Original Article

Outcome model analysis-based results of actual tissue anatomy exercise for nursing students using non-fixed pig organs

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Abstract

Purpose: Knowledge of anatomy and physiology forms not only the foundation of nursing, but is also a necessity of the profession. However, using donated formalin-fixed human cadavers for real-tissue anatomy exercises to teach nursing students is not the standard in Japan. Reports suggest that non-fixed tissues, specifically raw pig hearts and kidneys, can be used as an alternative to formalin-fixed cadavers for anatomical exercises. The purpose of this outcome model was to clarify the key elements of these real-tissue exercises to increase the safety and effectiveness of anatomy education for nursing students.

Subjects and Methods: An analysis of the ease of study and safety of real-tissue anatomy learning exercises for nursing students was conducted using an outcome model. Inputs, processes, and outcomes were the lateral aspects of the model, and client, provider, and setting perspectives were the vertical aspects. Inputs were represented by the organization of real-tissue anatomy exercises, processes by educational activities, and outcomes by the results of the anatomy exercises conducted. Clients comprised nursing students, providers comprised teaching staff, and the setting was the Department of Nursing.

Conclusion: The benefits of real-tissue anatomy exercises in helping nursing students understand course material were evaluated. Results suggest that both exercises, i.e. the anatomy learning exercises of hearts and that of kidneys, offered large advantages in anatomy instruction. In their post-exercise reports, students expressed that their understanding of course materials was deeper after participating in the real-tissue exercise. They also reported that 3 study sessions, the combination of the real-tissue exercise with pre-exercise study and writing post-exercise reports, were effective based on their understanding of the material. When reviewing the outcomes cases, students (clients) mentioned the difficulty of the dissection procedures, whereas teaching staff (providers) has to provide sufficient technique of anatomy. Although non-fixed pig hearts and kidneys are most suitable as alternative specimens, the need to ventilate the classroom laboratory (setting) to remove the odour of the dissection specimens and ammonia was raised. Compared with donated human cadavers, using non-fixed pig organs for real-tissue anatomy exercises allows for a more easily managed work environment. We believe that such specimens may also be used for dissection exercises among nursing students and students in other fields.

Keywords: Anatomical education, nursing students, heart, kidney, outcome model analysis.

Introduction

The field of anatomy and physiology, which is the study of the body's structure and function, is the foundation and an essential part of nursing education. A deep knowledge of anatomy and physiology is necessary to conduct adequate assessment of patients' conditions, and 98.7% of nurses believe that anatomical knowledge is critical in clinical contexts (Fujii, 2004). However, because it is difficult for students to develop a concrete image of the structures and functions of the body's organs from lectures and study of horizontal materials such as textbooks alone, anatomy is believed to be a difficult subject for students to fully comprehend. Donated human cadavers are used for dissection exercises for the studies of medical and dental students in Japan (Act on Body Donation for Medical and Dental Education, 1983; Postmortem Examination and Corpse Preservation Act, 1949); Japanese nursing students are not allowed to dissect cadavers legally. Although 55% of nursing training institutions in Japan conduct dissection activities (Sotozaki, 1997), the content of these activities consists of cadaver dissection observation, mock

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dissection activities using retail models, and animal dissections (Sotozaki, 1997). Specimens used for animal dissections are often pig hearts (Figure 1) and kidneys (Figure 2), because of their great similarity to those of humans and nearly identical size. Furthermore, using pig organs offers various advantages: 1) unlike cadavers, hearts and kidneys from pigs are not treated with formalin because they are also used as food products; 2) because they are non-fixed, the risk for tissue infection is very low; 3) students are not exposed to formaldehyde, which is believed to be carcinogenic in humans; 4) similar to living tissues, the tissues of pig organs are soft to the touch; and 5) these tissues are easily and inexpensively procured from butchers. In addition, because the firmness and flexibility of formalin-fixed tissues differ greatly from living tissues, using fresh tissues is recommended for dissections to allow for a greater sensation of the properties and characteristics of living tissue (Hubbell, 2002; Ingram, 2003; Robinson, 2004). As a result, non-fixed pig organs are used not only for dissection activities among nursing students (Mochiki, 2008; Takayanagi, 2007; Takayanagi, 2012; Yamaguchi, 2009), but also for educational activities performed at medical institutions (Suenaga, 2012), junior high, and high school students (Iijima, 2000; Ingram, 2003; Noritake, 2010).

The outcome model used for this study was proposed by Holzemer WL in conjunction with the publication, 'Outcomes model for health care research' (Holzemer, 1994; Holzemer, 1995; Holzemer, 2000). This model establishes the concepts of inputs, processes, and outcomes as horizontal aspects, and client, provider, and setting as vertical aspects, all of which combine to create a 2-dimensional model allowing for a more easily analysed framework to characterise the complex properties of health-related outcomes. Moreover, this model incorporates a table format designed to increase the clarity of the research framework, and can also be used as a tool to critique study design and paper content (Fujisaki, 2000; Matsuda, 2005).

As such, the purpose of this study was to improve the effectiveness and safety of the real tissue anatomy exercises for nursing students. The content of the report 'Real-tissue dissection exercises for nursing students using non-fixed pig hearts and kidneys' was represented in table format from an ergonomics perspective, and an analysis of outcomes as 3 discrete aspects—clients, provider, and setting—was conducted. Feedback regarding educational activities as future processes was also collected to promote further improvements.

We obtained approval from the Research Ethics Committee at the Faculty of Nursing of Toho University (permission number: 24034) and the Animal Research Committee for Animal Experimentation for Toho University (permission number: 15-54-212). As Tokyo Eisei Gakuen College does not have an ethics committee, permission to conduct this study was obtained in written format from the College's Dean and the Director of the Nursing School.

Targets and Methodologies

Nursing students participated in a dissection exercise using non-fixed pig hearts and kidneys for learning anatomy. One week after the anatomy exercise, 5 teaching staff members and 211 nursing students completed a questionnaire on the activity, which were analysed using an outcomes model.

A summary of a previous paper, published in Japanese, on dissection exercises for nursing students using non-fixed pig organs (Takayanagi, 2007; Takayanagi, 2012) is provided. The study focused on nursing students who—as part of an anatomy seminar course during the first semester of the first year—completed lectures on the anatomy of the abdominal and thoracic regions, including the circulatory and urinary systems. The lectures were then followed by laboratory activities conducted in June and July at which time dissection exercises using non-fixed pig hearts and kidneys were performed. Students submitted reports 1 week afterward the dissection exercises. The students observed a human dissection 2-4 weeks later, and also submitted reports regarding this experience. Non-fixed pig hearts and kidneys were obtained from meat wholesalers, and refrigerated until the start of the dissection exercise.

Each class included 32-45 nursing students, with 1 anatomy instructor, 1-2 nursing instructors, and 1-3 teaching assistants. A non-fixed pig heart and kidney was provided to groups of 4-6 students. Participants wore white aprons, gloves, and protective masks for sanitation and deodorising purposes. A silent prayer was held before and after the exercise.

The main dissection procedure for non-fixed pig hearts was as follows: 1) exterior identification of the ventricle, atrium, and aorta (Figure 1); 2) internal identification of the ventricular wall, atrial wall, fossa ovalis, atrioventricular valves, and aortic valves; 3) identification of the origin segment of the coronary arteries; 4) identification of the epicardium, myocardium, and endocardium; 5) weight measurements; 6) dissection of the coronary arteries; and 7) observation of simulated fluid transport through the coronary arteries by performing intermittent fluid injections into the origin segment via syringe. The procedure used for non-fixed pig kidneys was as follows: 1) examination of perirenal fat, and while removing it, identification of the hilum; 2) identification of the renal artery, renal vein, and ureter within the hilum; 3) measurement of the weight and size of the kidney; 4) examination of the fibrous capsule, followed by its removal; 5) obtaining a frontal section that passes kidney hilum; 6) identification of the renal cortex, renal medulla, calyx, renal pelvis, and ureter from the frontal plane (Figure 2); and 7) injection of 1-3 mL of India ink into the renal artery of another undissected kidney, and observe the renal glomerulus, which was made visible by being marked by black dots by the India ink at the frontal section that passes the hilum. The pig heart and kidney specimens were dissected on the same day.

The surveys completed by the nursing students and teaching staff were analysed using the outcome model approach (Holzemer, 1994; Holzemer, 1995; Holzemer, 2000). The conceptual framework was created as displayed in Table 1 in reference to the prior report (Holzemer, 2000), and the analysis of the non-fixed pig organ dissection exercise was conducted based on this framework. In this study, the clients were nursing students, providers were the teaching staff, the settings were the Department of Nursing, inputs were the organization of real-tissue anatomy exercise, processes were the educational activities, and outcomes were the results of real-tissue anatomy exercise.

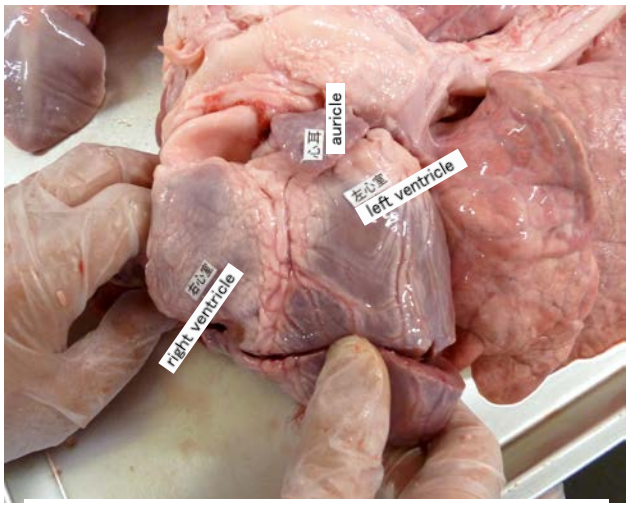

Figure 1. Anterior view of a pig heart. Nursing students photographed or sketched pig hearts with anatomical terms written on paper tags.

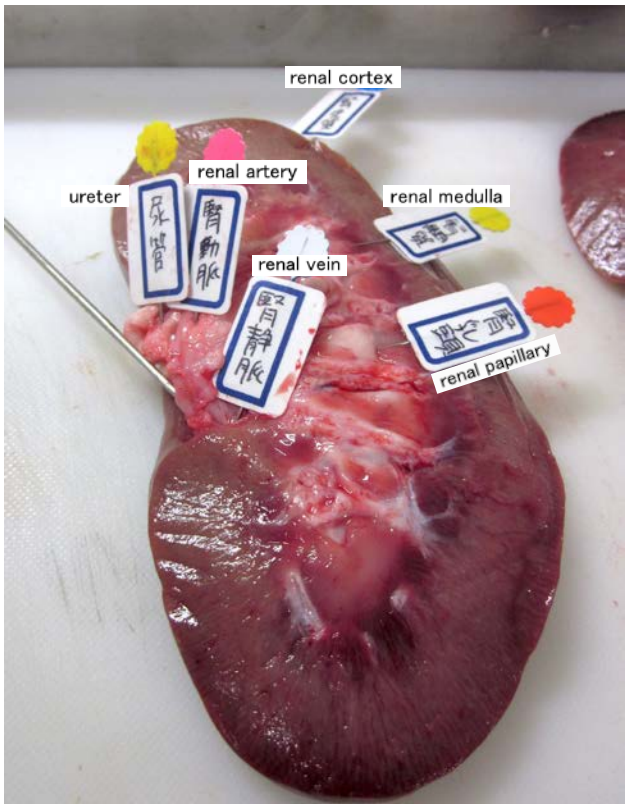

Figure 2. Representative frontal section of pig kidney with anatomical terms written on paper tags.

Results

The results of the outcome model analysis of the two reports on exercises using non-fixed pig organs are in Table 2. Regarding the nursing students (clients), the number of students receiving the lectures, students' gender, age, and year were collected. The number of anatomy instructors, nursing instructors, and teaching assistants also was collected for teaching staff (providers). As characteristics of the Department of Nursing (setting), it was noted that nursing students cannot perform human dissections, non-fixed pig hearts and kidneys are anatomically similar to human

Table 1. Conceptual framework of outcomes model in this study

	Inputs: Organisation of real-tissue anatomy exercise	**Processes: Educational activities**	**Outcomes: Results of real-tissue anatomy exercise**
Client: Nursing students	Regarding nursing students	Activities during real-tissue dissections, content of material studied	Student reports, student evaluations, student comments
Provider: Teaching staff	Regarding teaching staff	Preparations for real-tissue dissections, technique execution, guidance	Teaching staff assessments of real-tissue dissections
Setting: Dept. of Nursing	Circumstances, preparations for real-tissue dissections	Provision of exercise venue	Assessment of exercise venue

hearts and kidneys, no additional harm to animals is necessary as specimens can be obtained from ordinary food product suppliers, the risk for animal-to-human transmission of infection is low, and no ethical issues concerning the use of animals were raised.

Regarding the educational activity (processes), for nursing students, the pre-exercise preparation, studies, and post-exercise reports were noted. For teaching staff, pre-exercise preparation and work during the exercise were noted. Length of teaching time was noted for the Department of Nursing.

Lastly, regarding the results of the dissection exercise for the outcomes aspect of our analysis, for the nursing students, in conjunction with reports that the exercise was easy to understand, impressions from dissecting the non-fixed specimens, sense of the importance of prior study, and effect of report writing to deepen learning. There were also responses concerning the exercise indicating that the dissection techniques were difficult to perform and the time allotted for the exercise was insufficient, as well as desires for more teaching staff and longer exercise time. Students recognized the importance of studying before the exercise and that writing the post-exercise report actively reinforced the lessons they learned. Teaching staff indicated that all aspects of how the exercise was conducted were favourable, and that non-fixed pig hearts and kidneys were optimal substitutes for human organs. Regarding the Department of Nursing, we learned that although human dissections are not a possibility, conducting dissection exercises using non-fixed pig hearts and kidneys is a possible alternative. Even though students were not exposed to formaldehyde, as would be the case with preserved human specimens, some students may become irritated by fumes of ammonia from kidneys and the odour of the pig specimens themselves. We learned that adequate ventilation is necessary.

Discussion

This exercise was able to offer an opportunity for students to study 3-dimensional anatomical structures using real organs. The nursing students reported positive experiences when dissecting non-fixed pig organs, and observations of the effectiveness of these both exercises of anatomical study are indicative of their high efficacy as teaching tools. Because non-fixed fresh tissue specimens retain the same colour, shape, and texture as real tissues that may be encountered in clinical environments, using this kind of specimen for dissection exercises is recommended as a more practical and effective option for anatomical instruction (Hubbell, 2002; Ingram, 2003; Kikuchi, 2014; Robinson, 2004). As such, we believe that using non-fixed specimens is important for increasing the educational impact of dissection exercises. Students learned the importance of reading the textbook and procedural manual content concerning the applicable organs before performing dissections, deepened their understanding by reviewing what was learned in their textbooks afterward, and by preparing post-exercise reports. Therefore, we believe that the combination of pre-exercise study, real-tissue exercise, and writing post-exercise reports is effective in deepening their understanding and learning the material.

Because students noted the difficulty of performing dissection techniques and asked many questions to the teaching staff, we believe that there is a limit to students' dissection abilities, and a certain number of teaching staff members skilled in dissection techniques are necessary. To increase the educational effect of this exercise, it may be necessary to ensure a certain number of teaching staff.

Table 2. The outcomes model as the results of reports of real-tissue anatomy exercise using non-fixed pig hearts and kidneys

	Inputs: Organization of real-tissue anatomy exercise	**Processes: Educational activities**	**Outcomes: Results of real-tissue anatomy exercise**
Client	Non-fixed pig heart dissection exercise: 281 first-year nursing students, avg. age: 25.6±6.7 years 30 men (10.7%), avg. age: 26.6±4.1 years 251 women (89.3%), avg. age: 24.6±6.4 years 1 class; 40.1±4.2 students, total of 7 classes Non-fixed pig kidney dissection exercise: 472 first-year nursing students, avg. age: 27.2±7.4 years 59 men (12.5%), avg. age 28.1±6.5 years 413 women (87.5%), avg. age: 27.1±7.5 years 1 class; 39.3±4.2 students, total of 12 classes 211 nursing students responded to the survey.	Pre-exercise study. Pre-exercise meeting with group members. Delegate roles in activities during exercise. Numerous students actively conducted exercise. Asking teaching staff questions. Attaching labels to specimens, taking photos and sketches. Post-exercise report submission 1 week later.	**Survey Results** 'The exercise was easy to understand', 'pig kidneys look just like human kidneys', 'the real-tissue exercise was impactful', 'I was surprised', 'the exercise made an impression on me', 'the exercise had a real, visceral quality', 'I'm thankful to the pig whose organs we used', 'difficulty of techniques used', 'I would like more time for the exercise', 'I learned the importance of real-tissue exercises', 'I could reinforce my learning by writing the post-exercise report'. **Conclusions from Survey Results** This exercise had a large impact on students. There was educational effect that students could learn the importance of preparatory study. Instructor guidance and presentation is necessary during dissection. This exercise was an effective teaching tool and increased students' interest in anatomy. Ninety percent of nursing students felt the exercise was effective, with 63.5% responding that the exercise was beneficial, 28.0% reporting that it was somewhat beneficial, 6.6% that it was neither, 1.4% that it was somewhat useless, 0% that the exercise was useless, and 0.5% did not respond.
Provider	Anatomy instructors: 1 Nursing instructors: Several Teaching assistants: Several	Creating an activity manual. Distributing the activity manual in advance. Demonstrating and explaining dissection techniques. Providing instruction during student exercise.	**Conclusions from Survey Results** The exercise proceeded favourably. The non-fixed pig heart and kidney were suitable replacements for corresponding human organs. Use of non-fixed pig hearts and kidneys was an effective teaching method for this exercise. Allocation of approximately 60-90 mins. and approximately 30 mins. for dissection of the non-fixed pig hearts and kidneys, respectively, was adequate.
Setting	Nursing students cannot perform dissections on human cadavers. Non-fixed pig hearts and kidneys are anatomically similar to the corresponding human organs. Specimens were purchased from ordinary butcher shops. There was no need to kill animals as the specimens originated from a slaughterhouse. There was minimal risk of infection transmissible to humans due to the use of non-fixed pig tissue meant for food consumption. No animal-related ethical issues were identified.	A laboratory in the nursing dept. was used. Time allotted for dissection of the non-fixed pig heart was approximately 60-90 mins. Time allotted for dissection of the non-fixed pig kidney was approximately 30 mins.	**Conclusions from Survey Results** Laboratory ventilation is necessary. Formalin use was not necessary. In contrast with donated human cadaver specimens, students were not exposed to formaldehyde. This exercise can be conducted for not only nursing students, but also for any healthcare-related group. Some students may be irritated by the odour of the non-fixed pig specimens or the ammonia used on the kidney specimen, and adequate room ventilation is necessary.

Because this exercise used retail-available non-fixed pig organs as specimens and no additional harm to animals was necessary, the use of these specimens for exercise are not restricted by legal regulation, and no animal-related ethical issues were identified. Based on the use of this exercise in junior high and high school settings (Iijima, 2000; Ingram, 2003; Noritake, 2010), other education institutions could be able to prepare workspaces and specimens for students. Because the preparations needed for the workspace in this exercise were comparatively simplistic, this exercise also could be effective for students in the paramedical field, physical therapy, and occupational therapy programs. However, adequate ventilation is needed to counteract fumes and the odour of non-fixed specimens. Teaching staff should always carefully monitor for students who may become ill or irritated by the odour of the specimens.

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The authors have no conflicts of interest to report regarding the content of this paper.

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