Anatomical Science International (2022) 97:251–263
https://doi.org/10.1007/s12565-022-00667-6

ORIGINAL ARTICLE

Cadaver Surgical Training: Status quo from anatomy and surgery

Updates on cadaver surgical training in Japan: a systematic facility at Chiba University

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Received: 7 January 2022 / Accepted: 11 April 2022 / Published online: 6 May 2022
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Abstract
Cadaver surgical training (CST), which ensures medical safety by improving the skills of surgeons, is popular overseas. However, training involves ethical issues given the use of cadavers. In 2012, the Japan Surgical Society and the Japanese Association of Anatomists compiled and opened the "Guidelines for Cadaver Dissection in Education and Research of Clinical Medicine (Guideline 2012)" to the public. This has allowed Japan to conduct CST or research under the regulations of Postmortem Examination and Corpse Preservation Act and the Body Donation Act. However, its dissemination has been sluggish. The Clinical Anatomy Lab (CAL), established in 2010 at Chiba University, is a facility for conducting CST and research. In the 11 years since its inception, 250 programs have been implemented. Orthopedics had the most implemented in the clinical field, with 120 (48%), followed by emergency and critical care medicine with 27 (10.8%), and neurological surgery with 27 (10. 8%). Based on the purpose of the training, the most common objective for the programs (approximately 83%) was education. Further, the highest number of programs was recorded in 2018 (34) and participants in 2017 (631). The implementation of CST requires more than just guiding surgeons to a dissection practice room. There are several methods of preserving cadavers to make them suitable for CST. For various surgical simulations, an operating table is more suitable than a dissection table. The current paper provides information on how to implement CST in universities that have so far only worked on anatomy education for medical students.

Keywords Anatomy · Cadaver · Dissection · Research · Training

Introduction

Cadaver surgical training (CST), which ensures medical safety by improving the skills of surgeons, is popular overseas. However, this type of training involves ethical issues given the use of cadavers. In recent years, legal regulations on dissection (Hutchinson et al. 2020; De Caro et al. 2021) have been discussed in various countries along with reports of several problems (Champney et al. 2019). In Japan, the Postmortem Examination and Corpse Preservation Act (PECP) established in 1949 permits the dissection of human cadavers for the purpose of medical and dental education and research under specified conditions. However, given that the PECP has no criteria regarding use of cadavers for surgical training and research and development, such acts could be considered "destruction of corpses" under Article 190 of the Penal Code, carrying with it corresponding punishments. Hence, the dissemination of CST across Japan has been sluggish, which has prevented opportunities for improve surgical skills. Therefore, in 2012, the Japan Surgical Society (JSS) and the Japanese Association of Anatomists (JAA) were compiled into the "Guidelines for Cadaver Dissection in Education and Research of Clinical Medicine" (revised 2018: Shichinohe et al. 2022) for the public; it is has been translated into English and is included in this issue. This has allowed Japan to conduct CST or research under the regulations of PECP and the Body Donation Act.

However, it would still take time for CST to spread throughout Japan. According to a questionnaire survey (Sakakura 2021) conducted by JAA to all medical and dental schools in Japan, the main reasons for not starting CST were

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the lack of manpower, equipment, and security of training space, including infection prevention. We believe that this is largely due to the fact that all procedures related to the preservation and dissection of human cadaver remains in Japan has been concentrated in the Department of Anatomy, a basic medical science department, for over 100 years. From the latter half of the twentieth century to the present, science and technology have developed remarkably, and the focus of research has shifted to areas such as genetic analysis and developmental engineering. Several researchers in anatomy departments across Japan have also followed this trend, and many universities have only used cadavers for student dissection practice. Accordingly, setting up and running a cadaver laboratory to be used by all surgical fields places too much strain on an anatomy department. Under these circumstances, few anatomy departments would be willing to open their dissection rooms to surgeons year-round and take on the responsibility of managing them.

We established the cadaver laboratory, "Clinical Anatomy Lab" (CAL), at Chiba University in 2010. We are developing the facility into one that can be used by various surgical specialties. Consequently, we are requesting essential equipment that surgeons may require when performing CST and research and development (R&D). Many university officials without a cadaver laboratory have visited Chiba University and inquired about what to expect when setting up a new CAL. We hope to provide necessary information to many universities in need of similar facilities by reporting the relevant details in this paper.

Materials and methods

We investigated the numbers of cadavers stored at CAL and the preservation method. We analyzed 250 educational and research programs submitted to CAL and received completion reports over 11 years from 2011 to 2021. The raw data for each item were further reclassified based on the criteria described below.

The year of implementation

The approval date was used as the implementation year for programs implemented across the years. Several studies were performed over multiple years, and incomplete studies were excluded.

Purpose of the program

The purpose of the clinical use of donated cadavers was broadly categorized into the following two types: education (education and surgical training) and research and development (R&D; R&D of medical devices).

The number of cadavers used and preservation procedures by the program's purpose

The study was divided into education and R&D to determine which types of preservation method were used.

The number of participants

Classification of clinical fields

The university departments implementing CST or research were reclassified into orthopedics surgery, emergency and critical care medicine, neurological surgery, general surgery (gastroenterological, respiratory, and breast), oral surgery, otorhinolaryngology, plastic surgery, and internal medicine.

Ethical considerations

The ethical board at Chiba University approved all the programs. Similarly, anonymized data reported according to the guidelines were used for the current study.

Results

Number of cadavers stored and preservation procedures at CAL

The total number of cadavers stored at CAL from 2010 to 2021 was 389, excluding formalin-fixed cadavers for a dissection course for students (Table 1). The preservation methods included 187 fresh-frozen cadavers (FFC; 48%), 97 (25%) cadavers fixed using the Thiel embalming method (Thiel 1992, 2002), 103 (26.5%) formalin-fixed (FA) cadavers, and 2 (0.5%) cadavers fixed with the saturated salt solution method (SSS) (Coleman and Kogan 1998).

The trend of program implementation and participation

The total number of programs was 250 (Fig. 1, Table 2). From 2011 to 2021, the highest number of programs (34) was recorded in 2018 (Fig. 1, Table 2). The aggregate data is described in Fig. 1. About 83% (208) of the programs focused on surgical education and were categorized as education. In contrast, the use of cadavers for research and development of medical devices (R&D) was 17% (42). Following the COVID-19 pandemic and restrictions on social activities in Japan from April 2020 onward, the number of

Table 1 Annual trend of cadavers stored and preservation procedures at CAL

No. of/year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Total	12	21	26	42	68	58	42	33	31	31	25	389
FFC	12	21	21	22	19	15	14	8	21	18	16	187
Thiel			4	8	16	14	10	13	10	13	9	97
FA			1	12	33	29	18	10				103
SSS								2				2

Total: the total number of cadavers preserved at CAL over the 11 years was 389 excluding formalin-fixed cadavers for the dissection course for students

FFC fresh-frozen cadavers, *Thiel* Thiel embalming method, *FA* formalin fixed, *SSS* saturated salt solution method

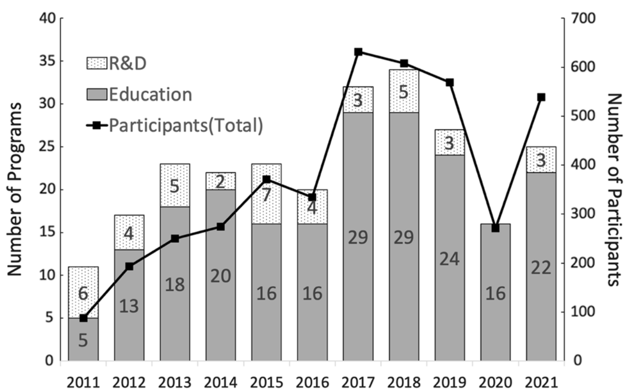

Fig. 1 Annual trends in the number of programs and participants. The annual breakdown of the number of programs is shown in the bar graph. The breakdown of the total number of participants by year is shown in the line graphs. Education: number of programs of education (CST). *R&D* number of programs of research and development

participants in the fiscal year 2020 showed a decline of 52% compared to 2019.

Number of cadavers used and preservation procedures for the program's purpose

The total number of cadavers used in the total number of programs was 1027 (Table 2). Typically, the total number of cadavers used exceeded the number stored at CAL because a single body is used in multiple programs. The preservation methods included 560 (54.5%) FFC, 310 (30.2%) cadavers fixed with the Thiel embalming method, 153 (14.9%) cadavers formalin fixed, and 4 (0.4%) cadavers fixed with the SSS (Fig. 2). Significant differences in trends were observed when preservation methods were classified according to the program's purpose. For educational purposes, Thiel fixation accounted for 297 (54.8%) cadavers, FFC accounted for 241 (44.5%) cadavers, and SSS accounted for 4 (0.7%) cadavers (Fig. 3). Whereas for R&D applications, FFC accounted for 319 (65.8%) cadavers, FA accounted for 153 (31.5%) cadavers, and Thiel accounted for only 13 (2.7%) cadavers (Fig. 4).

Number of participants

The median number of participants in one program was 14 (7; 25), and the highest number of participants was 47; they were doctors who took part in a workshop on neurological surgery using seven cadavers.

Classifications of clinical fields and the purpose of the program

The number of programs classified by clinical field is shown in Fig. 5. The highest number of programs was implemented in orthopedics (120), followed by emergency and critical care medicine (27), neurological surgery (27), general surgery (27), oral surgery (21), otorhinolaryngology (17), plastic surgery (10), and internal medicine (1) (Fig. 5).

Table 2 Annual trend of cadaver surgical training and clinical use of cadavers

No. of/year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Programs	11	17	23	22	23	20	32	34	27	16	25	250
Cadavers	80	76	67	43	117	64	129	164	135	75	77	1027
Participants	88	193	250	274	371	334	631	608	569	271	539	1277

The number of cadavers counted greatly exceeded the total number of cadavers stored at CAL, since a single body is used in multiple programs

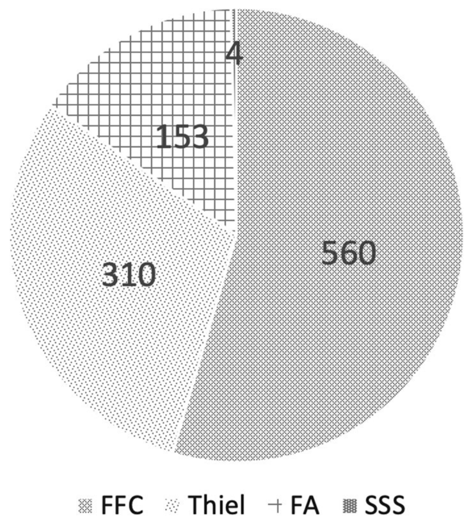

Fig. 2 Preservation procedure of the cadavers used. The total number of bodies preserved for education was 1027. The number of counted cadavers greatly exceeded the total number of cadavers stored at CAL since a single body is used in multiple programs. *FFC* fresh-frozen cadavers, *Thiel* Thiel embalming method, *FA* formalin-fixed method, *SSS* saturated salt solution method

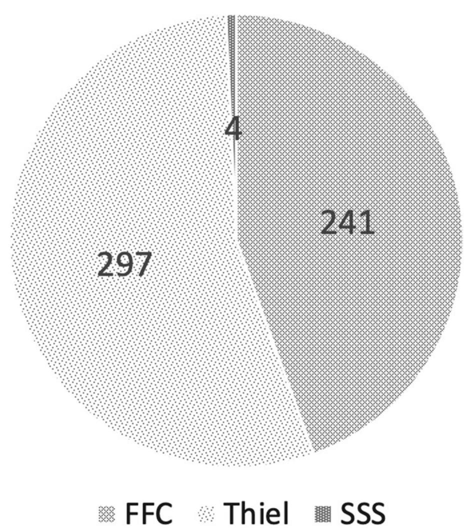

Fig. 3 Preservation procedure of the cadavers for education. The total number of bodies used for CST was 542. *FFC* fresh-frozen cadavers, *Thiel* Thiel embalming method, *SSS* saturated salt solution method

Programs offered at CAL

Neurological surgery

The Department of Neurological Surgery holds the "Chiba Neuroendoscopy Hands-On Seminar" every year, focusing on transsphenoidal sinusoidal pituitary surgery using neuroendoscopy. This program was performed on hard formalin-fixed cadavers before the establishment of CAL.

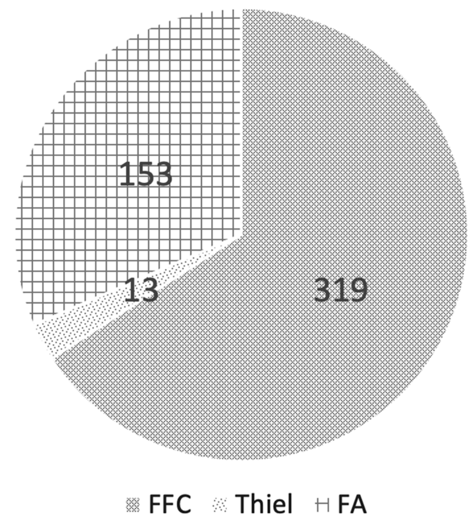

Fig. 4 Preservation procedure of the cadavers for R&D. The total number of bodies used for research and development was 485. *FFC* fresh-frozen cadavers, *Thiel* Thiel embalming method, *FA* formalin-fixed method

However, surgeons were frustrated because reproducing the intraoperative maneuver in the nasal cavity was too difficult. This CST requires a soft nasal cavity and a brain, which cannot be achieved with a normal formalin-fixed cadaver. Since the inception of CAL, this program has become an enriching program in which doctors from all over Japan are eager to participate.

Otorhinolaryngology

The Department of Oto-rhino-laryngology and Head & Neck Surgery holds CST two to three times a year for doctors in the Chiba prefecture to promote safe endoscopic surgery and to teach cochlear implantation. Moreover, training for techniques that are less popular in Japan than in Europe and the USA is actively conducted, showing the ideal trend for promoting the spread of surgery while improving its safety.

Thoracic surgery

The Department of General Thoracic Surgery has been conducting a simulation for brain-dead lung transplantation surgery. Currently, Chiba University Hospital has been accredited as a facility for brain-dead lung transplantation. The Department of General Thoracic Surgery has been training the transplantation operation with two cadavers, one donor, and the other a recipient, since the beginning of the university hospital's quest for accreditation. Our transplantation team (including our nurses) is constantly practicing and improving their skills to increase the success rate of brain-dead lung transplantations that are rare. Many cadavers are

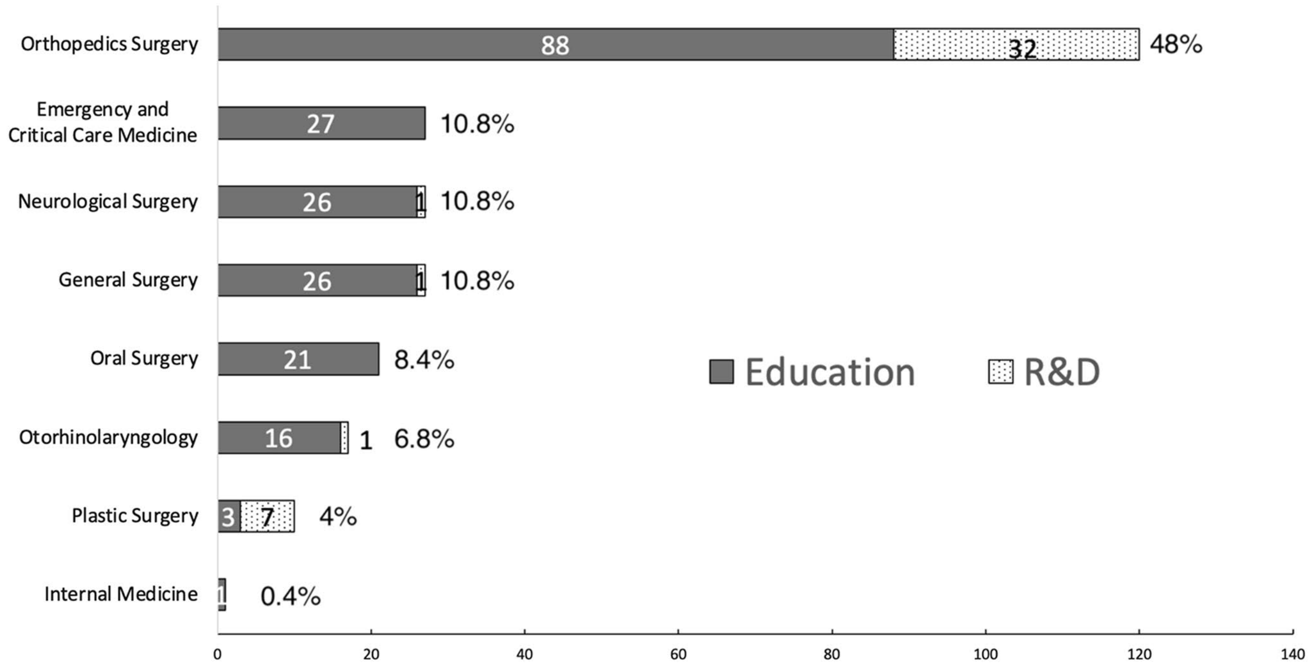

Fig. 5 Number of programs classified by clinical fields. The programs are categorized into each clinical field based on the affiliation of the implementation representative. The number of program implementations for each category is shown in the figure. The category "General Surgery" involved programs conducted by the department of "Esophageal–Gastro-Intestinal Surgery," "General Surgery, Hepato-Biliary–Pancreatic Unit," and "General Thoracic Surgery"

of patients who have died because of pneumonia. Therefore, this CST prefers to use Thiel-fixed cadavers rather than FFC, which are feared to be infectious.

General surgery

Training in laparoscopy is quite widespread in Japan in the form of skills centers and animal laboratories, and the cadaver laboratory is a much-needed complement to that training. The Department of Esophageal-Gastro-Intestinal Surgery performs various gastrointestinal surgeries by laparoscopy. Recently, CST in transanal total mesorectal excision and mediastinoscopic esophagectomy, which are difficult to understand anatomically in animals, has been actively introduced.

Trauma surgery

Educational opportunities for trauma surgeons are decreasing due to the decline in traffic accidents. The Department of Emergency and Critical Care Medicine has conducted several CSTs a year since the establishment of CAL to educate medical staff and physicians from city hospitals. Additionally, since 2016, we have introduced the Advanced Surgical Skills for Exposure in Trauma (Bowyer et al. 2013), the official CST of the American College of Surgeons, jointly with the Tokyo Medical and Dental University, for the first time in Asia, with great success. Trauma surgeons who previously had to go to the USA every year can now receive the same quality CST in Japan.

Orthopedics surgery

There have been several reports on efficacy in orthopedic CST (James et al. 2020; Erquicia et al. 2021). Similarly, the Department of Orthopedics Surgery is organizing the basic course of the "Orthopedic Surgery Cadaver Workshop in Chiba." This is a five-session program that covers five different areas, namely hand and elbow, shoulder, hip and pelvis, knee, and spine, and is intended for surgeons in the 3rd year after graduation who are seeking to become orthopedic specialists. All new residents of the Department of Orthopedic Surgery at Chiba University participate in this course. This suggests that they will experience basic orthopedic surgery on a cadaver before performing surgery on a patient. We believe that Chiba University is the only university in Japan that systematically introduces CST to the education of its residents. Since the introduction of this CST, the number of surgeons seeking to become orthopedic specialists at Chiba University has been increasing every year. We also offer more courses, such as the Applied Course and Advanced Course, which are designed for those aiming to become supervisors or experts. Each program also features the participation of operating room nurses, physical therapists, and occupational therapists, who gain information that goes beyond observing surgery at the hospital and apply it to their daily work. We feel that a major change is coming in the role of universities as educational institutions.

Discussion

Cadavers preserved at universities for students' dissection practice are formalin-fixed corpses that have stiffened tissues and immobile joints. What surgeons want to learn using cadavers differs from what students learn during practice. It is important to accurately observe the exact structure of the human body within the actual surgical field of view, following the surgical procedure. Furthermore, it is important to understand the difference between the image seen through the monitor of an endoscope or X-ray fluoroscope and that obtained through direct vision, and to match the sensation of touching an organ directly with the hand with that of touching it with forceps or a robotic arm. This information can only be obtained from a cadaver that maintains a texture and movement similar to that of a living body.

The cadavers handled in the cadaver laboratory must be storable for a long time without decomposition and must also be as flexible as a living body. These cadavers have muscles as soft as those of a patient under general anesthesia and joints that move. They can be dissected in a state that is extremely close to that of a living organism, except for the lack of respiration and circulation. In other words, it is the ultimate simulation education. Recently, some reports (Carey et al. 2015; Minneti et al. 2018) have shown that an artificial heart–lung apparatus can be attached and that blood vessels can be filled with a fluid that mimics blood flow to simulate bleeding to preserve blood vessels and provide training in hemostasis. However, in pursuit of too much realism, "moving" the internal organs of a corpse, which has finally been freed from suffering after a long struggle with illness, by reconnecting them to artificial heart–lung systems and other devices, may not be acceptable to everyone. Because different countries have different attitudes toward the handling of dead bodies, the introduction of this method requires careful consideration.

We had only hard, formalin-fixed cadavers before the establishment of CAL. Therefore, we should prepare soft cadavers when establishing CAL. Thus far, we have tried three preservation methods other than formalin fixation; we introduced FFC in 2011 and the Thiel embalming method in 2014, followed by SSS in 2018. Currently, besides formalin-fixed cadavers for students, we use both FFC and Thiel embalming methods, depending on the purpose of cadaver use in various surgical fields. Practically, SSS has an excellent brain fixation, but its use is almost identical to the Thiel embalming method. Orthopedic surgeons, the largest users, preferred the Thiel embalming method, which has softer joints; thus, SSS preservation was discontinued. The advantages and disadvantages of these methods are discussed below.

The protocol for preserving cadavers is determined as follows: All cadavers are tested with blood extracted from the heart immediately after transport. Accordingly, the seroprevalence of the hepatitis B virus surface antigen (HBsAg), antibodies against hepatitis C virus (anti-HCV), human immunodeficiency virus type 1/2 (anti-HIV 1/2), and *Treponema pallidum* were investigated. Cadavers transported within 48 h of death that tested negative for these infectious diseases are stored as fresh-frozen corpses. Bodies that tested positive for an infection and those transported within 72 h of death were fixed using the Thiel method, whereas those transported after > 72 h of death are fixed using FA.

FFC are preserved in freezers relatively soon after death. The muscles, tendons, and ligaments of cadavers frozen within 48 h are biomechanically similar to those of living organisms. However, given that repeated thawing and refreezing cause a gradual loss of strength (Ekiert et al. 2021), the number of times corpses can be used is limited. Moreover, if the donor was a carrier of a blood-borne virus, such as hepatitis or HIV, or died from bacterial or viral pneumonia or multi-drug-resistant bacteria, the chances of being frozen with such pathogens intact are high. Adequate infection control measures must therefore be taken when handling cadavers.

In Japan, the Thiel fixation method (Thiel 1992, 2002) and SSS (Coleman and Kogan 1998) are used as fixation methods, producing cadavers superior in terms of preservation and safety to fresh-frozen ones. Moreover, some reports have compared joint mobility, biomechanics, and histology (Hayashi et al. 2014; Beger et al. 2020), all of which have been evaluated to be suitable for CST.

Cadavers fixed using the Thiel method are fixed with a number of agents, such as formalin, propylene glycol, boric acid, and 4-chloro-3-methylphenol, which have sterilizing effects and flexibility and can be stored at room temperature for a long time. Benkhadra assumes that the boric acid in Thiel's solution causes a significant and distinct modification of the integrity and the alignment of muscle fibers (Benkhadra et al. 2011); however, McDougall found that boric acid was not the cause (McDougall et al. 2020). The cause of the fiber fragmentation is still unclear. The joints of the extremities are very soft, which is advantageous for CST; however, it is also extremely soft to be supportive, and it would be difficult for one person to set up the body on the operating table. Given that the elasticity of the brain tends to be too low, its use for CST in neurosurgery should be treated with caution. Thiel suggests injecting a mixture of 40 mL tap water, 45 mL ethanol, and 15 mL formaldehyde into the brain's ventricles. A recent study had attempted to adjust only the hardness of the brain parenchyma by injecting additional formalin directly into the ventricles (Miyake et al. 2020).

The SSS is a mixture of saturated saline solution and a small amount of formalin in the fixation solution, which takes several months for fixation to complete. Although the joints seem to be a little hard, this method has been thoroughly evaluated as being able to more closely resemble a living body than the Thiel method when fixing the central nervous system. Another considerable advantage is its inexpensiveness, given that it almost exclusively uses the saturated saline solution for fixation. SSS has also been increasingly reported to be suitable for CST (Burns et al. 2018; Homma et al. 2019; Watanabe et al. 2020). Although we have discontinued its adoption, SSS appears to be well adapted for use in educational purposes.

According to our survey, Thiel and FFC were used with equal frequency in CST, but FFC was used overwhelmingly in R&D at Chiba University. Compared with the FFC method, the Thiel method results in significant changes in the histological appearance and biomechanical properties (Benkhadra et al. 2011; Fessel et al. 2011; Wilke et al. 2011). Therefore, FFC is used almost exclusively in R&D at Chiba University, especially in biomechanical experiments. A cadaver fixed by an FA owned by a conventional anatomy department was used for studies that did not require joint mobility, such as clinical anatomical studies of nerve and blood vessel distribution.

Currently, Chiba University surgeons use the following methods to preserve bodies: The FFC or Thiel method is appropriate for orthopedic surgeon educational programs. However, the FFC method is strongly preferred for research programs. FFC, which are said to retain strength, are essential, especially for biomechanical research. The Thiel method of cadaver preservation was preferred among respiratory surgeons because of the relatively high number of cadavers of patients who had died of pneumonia. Initially, gastrointestinal surgeons preferred the Thiel method; however, they have begun preferring the FFC method. This is because surgeons believed that the Thiel method did not adequately fix the mucosal structures of the intestinal tract and that the texture of mesenteric and pancreatic fat was low. Neurosurgeons initially preferred the FFC method because of inadequate brain fixation with the Thiel method. However, by the 2nd day, the FFC had lost much of its brain shape, making it difficult to use for CST. Therefore, in 2018, we began injecting 100 cc of intracranial 20% formalin solution, as described by Thiel (1992, 2002). The brain then had good firmness over several days; thus, the Thiel method is always preferred.

We have recognized early on the importance of the cadaver laboratory in simulation education. Hence, in 2010, we had established the CAL at Chiba University, where doctors can freely use cadavers for education and research. The following 11 years of usage (Fig. 1) has shown a steadily growing trend. By 2020, however, half of the programs had been canceled due to COVID-19, but the numbers are expected to recover as soon as the pandemic is over. This steady increase in users cannot be achieved simply by guiding surgeons to the dissection room, but to constantly search for an environment that is more conducive to performing surgery rather than dissection. We also need an environment that makes it easier for surgeons to do everything from preparation to clean up to reduce the burden on the anatomy department.

In 2021, with the construction of a new medical school building, the CAL became an even more complete facility based on the experiences of the past decade. Currently, CAL stores cadavers using three preservation methods. The layout of the CAL is designed to provide surgeons with easy access to the cadavers and allow the transportation of cadavers without movement into the corridors to avoid biohazards from FFC. (Fig. 6). The facility consists of an operation theater (160 m^2) (Fig. 7), anatomical analysis room (60 m^2) (Fig. 8), mortuary (storage capacity of 190 bodies) (Fig. 9), anatomy preparatory room (50 m^2) (Fig. 10), dissecting practice room (416 m^2) (Fig. 11), conference room (80 m^2) (Fig. 12), and equipment room (35 m^2) (Fig. 13). Three types of cadavers are stored in the mortuary room: formalin-fixed cadavers used by students, Thiel method-fixed cadavers, and FFC for surgeons. The operation theater at CAL is a combination of the best parts of a hospital operating room and a dissecting practice room. The room is kept under negative pressure, and ventilation is controlled by downward airflow. We believe that this will reduce the risk of inhalation of chemicals contained in the fixation fluid and aerosols generated from the cadavers to the participants. We have also installed a similar ventilation system in the anatomical analysis room to ensure the safety of researchers during their long stays.

We describe the equipment surgeons require, which might not be replaced by conventional dissection laboratory equipment. CAL has six operating tables, not dissection tables. The operating tables should be prepared as early as possible; many surgeons who used the CAL appreciate having them. While dissecting tables have the advantage of being completely washable, which helps prevent contamination, operating tables have many more advantages. Many dissection tables are not height adjustable. The appropriate height of the table depends on the surgeon's height and surgical position. Dissection tables tend to be wide. The surgeon and assistant face each other and look into the same narrow surgical field in many surgeries. The distance between the two is greater on a dissecting table, and one of them cannot look into the field. The dissection table is not designed to hold the cadaver in various positions. There are many surgical positions; it is difficult to reproduce the Trendelenburg, lithotripsy, and sitting positions on the dissection table. The

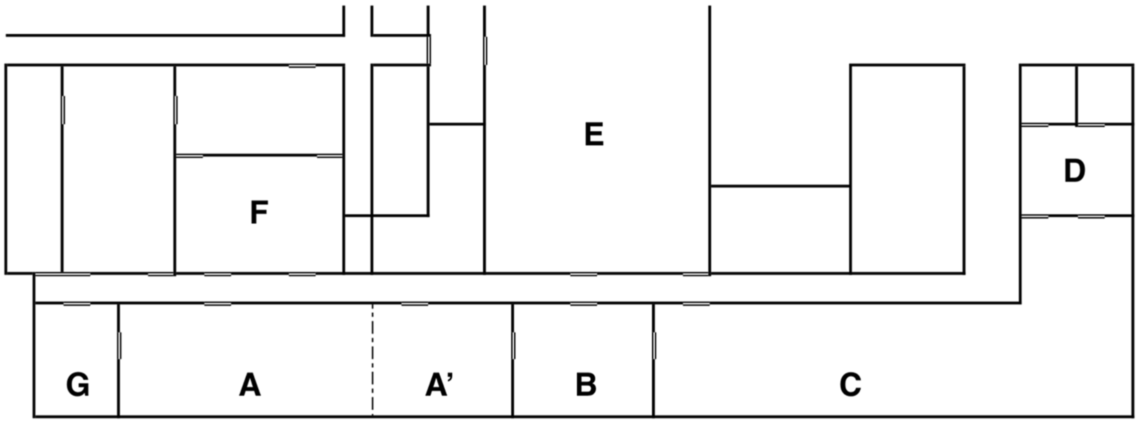

Fig. 6 Layout of the clinical anatomy laboratory at Chiba University. An indoor automatic door connects the mortuary to the anatomical analysis room and the operation theater. Infectious fresh-frozen corpses can be transported without sealing. There are no steps between the doors connecting the various rooms of the CAL, making it easier to transport instruments from the equipment room and corpses from the mortuary. Automatic doors open and close using foot switches and touchless hand switches; thus, contamination of the doorknobs does not occur. The operation theater can be divided into two sections, large and small, by mobile movable walls. Up to two programs can be performed in 1 day. A: operation theater, B: anatomical analysis room, C: mortuary, D: anatomy preparatory room, E. dissecting practice room, F: conference room, and G: equipment room

Fig. 7 Operation theater. The operating room is equipped with six operating tables, an excellent air conditioning system (negative pressure control and downflow control), and various audio-visual equipment

dissection table does not allow the use of X-rays. In some surgical areas, surgery is performed using X-rays, and an operating table is necessary to perform CST using X-rays. Surgeons must give up or compromise the procedure if the dissection table does not have the above conditions. The disadvantage of not being able to wash the entire operating table is adequately addressed by covering the table with drapes before placing the cadaver on it.

Similarly, surgical lights to illuminate the surgical field are also highly valued. The surgeon looks into a fairly

Fig. 8 Anatomical analysis room. The anatomical analysis room is equipped with equipment necessary for biomechanical analysis, including a universal testing machine and a 3-dimensional position sensor

Fig. 9 Mortuary. The mortuary has ten mortuary cabinets (100 bodies), six refrigerators (60 bodies), and six freezers (30 bodies)

Fig. 10 Anatomy preparatory room. There are two treatment tables. Formalin fixation and Thiel method are performed in this room. In addition, chemicals are administered here

narrow and deep surgical field. It is not possible to remove organs in the shallow layers and observe the deeper layers as in a normal dissection. Without surgical lights, it may be too dark to see.

Unlike an operating room, the CAL also has the aspect of being a room for lecturing trainees and is well equipped with audio-visual facilities. A 4 K camera is suspended from the ceiling, enabling real-time filming and distribution. There are three 65-inch 4 K monitors, microphones, and speakers to enhance information sharing in the operation theater. After watching an instructor's excellent demonstration, trainees are able to immediately train on the cadaver in front of us. Moreover, one or more sets of high-definition endoscopes, X-ray fluoroscopes, ultrasound diagnostic equipment, ultrasound coagulation incision equipment, high-speed drills, and surgical microscopes are available, making it easy to implement small-group programs. When implementing a large-group program, however, numerous surgical instruments will have to be borrowed. Nonetheless, we are ready to supply enough power for that.

It is preferable to use a cadaver with the same structure before treating the patient. A search in PubMed for "cadaver surgical training" showed that articles skyrocketed from 19 in 2000 to 108 in 2010 and 308 in 2020. Good surgeons develop new surgical procedures to push the limits of current surgical treatments, but there are ethical issues in performing them on patients without adequate research. Repeated studies are conducted on the remains to check for mistakes and make corrections. Pitfalls need to be identified for surgeons across the country to perform them safely and promote new surgical procedures.

Technology is transforming surgery. However, the training of surgeons is not a short-term process. Instead, the environment for training surgeons is deteriorating because of the increasing sophistication of medical equipment. Many surgical procedures are based on on-the-job training (OJT), in which the trainee learns while witnessing the treatment of patients. During the training period, the surgeon performs under the guidance of an instructor while being aware of patient safety. With the advancement in technology, more surgeries can be performed with smaller wounds without placing a burden on the patient. More procedures cannot be taught through traditional OJT, where the supervising physician can provide assistance, as more surgeries are performed in confined spaces. In other words, surgery is developing from a doubles game in which a learning surgeon is paired

Fig. 11 Dissecting practice room. There are a total of 32 dissecting tables with ventilation capacity and formalin countermeasures. Each dissection table is equipped with a 27-inch monitor

Fig. 12 Conference room. The conference room is equipped with two 86-inch 4 K monitors and two 49-inch 4 K monitors for viewing high-definition images; audio-visual facilities are linked to the operation theater for remote CST broadcast

Fig. 13 Equipment room. This room is used to store equipment used in surgery

with a supervisor to a singles game. There is a growing risk that the next generation of physicians who will succeed them will not have been trained in the future when the latest methods replace most surgeries.

Lastly, Japan has the tenth lowest number of doctors per 1,000 inhabitants among Organisation for Economic Co-operation and Development (OECD) countries (www.OECD.org, 2020) and the lowest percentage (22%) of female doctors (www.OECD.org, 2021). Given that the number of medical graduates per 1000 inhabitants in Japan is also the lowest (7.1%) among the OECD countries, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has continuously endeavored to increase the number of medical graduates in recent years from 5790 in 2005 to 7140 in 2020 (OECD.org, 2021). According to a report by the Ministry of Health, Labor and Welfare (MHLW 2018), although the number of doctors in each medical specialty has been increasing, the number of surgeons continues to decline given the belief that taking a leave of absence or leaving the profession due to life events, such as pregnancy or childbirth, can become an obstacle toward acquiring the necessary surgical skills while young. We believe that the current situation is a vicious circle, with the decrease in the number of surgeons leading to an even harsher work style.

Surgeons should have a facility to learn anatomy and surgical skills. Future surgeons will seek an environment with a cadaver laboratory that facilitates self-improvement. It is difficult to set up a cadaver laboratory in a country with strong legal restrictions on cadavers, such as Japan. However, it is necessary to shift to a more flexible educational and research environment, not only for conventional student education and morphological research, but also for the education and research required by medical personnel. We hope to see cadaver laboratories established in all Japanese universities soon. We hope that the environment in which CST can be performed will expand along with the cadaver donation system to countries where CST is currently unavailable. If more surgeons can learn from cadavers, it will help repay the valuable kindness of the donors.

Acknowledgements The authors wish to thank Mr. M. Ohta and Mr. Y. Sugata for their technical support with embalming. The authors sincerely thank those who donated their bodies for the advancement of scientific research and education. Results from such research can potentially increase mankind's overall knowledge, which in turn can improve patient care. Therefore, these donors and their families deserve our highest gratitude. The authors would like to thank Enago (www.enago.jp) for the English language review.

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