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A Comprehensive Unembalmed Cadaver-based Advanced Emergency Procedures Course for Medical Students

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ABSTRACT

Preparing medical students for residency in emergency medicine involves education in many areas of knowledge and skill, including instruction in advanced emergency procedures. We outline the logistics involved in running a training course in advanced emergency procedures for 4th year medical students and report student perceptions of course impact. The course is a cadaver based training lab which utilizes several teaching modalities including a web based syllabus and online streaming video, didactic lecture, hands on practice with models and ultrasound, and hands on practice with unembalmed (fresh) cadavers. The course focuses on 7 emergent procedural skills, including deep venous access via the subclavian, internal jugular and femoral veins, tube thoracostomy, saphenous vein cutdown, intraosseous line placement and emergency cricothyrotomy. It is taught by attending emergency physicians and anatomy department faculty.

After completion of the course, 33 students reported their self-assessment on a five-point Likert scale. Data was evaluated using a paired T –test (two-tailed). Students reported a mean increase in their understanding of the indications for the procedures from 3.3 ± 1.1 before to 4.8 ± 0.4 after the course, $p = 0.004$, 95% CI 0.7 - 2.0. Students reported a mean increase in their understanding of how to perform the procedures from 2.1 ± 0.9 before to 4.6 ± 0.6 after the course, $p = 0.003$, 95% CI 1.9 – 3.0. Students reported a mean increase in their comfort level performing the procedures from 1.6 ± 0.8 before to 4.2 ± 0.7 after the course, $p < 0.001$, 95% CI 2.0 – 2.9. Our experience supports the value of an advanced emergency procedural training course using an unembalmed cadaver-based lab and incorporating several teaching modalities. By outlining the logistics involved in running the course, including curriculum, equipment and cost, we hope to facilitate use of this teaching modality in other medical schools and to generate interest in future research regarding the utility of this approach to procedural training.

KEY WORDS: Emergency medicine; cadaver; procedures; education; medical students; ultrasound

INTRODUCTION

Teaching medical students to perform invasive procedures poses a number of challenges. Patients typically want the most experienced clinician to perform the procedure, not a medical student or resident who is doing it for the first time. The opportunity to perform invasive procedures may occur infrequently, when there is the greatest impact on patient outcomes and the greatest need for timeliness and success. Formal training in invasive procedures is often lacking in medical student and even resident curricula. Educational use of plastic mannekins, computer simulators¹, or animal models²⁻⁴ to teach invasive procedures may be a helpful adjunct but ultimately falls short of the physical reality of an actual human patient. While procedural practice on the recently deceased is an alternative, such opportunities are sporadic, may be uncommon, and remain ethically controversial^{5,6}.

The use of cadavers for medical student and resident procedural training has been cited as an effective educational model which improves clinical outcomes⁷⁻¹². Unembalmed cadavers that have not been “fixed” or chemically preserved more realistically simulate the feel of tissue and anatomic landmarks than either computer or mannequin simulation. Their use diminishes learners’ anxiety about patient safety and time limitations, and avoids the potential ethical conflict of performing procedures on the recently deceased without the consent of the donor or the family of the deceased¹³. We present the logistics of an advanced procedural training course utilizing unembalmed cadavers, including curriculum, equipment, and cost, in order to provide a model for other educators and generate interest in future research regarding the utility of this approach to procedural training.

METHODS

For the past three years at UCSF, we have run a medical student procedural training course using unembalmed cadavers. It is structured over two four-hour consecutive evening sessions, and incorporates multiple educational modalities (Table 1). Instruction during the cadaver session is provided by eight attending emergency physicians or residents (two per cadaver) and one faculty member from the department of anatomy who reviews anatomy using prepared dissections. Maximal student capacity is seven or eight per cadaver, allowing adequate faculty supervision and simultaneous practice of multiple procedures. Safe practices and universal precautions are reviewed and emphasized throughout, and recognition is given to the human donors who have made the exercise possible. Student interest has exceeded capacity each year, and priority is given to graduating 4th year medical students.

Didactics

The Model of the Clinical Practice of Emergency Medicine describes procedures and skills integral to the practice of emergency medicine, which include central venous access via the subclavian, jugular, femoral, and venous cutdown approaches, intraosseous infusion, thoracostomy, and cricothyrotomy as well as universal precautions¹⁴. We chose these procedures because they are frequently used, life saving, infrequently practiced, cause significant complications when improperly performed, and applicable to a wide range of specialty choices in addition to emergency medicine - surgery, internal

medicine, anesthesia, and pediatrics. We incorporate ultrasound guidance for vascular access into the training, given the Institute of Medicine mandate to reduce procedural errors through this approach¹⁵.

A course website provides a syllabus which is available in PDF format for students to print and review before, during, and after the course. Recommended preparation includes two hours of syllabus review. Two instructional videos on internal jugular venous catheterization using ultrasound guidance and percutaneous cricothyrotomy are available using Real Audio Media Player. Formal didactics during the first evening include Powerpoint presentations on central venous access and ultrasound guidance. During the second evening, thoracostomy, intraosseous access, and venous cutdown are demonstrated at the bedside, while cricothyrotomy is presented as a Powerpoint presentation outside of the lab while refreshments are served

Equipment

A variety of equipment is needed for the course (Table 2), and much of it can be recycled. Equipment such as micropuncture sets and ultrasound phantoms can be used repeatedly. Equipment used on cadavers can be recycled by soaking in enzymatic cleaner, including percutaneous cricothyrotomy tubes and dilators, chest tubes, clamps, scissors, and central venous catheters. Intraosseous needles may be recycled but are often bent and require extra care given the potential for sharps injury.

Unembalmed cadaver procurement

Faculty from the UCSF willied body program and department of anatomy coordinate procurement of unembalmed cadavers. Willied body programs or similar organizations exist in many states, often in affiliation with medical schools. In some states, such as Illinois and Pennsylvania, these are called state anatomical programs. The cost of per cadaver can range from \$800 - 3,000 depending on the region of the United States. In northern California, the cost is approximately \$1,850 per cadaver, and cremation after laboratory use adds an additional \$100 – 500¹⁶. Additional costs include testing for communicable diseases such as HIV, HBV, HCV and syphilis - if the cadaver tests positive, it is cremated prior to use. The costs for use of these unembalmed cadavers, however, may be shifted or deferred if they are subsequently embalmed for traditional use in other medical education programs (this may limit the ability to practice procedures such as thoracotomy) or harvested for fresh use in research. Additional expenses may include transportation and storage and fees to cover anatomy department personnel.

Funding Sources

We present our funding sources in Table 3. A combination of aggressive equipment recycling, student course fees, discounted equipment, small grants, and department support provide the ongoing sources of funding.

Student Self Assessment

Students complete a self-assessment questionnaire after the course, rating the quality of the course and their perceptions both before and after of their knowledge of procedural indications and contraindications, technical ability to perform the procedure, and comfort

level in procedure performance. The assessment uses a five point Likert scale, with 1 indicating the lowest score and 5 indicating the highest score. Statistical analysis was performed using a paired T-test (two-tailed).

RESULTS

A total of 33 students are included in the present data analysis, representing participation in UCSF advanced procedures courses from 2002 – 2003. Students reported improvements in each parameter surveyed for each individual procedure and overall for all procedures when pre and post values were compared (Table 4 and Figure 1). This included improved understanding of indications and contraindications, understanding of how to perform each procedure, and comfort level performing each procedure.

DISCUSSION

We have found this course to be a successful approach to procedural education for medical students. Experience has allowed us to maximize course efficiency. After noting substantial time and effort in teaching seldinger technique during a single session, we added an additional preliminary session to focus on anatomy, seldinger technique, and ultrasound. This additional session can be taught efficiently using only two attending faculty and several residents or even medical students who have previously taken the course. Additionally, we found that lumbar puncture training was suboptimal since it required repositioning of the cadaver and limited ability to simultaneously perform other procedures.

While extra course fees are discouraged at our medical school, they are essential to help offset costs for this course. Because some students who are financially limited may be discouraged from taking the course, our policy is to waive course fees if requested. When surveyed, 32 of 33 students felt that the fee was appropriate and acceptable.

Limitations

Adoption of this curriculum by other institutions may be limited by costs or availability of unembalmed cadavers. However, approaches that we describe to secure funding, minimize equipment costs, and offset unembalmed cadavers costs may help overcome these challenges. In our institution, the anatomy department is willing to offset cadaver procurement costs for medical student training but not for residents. We have shared the logistics and syllabi from this course with one other university medical school where it has been implemented ¹⁷.

Instead of completing self-assessments before and after the course, students assessed both after the course. This may introduce bias in favor of improvement and affect the validity of the self-assessment results. Additionally, the value of individual course components was not evaluated, so it is not possible to determine to what proportion the use of cadavers contributed. Since the present course is an elective and not a required part of the standard UCSF curriculum, the study population may not be representative of the overall medical student population. Finally, the inherent difficulty in correlating student self-report data with actual procedural competency and clinical outcomes, limits assessment of educational value.

Future Directions

Objective measurement of procedural improvement using explicit criteria and comparison of the individual teaching components would be helpful to document efficacy. Examination of subsequent clinical outcomes, such as procedural success and complication rates, could lead to improved clinical practice. In addition, comparison of this approach to organized curricula such as ATLS could prove informative.

CONCLUSION

By outlining the logistics involved in running a successful advanced procedures course, including curriculum, equipment and cost, we hope to facilitate use of this teaching modality and generate interest in future research regarding the utility of this approach. Our data indicate that completion of the course improves medical student self-reported understanding of procedural indications and contraindications, how to perform procedures and confidence level performing procedures.

This manuscript is dedicated to the memory of Dr. Hugh “Pat” Patterson who was instrumental in creating this course.

TABLE 1: Course structure / Teaching modalities

Evening 1 - Central venous access

- Central venous access: Powerpoint presentation– 45 minutes
 - Seldinger, anatomy, indications, contraindications, complications
- Ultrasound guidance: Powerpoint presentation (with refreshments) – 45 minutes
 - Literature and technique
- Seldinger technique lab – 45 minutes
 - Practice on models
- Ultrasound guidance lab – 90 minutes
 - Identify target vessels, ultrasound guidance on venipuncture models

Evening 2 – Unembalmed cadaver procedures lab

- Lecture: Introduction/ Logistics/ Universal precautions– 20 minutes
- Tube thoracostomy: didactic/demonstration – 15 minutes
- Practice with cadavers: central venous access and tube thoracostomy – 45 minutes
- Cricothyrotomy: Powerpoint presentation during refreshment break– 25 minutes
- Intraosseous catheters: didactic/demonstration– 15 minutes
- Review of anatomic dissections and practice on cadavers – 60 minutes
- Saphenous vein cutdown: didactic/demonstration– 15 minutes
- Practice on cadavers and clean up – 45 minutes

TABLE 2: Equipment for a 32-student Advanced Procedures Cadaver lab course (this list represents the minimal equipment requirements for the described UCSF course)

16 central venous access kits

4 Percutaneous cricothyrotomy kits
 8 intraosseous needles
 8 chest tubes
 8 safety scalpels
 8 large Kelly clamps
 Assorted suture material with 8 needle drivers and forceps
 8 vein hooks
 8 mosquito clamps
 40 assorted Angiocath IV catheters (14g, 16g, 18g)
 several packs of silk ties
 15-20 10 cc syringes and 18g, 22g needles
 4 sets of anatomy lab dissection tools, including assorted probes and scissors
 Gloves - 2 boxes each S, M, L
 50 protective gowns
 50 protective faceshields and/or eye protection
 Bleach/disinfectant
 4 large plastic basins for disinfecting reusable equipment
 8 large Biohazard trash bags
 Several large plastic storage containers for equipment
 Nametags and marker
 2-4 large sharps containers

TABLE 3: Funding Sources

Course development funding

- UCSF Academy of Medical Educators - one time grant
- Device company support in the form of expired/donated equipment

Ongoing course cost funding

- SAEM medical student interest group grants
- Device company discounts for educational product use
- Student fees
- Support from the anatomy department and emergency department.

TABLE 4: Results of Student Assessment

Understanding of the emergent indications and contraindications (mean values \pm standard deviations of the data samples)

	Before	After
Central line placement	3.8 (\pm 1.0)	4.9 (\pm 0.3)
Intraosseous access	2.5 (\pm 1.4)	4.6 (\pm 0.6)
Tube thoracostomy	3.8 (\pm 0.9)	4.8 (\pm 0.5)
Cricothyrotomy	4.0 (\pm 1.0)	5.0 (\pm 0.1)
Saphenous vein cutdown	2.6 (\pm 1.3)	4.5 (\pm 0.6)

All procedures 3.3 (± 1.1) 4.8 (± 0.4)
Mean difference for all procedures = 1.5 ($p = 0.004$), (95% CI, 0.7 - 2.0)

Understanding of how to perform procedures

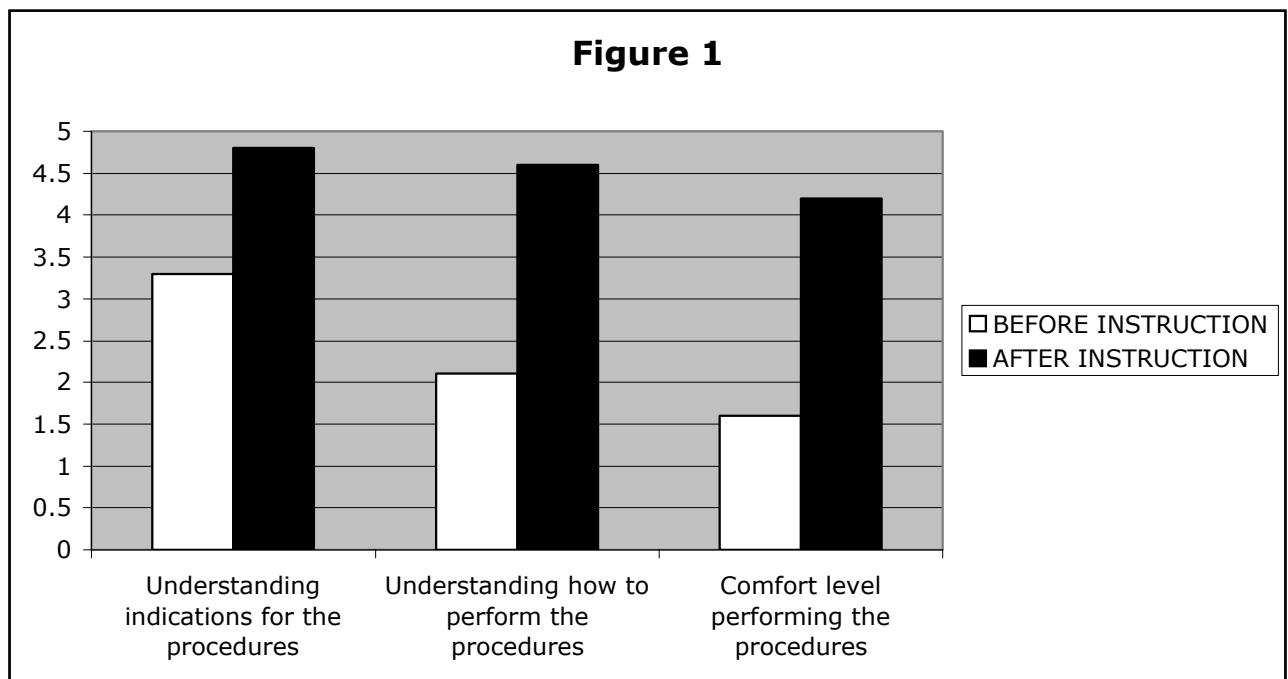
	Before	After
Central line placement	2.8 (± 1.2)	4.7 (± 0.4)
Intraosseous access	1.5 (± 0.9)	4.5 (± 0.6)
Tube thoracostomy	2.5 (± 1.0)	4.6 (± 0.7)
Cricothyrotomy	2.0 (± 0.9)	4.8 (± 0.4)
Saphenous vein cutdown	1.6 (± 0.8)	4.2 (± 0.9)
All procedures	2.1 (± 0.9)	4.6 (± 0.6)

Mean difference for all procedures = 2.5 ($p = 0.003$), (95% CI, 1.9 – 3.0)

Comfort level performing the procedures

	Before	After
Central line placement	2.2 (± 1.1)	4.2 (± 0.6)
Intraosseous access	1.4 (± 0.7)	4.3 (± 0.7)
Tube thoracostomy	1.8 (± 0.9)	4.1 (± 0.6)
Cricothyrotomy	1.8 (± 0.9)	4.3 (± 0.6)
Saphenous vein cutdown	1.4 (± 0.7)	3.9 (± 0.9)
All procedures	1.6 ± 0.8	4.2 ± 0.7 ,

Mean difference for all procedures = 2.6 ($p < 0.001$), (95% CI, 2.0 – 2.9)



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