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Emergency Procedure Training of Residents Using Lightly Embalmed Cadavers; 3-year Experience

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Purpose: Emergency procedures are highly dependent on the skill and experience of the physician performing them. Recent advances in light embalming techniques have enabled us to train students on more "realistic" cadavers. The purpose of this study was to report on our 3-year experience with lightly embalmed cadaver-based training and evaluate the student satisfaction with this approach.

Methods: Lightly embalmed cadavers were prepared by the Department of Anatomy. The course was held every March for 3 years. In 2007, we held a 6-hour course for 16 first-year emergency medicine residents from various hospitals. We had procedure and demonstration stations for airway management, tube thoracostomy, central venous catheterization, venous cutdown, pericardiocentesis, intraosseous insertion, open thoracostomy, and lumbar puncture. We evaluated the students' level of satisfaction with the course by giving pre- and post-course evaluations to all students.

Results: Based on our experience from the two prior courses, the 2007 curriculum was divided into three parts: didactic lecture, procedure stations and demonstration stations. Pre- and post-course scores were compared for the following: knowledge of the indications and contraindications for the procedures; ability and confidence in performing the procedures; and the ability to perform procedures on actual patients. For 26 items out of a total of 32 items(81.3%), the scores from the post-course evaluation were statistically higher than the scores from the pre-course evaluation.

Conclusion: Lightly embalmed cadavers are excellent training models for emergency procedures. From our 3-year experience with this method, we were able to develop a training course that was satisfactory to students.

Key Words: Procedures, Education, Embalming, Cadaver

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Introduction

Decision making is an important requirement of emergency management. Being able to make the right decision to perform critical procedures requires knowledge, training, and experience. Airway management, tube thoracostomy, central venous catheterization, venous cutdown, pericardiocentesis, intraosseous insertion, open thoracotomy, and lumbar puncture are a few examples of emergency procedures. These procedures are highly dependent on the skill and experience of the physician[1,2]. Procedures performed by an inexperienced physician could result in detrimental consequences. The traditional method of training was the "observe and follow" method. Physicians learned by observation only, and then performed procedures on patients without prior practice. Nowadays, for legal and ethical reasons, physicians must practice procedures on manikins before actually performing them on patients[3,4]. However, manikin training has its limitations as it lacks many of the realistic aspects of critical emergency procedures[5].

Conventional cadavers were all preserved with formalin-based substances, resulting in a stiff and fixed texture which made them inappropriate for procedural training[6]. Recent advances in light embalming techniques have enabled us to train students on more "realistic" cadavers. Our purpose is to introduce our 3-year experience with lightly embalmed cadaver-based training and evaluate students' satisfaction with this course.

Materials and Methods

1. Preparation

Lightly embalmed cadavers were prepared by the Department of Anatomy. Preparation took 1 month the first year the course was run, but we were able to shorten the preparation period to 1 week the following year. Four procedure stations for airway management, central venous catheterization, lumbar puncture, and pericardiocentesis were prepared prior to the workshop.

For the airway management station, a sagittally-sectioned head and neck specimen was prepared to show the anatomy. For the central venous catheterization station, the anterior neck and upper chest were dissected to expose the anatomical landmarks. This provided the students an opportunity to see the anatomical structures during the procedure. For the lumbar puncture station, saline was infused using the transsphenoidal approach to fill the cerebrospinal fluid. For the pericardiocentesis station, we positioned a catheter in the pericardial sac for saline infusion. The saline was dyed red, which enabled us to see whether the procedure was successfully performed.

2. Course Development

The course was held every March for 3 years (Table 1). In 2005, we started with only three cadavers and included only residents from our department. The second course was held the following year with four cadavers and emergency medicine residents from other hospitals. In 2007, we held a 6-hour course for 16 first-year emergency medicine residents from various hospitals. Each year, a post-course evaluation was handed out to all of the students. In the 2007 course, we developed a tool to evaluate the curriculum and students' level of satisfaction with the course (Fig. 1).

3. Evaluation and Analysis

Pre- and post-course evaluations were given to all students. The five-point Likert scale was used to evaluate the following: time allocation, didactic lectures, skill stations, preparation, knowledge of the indications and contraindications of procedures, and ability and confidence in performing the procedures.

Data were summarized as mean(±standard deviation). The Wilcoxon signed-rank test was used for statistical analysis using SPSS 12.0 for windows (SPSS Inc., Chicago, IL).

Results

1. Curriculum Development

The first course was a preliminary course that provided us with a foundation to develop a better program. In the second course, we gave students enough time to practice the skills rather than simply observe the anatomic structures, but due to the low cadaver to student ratio(1:7), the students did not have sufficient time to practice.

Based on our experiences with the two previous courses, we divided the 2007 curriculum into three parts (Fig. 2) and adjusted the cadaver to student ratio to 1:4. Four students were assigned to each cadaver station with 1-2 specialists and 1 senior resident as instructors. The senior resident demon-

Table 1. Course format and training skill contents in three workshops

Date	No. of Cadavers	No. of Participants	Course Hours	Contents
March 2005	3	12	4	ATPIC, open thoracotomy, anatomy of hand and neck
March 2006	4	28	5	ATPIC
March 2007	4	16	6	ATPIC, open thoracotomy, Lumbar puncture, venous cut down

ATPIC: Airway management, Tube thoracostomy, Pericardiocentesis, Intraosseous needle insertion, Central venous catheterization

Airway management	Lowest				Highest
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Tube thoracotomy					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Pericardiocentesis					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Spinal tap					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Open thoracotomy					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

IO insertion					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Central venous catheterization					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Cut down					
1 the knowledge on indication	1	2	3	4	5
2 the knowledge on contraindication	1	2	3	4	5
3 ability and confidence in performing the procedure	1	2	3	4	5
4 ability to perform the procedure to actual patient	1	2	3	4	5

Fig. 1. Course evaluation from self assessment for participants

strated the steps of the procedures under the supervision of the specialists. At the demonstration station, students observed the procedure performed by the specialists.

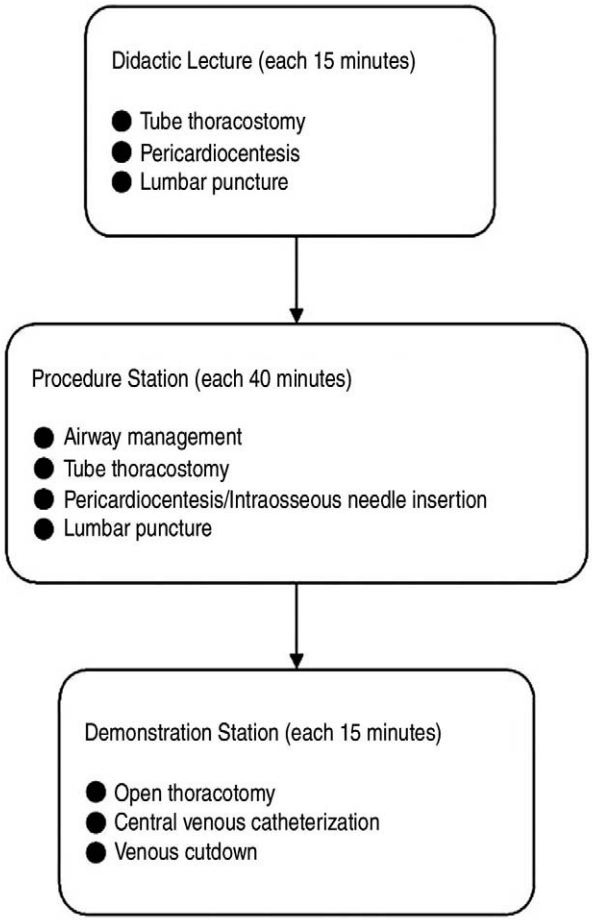

Fig. 2. The curriculum of the March 2007 course

2. Evaluation

Sixteen emergency medicine residents participated in the 2007 course. They completed post-course evaluations, and the scores for time allocation, didactic lectures, procedure stations and preparation were 4.00(±0.63), 4.19(±0.75), 4.38(±0.50), and 4.44(±0.51), respectively. Pre- and post-course scores were compared for the following: knowledge of the indications and contraindications of the procedures, ability and confidence in performing the procedures, and the ability to perform the procedures on actual patients. The scores from the pre- and post-course evaluation are shown in Table 2. For 26 items out of a total of 32 items(81.3%), scores from the post-course evaluation were statistically higher than the scores from the pre-course evaluation. There was no difference pre- and post-course in knowledge of the indications and contraindications of the airway management procedure, and no difference pre- and post-course in the ability and confidence in performing open thoracostomy and central venous catheterization procedures (Table 3).

Discussion

Formalin-based cadavers are not suitable for procedural skill training since their fixed and hard texture makes it difficult to perform procedures. Fresh cadavers have a better texture for procedural skill training, but require storage below 4°C with the

Table 2. Scores from pre- and post-course evaluations

	Indications		Contraindications		Ability to Perform		Confidence	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Procedure station								
Airway management	3.44	3.81	2.63	3.50	3.13	4.06	2.31	3.31
Tube thoracostomy	3.31	3.94	2.75	3.56	1.94	3.31	1.75	2.63
Pericardiocentesis	3.06	3.88	2.44	3.25	1.50	3.06	1.25	2.19
Lumbar puncture	3.13	4.13	2.75	3.88	2.38	3.50	1.75	2.88
IO needle insertion	2.44	4.06	2.13	3.94	1.38	3.75	1.25	3.00
Demonstration station								
Open thoracotomy	2.75	3.88	2.13	3.50	1.69	2.25	1.44	1.50
CV catheterization	3.50	4.13	3.13	3.88	3.38	3.81	2.94	3.44
Venous cutdown	2.25	3.88	1.88	3.13	1.50	3.81	1.25	2.06

IO: intraosseous, CV: central venous

internal organs removed as soon as possible in order to prevent decomposition. Furthermore, fresh cadavers are more costly that formalin-preserved cadavers and it is difficult to reuse the cadaver for other purposes. Furthermore, fresh cadavers may not always be readily available, which gives the course coordinator very little time to prepare. The awkward smell and the risk of infection is also a serious disadvantage[7,8]. We used lightly embalmed cadavers with milder fixing fluids than formalin that do not precipitate in the cadaver. These ensure that the cadaver is preserved for a longer period and also has a better texture without an unpleasant smell. Lightly embalmed cadavers are best utilized within 2 weeks of preparation, and can be preserved for up to 6 weeks[7,9].

In emergency settings, newly deceased patients may still be used to practice emergency procedures, but these procedures are usually performed without family consent[10]. This poses an ethical problem, and further research is warranted[11]. Kevin et al.[6] reported that traditionally fixed cadavers can be used for resident skill training for transcutaneous cricothyrotomy and fiberscopic retrograde intubation. There have been reports on skill training for emergency procedures such as central venous catheterization, tube thoracostomy, venous cutdown, intraosseous insertion, and surgical cricothyrotomy for medical students[5], and tube thoracostomy skill training for emergency medicine residents, using fresh cadavers[12]. Ronald et al.[8] used lightly embalmed cadavers to train obstetrics residents to practice laparoscopic surgery, but there have not been any reports in the emergency medicine field regarding procedural training using lightly embalmed cadavers.

In procedural skill training, high-fidelity simulators are replacing the traditional task models due to the ability to recreate various anatomical aspects and physiological consequences of the procedures performed. We used embalmed cadavers in procedural skills training, and we believe that simulations and cadaver-based training are complementary rather than competitive. While simulation training can help foster situational awareness, decision making, and a holistic approach in students, the cadaver model can foster the technical and anatomical aspects of procedural learning.

Our study received high overall evaluation scores (>4). Knowledge of the indications and contraindications section received high scores in the post-course evaluation. This can be attributed to the didactic lectures provided at the beginning of the course. The airway management section received low scores compared to the other procedures because the airway management station focused on explaining the functional anatomy of the airway rather than indications and contraindications. All of the skills actually practiced by the students resulted in significantly better scores in the post-course evaluation compared with the pre-course evaluation. The results of the skills at the demonstration station were mixed. The post-course score for the venous cutdown section was significantly better than the pre-course score, while the central venous catheterization and the open thoracotomy were not

Table 3. Differences of pre- and post-course evaluation scores for each procedure (average of mean differences)

	Indications	Contraindications	Ability to Perform	Confidence
Procedure station				
Airway management	0.37	0.87	0.93*	1.00*
Tube thoracostomy	0.63*	0.81*	1.37*	0.88*
Pericardiocentesis	0.82*	0.81*	1.56*	0.94*
Lumbar puncture	1.00*	1.13*	1.12*	1.13*
IO needle insertion	1.62*	1.81*	2.37*	1.75*
Demonstration station				
Open thoracotomy	1.13*	1.37*	0.56	0.06
CVP catheterization	0.63*	0.75*	0.43	0.50
Venous cutdown	1.63*	1.25*	2.31*	0.81*

* $p<0.05$,
IO: intraosseous, CVP: central venous pressure

significantly better post-course. This is probably because the participants were already familiar with performing the central venous catheterization procedure.

The ability to perform more commonly performed procedures (e.g. airway management and central venous catheterization) received higher scores before training (3.13 and 3.38, respectively). In contrast, procedures rarely performed in the emergency department (e.g. open thoracotomy and pericardiocentesis), received lower scores (1.69 and 1.50) pre-training. The scores for central venous catheterization and the open thoracotomy station showed no significant differences pre- and post-training. This is probably because no hands-on opportunity was given for these two procedures.

At this time, we are not certain of the educational impact of the procedural training using embalmed cadavers because we are still in the process of developing a better curriculum. During the past 3 years, we have incorporated didactic lectures, designed teaching templates, and made a list of procedures in accordance with the available cadavers and instructor pool. We included didactic lectures of some risky, unfamiliar procedures to emphasize the indications and contraindications, irrespective of the previously distributed syllabus. Some of the instructors thought that the didactic lectures were unnecessary, but because the students were satisfied with the content of the lectures, we concluded that they would become better oriented with the skills and that their performance ability would be enhanced. The students also had suggestions for next year's course, such as including stations for transcutaneous cricothyrotomy, tracheostomy, fasciotomy, suture techniques, exploratory laparotomy, tenorrhaphy, and arthrocentesis.

Thus, with 3 years' experience, we were able to find an educational niche for procedural training using embalmed cadavers, especially in the postgraduate training, even in this era of high-fidelity simulations.

There are several limitations to this study. First, since the number of students is small, the study population may not be representative of the overall emergency medicine resident population. Second, the condition of the somatic tissue present in the cadaveric state is significantly different from that found in the living human. Finally, the inherent difficulty in correlating the student self-report data with the actual procedural competency and clinical outcomes limits assessment of the educational value. This limitation could be mitigated by skills testing in the OSCE format 3 to 6 months after the course; this will be incorporated in the 2008 course. Nevertheless, despite these limitations, the positive impacts of the course were apparent through conversations with the students.

Conclusion

Lightly embalmed cadavers are excellent training models for emergency procedures. Based on our 3-year experience with this method, we were able to develop a training course that was satisfactory to students.

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