III. 研究成果の刊行に関する一覧表

書籍　なし

雑誌

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Ⅳ．研究成果の刊行物・別冊

Original Article

Evaluation of hands-on seminar for reduced port surgery using fresh porcine cadaver model

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Abstract

BACKGROUND: The use of various biological and non-biological simulators is playing an important role in training modern surgeons with laparoscopic skills. However, there have been few reports of the use of a fresh porcine cadaver model for training in laparoscopic surgical skills. The purpose of this study was to report on a surgical training seminar on reduced port surgery using a fresh cadaver porcine model and to assess its feasibility and efficacy. **MATERIALS AND METHODS:** The hands-on seminar had 10 fresh porcine cadaver models and two dry boxes. Each table was provided with a unique access port and devices used in reduced port surgery. Each group of 2 surgeons spent 30 min at each station, performing different tasks assisted by the instructor. The questionnaire survey was done immediately after the seminar and 8 months after the seminar. **RESULTS:** All the tasks were completed as planned. Both instructors and participants were highly satisfied with the seminar. There was a concern about the time allocated for the seminar. In the post-seminar survey, the participants felt that the number of reduced port surgeries performed by them had increased. **CONCLUSION:** The fresh cadaver porcine model requires no special animal facility and can be used for training in laparoscopic procedures.

Key words: Cadaver porcine model training, laparoscopic training, reduced port surgery, surgical education

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INTRODUCTION

From the 1990s, laparoscopic surgery started gaining in popularity for its minimally invasive approach and cosmetic benefit for the patients. For surgeons, a two-dimensional environment, longer instruments, fulcrum effect and decreased tactile response meant that completely new techniques were required to perform surgery using this method.[1] The surgical curriculum evolved from only consisting of observational learning to actual surgical performances by surgeons-in-training. The ethical and safety issues of practicing on patients gave rise to learning outside operating rooms. Box trainers, porcine models, human cadavers and, more recently, virtual reality simulators have significantly assisted modern surgeons in completing the early phase of their learning curve outside the operation rooms.[2,3] Studies have shown that training with simulators to achieve proficiency improves the performances of the surgeons in the operating room.[4-6]

Along with this, surgeons had also started pushing themselves further trying to achieve the holy grail of scarless surgery by using a single site to introduce instruments and using instruments with smaller diameters, or using natural

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orifices as access points.[7-11] "Reduced port surgery" is the term that was coined to include all these surgical techniques aiming to reduce trauma related to access in the surgical field.[12] In the last few years, a huge array of access ports and devices for reduced port surgery have been developed. Japan has also seen an exponential rise in the number both of performing surgeons and types of operations performed using reduced port surgery techniques. However, we felt that there was a lack of training seminars to introduce devices and techniques of various reduced port surgery to the surgeons. The First Reduced Port Surgery Forum provided us with an ideal opportunity to host such a seminar.

The use of live porcine models is well documented in the literature, and has shown to have improved surgical performance.[13] However, a huge effort is needed in order to hold a large-scale training seminar due to the need of animal lab and animal care facilities as well as anaesthesia. We thus decided to conduct our seminar using fresh porcine cadaver models.

Purpose

The purpose of this study was to report on a large-scale surgical training seminar on reduced port surgery done using the porcine cadaver model, and to assess its feasibility and efficacy.

MATERIALS AND METHODS

This hands-on seminar was jointly organised by the Reduced Port Surgery Forum (Japan) and Department of Gastrointestinal Surgery II, Hokkaido University, during the 1 Reduced Port Surgery Forum in August 2012. The seminar was held in the Hokkaido University animal laboratory. The seminar was approved by the Ethical Committee of the Hokkaido University animal experiment centre. The participants were chosen from among applicants from different centres all over Japan. A questionnaire survey was performed immediately after the seminar and again 8 months after the seminar to assess the efficacy of the seminar.

Hands-on seminar

The primary goal of the seminar was to give the participants an opportunity to try various access ports, platforms and devices that are used for reduced port surgery, and to get them used to the techniques and the concept of reduced port surgery. There were 24 participants from 17 institutions all over Japan. They were divided into 12 groups with 2 participants in each group. Twelve stations were set up with 10 fresh porcine cadaver models and two dry boxes. The porcine cadavers used for the seminar were sacrificed 3 h before the seminar. Each station had its individual unique access port and device used for reduced port surgery. All the companies involved in the production and sales of the access ports and devices used in reduced port surgery in Japan participated in this seminar by providing their access ports and devices for the seminar. In total, nine access ports/platforms, 3 needlescopic devices and two reduced port devices were provided for this seminar [Table 1]. Each station had one or more instructors who were experts in the use of the device at that station. In total there were 17 instructors, 1 advisor, 2 guest instructors, and 10 members as support staff. Each group spent 30 min at each station, performing various tasks. The tasks included laparoscopic knot-tying in the dry box, laparoscopic *in vivo* suture, laparoscopic appendectomy, laparoscopic cholecystectomy, laparoscopic gastrostomy (lymphadenectomy, resection and reconstruction), and laparoscopic colectomy using reduced port devices and procedures. The participants learned fundamental technical skills with the various access platforms and devices of reduced port surgery under the guidance of the instructors.

All the corporations involved in manufacturing and distribution of the instruments used for reduced port surgery in Japan were invited to participate in the seminar. The seminar did not advertise one product as being better than the other, but instead introduced the participants to all the products available in the market and gave them a chance to grow familiar through use with the concept of reduced port surgery and different devices used in this type of surgery. Participation fees collected from the participating corporations were used solely to cover the organisational expense of the seminar.

Table 1: Devices used in the seminar

Devices	Company
Multiport devices	
SILS port	Covidien
Free access	TOP
OctoPort	Dalim Surg
EZ access	Hakko
X gate	Ethicon Endo-Surgery
Gel point	Medical Leaders
Metal Port	Suzuki Precion
Multiple trocar method	
Xcel	Ethicon Endo-Surgery
MIT port	Create Medic
Forceps	
Prebend forceps	Adachi Kogyou
Minilaparoscopy	Karl Storz
BJ needle	Niti-on
Minilap graspers	Stryker
Roticulator forceps	Covidien

Questionnaire survey

A questionnaire survey was done immediately after the seminar to assess the satisfaction among the participants and instructors. Another survey was done 8 months after the seminar to assess the effectiveness of the seminar.

The survey done immediately after the seminar consisted of two types of questions based on 5-point Likert-type scale. The first set consisted of questions whose answers would check the level of satisfaction on various aspects of the seminar, with 5 being the maximum possible score and 1 being the minimum. The second set of questions checked for the overall impression of the seminar, with the neutral score of 3 representing the best possible answer, and 1 and 5 being the two extremes. The participants were also provided with another set of questions which evaluated their perception of the usefulness of each segment of their training. This set of questions was also based on the 5-point Likert-type scale, with 5 being the maximum score and 1 being the minimum score.

The survey conducted among the participants 8 months after the training consisted of questions on the number of single port and reduced port surgeries performed by them and at their institute after their training. They were also asked questions regarding increase in single port surgery and reduced port surgery and about the devices they used.

RESULT

Twenty-four surgeons participated in the hands-on seminar. There were differences in the backgrounds of the participants [Table 2]. The median practising period for the surgeons was 12.5 years (4-29 years). The participants had performed a median of 227.5 (0-2650) laparoscopic surgeries and median of 22 (0-280) single port surgeries. Though the porcine abdominal wall gradually became rigid and needed higher pneumoperitonium pressure (20 mmHg) during the seminar, we were able to perform all the tasks as planned. The response rate of the questionnaire done immediately after the seminar was 100% (24/24) among participants and 94% (16/17) among instructors. The response rate fell to 54% (13/24) in the questionnaire survey done among participants 8 months after the seminar.

Satisfaction level

On the survey done immediately after the seminar, both the participants and instructors showed a high degree of satisfaction. The average scores of participants and instructors were above 3 in all of the questions asked [Tables 3.1 and 3.2]. At the end of the seminar, the participants strongly felt that their single port surgery will increase with an average score of 3.7 (±1.02) [Table 3.1]. The instructors strongly felt that the hands-on seminar was effective with an average score of 4.62 (±0.78) [Table 3.2].

Overall impression

The majority of participants [22/24 (92%)] and of instructors [12/16 (75%)] felt that the number of participants per group was highly appropriate. Similarly, 23/24 (96%) participants and 12/16 (75%) instructors felt that the number of instructors was highly appropriate. Regarding the fees of the seminar (20000 JPY = approx. 200 USD), 7/16 (44%) instructors felt that it was highly appropriate, while 8/16 (50%) instructors felt that it was either very cheap or cheap. Of the participants, 20/24 (83%) felt that the fee was highly appropriate.

Seminar time

With regard to the total time allocated for the seminar, while 10/24 (42%) participants and 6/16 (37.5%) instructors felt that it was appropriate, 9/24 (37.5%) participants and 3/16 (19%) instructors felt that it was either short or too short. Meanwhile, 7/16 (44%) instructors felt that it was either long or too long. Of the participants, 7/24 (29%) could not perform all the tasks due to the lack of time.

Specific tasks

In response to the questions about the specific tasks, the participants responded that the training in simpler tasks

Table 2: Background of the participants

Category	Median (Range)
Number of participants	24
Postgraduate year	12.5 years (4 ~ 29 years)
Number of laparoscopic surgeries performed	227.5 (0 ~ 2650)
Number of single port laparoscopic surgeries performed	22 (0 ~ 280)

Table 3.1: Satisfaction level (participants)

Question topic	Mean score
Did you get used to the new devices?	3.62±1.11
Did you acquire basic skills?	3.37±0.86
How do you feel about the instructions given during the seminar?	4.43±0.65
Do you think your practice of single port surgery will increase?	3.71±1.02

Table 3.2: Satisfaction level (Instructors)

Question topic	Mean score
Were you able to teach how to handle the devices?	3.87±0.89
Were you able to teach reduced port skills?	3.53±0.88
What do you feel about the content of the seminar?	3.87±0.70
Do you think this seminar was effective?	4.62±0.78

such as suturing and knot-tying was the most useful, with an average score of 4.08 (±0.76), compared to more complex tasks such as cholecystectomy (3.42 ± 1.5), gastrectomy (3.48 ± 0.93), colectomy (3.33 ± 0.94), appendectomy (3.29 ± 0.98), and *in vivo* suturing (3.12 ± 1.33) [Table 4]. The time allocation of only 30 min for each station for each group could be the main factor explaining this.

Impact after 8 months

The response rate from the survey done 8 months after the seminar was 54% (13/24). In that period the participants had performed a median of 10 (0-81) single port surgeries, and their institutions had performed a median of 30 (0-109) single port surgeries. Only 3/13 (23.1%) of the responders replied that the number of single port surgeries they performed increased and 3/13 (23.1%) of the responders had changed the platform or devices they had previously been using. Similarly, 8/13 (61.5%) of the responders replied that the number of reduced port surgeries they performed had increased [Table 5].

DISCUSSION

Studies have proved that surgeons who undergo training and achieve proficiency using biological or non-biological simulators perform better in the operating room compared to surgeons who have only received conventional training in the operating room.[4-6] However, the type of surgical training using simulators is still in its infancy in Japan.[13]

While training involving dry boxes is relatively easier to perform with no constraint on where the training can be performed, it is only suitable for the training of basic laparoscopic skills such as suturing and handling of the instruments. In this seminar, our purpose was focused more on the training of advanced surgical skills, for which we felt that training using only the dry boxes was inadequate. While animal models play an important role in the field of surgical training, especially for training in advanced surgical procedures,[14] factors such as the lack of an animal lab facility, need for an animal care facility, and the anaesthesia setup make it difficult for this type of training to be performed in any medical facility. These factors may have been limiting the development of animal lab for surgical training.

Our institution has been conducting small-scale training seminars using live porcine models for our residents for the past few years. With that experience, when we collaborated with the Reduced Port Surgery Forum to organise the large-scale hands-on seminar, we were able to determine the requirements for the anaesthesia of 10 porcine models. While a human cadaver solves the problem of anaesthesia, it is not always easy to secure the large required number of human cadavers for a seminar as seminars using human cadavers are not very common in Japan. Hence, we felt that the porcine cadaver model was our best option. Though at the time of the seminar there was a lack of literature with regard to the use of a fresh porcine cadaver model for surgical training, we felt that it would meet our primary goal of giving the participants the opportunity to try various access ports, platforms, and devices. Bordeianou *et al*. (2014)[15] recently reported the use of a fresh cadaver porcine model for training in the transanal endoscopic microsurgery (TEM) procedure. To our knowledge this is the first report of the use of a fresh cadaver porcine model for training in laparoscopic procedures. Using a fresh porcine cadaver model has its own limitations. Being an animal model, a difference in anatomy exists. In addition, as we do not use anaesthesia, there are no respiratory movements. It is also impossible to recreate bleeding as in real operations or in live animal models. However, compared to cadavers, fresh cadaver models do have some oozing from the blood vessels. Our training did not involve simulation of bleeding or haemostasis technique, but involved the adaptation and overcoming of the loss of angulation that comes with single port surgery, and the use and adaptation of different devices available to perform different steps in the surgeries performed with conventional laparoscopy. A fresh porcine cadaver model provides that platform without the need of anaesthesia or an animal care facility.

The abdominal wall of the model becomes rigid with time. Except for the higher pneumoperitonium pressure (20 mmHg) found needed to counteract the rigidness of the abdominal wall, the seminar was conducted as planned and the participants were able to perform all the tasks without any difficulty. As indicated by the survey done among the

Table 4: Task-specific response

Tasks	Mean score
Cholecystectomy	3.42±1.5
Distal Gastrectomy	3.48±0.93
Colectomy	3.33±0.94
Appendectomy	3.29±0.97
In vivo suture	3.13±1.33
Dry box suture	4.08±0.75

Table 5: Survey after 8 months: How did the surgeries you perform change after the seminar?

The number of single port surgeries I perform increased	3 (23.1%)
The number of reduced port surgeries (decreasing the number/diameter of port) increased	8 (61.5%)
I changed the device/platform I was using after the seminar	3 (23.1%)
No changes	3 (23.1%)

participants and instructors, the participants and instructors were highly satisfied with the seminar.

We feel that training seminars using fresh porcine cadaver models have huge potential as an important tool in surgical education. As there is no need for an animal care facility to take care of the animals before the seminar or an anaesthesia facility during the seminar, a seminar using fresh porcine cadaver models can be conducted at any institution. This can increase the number of surgeons who can participate in these sorts of seminars and also pave the way for simulator-based training to be included in surgical residencies or fellowship courses.

As discussed earlier, there are some minor differences from real surgeries or training seminars using live animals, but it should not hamper training in laparoscopic skills.

There were concerns about the total time allocated at each station. Although the allotted time may have been adequate for the participants to be able to satisfactorily acquire simple skills such as suturing in the dry box, it may have been the factor that resulted in lower scores for the complex tasks. The main aim of this seminar was to teach the participants the basic skills of reduced port surgery, thus giving them an opportunity to try different access ports, platforms and devices. By collecting all the access ports, platforms and devices sold in Japan at the time of the seminar and using them to teach the participants the basic skills of reduced port surgery, with which most of the participants were highly satisfied, we feel that we were able to fulfill the main aim of our seminar.

With regard to the impact of the seminar for the participants from different backgrounds, it was difficult to numerically prove if the number of reduced port surgeries actually increased. There were several participants who only started doing single port and reduced port surgeries after attending the seminar, and 8 out of 13 (61.5%) of the responders in the post-seminar survey indicated that the number of reduced port surgeries performed by them had increased. Even if the majority of the participants could not advance promptly to single port surgery, they had been introduced to the concept of reduced port surgery, and they started thinking about and practising reduction of the number and diameter of the ports they used. In that respect, we feel that our seminar has been successful in introducing the concept of reduced port surgery.

Our seminar was the first of our efforts using the fresh porcine cadaver model and was mainly engaged in introducing the participants to the concept and basic skills of reduced port surgery. The main drawback of our seminar was that we did not focus on the teaching of specific skills. Neither did we evaluate how much the participants had learnt from the seminar. As we have successfully shown that the fresh porcine cadaver model can be used in training surgeons in advanced laparoscopic surgery techniques, we feel that our next step should be to use these models to teach specific skills with more specific purposes, giving ample time for the participants to acquire the skills, and establish appropriate measures to evaluate the impact of training.

CONCLUSION

The fresh porcine cadaver model was used successfully in training for reduced port surgery. It requires no special animal facility, and it demonstrated great potential for surgical training.

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Nil.

Conflicts of Interest

The authors do not have any conflicting financial relationship with the corporations that participated in this seminar.

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特集
イノベーション
ービジネスの新しいかたちー

サージカルトレーニングが推進する地域医療と産学連携

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はじめに

超高齢社会を急速に迎える我が国では、2025年には「団塊の世代」が後期高齢者となり、手術患者数は現在の1.3倍に増加する[1]。総人口は減少するものの、がん年齢人口は増加し2030年をピークに３人に１人ががんで死亡するがん多死社会を迎える[2]。現在のがん治療の基本は外科治療、抗がん剤治療、放射線治療であるが、超高齢社会では治療後も変らず日常生活を営むことのできることが重要で、「体にやさしい」腹腔鏡などの内視鏡手術による短期入院が治療の基本となる。

また、食道がん、膵臓がんなどの難治がんは都道府県単位の三次医療圏[3]の専門病院へ集約されるが、患者数の多い５大がん（胃、大腸、肺、肝臓、乳がん）の治療は二次医療圏[3]（地方都市）の中核病院へと医療の役割分担が進むことが予想される。来るべき超高齢社会に備えて、がんに対する高度な内視鏡手術の技能を有し、地域の外科治療を支える外科医の育成が急務である。

本稿では、地域ビジネスの発展に欠かせない、高度な医療を受けることができる社会基盤の確立と、地域から発信する産学連携の可能性について、その現状と課題及び課題解決に向けた取組について明らかにする。

1　現状と課題

高度な手術治療を安全に提供するには、サージカルトレーニングが欠かせない。トレーニング方法としてon the job training（OJT）が主に用いられるが、がんに対する内視鏡外科手術などの高度な手術手技の修練やまれな疾病の治療法の習得には限界がある[4]。昨年、群馬大学医学部附属病院及び千葉県立がんセンターで、「体にやさしい」はずの腹腔鏡手術を受けた患者が複数名亡くなられたことが報道され、術前説明の不備、手続き上の違反や病院組織のガバナンスの不在などが指摘され、社会問題化した。筆者は、問題の本質は医師の技能であり、その解決策はOJTを補完するトレーニング方法の確立であると考えている。

OJTの限界について別の例をあげる。外傷患者の救命率向上の切り札は、ドクターヘリによる救命救急センターへの搬送と迅速な治療であるが、ヘリコプターの運航ができない日没後や悪天候時には、地域の中核病院で治療を完遂しなくてはならない。外傷外科手術の修練は、交通事故による外傷患者の救命がその主な機会であったが、近年の交通事故件数の減少によりOJTの機会が減る結果となり、OJTに替わるトレーニング方法の確立による地域医療を支える外科医育成が喫緊の課題となっている。

2　高度な医療を安全に提供するための新たな取組み

上述のように、地域医療を守るためには、OJT以外の教育手法を模索しなければならない。OJT以外の機会は極めて少ない[4]が、近年、急速に整備されてきているものとして、シミュレーション、実験動物（ブタ）を用いたアニマルトレーニング、遺体（cadaver：カダバー）を用いた手術手技修練（カダバートレーニング）が挙げられる。

(1) シミュレーション

航空業界ではパイロット養成にフライトシミュレーターが用いられるが、医療分野でも医学生や研修医の教育を対象とした患者を模したシミュレーターや内視鏡外科手術の基本手技を体験できるバーチャルリアリティー（VR）シミュレーターが市販されている。しかし、これらは高難度手術の習得には対応していない。こうした現状に鑑み、北海道大学医学研究科消化器外科学分野 II では、平野聡教授の指導のもと、情報科学研究科システム情報科学専攻 近野敦教授と共同で、患者個別の画像データを用いた VR による手術シミュレーション＆ナビゲーションシステムの開発に着手した。また、先端生命科学研究院ソフト＆ウエットマター研究室の黒川孝幸准教授と連携し、臓器をゲル素材で再現した超リアルなシミュレーターを開発中である。さらに、平成28年には新たにクリニカルシミュレーションセンターが竣工し、医学教育と研究開発の拠点となる予定である。

(2) アニマルトレーニング

生体ブタを用いるアニマルトレーニングは、実際の手術同様に出血や臓器損傷に対処した手術操作の習得に有用であるが、動物福祉に配慮し設備の整った動物実験施設で実施する必要があり、外科医のニーズに比して国内での実施可能施設は少ない。北海道大学では、平成26年に医学研究科動物実験施設の改築により手術手技講習会の実施可能な環境が整備されたことを機に、定期的なトレーニングの開催が可能となった（図１）。

図１　動物実験施設での手術手技研修

北海道大学では平成27年から日本外科学会公認の外傷外科手術のトレーニングコースである ATOM（Advanced Trauma Operative Management）を実施している。

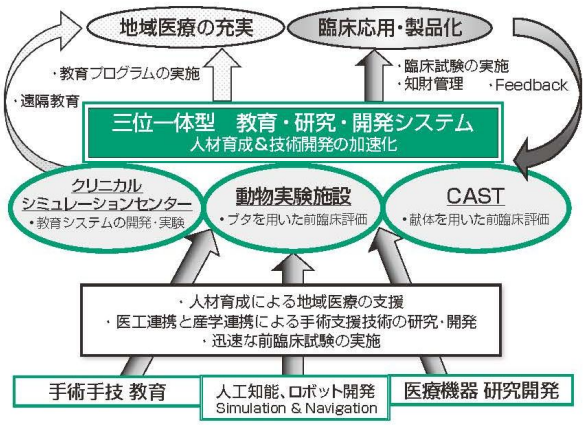
(3) カダバートレーニング

カダバートレーニングは、詳細な解剖学的知識の習得と実際の手術に沿った模擬手術が可能で、すでに海外では教育手法として確立している。我が国でも平成24年に「臨床医学の教育及び研究における死体解剖のガイドライン」（ガイドライン）[5] の公表により医科（歯科）系大学で献体制度の枠組みの中でのトレーニングが実施可能となったものの、未だ広く普及するに至っていない（表１）。北海道大学では、平成27年に大学病院の診療各科と卒後

表１　臨床医学の教育及び研究における死体解剖のガイドライン[5]

臨床医学の教育及び研究における遺体使用の実施条件
① 臨床医学の教育及び研究を通じて医療安全の向上をはかり、国民福祉への貢献を目的とするもの
② 医学教育、医学研究の一環として、医科大学（歯科大学、医学部・歯学部を置く大学）において、死体解剖保存法、献体法の範疇で実施するもの
③ 使用する解剖体は、以下を満たすものであること。１. 死亡した献体登録者が生前に、自己の身体が学生に対する解剖教育に加えて、医師（歯科医師を含む）による手術手技研修等の臨床医学の教育及び研究に使用されることについての書面による意思表示をしていること。２. 家族がいる場合には、家族からも理解と承諾を得られていること。
④ 実施にあたり、大学の倫理委員会に諮り、実施内容を十分に検討し承認を得ていること

図２　先端医療の研究、開発、教育を支援するプラットフォームとしての「先端医工連携橋渡しコンソーシアム」



臨床研修センター、医学研究科の解剖学講座などからなる北海道大学病院 CAST（cadaveric anatomy and surgical training；遺体を使用した外科解剖・手術手技研修）実施運営委員会が設置され、本格的なカダバートレーニングを可能にした。これによりシミュレーション、実験動物、カダバーによるサージカルトレーニングに対する「三位一体」のプラットフォームが完成し、手術手技教育を加速度的に推進する環境が整った（図２）。

３　地域医療への貢献と産学連携への発展

北海道大学病院 CAST を中心に据えた「三位一体」のサージカルトレーニングは、地域医療や産学連携へも、少なからずプラスの影響を及ぼすものと考えられる。

まず、「三位一体」のサージカルトレーニングによって、地域医療の最前線を支える臨床医のレベルアップのための生涯教育の場を継続的に提供することができる。これは臨床医学への貢献を望まれた献体される方々の篤志にこたえることにもなるのではないかと考える。前述のガイドラインにおいても、安全で高度な手術手技が広く普及するために、大学に所属する医師以外の臨床医も医科系大学で行うトレーニングに参加可能であることが望ましいとされている。

また、サージカルトレーニングの一翼を担うカダバートレーニングは、新たな手術手技の研究や新規の医療機器の前臨床研究など、広く医療安全と医療の質の向上を目指した臨床医学の進歩に資する研究開発も可能にする（表２）。

さらに、現状では課題の多い医工連携及び産学連携にも効用があると思われる。日本各地には卓越した技術を持つ特色ある中小企業が数多くあり、新たな医療機器のアイディアを持つ意欲的な医師も多い。一方、そうした医工連携の土壌はあるものの、新規の医療機器の開発における製品化までの難関は「死の谷」と呼ばれ、製品化に至るものは極僅かである。その一因として、試作品の安全性や有効性を検討する前臨床研究の実施環境の不備があげられる。シミュレーション、実験動物、

表２　臨床医学の教育及び研究における遺体使用の例[5]

① 基本的な医療技術
➢ 臨床研修医等を対象にした、安全な医療技術の習得に必要な解剖学的知識の教育を目的とした遺体使用等
② 基本的な手術手技、標準手術
➢ OJT（on the job training）や動物を用いたトレーニングが可能であるが、手術手技の習得に必要な解剖の教育を目的とした遺体使用等
③ 確立した手技であるが、難度が高く、高度な技術を要する手術手技
➢ 先進的であるためにOJTの機会が少ない手術手技や、人体との解剖学的差異から動物を用いたトレーニングが難しい手術手技の習得に必要な解剖の教育や研究を目的とした遺体使用等
④ 新規の手術手技、医療機器等の研究開発
➢ 研究段階の手術手技や、新たな手術器具の開発に必要な人体での研究を目的とした遺体使用等

カダバーからなる「三位一体」プラットフォームにより、医療機器等の研究開発に必要なフェーズごとに異なる前臨床試験の包括的な検証と、それに引き続く北海道大学病院での臨床研究の実施体制が整い、シームレスな医工連携、産学連携の橋渡しが可能となることであろう（図２）。

おわりに

地域ビジネスの発展には全国どこででも高度な医療を安心して受けられる医療基盤の確立が重要である。都市部への医師の偏在化は地域が抱える社会問題であるが、その一因として医師の手術手技修練が自己研鑽によるため、症例の多い都市部の大病院での研修を若手の医師が望むことがあげられる。高度な外科治療を地方で維持するための制度設計は、石井吉春教授をはじめとする北海道大学公共政策学連携研究部との連携でスタートしたところであるが、本稿ではシミュレーション、実験動物、カダバーによる「三位一体」のサージカルトレーニングによる外科医の育成が地域医療の充実の解決策となりうることを示し、さらに、医工連携の研究開発基盤の確立が地域産業の活性化につながる可能性も提示した。今後は、サージカルトレーニングを新たな社会資本と位置づけて、行政・地元企業と連携して推進していきたい。

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