ORIGINAL ARTICLE

Integration of Simulated Thoracentesis Using Thiel-preserved Cadavers in the Teaching of Thoracic Anatomy for Learning Unit III Medical Students: An Innovative Learning Strategy

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ABSTRACT

Background. Proficiency in performing thoracentesis is a key competency recommended in the Medical Schools Objective Project (MSOP) adopted by the American Association of Medical Colleges, USA, that medical students should possess prior to graduation, although they often do not practice it clinically until the later stages of their training. Thiel-embalmed cadavers, which offer a lifelike experience with less irritation than formalin-preserved cadavers, have been increasingly used as early as 1st year medical school to teach such procedures because of their feel-like and look-like real patients. There are no studies on the use of Thiel- cadavers for simulated thoracentesis among medical students in the Philippines.

Objective. To evaluate the attitudes and perceptions of medical students on the use of Thiel-soft embalmed cadavers for simulated thoracentesis as to the understanding of thoracic anatomy, overall learning experience, and confidence in performing the procedure in the cadaver and possibly in the clinical setting.

Methods. This is a descriptive cross-sectional study among Learning Unit III medical students in the University of the Philippines conducted from June 13 to 17, 2022. In the final station of the Organ System Course 205 of the Department of Anatomy's LEAP II program, a simulated thoracentesis procedure was set up using a Thiel-preserved cadaver with artificially created pleural effusion. After watching and studying thoracic anatomy, watching a video on how thoracentesis was performed by a general surgeon, students performed the procedure, and were asked to answer a 6-question Likert-scale survey to assess their perceptions and attitudes of the simulation procedure. Data was analyzed using descriptive statistics.

Results. Most of the students strongly agreed that practicing thoracentesis on the soft cadaver has improved their understanding of the anatomical basis of doing thoracentesis (97%) and of the steps of the procedure (94.9%). Similarly, when asked about how they felt doing the simulated thoracentesis, almost all (98%) strongly agreed that it was an enjoyable and stimulating learning experience. Majority strongly agreed (68%) that they felt capable doing the procedure on a soft cadaver against less than half (38.4%) feeling capable of doing it in the clinical setting. Almost all (97%) strongly agreed that

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simulated thoracentesis on a soft-embalmed cadaver should be part of the learning competencies of medical students because of the skills they learn by doing the procedure.

Conclusion. Integrating a simulated thoracentesis using a Thiel-preserved cadaver early in the course of a student's medical education, provided students with a better understanding of the anatomy of the thoracic wall and the anatomical basis of doing this simulation procedure. Though confidence in performing the procedure in a soft cadaver is higher than in a clinical setting, the latter setting may need repeated training to further hone their skills. Practicing thoracentesis on soft-embalmed cadavers significantly enhanced medical students' understanding and enjoyment of the procedure. This innovative approach can be considered by anatomy educators as an integrative learning activity when teaching thoracic cage anatomy. This can also be extended to senior medical students and residents across different specialties.

Keywords: Thiel-embalmed cadaver, thoracentesis, simulation, medical education

INTRODUCTION

Thoracentesis is a common procedure that is done for diagnostic and/or therapeutic purposes for patients presenting with pleural effusion. This procedure is generally done at the very least, by residents in training. In the Medical Schools Objective Project (MSOP) adopted by the American Association of Medical Colleges (AAMC), the goal was "to develop a consensus within the medical education community on the attributes that medical students should possess at the time of graduation."[1] Included in the MSOP was the recommendation that students have the ability to perform routine technical procedures that include venipuncture, intravenous catheter insertion, arterial puncture, lumbar puncture, nasogastric tube insertion, Foley catheter insertion, suturing of lacerations, and thoracentesis. Medical students and residents are taught to master ultrasound needle-guided procedures throughout their medical training because these procedures are used commonly across a variety of medical specialties. It is unacceptable for students to practice clinical skills on patients and so medical educators are constantly searching for new methods to teach procedural skills.[2]

In 1992, Prof W. Thiel developed his technique of soft embalming with the use of a new soft solution using various chemicals. Soft-embalmed human cadavers are now being used increasingly as a model to train surgeons and anesthesiologists because of their look-like and feel-like real patients.[2] A soft-embalming solution was developed by Walter Thiel in 1992.[3] Thiel embalming solutions (8.9% formaldehyde) are noted to be less carcinogenic than formalin embalming solutions (37%-40% formaldehyde). Thiel-preserved cadavers are however, much more expensive.[2] Despite the high cost, Thiel-embalmed cadavers are described as exceptionally lifelike with representation of structures almost corresponding to a real patient. They also produce more realistic ultrasonography images and fascial "pop" sensations than fresh (recently deceased) cadavers.[2] A Thiel-embalmed cadaver has well-preserved organs and tissues with natural color, consistency, and flexibility. Thiel-embalmed cadavers have been reported to have a positive impact on dissection and skills training because of their exceptionally lifelike character.[3] Moreover, the peritoneal cavity was so inflatable this Thiel-embalmed cadaver can be used for teaching and learning laparoscopic procedures.[4]

This method of handling the cadaver is more efficient and convenient, and lacks the emission of noxious or irritating gases due to its minimum formaldehyde concentration; it also provides passive joint mobility without stiffness and maintains the color, flexibility, and tissue plasticity at a level equivalent to that of a living body.[5]

Results of a survey administered to undergraduate and graduate anatomy students on their experience of working with Thiel-embalmed (TEC) and formalin-embalmed cadavers (FEC) were published by Balta et al.[3] All undergraduate and postgraduate students as well as clinical staff were asked to comment on the appearance of the TEC. Some respondents preferred TEC for the entire dissection while some others only for certain areas of dissection such as the musculoskeletal system. There was no overall consensus concerning the use of TEC. On a technical level, one-third of the participants considered TEC as less hazardous than FEC while fewer than 10% regarded TEC as more irritating than FEC. Psychologically, 32.7% of undergraduate students expressed the view that TEC made them feel more uncomfortable compared with FEC because of their life-like appearance.[4] In this published report, students found that the Thiel solution was less irritating than formalin. Concerns were raised about the preservation of the nervous system and the difference in appearance of Thiel-embalmed cadavers and the images in the texts.

In one published study, all student-respondents (100%, 13/13) agreed that practicing vascular access on a cadaver improved their understanding of both the Peripherally Inserted Central Catheter (PICC) line and Central Line procedures.[2] Majority of the student-respondents (92%, 12/13) felt capable of performing the PICC line and Central Line procedures on a cadaver after completing the training. However, only 69% (9/13) and 85% (11/13) felt capable of performing the PICC line procedure and the Central line procedure respectively, in a clinical setting. All students (100%, 13/13) did not agree that it was challenging to interpret ultrasound images on either of the commercial models, but only 54% (7/13) disagreed that it was challenging to identify structures on the cadaver using ultrasonography. Eighty-five percent (85%, 11/13) of the participants agreed

that the Thiel-embalmed cadaver was a more useful tool to learn and practice vein cannulation.[2]

There are no current studies on the students' skill level with thoracentesis procedures because medical students are not generally allowed to perform them on patients until they become clinical clerks and postgraduate interns. The University of the Philippines College of Medicine has adopted the learning outcome-based medical education with 10 learning outcome competencies, the first being Clinical Competence. However, there is no mention of the exact clinical competencies that the graduates must possess by the end of their internship. Part of the clinical competence is the proficiency in performing a list of procedures similar to those of the MSOP of the AMMC. This study evaluates the perceptions of Learning Unit III (LU III) medical students in the University of the Philippines on using simulation on a soft cadaver as one of these clinical skills, i.e. thoracentesis.

OBJECTIVES

General Objective

To evaluate the attitudes and perceptions of LU III students on the use of Thiel-soft embalmed cadavers for simulated thoracentesis.

Specific Objectives

1. To determine the students' perception on the value of simulated-thoracentesis on their understanding of the thoracic wall anatomy and the anatomical basis of the procedure.
2. To describe the overall learning experience of first year medical students when performing simulated-thoracentesis using Thiel-preserved cadavers.
3. To evaluate the level of confidence of LU III medical students in performing a simulated thoracentesis and if done in a clinical setting.

METHODS

Study Design and Setting

This is a descriptive cross-sectional study design to determine the initial experience of implementing a learning enhancement program and determine areas for improvement. This study is one of the modules in the Learning Enhancement in Anatomy Program (LEAP) of the Department of Anatomy. It was conducted at the Dualan Laboratory of the Department in Calderon Hall of the UP College of Medicine.

This program was a bridging face-to-face activity that was introduced in response to the suspension of academic activities due to the COVID-19 pandemic. The Department of Anatomy of the College of Medicine of the University of the Philippines Manila introduced a bridging program - Learning Enhancement in Anatomy Program (LEAP). This is a face-to-face learning activity conducted from June 13-17, 2022.

Study Population

The study population included 178 first year medical students at the University of the Philippines who participated in the LEAP.

Informed Consent Procedure

The learning activity was conducted in fulfillment of the course requirements of the Department of Anatomy. Prior to the activity, students were made to accomplish an informed consent detailing the need for compliance with CHED guidelines on face-to-face learning. These guidelines included the need 1) to be fully vaccinated, 2) to wear face masks throughout the activity, 3) to maintain social distancing, 4) to refrain from eating and / or socializing, and 5) to report any symptoms that would suggest the presence of an infection.

The informed consent included a section informing the students that the learning activity will include the collection of data to determine the effectiveness of the learning stations. The informed consent also assured the students that their privacy will be protected, that no names will be divulged in the reporting of the results, and that the research objective of the activity will not be graded and will not influence their overall grade for the learning activity. Informed consent was obtained as part of the LEAP Program led by the Department of Anatomy, which includes several projects, including this specific research study.

Study Procedure

The study analysed the secondary data that was collected for program evaluation purposes. The data included individual performance and feedback of the students in each of the stations that they have rotated through. The analysis will investigate students' performance scores for each of the stations and sub-analyze the scores by learning modality and student feedback. Data was encoded using Microsoft Excel software by a research assistant who was not employed by the Department of Anatomy and did not participate in implementing the LEAP. The evaluation sheet was provided for by an applicant to the faculty of the Department of Anatomy and has not given any lecture in Anatomy, and in thoracic anatomy in particular. The name of the student-evaluator was optional.

Conduct of the Simulated Thoracentesis

The simulated-thoracentesis substation is the last of the OS 205 station in the Department of Anatomy's LEAP II. One hundred fifty-four (154) LU III students participated in this study but only ninety-nine (99) were included because of technical reasons related to the Likert survey scale. The students started with a study of the thoracic anatomy on a formalin-preserved cadaver in substation 1 and ended at the simulated-thoracentesis simulation substation. A Chest Xray film and CT Scan films were shown (Figure 1A) and the faculty-preceptor described and explained the findings. The students were then required to watch a

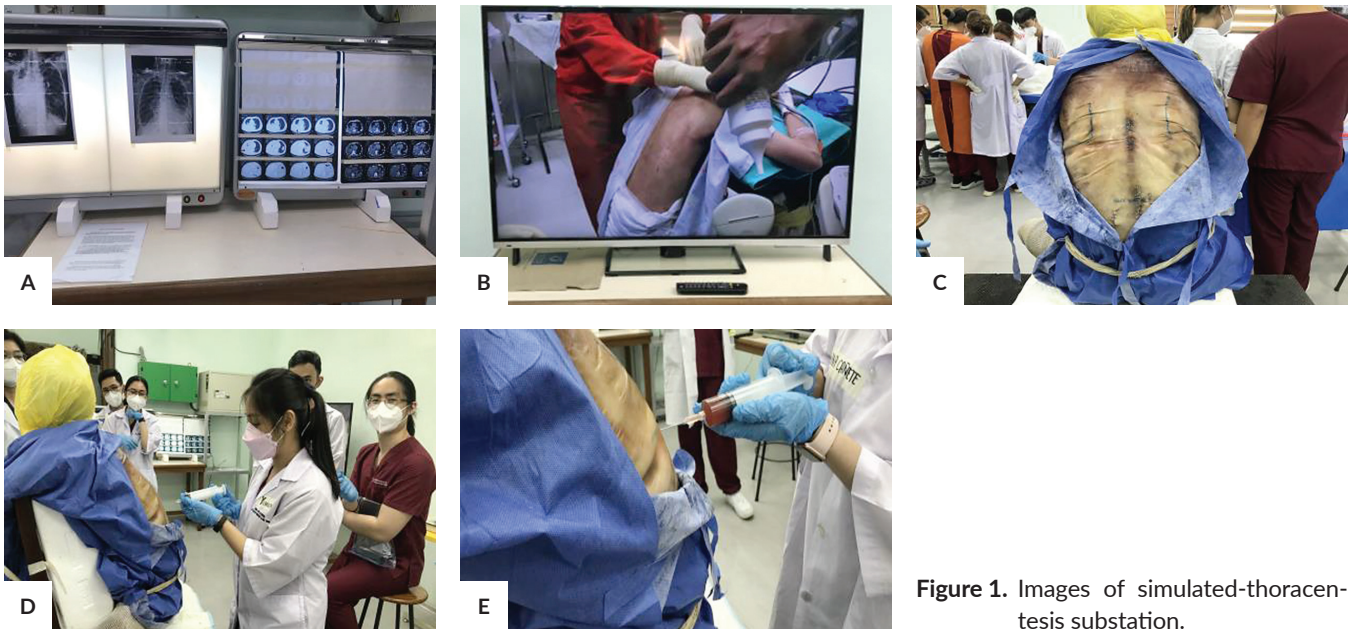

Figure 1. Images of simulated-thoracentesis substation.

video on thoracentesis (Figure 1B) performed by a general surgeon.

A step-by-step how-to-do-thoracentesis was posted at the simulation station. They then performed the simulation procedure on a Thiel-preserved cadaver with Pleural Effusion. The effusion was artificially created by infusing into the pleural cavity using a manual pump, a solution prepared by a mixture of water and a few drops of food coloring, with the tube inserted through a small incision at the 2nd intercostal space on anterior or mid-axillary line. This was done by the Anatomy faculty member who is a general surgeon and assisted by the members of the Laboratory Section of the Department.

The soft cadaver was placed in a sitting position with the chest against the chair as shown in Figure 1C. To confirm the successful development of pleural effusion, the faculty member performed the thoracentesis in the manner done on actual patients. At least two points of entry for the needle were marked on the chest wall along the posterior scapular line at the level of the 8th-9th intercostal spaces to guide the students on their needle placement when performing the procedure. The students were asked how to accurately identify the intercostal space. The students were allowed to do the procedure at least twice if the first try was unsuccessful (Figures 1D and 1E).

After performing the procedure, the students were asked to complete a 6-question Likert-scale survey on their attitudes and perceptions on the simulation procedure performed on a soft cadaver, on their understanding of the thoracic wall anatomy and the basis for the performance of thoracentesis, overall learning experience, confidence in performing thoracentesis in the cadaver and clinical setting, and belief in including the simulated procedure as a core competency in the medical curriculum. The Likert-scale survey questions were answered on a scale of 1-4 (strongly disagree, disagree, agree, strongly agree) reflecting their agreement or disagreement with the statements pertaining to the simulated procedure. The identities of the students remained anonymous. Included in the survey were demographic data of the student-participants in the simulation. Their responses to each of the six questions were recorded in frequency and percentage. The survey forms were then collated in a Google sheet. We did not include in the study, the correlation between the feeling of their capability of doing the thoracentesis in the soft cadaver and performing it in the clinical setting.

RESULTS

One hundred fifty-four (154) LU III students participated in this study but only ninety-nine (99) were included because of technical reasons related to the Likert survey scale. Fifty-six of the 154 survey forms had five-graded scales instead of the standard four-graded scale. There is almost an equal number of male and female students who participated in this study (51.5%:48.5%) (Figure 2).

These medical students graduated from different courses but the most common were BS Biology (16.2%) and the Intarmed (13.1%). Less than half of the students (42.7%) graduated with a previous human anatomy course (Figure 3).

Most of the students strongly agreed that practicing thoracentesis on the soft cadaver has improved their understanding of the anatomical basis of doing thoracentesis (97%) (Figure 4) and of the steps of the procedure (94.9%), respectively (Figure 5).

Similarly, when asked about how they felt doing the simulated-thoracentesis, almost all (98%) strongly agreed that it was an enjoyable and stimulating learning experience (Figure 6).

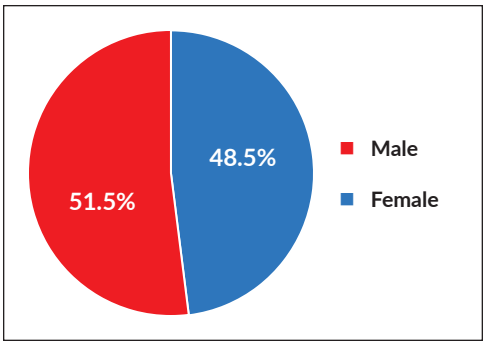

Figure 2. Ratio of respondents as to sex.

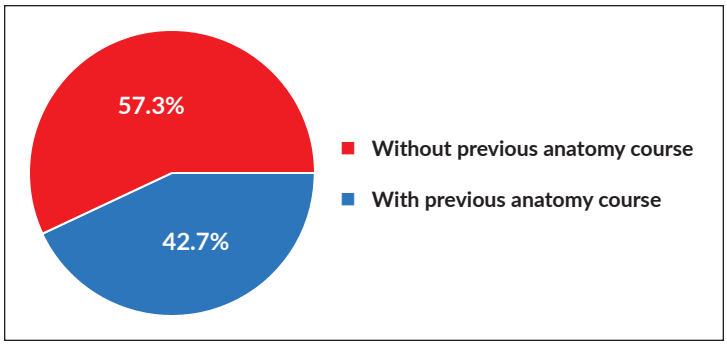

Figure 3. Number of students with a previous human anatomy course.

Majority strongly agreed (68%) that they felt capable of doing the procedure on a soft cadaver (Figure 7) against less than half (38.4%) who felt capable of doing it in the clinical setting (Figure 8).

Almost all (97%) strongly agreed that simulated thoracentesis on a soft-embalmed cadaver should be part of the learning competencies of medical students because of the learning skills obtained (Figure 9).

DISCUSSION

The study included 99 medical students, with an almost equal gender distribution, and 42.7% having had prior anatomy courses. Most students strongly agreed that practicing thoracentesis on a soft cadaver improved their understanding of the anatomical basis (97%) and the procedure steps (94.9%), as well as provided an enjoyable learning experience (98%). Although 68% felt capable of performing thoracentesis on a cadaver, only 38.4% felt confident in a clinical setting, but

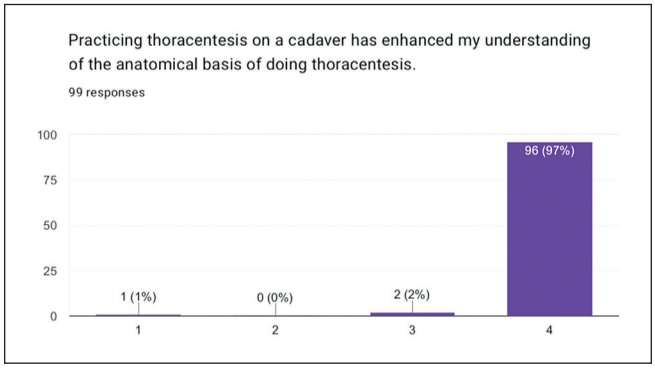

Figure 4. Practicing thoracentesis and understanding the anatomical basis of the procedure.

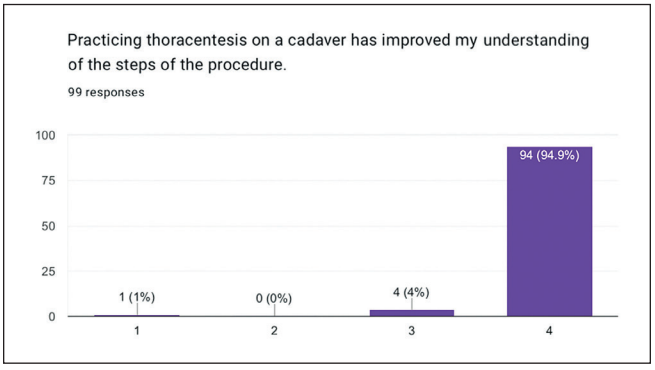

Figure 5. Practicing thoracentesis and improved understanding of the steps of the procedure.

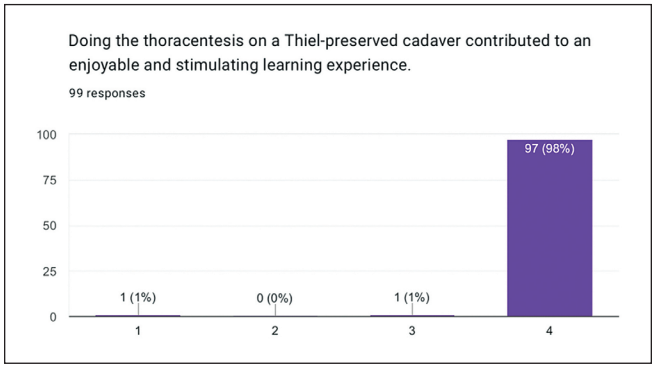

Figure 6. Thoracentesis contributed to an enjoyable and stimulating learning experience.

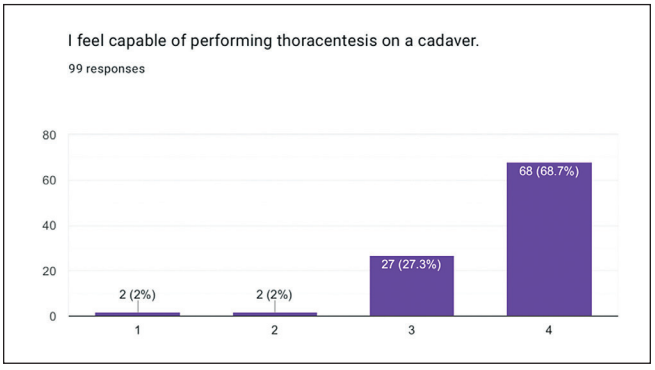

Figure 7. Capability of performing thoracentesis on a cadaver.

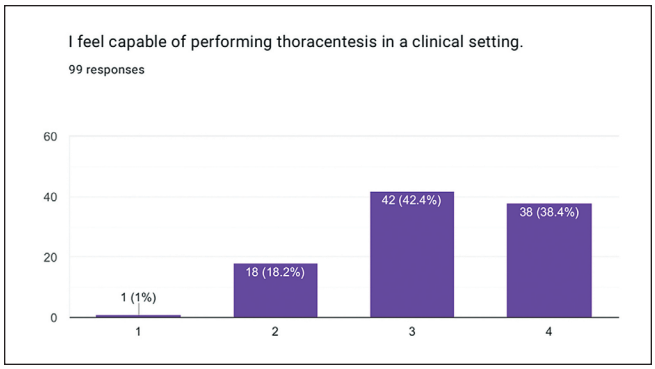

Figure 8. Capability of performing thoracentesis in a clinical setting.

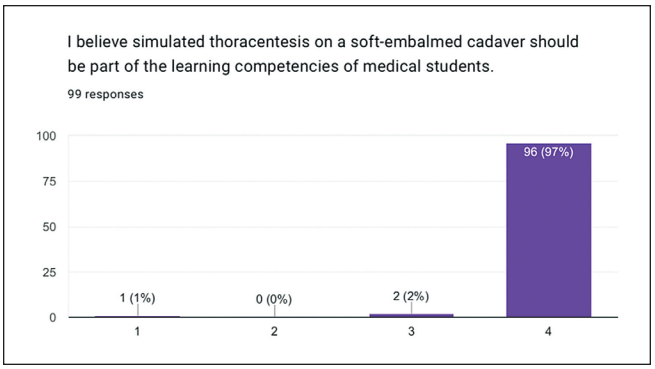

Figure 9. Thoracentesis on a soft-embalmed cadaver as part of the learning competencies of medical students.

97% believed that thoracentesis on a soft-embalmed cadaver should be part of the medical curriculum.

Integrating procedural skills using simulation and utilizing soft Thiel-preserved cadavers early in the course of the medical education of our medical students may improve clinical practice and build their confidence and competence when presented with the challenges of doing a procedure in a clinical setting. Equally important is this simulation activity also enhanced their understanding of the anatomical basis of doing the procedure and the steps involved in such procedure. This cannot however, be achieved with one simulation session. The main goal of this study was to evaluate the perception, attitude, and potential benefits of doing simulation in a Thiel-preserved soft cadaver, in this case, a thoracentesis. In one study on ultrasound-guided IV cannulation using a soft cadaver, students commented that the Thiel-embalmed cadaver "gives more of a real feel compared to models," "gives feel for human tissue," and provides a "real life experience."[2]

We envision the use of a Thiel-preserved cadaver to be an added clinical training tool to our anatomical models, mannequins, that would enhance the students' anatomical knowledge and provide an enjoyable and a stimulating learning experience.

Simulation and utilizing soft Thiel-preserved cadavers can improve a medical student's confidence and competence when presented with challenges in a clinical setting. Repeated performance of the simulation procedure in a soft cadaver can help medical students build their confidence in doing the procedure in the clinical setting. Thiel-preserved cadavers present a realistic anatomical representation, allowing students to practice the correct techniques, positioning, and anatomical landmarks required for successful thoracentesis. This integration promotes a realistic learning experience that closely mimics real-life scenarios, enabling students to develop the necessary skills to become competent and confident future physicians promoting patient safety.

The integration of simulated thoracentesis using Thiel-preserved cadavers in the teaching of anatomy for medical students is an innovative approach that offers numerous benefits. These medical students who performed the simulated procedure appreciated the anatomy of the thoracic wall and anatomical basis of doing thoracentesis. These students enjoyed doing the procedure with some of them repeating doing it. It was also a stimulating learning experience for them that gave them the confidence in doing the simulated thoracentesis on a Thiel-preserved cadaver and for a number of these students, their confidence extend to their perceived capability of doing the procedure in a clinical setting.

Incorporating simulated thoracentesis using Thiel-preserved cadavers promotes teamwork and communication among medical students. Collaborative learning during simulated scenarios encourages students to work together, develop effective communication skills, and make informed decisions as a team. These essential aspects of medical practice are often challenging to teach solely through theoretical lectures or textbooks. This innovative approach prepares students to become competent and confident physicians, well-prepared to handle the challenges they will face in their medical careers.

A limitation of this study is the missing data from those who were not included in the study for technical reasons, which may affect the findings. Another possible limitation is related to patient safety during the procedure when a common complication following thoracentesis like pneumothorax cannot possibly be assessed in a cadaver and which can also affect the student's confidence and experience in doing the procedure.

CONCLUSION

In our study, integrating a simulated thoracentesis using a Thiel-preserved cadaver early in the course of a student's medical education, provided students with a better understanding of the anatomy of the thoracic wall and the anatomical basis of doing this simulation procedure. Though confidence in performing the procedure in a soft cadaver is higher than in a clinical setting, the latter setting may need repeated training to further hone their skills. Future

recommendations include incorporating more hands-on cadaver-based simulations in higher year levels to boost skills and confidence in thoracentesis and similar procedures, and including it as a core competency in the medical curriculum, and correlating the level of skills and confidence learned in simulated thoracentesis to actual clinical proficiency in internship and residency training. This innovative approach can be considered by anatomy educators as an integrative learning activity when teaching thoracic cage anatomy. This can also be extended to senior medical students and residents across different specialties.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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REFERENCES

1. Promes SB, Chudgar SM, Grochowski CO, Shayne P, Isenhour J, Glickman SW, et al. Gaps in procedural experience and competency in medical school graduates. Acad Emerg Med. 2009 Dec;16 Suppl 2:S58-62. PMID: 20053213 DOI: 10.1111/j.1553-2712.2009.00600.x
2. Kondrashova T, Canaan R, Gunn B, Pazdernik V, Houser JJ. Development of competency in needle-guided procedures through the use of soft-embalmed cadavers. Mo Med. 2020 Sep-Oct;117(5):461–8. PMCID: PMC7723151 PMID: 33311756
3. Balta JY, Lamb C, Soames RW. A pilot study comparing the use of Thiel- and formalin-embalmed cadavers in the teaching of human anatomy. Anat Sci Educ. 2015 Jan-Feb;8(1):86–91. PMID: 24996059 DOI: 10.1002/ase.1470
4. Srivastava G, Nagwani M. Embalming of human cadavers from Egyptian era to the most modern techniques - a review on preservation of human cadavers. EJMR. 2019 Jul-Dec;6(2):94–7.
5. Ottone NE, Vargas CA, Fuentes R, Del Sol M. Walter Thiel's embalming method: review of solutions and applications in different fields of biomedical research. Int J Morphol. 2016 Dec;34(4):1442–54. DOI: 10.4067/S0717-95022016000400044