**Title and Focus of Activity**: Neurologic Intensive Care Unit Simulation: Case Multi-trauma Traumatic Brain Injury

*Patient Client Management; Innovations*

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**Course Information:**

Advanced Clinical Decision-making; 2 credits; Winter of 3rd year of DPT program (semester 8 of 9). This advanced decision-making course focuses on maturation of critical and reflective clinical judgment across clinical practice areas. This course occurs after completion of foundational courses in neuroanatomy, neuroscience, clinical science in neurological conditions, and after completion of didactic courses in patient/client management in neurologic physical and cardiopulmonary physical therapy The students have also had 4 clinical education experiences (total of 29 weeks).

**Learning Experience Description**:

Context and Purpose: This is a simulation experiential learning event where students are responsible for conducting a physical therapy examination and determining readiness for intervention in a young adult patient with traumatic brain injury (TBI) in the neurologic ICU setting. Since many students do not get the opportunity to safely practice examination skills in actual acute care-neuro ICU setting during their clinical experiences, this serves as a safe environment to learn and apply these skills. Students can learn from their errors without risk of “doing harm” to the patient and gain confidence in this high acuity setting. Additionally, it is difficult, if not impossible, to schedule observation exposure to the neuro ICU setting for a large DPT class size (60 students). Further, observation-only experiences limit students to passive observers. In contrast, active learning is optimized with engagement in this simulation learning experience. Students are required to integrate foundational knowledge in clinical sciences and apply physical therapy examination skills across neurologic, cardiopulmonary, integumentary and musculoskeletal practice areas during this examination. The debriefing process encourages articulation of the clinical decisions made during the examination, interpreting findings, and learning from peers in an active discussion about these decisions and the experience.

This teaching activity utilizes trained standardized patients (SPs) in a high fidelity neuro ICU setting. . The teaching setting is in the ICU simulation suite in the Simulation Center at the GVSU Center for Health Sciences.

The simulation uses SPs and a Nursing faculty member participating as the patient’s primary nurse. High fidelity medical equipment (ICP bolt/line, Swan-Gannz catheter, arterial line, ECG electrodes, pulse oximeter probe) provides simulated invasive telemetry data that must be monitored and interpreted by the student, including arterial pressure, intracranial pressure, oxygen saturation, heart rate, and ECG. Invasive and noninvasive interventional devices include a mechanical ventilator, chest tube, PEG tube, central line, Foley catheter, and a knee immobilizer. The mechanical ventilator is set to assist control mode and is connected to the SP via simulated ventilator tubing, a modified tracheotomy tube with T-piece and in-line suction catheter. The actual ventilator tubing is connected to a rubber lung behind the curtain and can be manipulated by the simulation staff to trigger various ventilator alarms (the simulation staff are also controlling the telemetry parameters). [For programs that do not have access to actual ventilators, a simulated ventilator display of settings, patient parameters, and alarms can be created using powerpoint slides (Appendix E) with simulated ventilator circuit tubing attached to the SP.] The modified tracheostomy tube provides a space that wraps around the side of the SP’s neck under the tracheostomy tube tie that allows for pre-loading of simulated secretions and insertion of the suction catheter to remove the simulated secretions.

The SPs are trained in advance by two physical therapy primary instructors. Instruction includes the planned simulation progression and emphasizes how to portray clinical characteristics and responses of the patient with multi-trauma and TBI who is just emerging from coma. In addition, during the simulation session the SPs have a hidden ear piece and the primary physical therapy instructors (who are observing the evaluation through a glass window and have one way communication device with the SPs) are verbally prompting the SPs through their responses to the examination process. The real-time cued responses to ongoing examination is a critical feature of this simulation, as the SPs are trained and cued to portray posturing, non-purposeful movements, bruxing, agitation, and specific responses to the therapist’s arousal stimuli. A pair of students is responsible for completing the physical therapy neurologic examination over a 30-35 minute period and 1-2 students serve as observers. These student observers are responsible for leading the debriefing session following the simulation event with the student evaluation team and the faculty facilitator. There are two neuro ICU patient simulations running simultaneously and the debriefing session is combined with both groups, which runs approximately 20-25 minutes in length (e.g. a total of 8 students complete the simulation per hour). Primary physical therapy instructors serve as facilitators in the debriefing session, which is an important active learning, reflective process for the students and allows for formative evaluation with feedback from peers and faculty.

The following materials\*\* were developed to support this teaching activity:

1. *Neuro ICU Simulation Orientation* (provided in advance to students, includes TBI case information, learning objectives, and expectations during simulation for student examiners and observers)
2. *Neuro ICU Simulation Preparation Notes for Students* (provided in advance to students, includes assigned preparatory materials, readings and video; and an overview of the examination process)
3. *Neuro ICU Simulation Facilitator Guidelines* (Instructor information and specific cued responses to provide the SPs during the physical therapy examination)
4. *Simulation Team Preparation* (description of the collaboration and planning meeting agenda between PT faculty and GVSU Simulation team, who assist in preparing the medical equipment, programming the physiologic events, setting up the ICU environment, and prepping the SPs with necessary lines/devices)
5. *Neurologic Examination-TBI in Neuro ICU setting* (training video developed by instructor and provided in advance to students, accessed online via Blackboard course videos)

\*\* See Appendices (A--E) with respective names at the end of the submission

Time for student to complete the activity: 1. Preparation outside of/before class: (3.5 - 4 hours total)

* View online training video on TBI examination in ICU setting (45 minutes)
* Review preparation materials, references, and readings (approximately 3 hrs)

2. Class time for completion of the activity: 1 hour including debriefing session

**Readings and Preparatory Materials**:

1. Review the two handouts provided for this simulation:
2. Neuro ICU Simulation Orientation (*Appendix A*)
3. Neuro ICU Simulation Orientation Preparation Notes for Students (*Appendix B*)
4. Review *Glasgow Coma Scale* and the *Rancho Los Amigos Scale of Cognitive Functioning* for Traumatic Brain Injury. (covered in previous courses in PT 641 Neurologic Examination and PT 642 Interventions in Neurologic Physical Therapy)
5. Review and Practice examination procedures for the *JFK Coma Recovery Scale-revised*:

<http://www.tbims.org/combi/crs/CRS%20Syllabus.pdf>

*Evidence-based reference*: Giacino JT, Kalmar K, Whyte J. the JFK coma recovery scale-revised: Measurement characteristics and diagnostic utility. *Arch Phys Med Rehabil* 2004; 85 (12) 2020-2029

1. Review the materials from PT 643 Clinical Medicine and PT 642 Interventions in Neurologic Physical Therapy on acute care medical management and prognostic factors in TBI.

Equipment review: Mobility in Context: Principles of Patient Care Skills, Johansson C, Chinworth SA (eds), 2012. Chapter 3: *Special Environments*-*Critical Care*, pp 61-71 (PT 642 assigned reading)

Review cardiopulmonary and acute care information on 1) vital sign normal parameters 2) ICP normal values, 3) ventilator settings and controlled ventilation.

1. View the *customized online training video* on neurologic examination of TBI patient in Neuro ICU setting (posted on Blackboard course website) {author CC Harro}

**Learning Objectives:**

1. Articulate decision-making process for planning and conducting the initial physical therapy examination and intervention of a patient with TBI in Neuro ICU setting. 2. Demonstrate awareness of and competent management of all medical interventional and monitoring devices in Neuro ICU setting with regard to purpose and precautions during physical therapy examination and mobilization of the patient. 3. Competently conduct physical therapy examination of a patient with multi-trauma and TBI in the Neuro ICU setting. 4. Interpret the patient’s neurologic and cardiopulmonary status and response to physical therapy examination, including physiologic stability and determination of Rancho Los Amigos Cognitive Functioning Scale (RLA). 5. Reflect on errors in decision-making and identify possible sources for those errors. 6. After completion of examination in Neuro ICU setting, articulate decision-making process for planning and conducting the initial physical therapy intervention. (Intervention to be initiated during this simulation only if time allows)

Methods of Evaluation: “Debriefing Process””

Formative evaluation is provided by both peers (student observers in the simulation) and faculty facilitators, and self-reflection is encouraged in a nonjudgmental environment during the debriefing process. Students are expected to articulate their decision-making process for conducting the examination and how the patient’s responses informed their decisions. Students are asked to interpret their examination findings and summarize their evaluation of the patient’s level of arousal, awareness of environment, responsiveness to stimuli, and RLA Level of Cognitive Functioning. Students are also asked to interpret the patient’s neurologic and cardiopulmonary responses during the course of the physical therapy examination.

The team discusses the medical and physiologic events that occurred during the event, and reflects on how effective they were in managing these events in a timely and safe manner. The team also discusses prognosis, PT plan of care and readiness for PT intervention for this patient in the Neuro ICU setting. Finally, students honestly reflect on any errors in decision-making and the possible sources of these errors. The SPs also have an opportunity to provide students feedback about their interactions with them during the examination and the primary nurse provides students feedback on their professional communication as a medical team member. Faculty facilitators provide the entire class overall summary feedback of key learning points from each simulation and areas for professional development are identified.

**APPENDIX A**

**Neuro ICU Simulation Orientation**

**Case History**

Trevor Smith is an 18 year-old male who was an unrestrained driver in a high-velocity MVA 1week ago. He was thrown from the open-top jeep and was found 75 feet from the wreckage. Glasgow Coma Scale (GCS) on scene was 5 (E1, V2, M2). He was transported by helicopter to your regional Level 1 trauma center. Upon evaluation in the emergency department GCS was 6 (E2, V1/t, M3), tested while on the ventilator. He was found to have multiple rib fractures and hemothorax on the right, left femur fracture, splenic rupture, and a large subdural hematoma over the left parietal area with lateral shift evident on CT scan. He subsequently underwent evacuation of the hematoma, placement of a subdural, closed system intracranial pressure bolt, splenectomy, and IM rod placement in the left femur. He began spontaneous breathing 3 days ago but remains on pressure support via mechanical ventilation and tracheostomy tube. His post-operative course has been uneventful. Neurologically, his GCS has improved to 8 (E3, V1/t, M4); however neurologic status has been fluctuating in response to intermittent changes in ICP, which has ranged from 16-22.

Medications include Ativan IV push, IV Mannitol, IV Keflex, and Vicodin and Tylenol via PEG tube.

**Simulation Objectives**

1. Articulate decision-making process for planning and conducting the initial physical therapy examination and intervention of a patient with TBI in Neuro ICU setting.
2. Demonstrate awareness of and competent management of all medical interventional and monitoring devices in Neuro ICU setting with regard to purpose and precautions during physical therapy examination and mobilization.
3. Competently conduct physical therapy examination of a patient with multi-trauma and TBI in the neurologic ICU setting.
4. Interpret neurologic and cardiopulmonary status and response to physical therapy examination, including physiologic stability and determination of Rancho Los Amigos Cognitive Functioning Scale (RLA).
5. Reflect on errors in decision-making and identify possible sources for those errors.
6. After completion of examination in Neuro ICU setting, articulate decision-making process for planning and conducting the initial physical therapy intervention. (Intervention to be initiated during this simulation if time allows)

**Progression of Simulation**

Stages I and II:

* Identify all necessary information from monitors and patient- HR, BP, RR, SpO2, EKG, ICP
* Identify all lines and tubes
* Perform baseline neurologic exam: cognitive level, arousal level, systematic assessment of response to auditory, visual, and motor/command stimuli, considering consistency of response and responses of all 4 limbs/face, and allowing sufficient time for response; muscle tone/reflexes, and cranial nerves.

Stage III:

* Assess response to ROM and mobilization as appropriate
* Respond to any changes in the patient’s status or alarms from monitoring equipment.

**Monitoring and Interventional Devices**

The following page demonstrates the ventilator screen and the patient monitor (the screen you will see is only the upper right portion of the screen shot).

Patient Monitor:

* HR, continuous BP, PAP, and SpO2 are along the right side of the screen.
* ICP is in the bottom of the screen

Ventilator:

* Take some time to review your supported ventilation lecture from last year. Notice the location of the alarm silence and reset buttons on the bottom right panel and the 100% O2/Suction button in the center bottom panel.

Standardized Patient:

* The tracheotomy tube will allow for insertion of the in-line suction catheter, so treat it is you would a real tracheotomy tube.

**Student Clinician**

1. Remember, this simulation is to be performed as close to reality as possible. Stay in character. Talk to your patient!
2. The patient’s primary nurse will be available to address any questions you have about the patient prior to working with the patient. The nurse will also be available (at nursing station) for any nursing-related questions or medical needs. For the purposes of the simulation, you should pretend the nurse is out of the room and needs to be called or retrieved.
3. There will be two student clinicians per group randomly chosen at the beginning of your session. The other two students will be active observers. You are encouraged to dialogue and verbalize your thought processes for the observer’s benefit.
4. You should follow all precautions for the lines and tubes attached to the patient
5. The key is to orient yourself to what information is available and where it is located, and to use that information in your clinical decision-making.
6. Remember to act calmly and decisively, and take your time in executing an action. If you would like to take an action but don’t know how to do it (e.g. silence an alarm), verbalize your intent and try to actually do it. Ask for assistance from the facilitator or primary nurse if you are not successful.

**Observer Questions for Reflection:** Observers are responsible for starting the discussion during the debriefing. During your observation actively reflect on the following questions:

1. At the start of the simulation, what is your interpretation of the patient’s neurologic status? Is the patient aware of himself and his environment? As the simulation progresses, is the patient responding to stimuli, how consistently, type of stimuli? Is the patient following commands? What was the patient’s neurologic and physiologic status throughout the examination?
2. What alarms were triggered? How did you know? How did the patient respond physiologically?
3. Is the patient appropriate for mobilization? Why or why not?
4. How did the patient respond to ROM? Mobilization?
5. What is the RLA Cognitive Functioning Level for this patient during today’s examination?
6. What is his prognosis? What medical and PT examination information informs you about his prognosis?
7. What factors affect your decision-making regarding this patient’s readiness for initiating physical therapy intervention? What is your plan of care for this patient in Neuro ICU setting?
8. Student Clinician Performance
	1. What was done well?
	2. What errors were made? Why? How could those errors have been avoided?
	3. What could have been done differently?

**Ventilator Screen Shot**



**Patient Monitor Screen**



**ICP**

**IABP**

**APPENDIX B**

**Neuro ICU Simulation Preparation Notes for Students**

1. Review the two handouts provided for this simulation:
2. Neuro ICU Simulation Orientation
3. Neuro ICU Simulation Orientation Preparation Notes for Students
4. Review *Glasgow Coma Scale* and the *Rancho Los Amigos Scale of Cognitive Functioning* for Traumatic Brain Injury. (covered in previous courses in PT 641 Neurologic Examination and PT 642 Interventions in Neurologic Physical Therapy)
5. Review the JFK Coma Recovery Scale:

<http://www.tbims.org/combi/crs/CRS%20Syllabus.pdf>

\*\*it is important for you to review the JFK coma scale to get a feel for how to adjust/modify your sampling strategies for different levels of functioning. Below is only a summary with some examples.

Evidence-based reference: Giacino JT, Kalmar K, Whyte J. the JFK coma recovery scale-revised: Measurement characteristics and diagnostic utility. *Arch Phys Med Rehabil* 2004; 85 (12) 2020-2029

1. Review the materials from PT 643 Clinical Medicine and PT 642 Interventions in Neurologic Physical Therapy on acute care medical management and prognostic factors in TBI.

Equipment review: Mobility in Context : Principles of Patient Care Skills, Johansson C, Chinworth SA (eds), 2012. Chapter 3: *Special Environments*-*Critical Care*, pp 61-71 (PT 642 assigned reading)

Review cardiopulmonary course and acute care information on 1) vital sign normal parameters 2) ICP normal values, 3) ventilator settings and controlled ventilation.

1. View the online video training on neurologic examination of TBI patient in Neuro ICU setting (posted on Blackboard course website)

**TBI Multi-trauma Case-Neurologic Examination in Neuro ICU**

1. Survey the scene:
* Vital signs, especially BP and ICP (determinants of cerebral perfusion)
* Check lines, leads, tubes
1. Cranial Nerve Exam
2. Proceed with the neurologic examination:
* The goal is to answer whether they can hear, see, and move. You want to make conclusions about ability to receive sensory input, process/understand the environment and stimuli, follow commands, and make purposeful movements.

Key Guiding Principles for Sampling/Testing:

* Allow time for a response, systematically test left and right, arms and legs. Understand that a lack of a motor response may be due to paralysis/impaired motor control.
* Change up the stimuli to be sure the response is actually a response to the stimulus, and not a random movement or response.
* Use the stimulus for the highest level of functioning first, then go to more basic levels as needed (e.g. stimuli to elicit voluntary, purposeful responses first, if no response, then automatic responses, and if no response, then elicit reflexive responses).
* Your interpretation is either: no response, general response (posturing, tone changes, etc), or a localized response.
1. Systematically assess awareness and responsiveness to the following stimuli (refer to JFK Coma Recovery Scale administration guidelines)
	1. Auditory Assessment
* Responsiveness and localization to sound
* Auditory command following
	1. Visual Assessment

• Responsiveness and localization to visual stimuli

* 1. Combined visual/auditory stimuli and command following

Arousal Protocol:

* Arouse the patient if necessary to start exam and as needed throughout the exam by providing a deep pressure stimulus progressively in the face arms and legs. Be observant for any painful responses or pain behaviors.
1. Motor Assessment:
* Assess for any spontaneous movement throughout the examination
* Functional movements- verbal commands to do a functional task like brushing hair
* Familiar, automatic movements-waving, giving a thumbs up (follow JFK guidelines)
* Voluntary purposeful movements/object manipulation- e.g. grab the ball with tactile stimulation of the ball on the back of the hand
* Responses to noxious stimuli in fingers and feet
1. Muscle Tone and ROM Assessment
* Don’t forget your bread and butter exam skills!!!

**✓ Remember this is a High Acuity setting: Closely monitor neurologic and physiologic status throughout the examination**

**APPENDIX C**

**Neuro ICU Simulation Facilitator Guidelines If this appendix remains in the submission, some of the other information regarding the role play, student examination ‘checklist’ could be removed for brevity.**

*Instructor Information and Cued Responses to Standardized Patients*

*Multi-trauma TBI case in Neuro Intensive Care Unit setting*

**At Rest**: Eyes closed, no posturing, no spontaneous movement, no purposeful behavior or evidence of awareness of self or of his environment

**Cranial Nerves**

* II, III intact (pupillary response to light; tracking on visual testing-oculomotor)
* IV, VI intact (when inconsistent tracking of mirror/photo, good ocular control)
* V/VII (corneal reflex intact—blink response)
* VIII-XII unable to assess
* VOR/oculocephalic reflex intact

**Responses to Systematic Auditory Stimuli**

* If students just call out his name repeatedly initially, no response or eye opening. Once they start stimulation protocol assessment, he may intermittently respond to his name (1/4 times)
* Eyes open in response to bell/clapper both right/left side with slight delayed head turn toward sound (consistently early in simulation, but not responding later in examination as he declines in arousal and ICP rises)
* Eyes open in response to noxious stimuli or arousal protocol (consistent, but degrades by the end of simulation as he declines physiologically)
* No consistent response to auditory commands (“look at object”)
* Inconsistent (1/4 times) response to touch “the ball” (gross left UE movement increases thrashing but not moving to target); no response to LE directed movement commands
* As simulation progresses, he is less responsive and by end of examination he is not responding with eyes open even to repeat auditory stimuli

**Vision-reflexes & Responses to Systematic Visual Stimuli**

* Pupils are reactive and equal
* Oculocephalic reflex is present (VOR)
* Reactive blink to visual threat (multiple blinks)
* Visually fixates on ball (75% of time) when aroused, eyes open with stimulation
* Inconsistently tracks visually (ball, photo, mirror) 2/4 times
* No consistent object localization when given two objects and command to’ Look at “x” or look at “y”’
* Eyes are not actively searching the environment when open, staring only and roaming across the ceiling. He does not make eye contact with examiner.
* As examination period progresses and he declines physiologically, he is no longer fixating or tracking objects. Difficult to get him to stay aroused with eyes open.

**Motor Responses and Active Movements**

* No spontaneous movement initially; when aroused with auditory or noxious stimuli he demonstrates intermittent non-goal directed thrashing of left UE.
* Left UE Movement is gross stereotypic, elbow flexion with pronation, wrist flexion, and tight fisting of hand
* No object manipulation when placed on dorsum of hand
* No response to motor commands (automatic, e.g. thumbs up/wave with or without gesture)
* No response to goal directed motor commands (object or nonobject directed; e.g. “touch the ball”, “wiggle your toes”, etc…)
* Oral motor, during stimulation and in response to noxious stimuli he demonstrates grimacing and intermittent teeth grinding
* Touch to side of cheek, early in evaluation elicits eyes open with slight delayed head turn towards side of the touch
* Response to noxious stimuli is flexor withdrawal (full limb L UE, mild flex R UE, increase extension tone in LE); no directed attempt to localize noxious stimuli
* During the examination as he deteriorates, his response to any noxious stimuli is slow increased in tone with decorticate posturing

**Muscle Tone Evaluation**

* Moderate flexor tone in both UE (Right>Left), as examination time progresses clear rigidity in flexion in UEs; strong grasp reflex bilaterally
* Moderate extensor tone in R LE (Modified Ashworth grade 3) evident in quadriceps, gastrocsoleus, hip adductors, with sustained clonus bilaterally

 Note: (L LE is immobilized) He is very reflexogenic on bottom of foot, marked plantarflexion response to any touch. As time progresses, marked extensor rigidity increases in both legs.

* DTRs 3+ wrist, biceps, and gastrocsoleus muscles
* PROM examination: eyes open intermittently, grimacing when moving R UE and L LE

**Simulation Events (Equipment and Physiologic online monitoring):**

⮚ Ventilator event (10-15 minutes into examination): signal for the high pressure alarm (did students note the increased HR and respiratory rate or SpO2 decrease prior to alarm?)

Trevor demonstrates notable increased arousal, agitation, and increased tone during event and subsequent suctioning. Did student check the ventilator for any kinked tubing?

Did student listen to lungs and note secretions, gurgling sound? Trevor demonstrates some coughing and gagging. HE NEEDS SUCTIONING.

Did students competently suction patient? Did they talk to Trevor to calm him and explain briefly what they are doing?

Post-event, did students recheck SpO2 and respiratory rate to determine if he is stable to continue with examination?

⮚ Vitals/Physiologic Status during 25 min exam

Over course of examination, Trevor’s ICP is gradually rising (16 to 20). Is the student aware of this change and were any clinical decisions made or communication with nursing?

Over course of examination, systolic BP is gradually dropping and HR is increasing. Is the student aware of these important vital signs to monitor? Were any clinical decisions made or was there any communication with nursing?

⮚ If student team decides to mobilize Trevor, e.g.. roll to right (chest tube side), then there is a marked jump in HR, reduced arousal, eyes closed, teeth grinding, rise in ICP, systolic BP drop.

If student team decides to sit Trevor at edge of bed, then precipitously drop in BP, tachycardia, with unresponsiveness.

**Questions for the Instructor to consider during observation of examination process**:

How did the students organize their neurologic exam? How did they modify the exam based on Trevor’s responses and physiologic status? Were the students systematic in their examination of responsiveness to self/environment/specific stimuli? Did they complete the hands-on aspects of neurologic exam, e.g. reflexes, muscle tone, ROM, response to touch? How much of exam did they complete? How did they chose to arouse patient (auditory stimuli, deep pressure, vs. noxious stimuli)? How aware of changes in vital signs were they and what clinical decisions ensued? How did the students interpret the patient’s neurologic and physiologic responses throughout the examination? What was their clinical interpretation of these evaluation findings? How effectively did they communicate with the primary nurse before, during, and at the conclusion of the examination?

**Abbreviations:**

UE= upper extremity

LE= lower extremity

ICP= intracranial pressure

VOR= vestibular ocular reflex

BP= blood pressure

spO2= oxygen saturation

**APPENDIX D**

**Simulation Team Preparation**

In advance of the scheduled event, the Simulation Center staff are provided the ICU Simulation Orientation, Neuro ICU Prep Notes, and Neuro ICU Facilitator Guidelines documents. A preparatory meeting is then scheduled. During this meeting between coordinating PT faculty and the Simulation Center staff, the main areas of discussion include standardized patient (SP) selection and training, simulation equipment set-up and needs, scenario progression. It is important to note this is a collaborative discussion that has yielded many important refinements of the simulation over the past several years. With regard to SP selection and training, the desired age (late teens or early 20s) and gender (male or female) are decided and an SP training date is selected.

[Note: In our first few years running this Simulation Event we used a “sim man” instead of the SP, however we soon realized that use of the sim man lacked the actual behavioral responses of a patient emerging from coma during the physical therapy examination. Instead, the faculty facilitators had to just verbally state the behavioral responses (“eyes slowly open”, “head turns to left” , “legs stiffen into extension” etc…). Students were not watching the sim man for responses but just focusing on the medical monitoring vitals and listening to faculty information on behavioral responses.

With the assistance of the simulation staff we are able to create a high fidelity ICU simulation using the Laerdal SimMan software combined with trained standardized patients.]

The equipment set-up is then discussed. The simulation team is responsible for SP set-up on the day of the event with following simulated equipment:

1. **Simulated medical monitoring equipment**: ICP bolt/line, Swan-Gannz catheter, arterial line, ECG electrodes, pulse oximeter probe
2. **Invasive and noninvasive interventional devices**: mechanical ventilator, chest tube, PEG tube, central line, Foley catheter, and a knee immobilizer.
3. **Ventilator set up and events**: The actual ventilator tubing is connected to a rubber lung behind the curtain. During the simulation hand signals from the faculty facilitator are established to signal the start of the high pressure alarm and oxygen desaturation. This event is triggered by simulation staff member who occludes the rubber lung. As the students correctly and successfully perform endotracheal suctioning, another hand signal is given by the faculty facilitator for releasing the rubber lung and restoring oxygen saturation.
4. **Specialized simulated tracheostomy**:The modified tracheostomy tube provides a space that wraps around the side of the SP’s neck under the tracheostomy tube tie that allows for pre-loading of simulated secretions and insertion of the suction catheter to remove the simulated secretions. The inner and outer cannulas of a Shiley tracheostomy tube were cut just past the outer cannula retainer. A 6-inch long, 1/4-inch diameter flexible tubing was glued to the remaining outer cannula taking care to maintain patency of the tubing. The flexible tubing was taped to the inside of the tracheostomy collar. A plug was fashioned using a pencil eraser. A 3x2x1 inch foam block was placed around the cannula in the area behind the retainer to allow for a curved transition of the flexible tubing to prevent kinking. Lubricant jelly mixed with white hand lotion and yellow water coloring can then be inserted into the tubing using a syringe to simulate secretions. With the simulated tracheostomy tube attached to the SP with the collar, simulated ventilator circuit tubing with an in-line suction catheter permits students to perform all tasks associated with endotracheal suctioning, including inserting an appropriate length of the catheter, assessing for the effectiveness of suctioning, and making multiple passes until secretions are removed.

With regard to scenario progression, telemetry values are decided upon for each of the main phases of the simulation. Simulation staff program and manipulate telemetry data using the Laerdal SimManTM software (Laerdal Medical Corporation, Wappingers Falls, NY). The telemetry values and simulation progression is as follows:

1. **Resting Vitals**: Heart rate high 80s with sinus rhythm, oxygen saturation 97-98%, with the ventilator set to 40% FiO2, blood pressure low 130s/low 90s, and intracranial pressure (ICP) of 16 mmHg.
2. **Ventilation Event**: Immediately preceding the high pressure ventilator alarm, oxygen saturation is set to drop to mid-80s over 2 minutes, and is restored to high 90s following successful endotracheal suctioning.
3. **Simulation Progression-Physiologic decline**: Over the course of the entire scenario, heart rate is programmed to rise to 115, blood pressure to decrease to 90/50, and ICP to rise to 20.

Note: Because the Laerdal SimMan software does not have an ICP field, the end-tidal CO2 field is used to simulate ICP and an appropriately label is placed on the telemetry monitor.

**APPENDIX E**

**Alternate, Lower-Fidelity Simulated Mechanical Ventilator**

The following images demonstrate how a laptop computer and PowerPoint Slides can be used to simulate a mechanical ventilator. Slides can be advanced to portray changes in parameters and alarm status. Application of this set-up has been previously described in: Shoemaker, M.J., Riemersma, L., Perkins, R. (2009) Use of High-Fidelity Human Patient Simulation in Physical Therapist Educational Curricula. *Cardiopulmonary Physical Therapy Journal*, 20(1), 13-18.

In the following example, the slides were advanced from a baseline setting to a high-pressure alarm with an embedded audio file of an alarm.



