.[18] In addition, most of the reports focus on the training effects on medical students or residents. From these, it was hypothesized that neurointerventional simulation training for experts was not popular. Indeed, we revealed that the simulation training adoption rate for instructors is lower than that in education (university hospitals–education: 64.9%, self-improvement: 21.1%; general hospitals–education: 41.0%, self-improvement: 27.6%). However, we expect that the purpose of the simulation training of experienced operators differs from that of inexperienced operators. Ospel et al. described that simulation training is most valuable when trying new devices.[13]

A training system for introducing a new device has already begun, as seen in the Woven EndoBridge (WEB) device, for example. The WEB-IT study provides the clinical outcomes of unruptured aneurysms treated by WEB.[19] The WEB-IT study investigated a training system involving preoperative simulation for first-time users.[20] The study's thromboembolic events (<1%) and mean fluoroscopy time (30.1 min)[19,20] were lower than those of the WEBCAST study (thromboembolic events: 17.7%; mean fluoroscopy time: 37.0 min),[21] which did not have a preoperative training system. The two studies show good contrast that preoperative simulation leads to better treatment quality. New neurointerventional devices are being introduced at a rapid pace. As such, the number of operator training programs is predicted to increase. Our open-ended question results included requests to establish a standard training program. To support the needs of operators, a standard training program and affordable training tools must be developed.

### Limitations

Since one of the primary purposes of this survey was to compare differences between facilities, anonymity could not be maintained. Moreover, due to the format of the questionnaire survey, there is a possibility that differences in understanding or interpretation, or ignoring of questions may occur. Finally, although the response rate was low (66.7%), results indicate a trend in the actual situation of neurointerventional simulation training.

## Conclusion

The simulation training adoption rate was 53.7% among the JSNET training facilities, and it was higher in the university hospitals than in the general hospitals. Most respondents answered that simulation training is an effective tool to improve neurointerventional skills. There were limiting factors such as financial constraints. It is necessary to establish a standard simulation training program of neurointerventional education.

## Disclosure Statement

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