Acquisition of surgical technique by surgical training using a Swine model—evaluation of the suture technique using a WKS-2 simulator

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Background: In recent years, surgical training on real patients has become increasingly difficult because of reasons, such as medical litigation and information disclosure. This study aimed to assess whether surgical training using swine models improved surgical skills.

Methods: A total of 29 medical interns who underwent surgical training using the swine model at the Tohoku University Hospital Advanced Medical Training Center, were evaluated for their suture technique using the WKS-2 system before and after the training. The training evaluation items included time, tension, force, ligature interval, uniformity, and wound opening. The trainees performed thoracic (tracheostomy, thoracotomy, vascular treatment, thoracotomy, and thoracic drainage placement) and abdominal (laparotomy, splenectomy, vascular treatment, intestinal transection, intestinal anastomosis, and abdominal closure) surgeries. The operation time for each surgery was approximately 2.5 h, and students switched between the chest and abdomen with a 10-min break between each switch. The duration of training was 5 h. Changes in the evaluation items before and after training were compared and examined. The evaluation score (ESuture) in the parameters of six evaluation items was calculated.

Results: The suture time had significantly shortened after training than before training. Suture tension tended to increase slightly, but the change was not significant. Suture intervals, uniformity, and wound dissection did not change significantly. On the contrary, the power of suture ligature reduced significantly after training than before training.

Conclusions: Surgical training using swine models can not only shorten the suturing time but also enable surgeons to master tissue-friendly suturing. We, therefore, conclude that wet lab training helps achieve a learning effect similar to real-world clinical practice.

Keywords: Surgical training; wet lab; surgery

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Introduction

The surgical training ecosystem has recently undergone a major transformation, shifting from on the job training to wet lab training using swine models and dry lab simulators (1,2). Traditional surgical training heavily relied on 'on the job' training on real patients, similar to an apprenticeship system. However, in recent years, surgical training on real patients has become increasingly difficult because of reasons such as medical litigation and information disclosure. Instead, the use of educational simulators has become commonplace. Simulation labs have been installed in medical colleges and university hospitals, improving the quality of surgical education. Dry lab training helps trainees perform basic clinical procedures using simulators. In contrast, wet lab training involves operating on a live body, such as a swine, in an environment identical to real-world scenarios. Robotic surgery has also been gaining popularity and has been granted necessary insurance and licenses required for use in dry lab simulators and off-site wet lab training using a swine model.

Discipline-based education in the field of internal medicine began in the 1970s, with the addition of advanced educational methods such as organ system, problem-based-learning, and outcome-based education (OBE). OBE was coined by William Spady, a US educational sociologist, who defined outcome as 'the demonstration of meaningful learning in certain situations at the end of learning with high quality' (3,4) further set the milestones for OBE using the Dreyfus model, a skill acquisition stage model, to evaluate the achievement of competency and test whether the leader can trust the work from the concept of being independent. Professor ten Cate emphasised the need for entrustable professional activities (EPAs) (5). From an OBE perspective, the important qualities of surgical training include dexterity, hands-on experience, accuracy, communication skills, and social skills, all of which are important to provide the best medical care for patients. EPAs can help supervisors assess the competency level of their trainees based on the surgeon's apprenticeship. The criteria for evaluating the skills of surgeons include evaluation during classroom lectures (pre-operation presentations, informed consent before the operation, and evaluations based on practice), simulation skill evaluation (first assistant on the job training), work performance evaluation (invasive treatment such as postoperative management, the decision of management policy after discharge), and on-site evaluation of continuity and reliability. In short, the qualities of a typical surgeon, like a physician, can be demonstrated to society based on predefined pointers such as the one used by EPAs.

Conventionally, the evaluation of EPA has only been done by oneself using methods such as CanMEDS and SCORE® systems (6). However, it is undeniable that the evaluation of medical training by a third party not only reduces objectivity, but also makes uniform and accurate evaluation difficult.

We assessed the effectiveness of surgical training using a training evaluation kit. This study aimed to assess whether the surgical training performed on swine models improved surgical skills. We present the following article in accordance with the MDAR reporting checklist (available at https://amj.amegroups.com/article/view/10.21037/amj-21-59/rc).

Methods

A total of 29 medical residents who had undergone surgical training at the Tohoku University Hospital Advanced Medical Training Centre using the swine model were evaluated for their suture technique using the WKS-2 system (7) before and after training. The training evaluation items included time, tension, force, ligature interval, uniformity, and wound opening. The trainees performed thoracic (tracheostomy, thoracotomy, vascular treatment, thoracotomy, and thoracic drainage placement) and abdominal (laparotomy, splenectomy, vascular treatment, intestinal transection, intestinal anastomosis, and abdominal closure) surgeries. The operation time for each surgery was approximately 2.5 h, and students switched between the chest and abdomen with a 10-min break between each switch. The duration of training was 5. Changes in the evaluation items before and after training were compared and examined.

The evaluation score (ESuture) in the parameters of six evaluation items was calculated using the following formula (8):

$$\begin{aligned}\mathrm{ESuture} = {} & \omega\mathrm{TIT} + \omega\mathrm{FOTIFOT} + \omega\mathrm{JuTIJuT} + \omega\mathrm{DbSIDbS} \\ & + \omega\mathrm{EqDIEqD} + \omega\mathrm{WoDIWoD}\end{aligned} \qquad [1]$$

where, ωT, FOT, JuT, DbS, EqD, WoD are weight coefficients, and Time IT: index of completion time (*Figure 1*); IFOT: index of force on the tissue; Ligation force IJuT: index of judging tension; Suture interval IDbS: index of distance between suture; Suture width IEqD: index of equidistance from the wound edge; IWoD: index of wound dehiscence.

Wet lab training using the swine model was conducted in accordance with the EPAs, and the content of management was set as follows. The training included: anaesthesia induction (procedure from intubation to mechanical ventilation), a tracheostomy in cooperation with the team, incision suturing procedure and thoracic drainage. The most relevant competency areas were as follows: doctors without surgeon training, necessary knowledge,

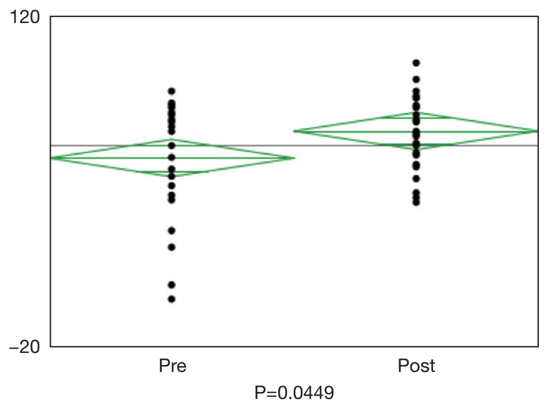

Figure 1 The change in suture time value before and after the wet lab training.

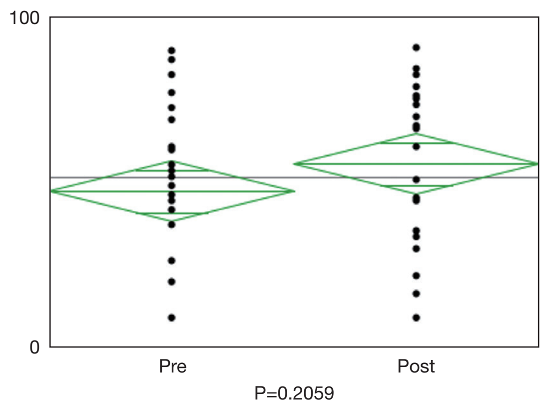

Figure 2 The change in suture tension value before and after the wet lab training.

skills, attitudes, behaviour, and other conditions such as knowledge (pulmonary and intestinal suturing, needle operation techniques), skills (anaesthesia induction methods, tracheostomy method, thoracotomy method, laparotomy method, and thoracic drainage insertion method), attitude (cooperation between operator and assistant, cooperation with animal ethics and welfare), experience (1 swine). The evaluation was performed as follows: evaluation of the suture technique training by WKS-2 before and after the self-assessment.

We show an example data by normalizing the time, the doctor's average suturing time is 107 s and that of the inexperienced person is 398 s, so if the suturing time is 107 s or less, IT becomes 1, and if it takes 398 s or more, it becomes 0.

The study was conducted in accordance with the

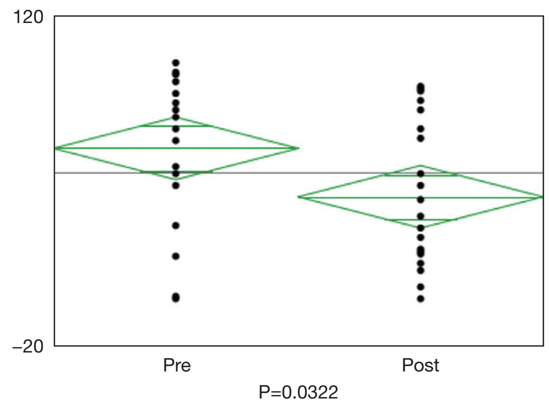

Figure 3 The change in suture ligation force values before and after wet lab training.

Declaration of Helsinki (as revised in 2013). This study was approved by the Institutional Review Board of the Tohoku University Hospital (No. 2019-1-651) on December 16, 2019. Individual consent for this retrospective analysis was waived.

Statistical analysis

Statistical analysis was performed using JMP®, Version 14 (SAS Institute Inc., Cary, NC, 1989-2019). The variation in the acquired data before and after was analysis was compared using an unpaired *t*-test, and P<0.05 was considered statistically significant.

Results

Figure 1 shows the change in the suture time before and after the wet lab training. The higher the stitching time value, the shorter the stitching time, the suture time reduced significantly after the training (P=0.0449). *Figure 2* shows the change in the suture tension value before and after the wet lab training. The higher the suture tension value, the more the tension applied to the skin. No change in suture tension was observed before and after training (P=0.2059). *Figure 3* shows changes in suture ligation force before and after wet lab training. The higher the ligature value of the suture, the tighter the tie. The suture ligation strength reduced significantly after training (P=0.0322). *Figure 4* shows the change in suture spacing before and after wet lab training. A higher suture spacing value indicated more uniform stitching. The suture spacing did not change significantly after training (P=0.8632). *Figure 5* shows

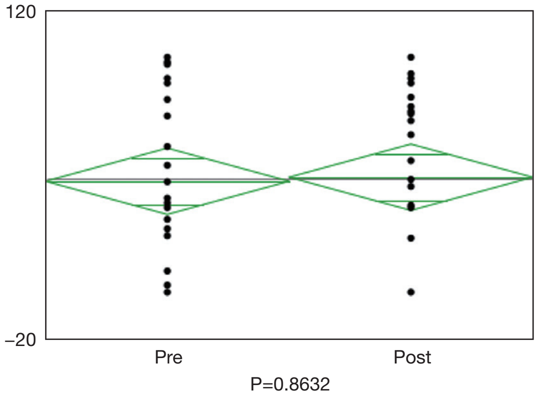

Figure 4 The change in suture spacing values before and after wet lab training.

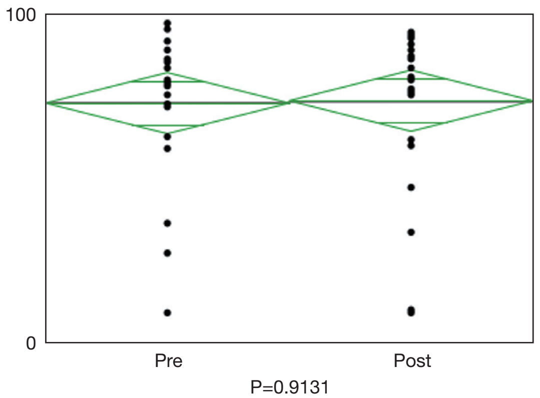

Figure 5 The change in suture equivalency before and after wet lab training.

the change in suture equivalency before and after wet lab training. The higher the value of the suture, the higher value, which means that the finished three needles have the same shape. The suture equivalence was unchanged before and after training (P=0.9131). *Figure 6* shows the change in suture open value before and after wet lab training. The higher the suture opening value, the tighter is the suture strength. The suture opening value did not change after training (P=0.9902).

Discussion

The WKS-2 simulator is a suture training kit developed by the Waseda University and Kyoto Science (6). This kit enables the numerical evaluation of factors associated with the suturing technique and enables objective evaluation.

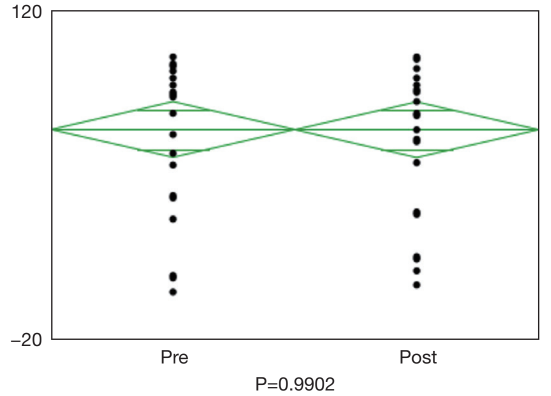

Figure 6 The change in suture open value before and after wet lab training.

The actual application is a simulator that assumes a skin suturing procedure that performs three simple knot sutures on the simulated skin. The simulated skin has various built-in sensors. Suturing techniques can be gradually improved by repeatedly performing suture training using this training kit (8). By performing the suture technique training using this simulator, all parameters increase over time, and the student receives scores indicative of their outcome. Therefore, the suturing technique and skill gradually improves (8). The simulator has six parameters. In a report by Oshima *et al.*, to determine the importance of the parameters, each parameter was analysed using the discriminant analysis to compare the suturing data between a trained doctor and an inexperienced person. The results showed that the item with the highest score was the ligation force, followed by the importance of uniformity (8). In this study, we performed wet lab training and technical evaluations before and after using a WKS-2 simulator. We noted that only the suturing time was shortened, and most other parameters did not change significantly. Also, the ligation force reduced significantly after training. This result is inconsistent with the results of the dry lab study by Oshima *et al.* reporting on the impact of using WKS-2 on skill acquisition.

Technical evaluation of suture ligation is difficult. In dry lab training with WKS-2, the position of the skin, type of needle, and type of thread remain constant. The trainee, therefore, gradually becomes familiar with repeated training, and the technical abilities such as the strength of the suture improve. In contrast, in wet lab training, the procedure is often not fixed, and the trainees constantly swap organs between skin, muscle tissue, intestinal tract, and blood vessels during the training period.

In this study, we observed that the suturing time shortened significantly after wet lab training. In addition, the reduction in ligature after wet lab training is also an important benchmark. In the dry lab training, the trainees can only learn the tight binding technique, whereas, in the wet lab training, both tight binding and delicate suturing technique can be learnt. Therefore, with wet lab training, a trainee can gain the ability to adapt the ligating power based on the tissue at hand.

In this study, we conducted wet lab training using the swine model using parameters of EPAs. EPA indicates the clinical ability to perform the procedures in the clinical field. However, evaluation at the clinical site itself is naturally more important than EPA. Although evaluation is best performed through direct observation of procedural skills by a medical evaluator, it is practically difficult to train a large number of medical education evaluators. Therefore, to perform a uniform and efficient evaluation, we used the objective evaluation system of the WKS-2 simulator.

Our study may have several potential limitations. First, the size of the study group was very small to enable a generalisation of results. In addition, our study lacked a control group which could have enabled a more direct comparison. Finally, we did not conduct any dry lab training for direct comparison and instead used the results from previous studies.

Conclusions

Surgical training using swine models can not only shorten the suturing time but also enable surgeons to master tissue-friendly suturing. The wet lab training can provide a learning experience similar to real-world clinical practice.

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Footnote

Reporting Checklist: The authors have completed the MDAR reporting checklist. Available at https://amj.amegroups.com/article/view/10.21037/amj-21-59/rc

Data Sharing Statement: Available at https://amj.amegroups.com/article/view/10.21037/amj-21-59/dss

Peer Review File: Available at https://amj.amegroups.com/article/view/10.21037/amj-21-59/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://amj.amegroups.com/article/view/10.21037/amj-21-59/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Institutional Review Board of the Tohoku University Hospital (No. 2019-1-651) on December 16, 2019. Individual consent for this retrospective analysis was waived.

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