Acta Med. Okayama, 2024
Vol. 78, No. 4, pp. 313–322

Acta Medica Okayama
http://escholarship.lib.okayama-u.ac.jp/amo/

Original Article

Multicenter Remote-Access Simulation of Vaginal Delivery for High-Flexibility Medical Education during the Coronavirus Pandemic

Eriko Eto[a]*, Jota Maki[a], Noriyuki Yamashita[b], Toru Hasegawa[c], Ayano Suemori[a], Hikari Nakato[a], Hikaru Oba[a], Tomohiro Mitoma[a], Sakurako Mishima[a], Satoe Kirino[a], Akiko Ohira[a], and Hisashi Masuyama[a]

Departments of [a]Obstetrics and Gynecology, [c]General Medicine, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, [b]Center for Education in Medicine and Health Sciences, Okayama University, Okayama 700-8558, Japan

During the coronavirus pandemic, face-to-face simulation education became impossible. Therefore, we aimed to develop remote-access simulation education with a sense of realism through Information and Communication Technology (ICT) using a perinatal whole-body management and delivery simulator. In September 2021, we administered a multi-center simultaneous remote simulation based on our developed model. Ten universities in the Chugoku–Shikoku region were connected via a web-conferencing system to a live broadcast of a virtual vaginal birth in which a fictional hospitalized pregnant woman experienced accelerated labor and gave birth through vacuum delivery for fetal distress. A Video on Demand (VOD) was made beforehand using a new simulator that allowed for a visual understanding of the process of the inter-vaginal examination. We provided a participatory program that enhanced the sense of realism by combining VOD and real-time lectures on each scenario, with two-way communication between participants and trainee doctors using a chat function. Most participants answered "satisfied" or "very satisfied" with the content, level of difficulty, and level of understanding. From November 2021, we have used the videos of all processes in face-to-face classes. Our construction of a high-flexibility education system using remote simulation in the field of obstetrics and gynecology, especially in the vaginal delivery module, is unique, creative, and sustainable.

Key words: remote simulator education, perinatal simulator, information and communication technology, high-flexibility education

Our Obstetrics and Gynecology Department has focused on the education of medical students, residents, and specialty doctors as one of the most important issues in our field of research and practice. Various educational activities have been integrated to provide training in obstetrics and gynecology that meets the needs of students and residents, ultimately leading to recruitment and competent professional practice.

The need for simulation education is clearly stated in the guidelines for physician clinical training guidance in Japan. In addition to delivering knowledge, much more is required: nurturing the students' technical skills, habits of communication, and attitudes is also essential. Many problems regarding ethics and safety management arise when inexperienced trainee doctors perform invasive procedures on patients; they should be given sufficient simulation training to develop minimal com-

Received December 12, 2023; accepted April 24, 2024.
*Corresponding author. Phone: +81-86-235-7320; Fax: +81-86-225-9570
E-mail: eeto@okayama-u.ac.jp (E. Eto)

Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

petence before performing actual procedures. The advantages of simulation education include self-study, the ability to practice repeatedly, and enhanced learning through a combination of simulations and other methods such as lectures.

Prior to the coronavirus pandemic, instructors and learners at our institution conducted face-to-face simulation education in groups. For example, in the pre-resident seminar, participants gathered in a specialized facility such as the simulation center within the university. They were taught whole-body management of shock vitals, ultrasound examination using a fetal phantom, laparoscopic operation, and other powered devices. It was possible to guide each student as they rotated through booths about devices, suturing, and thread tying. Additionally, a face-to-face meeting was held at the medical office with the executive committee, which had recruited student volunteers and discussed the contents of the project.

When we surveyed 5th and 6th year medical students undertaking clinical training in our department before the pandemic, most students wanted to participate in simulation training, even though the training period lasted only one to two weeks. The most popular topics were general management, pelvic examinations, ultrasound examinations, uterine cancer screening, and childbirth (Fig. 1). In short clinical clerkships, the primary medical procedures (vaginal sampling, colposcopy, intravenous injection, and childbirth assistance) defined by the Ministry of Health, Labor, and Welfare are often not possible to witness and perform; thus, simulation training will always be necessary for train-

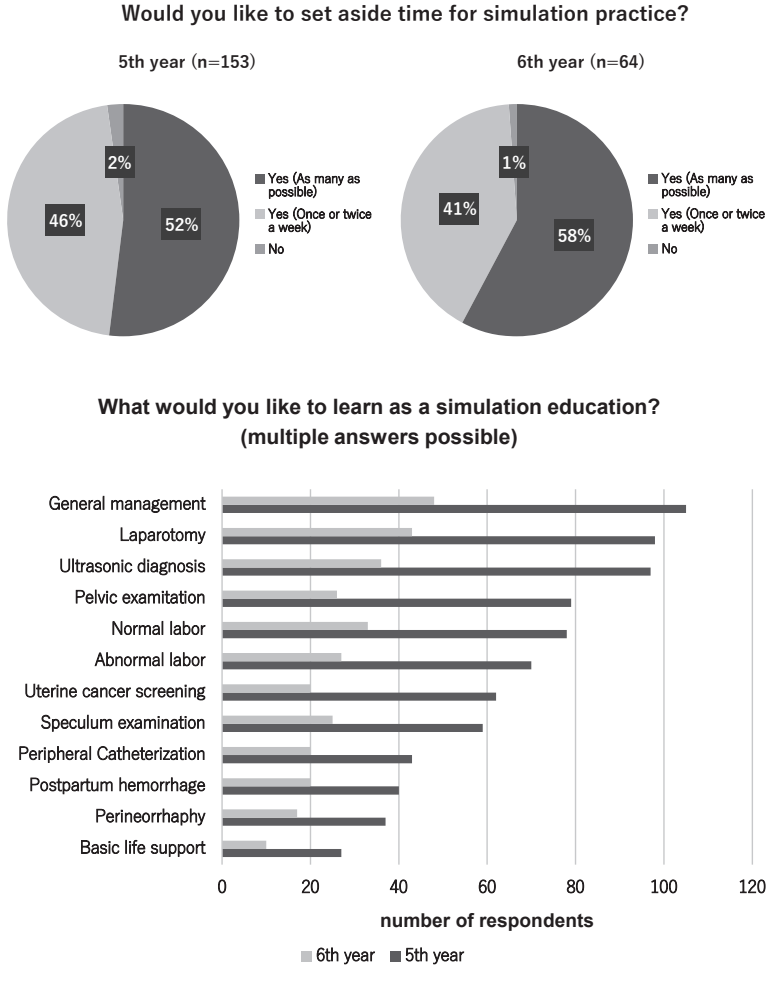

Fig. 1 Questionnaire for learners: Answers from 217 5th and 6th year medical students.

ing. We decided to aim for effective simulation education that would meet the needs of learners. Several previous studies reported that medical students need to be repeatedly exposed to simulation education to have a sense of psychological stability and to competently deliver medical treatment in a clinical setting [1,2]. Moreover, simulation education not only improved students' short-term medical knowledge but also had a long-term impact on their understanding [3,4].

Materials and Methods

New developments in remote-access simulator education. We decided to administer multicenter, simultaneous remote simulation education at the Chugoku–Shikoku Society of Obstetrics and Gynecology Plus One seminar in September 2021. Titled "Live Broadcast of Vaginal Delivery at Okayama University," the program provided participants with the opportunity to relive rotations and internal examinations, which are challenging to teach, through a virtual vaginal delivery program using the childbirth simulator developed by our department just prior to the pandemic, together with videos and scenario acting. The program also included lectures, group discussions, and other horizontal developments. Moreover, we planned an expansion program. This program was 80 min long and was prepared over nine months, targeting early trainee doctors and 6th year students interested in obstetrics and gynecology. Given the timing of the pandemic and the sense that instructional delivery would never be the same as before, the purpose of the seminar was to establish a high-flexibility educational module in the field of obstetrics and gynecology.

High-flexibility education is an method of instructional delivery that grew out of the changes in class policy required by the coronavirus 19 pandemic. It is an educational style in which the same class content is taught face-to-face and online simultaneously, combined with asynchronous online or on-demand classes later. High-flexibility education is a term coined to mean hybrid-flexible classes, in which students, depending on their preference and diverse schedules, can choose to take a course face-to-face or online [5].

We conducted what is informally called "on-the-job training" (OJT) through theexperience by streaming in real-time and created a retrospective video for asynchronous online education; the basic aim was to reach students throughtout the region. The regions of Chugoku and Shikoku are located in western Japan and span approximately 400 km straight from the Sea of Japan to the Pacific Ocean. With the Setonaikai Sea and the Sanin Mountains in between, it would take a person four to five hours to drive from Kochi Prefecture to Tottori Prefecture via Okayama Prefecture, for example. University hospitals are located in each prefecture, and 10 universities serve students' academic needs while establishing exchanges with one another for more in-depth studies and experiences.

Planning and preparations leading up to the event. During the planning process, which was nine months prior to the program, we used a delivery simulator to create a scenario called "live broadcast of a virtual vaginal birth" that combined Video on Demand (VOD) and real-time streaming. The 10 universities were connected using the web-conferencing system Zoom; furthermore, some face-to-face instructions were given at the headquarters, Okayama University, with students participating from home together with remote participants from the other nine universities simultaneously in an online format. Lectures pre-recorded from the headquarters were used to present cases and pose problems, along with two-way communication using the chat function. Simulation videos, played during each phase of childbirth, were also recorded in advance to ensure smooth progress (Fig. 2).

Six months in advance, we contacted each of the 10 universities to request that they recruit instructors and participants. After repeated team discussions, we developed a scenario where a pregnant woman was admitted to the hospital with ruptured membranes and experienced weak labor, accelerated labor, rotational abnormalities, fetal dysfunction, and rapid delivery before birth.

One month before the program, we recorded lectures, filmed the new training mannequin from multiple viewpoints at close range, and created videos for VOD. With the cooperation of an external video company, medical staff became the actors, and each scene was filmed and edited. Images were taken from two viewpoints, the perineum side and the inside of the pelvis, at a close range from the simulator and with repeated trial and error to see if we could create a video that enhanced the sense of realism (Fig. 3).

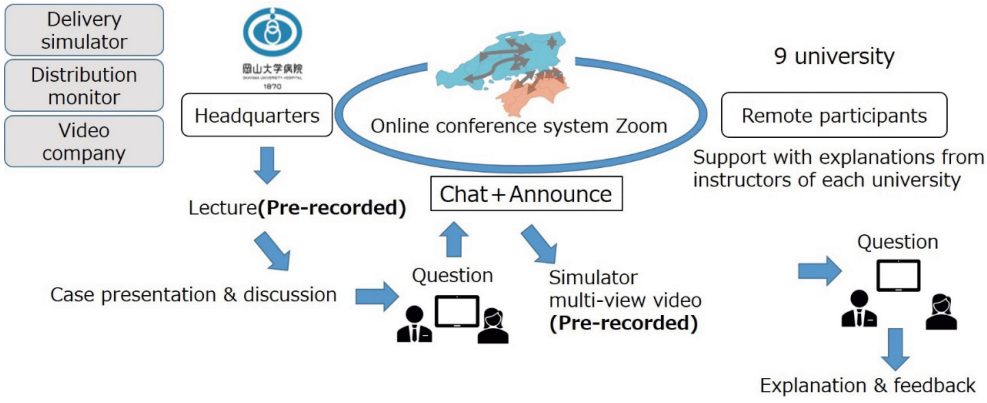

Fig. 2 Concept of multicenter simultaneous remote-access simulator education.

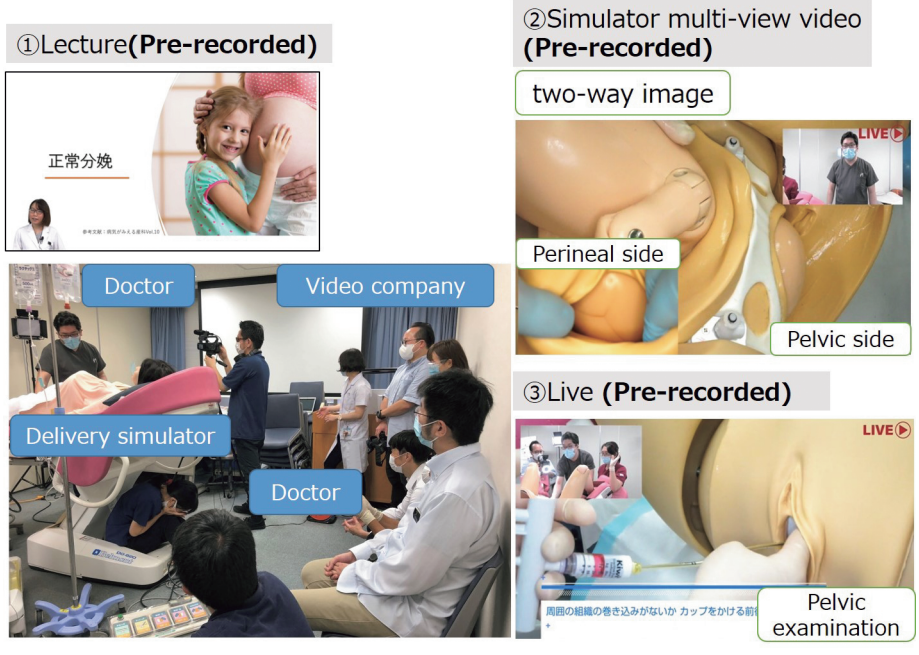

Fig. 3 Pre-recording for VOD video creation.

Results

At the September, 2021 seminar, we ran the multicenter remote delivery simulation education connecting the 10 universities in Chugoku and Shikoku. The number of participants and instructors from each prefecture is shown in Table 1.

On that day, the moderators made announcements via video. The delivery simulator was also set up for question-and-answer sessions on the same day. We enabled two-way communication via Zoom for remote participants (Fig. 4). To imitate a TV program, we switched to a pre-recorded video midway through the program when an announcement started to connect the exam room to the broadcast. The moderator proceeded with the scenario, alternating between the studio and pre-recorded videos. As the lectures that were inserted midway were also pre-recorded, we had to be careful about the timing to make it appear as if the lecture was being live-streamed from an adjacent lecture room. The students answered questions about reading comprehension on the cardiotocogram (CTG) monitor. Question

Fig. 4 Scenes of the day of the simulation.

Table 1 The number of participants and instructors from each prefecture

Prefecture	Instructors	Participants
Okayama (Okayama)	6	8
Okayama (Kawasaki Medical)	1	2
Tottori	1	2
Shimane	1	2
Hiroshima	1	2
Yamaguchi	1	2
Kagawa	1	12
Ehime	1	3
Kochi	1	2
Tokushima	1	2

(Q) 1 was "How should this CTG finding be interpreted?" Q2 was "What does this ultrasound finding mean?" Q4 was, again, "How should this CTG finding be interpreted?" Q5 was "What treatment decision will you make?" They received answers using a chat function, with instructors providing support to students at each university in the remote venue, and the answers were submitted on the chat. In the scene where the ultrasound movement and ultrasound images were shown, and the abnormal rotation was disclosed, the time axis was expressed by combining the ultrasound procedure scene and the ultrasound image one frame at a time, together with changes in the CTG. We explained rotation and how to evaluate pelvic examination findings while showing the position in the pelvic region of the simulator. A medical staff member was also placed at the head of the simulator to move the baby.

We simulated a vacuum-assisted delivery as a rapid delivery for fetal distress, taking care to make the scene as realistic as possible (Fig. 5). The lecture immediately prior to the session had taught participants how to deal with malrotation, weak labor, and fetal dysfunction. After the session, our instructors repeatedly raised problems and provided feedback, enabling participants to understand the content and leaving them with the feeling of "being there". The medical staff, whose role was to push the baby model from above the simulator in line with the suction side, found it quite challenging to match the amount of force and timing; this had taken much practice the day before. Subtitles reported key details regarding the patient and procedure, and the session ended with everyone working together to deliver the baby successfully.

We evaluated the impact on participants and instructors. A total of 33 participants, comprising early trainee doctors and medical students, answered the questionnaire, and three-quarters were women. Most respondents were satisfied with the content and felt the difficulty level was appropriate. The majority also regarded 80 min as rather long for a learning experience. Many respondents said they would like to participate in future seminars like this, both locally and online. However, the online seminars would have been

Fig. 5 Video streamed from headquarters on the day of simulation education.

more effective held in other prefectures. We received positive responses in the free writing section — for example, students felt motivated and enjoyed getting to know the atmosphere of each university's medical office through the scenes conveyed by Zoom; it was hands-on and effortless to understand — and we were glad we could produce some output. Fifteen preceptors responded that the event schedule and recruitment period were appropriate, and that the content, difficulty level, and duration were also appropriate.

All participants answered that they would like to continue attending future Plus One seminars, and most of them had positive opinions regarding the practical content of this seminar, making this first attempt a success (Fig. 6). The video created by recording the entire process was also used for face-to-face and asynchronous online classes commencing in November 2021.

Discussion

Our department jointly developed a perinatal whole-body management simulator with a company specializing in medical mannequins. The simulator was made to be as realistic as possible, and the scenario included rotation during delivery, pelvic examination findings, and changes in maternal vital signs. New features included the ability to realistically observe the inside of the vagina and external cervix and a device that allowed for administering fluids from an intravenous drip after securing an intravenous route.

This novel simulator had been introduced into the teaching environment in January, 2020, and training was conducted based on situations that young doctors are likely to encounter while on duty, such as obstetric emergencies and ultrasound diagnoses. Simulation education can be expanded to other areas. In ultrasonography, while transabdominal ultrasound was used to guide Focused Assessment with Sonography in Trauma, assuming intra-abdominal bleeding due to ectopic pregnancy rupture, transvaginal ultrasound can also be simulated. Practicing internal examinations, CUS examinations, and cytological examinations repeatedly in a more realistic manner is now possible. Furthermore, the range of instruction will be expanded, such as the perineal suture model and intravaginal techniques for shoulder dystocia. Questionnaires conducted before and after the training revealed that the simulation education gave students the abilities "to explain the role of an obstetrician and gynecologist in delivery," "to explain emergency obstetrics and gynecology," and "to use specific methods and useful responses in team-based medical care." The number of respondents who found the new simulator applicable for practice increased (Fig. 7), confirming that the introduction of the new simulator was practical.

Of course, within the month, all simulator-based education, including face-to-face classes, and group learning became impossible. All aspects of medical and surgical education were severely impacted by the pandemic. Shortages of personal protective equipment, suspension of clinical clerkships, and reduction in elective surgical cases unavoidably affected education [6,7].

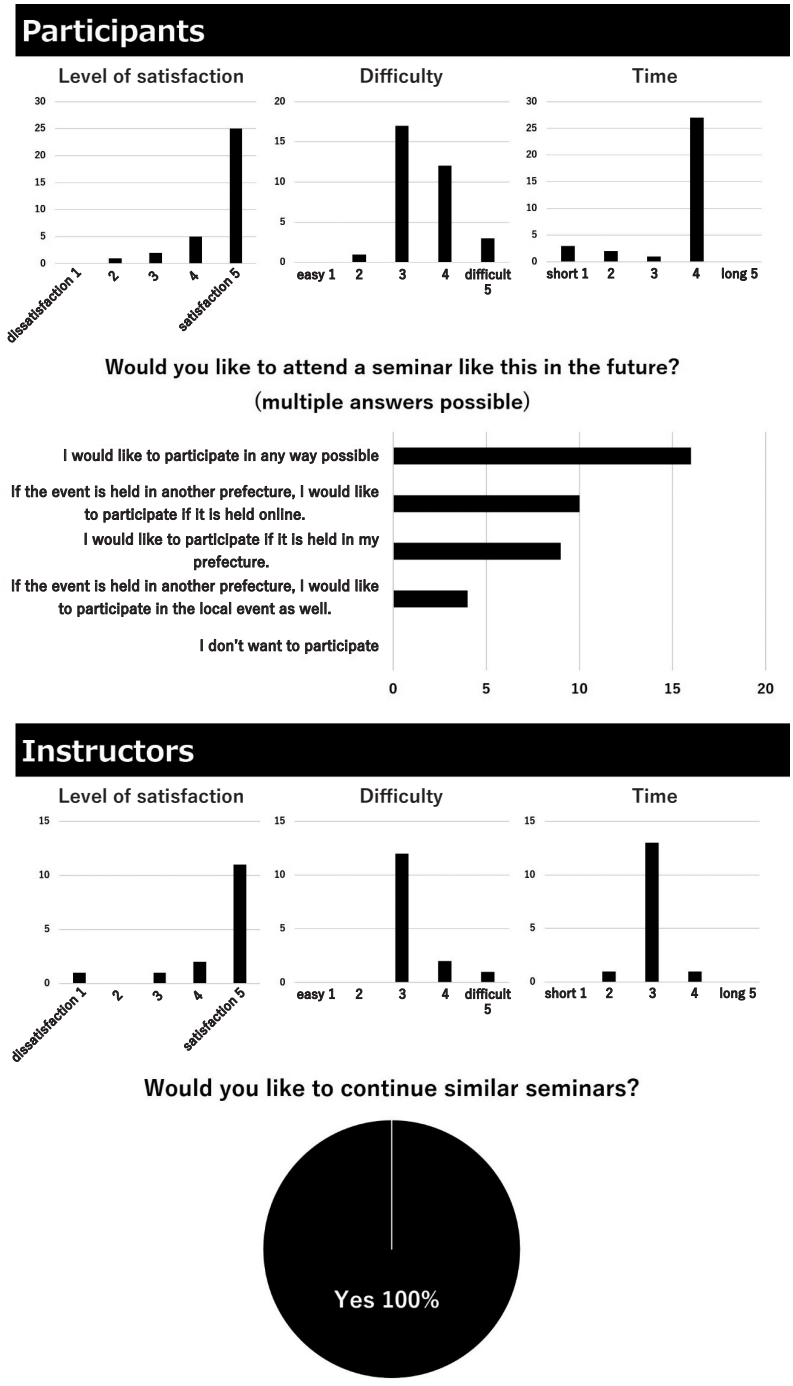

Fig. 6 Post-seminar questionnaire.

Educational activities had to be redesigned on very short notice. Online classes soon started [8,9]; however, OJT, which is practical training, including training in obstetrics and gynecology, was still needed. There followed a period of alternative implementation of so-called off-the-job training (Off-JT), typically classroom lectures. As reported by the Ministry of Education, Culture, Sports, Science, and Technology, while this format is effective for individual learning, it is disadvantageous for team or group learning.

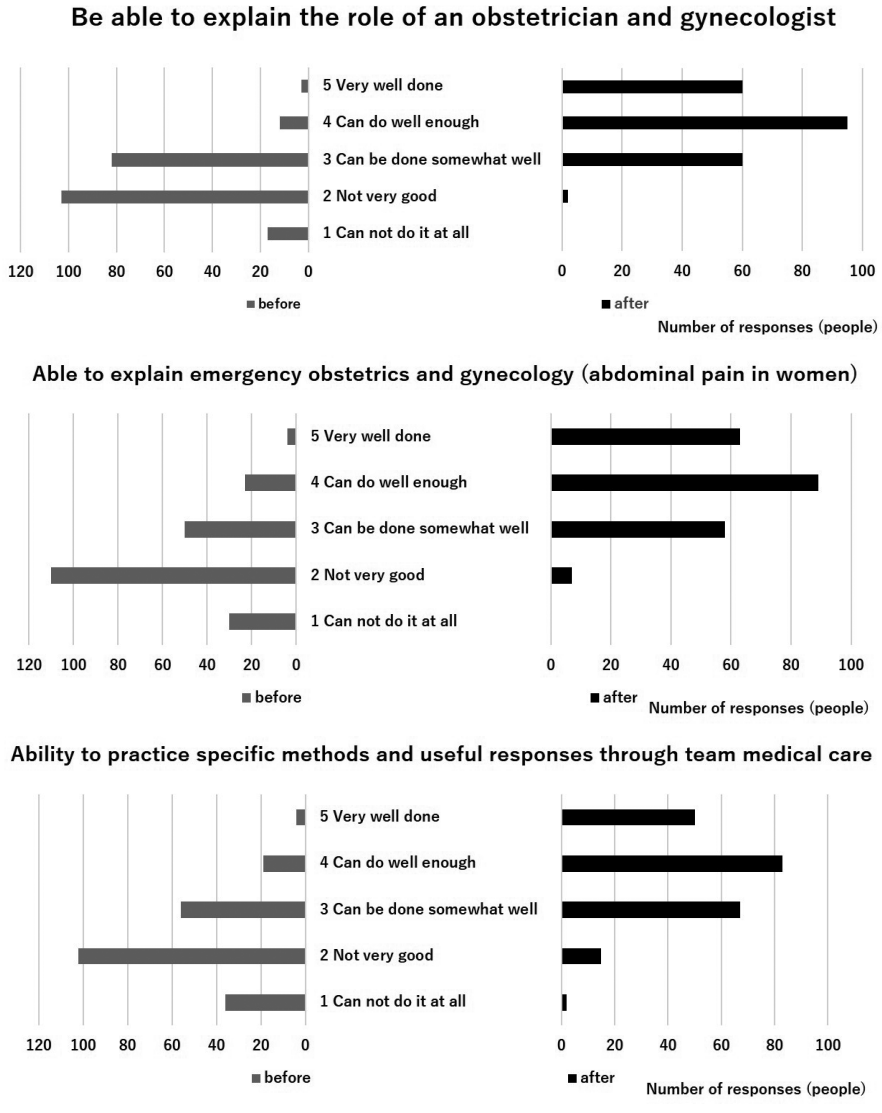

Fig. 7 Survey results before and after training with the introduction of the new simulator: Responses from 217 5th and 6th year medical students.

Disadvantages of online classes, such as less interaction, that is, asking questions, also became apparent, as well as the fact that content is more difficult to grasp remotely than in face-to-face classes [10, 11]. By combining OJT and Off-JT while using a perinatal whole-body management/delivery simulator, remote simulation education with a sense of realism could be developed. ICT could be used effectively to implement remote-delivery simulation education in a multicenter setting with a sense of realism even when face-to-face sessions were impossible.

Since the COVID-19 pandemic, educational programs are increasingly moving online, and there is a need to share examples of multi-disciplinary collaborative education that is flexible and can be repurposed and realized according to the circumstances of each facility. In this study, we focused on high-flexibility education that is delivered remotely while trying to maintaining a sense of realism and direct participation. In the development of the simulator itself, we received full support from the company and cooperation from an external video company. And, because the simulator we used was jointly developed between the company and our school, it is permanently leased to us free of charge. We

also received the company's full cooperation in the preparations, and the video company was able to shoot, edit, and air the film on the day for a price of 1 million yen, which was a great advantage for us in terms of management. The pre-recording took about 6 h, and the preparation the day before took about half a day; overall, we believe the results were both cost- and time-effective.

As a result, a hybrid-flexible educational module was devised (Fig. 8). To conduct two-way communication while streaming the teacher's video and audio in real-time, careful decision-making with the moderator was necessary regarding the timing of switching over to VOD. On the day of the event, there was no time lag for remote participants. We have now established a system that provides highly flexible education by fully utilizing ICT and simulators, allowing us to be highly adaptable in case of infectious disease epidemics and situations that make face-to-face education impossible, such as natural disasters. As simulator education is a helpful tool, it could expand educational activities in the future.

In the participant survey, many participants answered that the program duration was rather long. There were five questions this time, and one to three minutes were allocated for writing in the chat function. The majority of respondents answered that the difficulty level was just right or slightly difficult, and the majority expressed that the seminar took a long time because the required writing took up a considerable amount of time. We agreed that it was necessary to consider shortening the scenario.

Simultaneous education via remote access also provides an opportunity to deepen horizontal connections among obstetricians and gynecologists responsible for local medical care in regional cities. In addition to recruiting medical students and residents at each facility and university, this initiative connecting the nine prefectures of Chugoku and Shikoku has the potential to contribute to an increase in the number of obstetricians and gynecologists in this region.

Finally, nationwide expansion of our program, and expansion of remote simulation education into other medical fields is possible. Even in the post-COVID era, remote and asynchronous methods of providing instruction and feedback through digital platforms have been effectively employed in the creation of a network of ongoing simulation-based training [12,13]. This style of education has become very popular in the laparoscopy education field [14,15]. We believe that remote-access simulator education can be applied in all fields. In the field of laparoscopic surgery training, attempts have already been made to perform simultaneous training remotely. In other surgical fields, such as the field of surgical techniques, which requires the preparation of relatively large-scale simulators and educational materials, it is possible to practice using the environment at each site and connecting other learners using ICT technology, eliminating the need to prepare a simulator at each site. The system could thus prove highly beneficial in terms of reducing the effort involved in moving human resources from site to site. Moreover, equal educational opportunities can be created regardless of location.

As far as we know, this is the first report of a remote-access vaginal delivery learning module A survey of the participants' subsequent career paths revealed that 19 of the 23 participants, still in early training at

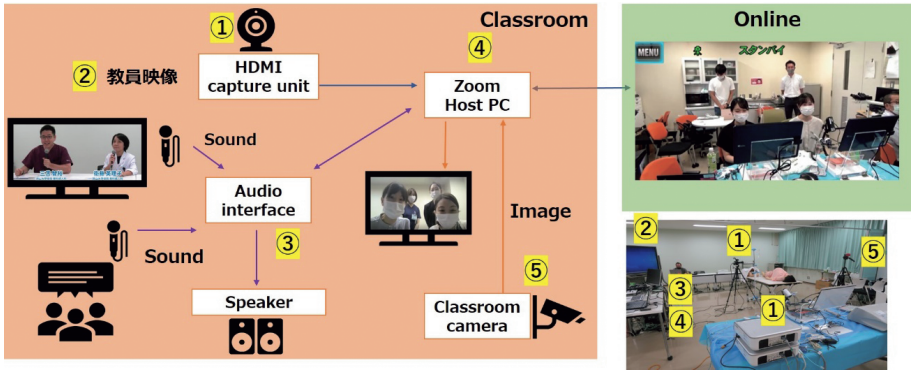

Fig. 8 Practicing high-flexibility education using ICT and simulators.

the time of participation, became obstetricians and gynecologists and worked primarily at the 10 university-affiliated hospitals. We were pleased to hear that the students were encouraged by the training.

Our study contains the following limitation. It focuses on reporting the benefits of remote practice and is unable to compare and examine the effects of educational activities before and after the coronavirus pandemic, excluding remote practice. It is difficult to assess whether this simulation education is superior to the educational methods used before the coronavirus pandemic in terms of participants' understanding, skills, and motivation. However, when participants were asked in a post-survey, "Would you like to participate in a seminar like this in the future?," the most common response was, "I would like to participate either face-to-face or remotely." This certainly shows a positive educational effect.

In conclusion, we designed a remote-access educational simulation program as a response to the special conditions of the coronavirus pandemic and propose its usefulness for high-flexibility education post-pandemic. At the 10 universities in the Chugoku–Shikoku region, we implemented multicenter, simultaneous remote-access simulation education that maximized the sense of realism even when face-to-face meetings were impossible, and confirmed the value of this learning to students. This study has the potential to promote the connection of students with appropriate preceptors and recruitment. We believe our construction of a high-flexibility education system using remote simulation in obstetrics and gynecology, especially in the perinatal field (a vaginal delivery module), is unique, original, and sustainable.

Acknowledgments. We thank Kyoto Kagaku Co., Ltd. for the joint development of a perinatal whole-body management simulator.

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