INNOVATIONS

Introducing Point-of-Care Ultrasound Through Competency-Based Simulation Education Using a Fractured Chicken Bone Model

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ABSTRACT:
Audience: Medical students and interns in emergency medicine.

Introduction: Integration of point-of-care ultrasound (POCUS) into undergraduate medical education has many potential benefits, including reinforcing core anatomic and physiologic concepts, demonstrating clinical correlates to pathology, and aiding in learning of the physical examination. Patients, standardized patients, commercial training models, or cadavers are typically required for training students on POCUS, and are associated with substantial costs to educators and medical schools.

Objectives: At the end of this educational session, learners will be able to: 1) understand core POCUS concepts, including probe selection, image optimization, and probe orientation, 2) identify simulated long-bone fractures using POCUS.

Methods: Medical students are pre-tested with an affective style questionnaire, a multiple-choice knowledge test, and a hands-on skill test pertaining to POCUS and assessment of long-bone fractures. The hands-on skill test consists of POCUS evaluation of 16 chicken tibias (half of which are fractured) set in an opaque gelatin solution. Subjects undergo a standardized educational intervention consisting of a video and deliberate practice on clear gelatin models until a predetermined performance standard is met. The investigators defined the performance standard as successful identification of the presence or absence of fracture in five consecutive clear gelatin modules using correct technique. Subjects are post-tested using an affective style questionnaire, a multiple-choice knowledge test, and a hands-on skill test, and these are repeated eight weeks later to assess retention.

Topics: Ultrasound, point-of-care ultrasound (POCUS), orthopedics, ortho.

USER GUIDE

List of Resources:

Learner Audience:
Medical students, interns

Time Required for Implementation:
The instructor will spend about two hours creating this innovation.

The innovation / session will require approximately two hours.

Recommended number of learners per instructor:
Approximately eight learners per instructor

Topics:
Ultrasound, point-of-care ultrasound (POCUS), orthopedics, ortho.

Objectives:
At the end of this educational session, learners will be able to:

1. Understand core POCUS concepts, including probe selection, image optimization, and probe orientation
2. Identify simulated long-bone fractures using POCUS

Linked objectives and methods:
Hands-on practice is the ideal way to learn POCUS. This educational session allows learners to practice identifying long-bone fractures on POCUS (objectives 1 and 2). For evaluations, see attached Pre-Test, Pre-Survery, Hands-On Test, Post-Test and Post-Survey.

Recommended pre-reading for instructor:
Point-of-care ultrasound (POCUS) is an increasingly prevalent imaging modality and has many uses across multiple specialties. In undergraduate medical education, POCUS can serve to reinforce core anatomic and physiologic concepts, demonstrate clinical correlates to pathology and disease processes, and aid in learning of the physical examination. Multiple organizations, including the American Academy of Emergency Medicine and the American Institute for Ultrasound in Medicine, have advocated for the incorporation of POCUS into undergraduate medical education for these reasons.[1-2]

POCUS has been demonstrated to be an accurate diagnostic test for emergency physicians to evaluate extremity fractures at the bedside in both pediatric and adult patients,[3-7] and is a useful skill in resource-poor environments with limited access to x-ray. Emergency physicians can reliably detect skull and long-bone fractures in a cadaveric model using POCUS after standardized orientation,[8] and both Emergency Medical Technicians and emergency nurses have been shown capable of utilizing POCUS to accurately identify fractures in a simulated setting utilizing a turkey bone model.[9-10] Basic POCUS training has been shown to be feasible for undergraduate medical students.[11]

Learner responsible content (LRC):
We did not have the learners prepare ahead of time. Optionally, the learners could review the instructional video (which we instead showed to the learners during the educational session): https://youtu.be/eX1YE6IG2EI

Associated content:
Instructional video:
https://youtu.be/eX1YE6IG2EI

Implementation Methods:
Medical students are first pre-tested with a written test, an affective style questionnaire, and a hands-on skill test (provided below). The written test will evaluate core POCUS concepts, while the affective questionnaire will evaluate students' confidence using POCUS in the identification of long-bone fractures. The skill pre-test utilizes the opaque gelatin modules, and students are allowed to scan each of the 16 bones for 60 seconds using a linear high-frequency transducer. Students can then indicate whether or not a fracture is present.

After pre-testing, a standardized educational intervention is conducted. A 12-minute video presentation is shown (linked below), which introduces POCUS fundamentals and demonstrates techniques for identifying fractures using POCUS. Students are given a hands-on demonstration of standard technique for identification using the clear gelatin modules. Students then practice with the clear gelatin modules under direct observation of the investigators. An opaque towel is next placed over the student's hand, transducer, and clear gelatin module to blind the subjects. The subjects then employ deliberate practice until sufficient performance is demonstrated. Sufficient performance is defined as successful identification of the presence or absence of fracture in five consecutive clear gelatin modules using correct technique. The total hands-on training time is approximately 45 minutes.

Subjects are next post-tested with an affective survey, a written test, and a hands-on skill test, identical to corresponding pre-intervention assessments. Eight weeks later, these are repeated to assess retention.

List of items required to replicate this innovation:

1. 10 clear plastic containers with two compartments
   a. https://www.amazon.com/Paksh-Novelty-Lunch-Containers-2-Compartment/dp/B00SVGQXIS/ref=sr_1_fkmr2_3?ie=UTF8&qid=1495318366&sr=8-3-fkmr2&keywords=tupperware+two+compartment
2. Clear gelatin
   a. https://www.amazon.com/Knox-Gelatin-Unflavored-Individual-Packets/dp/B007Y3HM5C/ref=sr_1_2_a_it?ie=UTF8&qid=1495318461&sr=8-2&keywords=clear%2Bjello&th=1
3. Black food coloring
   a. https://www.amazon.com/Lorann-Oils-Liquid-Color-Black/dp/B0000VLRNS/ref=sr_1_5?ie=UTF8&qid=1495318521&sr=8-5&keywords=black+food+coloring
4. 20 chicken tibias
5. Handsaw, osteotome, hammer, or other device to implement fractures in chicken bones
6. Ultrasound machine
7. Ultrasound gel
8. Towel
9. Glue
10. Stovetop or hotplate, pot, and water to prepare gelatin

Approximate cost of items to create this innovation:
Approximately $30 (exclusive of an ultrasound machine with a linear probe)

Detailed methods to construct this innovation:

1. Clean and boil the 20 chicken bones, and implement fractures in 11 of them using a hammer, osteotome, saw, or other device, leaving nine bones intact to serve as controls.
2. Secure the bones to the bases of the Tupperware containers with glue.
3. Prepare clear and opaque gelatin (using the black food coloring) per package instructions.
4. Pour the gelatin into the Tupperware containers, creating four clear (three fracture, one control) and sixteen opaque (eight fracture, eight control) modules.
5. Allow the gelatin to set per package instructions.

Clear gelatin training module (left) and opaque gelatin testing module (right)

Results and tips for successful implementation:

1. Secure the bones to the floor of the containers prior to pouring gelatin because it is difficult to maintain desired bone orientation without doing so.
2. Encourage and remind students to press lightly with the ultrasound probe because the gelatin modules can begin to break down with repeated use.
3. Having access to multiple ultrasound machines will allow for less downtime/ waiting in line for learners.

We observed the following results:

	Pre-Intervention	**Immediately Post-Intervention**	**Eight Weeks Post-Intervention**
Hands-On Testing (of 16)	13	15	15
Written Testing (of 5)	3	5	5
Confidence Level (of 5)	1	4	4

Table 1: Median Hands-On Test Performance, Written Test Performance, and Confidence Level

	Mean Response (of 5)

How helpful was this module in introducing you to POCUS?	**4.8**
How helpful was this module in introducing you to identifying long-bone fractures using POCUS?	**4.8**

Table 2: Affective Survey Results

Students demonstrated a statistically significant improvement in identification of fractures using POCUS (median improvement 2/16, $p<0.0001$). Improvement in student confidence was also statistically significant (median improvement 2/5, $p<0.0001$). Following intervention, students were able to identify fractures using POCUS with an overall sensitivity of 94% and specificity of 92%.

At eight weeks post-intervention, participating medical students (59% of original students) still demonstrated a significant improvement from pre-intervention values in hands-on testing (median improvement 2, $p=0.0002$) and confidence (median improvement 3, $p=0.0002$), suggesting retention.

References/suggestions for further reading:

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Fractured Chicken Bone Ultrasound Model
Pre-Test

1. Which ultrasound probe type is ideal for detecting fractures?
   a. A high-frequency probe, e.g. linear array probe
   b. A low-frequency curvilinear probe
   c. A phased-array probe
   d. Probe types are all equally effective

2. How can you better visualize a superficial structure?
   a. Increase the depth of the image
   b. Use a standoff pad or water bath
   c. Use less gel
   d. Place dry gauze over the structure

3. Depth of the ultrasound penetration depends on what?
   a. Amplitude
   b. Resolution
   c. Frequency
   d. Transit time

4. What is the correct position of the ultrasound indicator for detecting fractures?
   a. To the patient's right or cephalad
   b. To the patient's left or caudal
   c. Always toward the center of the body
   d. Always toward the periphery of the body

5. Bone cortex will appear __________ relative to the intramedullary cavity with ultrasound imaging.
   a. Isoechoic (similar brightness)
   b. Hyperechoic (brighter)
   c. Hypoechoic (less bright)
   d. Depends on the patient

Fractured Chicken Bone Ultrasound Model
Pre-Survey

How confident are you in your ability to identify long-bone fractures using ultrasound?

Not Confident at All				Very Confident
1	2	3	4	5

Fractured Chicken Bone Ultrasound Model Hands-On Test

Bone Number:	Fracture Identified? (best guess, please circle one)
1	Yes / No
2	Yes / No
3	Yes / No
4	Yes / No
5	Yes / No
6	Yes / No
7	Yes / No
8	Yes / No
9	Yes / No
10	Yes / No
11	Yes / No
12	Yes / No
13	Yes / No
14	Yes / No
15	Yes / No
16	Yes / No

Fractured Chicken Bone Ultrasound Model Post-Test

1. Which ultrasound probe type is ideal for detecting fractures?
    a. A high-frequency probe, e.g. linear array probe
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2. How can you better visualize a superficial structure?
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    d. Depends on the patient

Fractured Chicken Bone Ultrasound Model Post-Survey

1. How confident are you in your ability to identify long-bone fractures using ultrasound after today's session?

Not Confident at All				Very Confident
1	2	3	4	5

2. How helpful did you find this session in exposing you to general principles of ultrasound?

Not Helpful at All				Very Helpful
1	2	3	4	5

3. How helpful did you find this session in teaching you to identify long-bone fractures using ultrasound?

Not Helpful at All				Very Helpful
1	2	3	4	5

INSTRUCTOR MATERIALS

Fractured Chicken Bone Ultrasound Model KEY

1. Which ultrasound probe type is ideal for detecting fractures?
    - **a. A high-frequency probe, e.g. linear array probe**
    - b. A low-frequency curvilinear probe
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    - d. Probe types are all equally effective

2. How can you better visualize a superficial structure?
    - a. Increase the depth of the image
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